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Chapter 10

MEASURING PHYSICAL ACTIVITY IN CHILDREN AND YOUTH: LEARNING FROM EXPERIENCE

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ABSTRACT

Given the myriad issues surrounding the self-report of physical activity, particularly in children and youth, objective measures are preferred. One particular objective measurement tool which provides considerable detail in the data it records is the accelerometer. When accelerometers are used to collect physical activity data, the range of possibilities include: the length of the epoch, time of day, intensity of activity, steps, etc. As such, these data collection tools are useful for not only quantifying the physical activity data collected, but also in determining when the bouts of health-related intensity of physical activity (moderate, hard and very hard) and sedentary time occur. This information can then be used to inform various health promotion initiatives. Uniaxial accelerometers (Actigraph GT1M, Model 7164; Manufacturing Technologies Inc., Health Systems, Shalimar, FL) were used in the Physical Activity of Children and Youth (2001; 2005) and Keeping Pace (2009) surveillance studies of the physical activity and dietary intake of boys and girls in Grades 3, 7, and 11 from Nova Scotia, Canada. In each of the three cross sectional surveillance studies, more than 1700 students provided one to seven days of physical activity data. This paper will describe the methodologies used to collect, analyze, and describe the physical activity data obtained using the Actigraph

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accelerometer as well the various issues that arose during data collection, analysis, and description in these studies with a focus primarily on the Keeping Pace project.

INTRODUCTION

Physical activity can be broadly defined as “all bodily actions produced by the contraction of skeletal muscle that increase energy expenditure above basal level” [1; p S5]. Examples of physical activity include, but are not limited to, various forms of active transportation, sport, exercise or training, active play, yard and house work, etc. Physical activity can also be defined or classified according to its intensity or how hard it is done, the frequency of the movements, and the amount of time spent doing it [1]. Given the many forms that physical activity can take and the different ways it can be quantified, it is not surprising that it can be challenging to measure in adults and in children. Further compounding this measurement issue are two realities. First, level of physical activity usually varies from day to day depending upon personal and professional responsibilities. Second, personal goals, values, and attitudes toward physical activity also influence choice and desire to engage in physically active pursuits, thus impacting level of physical activity participation.

Many measures ranging from self-report to doubly labeled water have been developed to assess children’s and adult’s physical activity with varying levels of validity and reliability as well as varying levels of burden on the participants [2]. Subjective measures of assessing children’s physical activity, such as self-report or proxy-report tend to have lower validity and reliability partly because of the difficulty remembering what was done in the previous day or week or year. Proxy reports involve further challenges as parents/guardians or teachers do not always know what the child is doing in all parts of his or her day. Further complication of self-report relates to the understanding and correct application of the intensity of physical activity. As well physical activity among children, particularly those of a younger age is often erratic, that is, done with short bursts of intensity.

One objective assessment tool that compensates for these shortcomings of self-report is the widely used and accepted Actigraph accelerometer [3-5]. Accelerometers are devices that quantify body accelerations of movement and are considered the ‘gold standard’ for measuring physical activity among children. Accelerometers are small devices (5 x 4 x 1.5 cm) that can be placed into a pouch, affixed to an elasticized belt and put around one’s waist to measure body accelerations in one or more axes. When the uniaxial accelerometer is used, the motions detected occur in the vertical plane. The more recently developed triaxial accelerometer quantifies body movements in the three anatomical axes; vertical, anteroposterior, and mediolateral. The accelerations are measured and averaged over a specific time frame, the most frequently being the 60 second epoch [6], although shorter times have been used as well (e.g., 10, 15, 30 seconds). The ability to ‘count’ the accelerations over these short time periods allows for a better determination of time spent in various intensities of physical activity and accommodates for the erratic nature of children’s typical participation. Using the counts and a 60-second epoch, the accelerometer data can then be converted for each minute into sedentary time, or light, moderate, hard, or very hard physical activity.

Although participation in physical activity varies from day to day throughout the year, seven days is considered adequate for an estimation of a child’s usual participation in physical

activity [3, 6, 7]. A consecutive 7-day monitoring period covers the weekend and weekdays and provides a sufficient number of days to achieve an intraclass correlation of 80% [3]. Although there is considerable variability and controversy over what should be used to quantify a full day of accelerometer data to be considered valid [6], the general consensus is there should be minimally 10 hours or 600 minutes of ‘counts’ [7].

Advantages to using the accelerometer include the ability to capture all physical activity – as well as the intensity of that physical activity – that occurs when it is worn. Further, the accelerometer provides time of day data and can be downloaded in time frames for weekdays and week-end days to help to better understand patterns of physical activity participation, or lack thereof in children and youth [8].

An obvious disadvantage to the accelerometer is that the participant has to remember to put it on for it to collect appropriate data. Although it is relatively small in size, it may be uncomfortable for some. Other disadvantages to using the accelerometer include that there are some physical activities it cannot measure, such as anything that is water-based and others such as cycling, skating, skateboarding, etc. where the accelerometer may not determine the actual intensity of the activities very well. Further, the accelerometer does not recognize if there is an extra load added to the physical activity, for example, carrying a heavy backpack when walking. The accelerometer also cannot provide an indication of where the physical activity takes place, if it is done alone or with someone else. Nor can it provide the motivation or reason the physical activity was done.

There are also practical issues with using accelerometers that should be considered. The accelerometers should be fully charged between uses and initialized for each user so that the time is set to start and stop collecting data. The initialization process involves entering the participant’s name and/or subject number, choosing the appropriate options (activity, step, number of axes, epoch, etc.) as well as the time for the device to start and stop collecting data. Data must be downloaded upon completion of the established data collection period and the process repeated for the next participant. Pouches and belts should be washed between participants and the appropriate size belt needs to be available for each participant.

This chapter shares the methodology used to gather and analyze the physical activity data collected using accelerometers from the Physical Activity of Children and Youth (PACY 2001, PACY 2005), and the Keeping Pace 2009 surveillance projects and the extensive physical activity results from the Keeping Pace project. The purpose of these surveillance projects was to monitor provincial and sport and recreational regional trends in the physical activity and body mass index of students in Grades 3, 7, 11 and dietary intake and behaviour of students in Grades 7 and 11 in Nova Scotia (PACY 2005 and Keeping Pace).

METHODS

As in the previous surveillance studies (PACY 2001; PACY 2005), the goal of participant selection in the Keeping Pace Project was to obtain 2160 students from randomly selected schools such that 60 male and 60 female students were represented from each of grades 3, 7, and 11 in each of the six Nova Scotia Sport and Recreation regions [9, 10]. This sample size was based on an estimate of the probability of detecting a 5% significance level as noted in

PACY 2001 [9]. The Nova Scotia Department of Education randomly selected schools from each of the six Sport and Recreation Commission regions in Nova Scotia.

Superintendents and Directors of the School Boards were sent a letter describing the project and requesting permission to collect data in their school boards. Once permission was granted, Principals of the randomly selected schools were sent a letter to request permission for data collectors to (1) discuss the research project with the applicable grades of students, (2) distribute letters of invitation and consent forms, and (3) use the school as the designated site to obtain anthropometric measurements, place accelerometers, and collect physical activity and on-line dietary data. When a principal did not give permission to have the students from the randomly selected school to participate in the study, an additional school was randomly selected and another principal contacted.

Again, similar to the previous projects, each participating school was given \$250 to be used for one of their Health Promoting Schools initiatives. The incentive for student participation was an opportunity for one student from each of the six Sport and Recreation Regions to win a \$100 sports store gift certificate. Once in the schools, the data collection teams spoke to the students most often in smaller classroom settings to allow for an enhanced opportunity for questions and discussion of the research project. Following the presentation and discussion of the research project, the students were invited to pick up a package that included a written invitation to participate in the study as well as informed consent forms for their parents. Once the returned consent forms were collected from each school, participants were randomly selected to participate to a maximum of 30 students (15 boys and 15 girls) from a particular grade and school.

For Keeping Pace, ethical approval was obtained from the St. Francis University Research Ethics Board. Approval to invite the students to participate was obtained from all School Boards and the principals of randomly selected schools. Informed consent was obtained from the primary guardian for each child or youth, while verbal assent was obtained from the children and youth prior to the collection of data.

PHYSICAL ACTIVITY

Students were asked to wear an accelerometer during all waking hours with the exception of showering or other water-based activities (swimming, water sports, etc.) for seven consecutive days. The Actigraph GT1M accelerometers (Model 7164; Manufacturing Technologies Inc., Health Systems, Shalimar, FL) were used to provide an objective measure of the children and youth's physical activity. The Actigraph accelerometer is a valid and reliable tool for measurement of physical activity among children and youth and is considered the accepted standard for field studies of physical activity in children and youth [11, 12]). In brief, the sensor in the GT1M is the ADXL320 (Analog Devices, Norwood, MA) which is a small (4 x 4 x 1.45 mm) surface micromachined monolithic integrated circuit chip, dual-axis microelectromechanical system accelerometer [13]. The GT1M accelerometer is designed to only detect vertical accelerations ranging in magnitude from 0.05 to 2.00 Gs with a frequency response of 0.25 to 2.50 hertz [13]. These parameters allow for the measurement of normal human motion with the rejection of high frequency vibrations from other sources. The accelerations are filtered and digitized with the magnitude summed over a user specific

interval of time. At the end of each interval, the summed value or activity “count” is stored in memory and the numerical integrator reset. Each ‘count’ represents raw movement signals that can be used to quantify the length and intensity of movements the user produced [13].

Prior to use, each accelerometer was initialized or prepared to monitor and collect physical activity data. The accelerometer was then put into a small, tight fitting Velcro pouch attached to a waist strap and placed over the right hip of each participant at the beginning of the first day of data collection.

Since the accelerometer is small (5 x 4 x 1.5 cm), it should not have interfered with the activities of daily living and could be worn over or under the participants’ clothes, based on their preference – so long as the accelerometer was held firmly in place. As previously noted, research indicates a seven-day data collection period provides a reliable estimate of usual physical activity patterns in children and youth [7, 13] To document when the accelerometers were not worn and the physical activities potentially not measured effectively through accelerometry (i.e., skateboarding, cycling, and skating), participants were asked to complete an accelerometer non-use log.

The questions included in this log addressed the reason(s) the accelerometer was not worn in addition to queries regarding water sport activities during which the accelerometer cannot be worn and about physical activities that involve limited vertical motion, such as skateboarding, cycling, and skating.

The raw accelerometer data were reduced to one-minute (60-second) counts and categorized according to physical activity intensity. To be included in further analyses, the downloaded data file had to minimally contain 4 hours or 240 minutes of data. Physical activity intensity was measured according to the metabolic equivalent (MET) used where 1 MET is accepted to be resting energy expenditure (i.e., 3.5 ml/kg/min) [14]. As such, the age specific physical activity counts were categorized into sedentary (≤ 1.0 MET) time as well as light ($> 1 < 3$ METs), moderate (3-5.9 METs), hard (6-8.9 METs) or very hard (≥ 9 METs) intensity physical activity using the following equation [15]:

$$MET_s = 2,757 + 0.0015 * \frac{counts}{min} - 0,08957 * age[yrs] - (0,000038 * \frac{counts}{min} * age[yrs])$$

Various time filters were applied for a better understanding of when children accumulate their physical activity prior to downloading the accelerometer data. These time filters included: before school (6:00 – 8:44 a.m.), during school (8:45 a.m. – 3:00 p.m.) recess for the students in grade 3 (10:15 – 10:30 a.m.), lunch time (12:00 – 12:55 p.m.), after school (3:01 – 6:00 p.m.), and evening (6:01 – 11:00 p.m.). Data were also categorized as weekdays or weekend days.

Prior to statistical analyses, the data were weighted to be provincially representative. Given the two-stage cluster sampling with stratification at the first level used in the participant recruitment in this survey, a complex weighting factor was created and applied to each variable.

Descriptive and inferential statistics were then conducted to describe the physical activity level of boys and girls in grades 3, 7, and 11 in Nova Scotia with paired or unpaired t-tests used to compare the physical activity variables between boys and girls or between weekdays and weekend days. Significance was determined at a level of $p \leq 0.05$.

RESULTS

The Keeping Pace total sample, comprised of boys and girls in grades 3, 7, and 11, was 1858 with usable accelerometer data available from 1855 participants (Table 1). The reason for this slight discrepancy relates to accelerometer failure in three separate cases. More girls than boys in each grade provided data for this provincial surveillance project. Although all participants were instructed to wear the accelerometer for 7 days in a row from when they woke in the morning until they went to bed at night with the exception of when showering or engaged otherwise with water, only 973 or 52.5% of the students provided these data. The percentage of students that provided 0 to 7 days of accelerometer data are presented in Table 2. There were no significant differences in the percentage of students in grade 3 for providing 0 to 7 days of accelerometer data except where significantly fewer girls in grade 3 provided only 1 day of data ($t = 4.11$; $df = 397.08$; $p < 0.0001$). In grade 7, significantly more girls provided 4 ($t = -2.19$; $df = 681.73$; $p = 0.0029$) and 7 days of accelerometer data ($t = -6.31$; $df = 610.93$; $p < 0.0001$). Significantly more boys provided no data, 1, 2, 3, and 6 days of accelerometer data (0 days: $t = 2.04$; $df = 587.56$; $p = 0.042$; 1 day: $t = 3.84$; $df = 332.83$; $p = 0.00015$; 2 days: $t = 3.36$; $df = 434.18$; $p = 0.00086$; 3 days: $t = 4.93$; $df = 468.69$; $p < 0.0001$; 6 days: $t = 2.26$; $df = 586.18$; $p = 0.024$). In grade 11, the only significant differences in the percentage of students providing 0 to 7 days of accelerometer data were with significantly fewer girls providing either 1 ($t = -2.46$; $df = 229.18$; $p = 0.015$) or 2 days of data ($t = -2.41$; $df = 301.06$; $p = 0.016$).

Data from the self-report Accelerometer Non-Use Log were available from a smaller portion (81.2%) of the sample (Table 1). Significantly more girls in grade 3 and significantly fewer girls in grade 7 and 11 who completed the non-use log indicated they wore the accelerometer for 7 days (Table 3: grade 3: $t = -3.29$; $df = 711.30$; $p = 0.0010$; grade 7: $t = 5.18$; $df = 589.70$; $p < 0.0001$; grade 11: $t = 8.51$; $df = 318.75$; $p < 0.0001$).

Table 1. Keeping Pace Participants and Data Sources

	Grade 3		Grade 7		Grade 11	
Invited to Participate	1482		3048		3495	
Volunteered to Participate	755 (50.9%)		715 (23.5%)		447 (12.8%)	
Participated	747 (98.9%)		703 (98.3%)		408 (91.3%)	
	Boys	Girls	Boys	Girls	Boys	Girls
Accelerometer Data	328 (43.9%*)	417 (55.8%)	286 (40.7%)	417 (58.3)	165 (40.4%*)	242 (59.3%)
7 Days Accelerometer Data	174 (52.9%)	225 (54.0%)	133 (46.5%)	239 (57.2%)	84 (50.9%)	118 (48.8%)
Accelerometer Log	277 (84.4%)	360 (86.3%)	230 (80.4%)	338 (81.1%)	127 (80.0%)	175 (72.3%)

Percentages do not add up to 100 as there were a small number of participants who did not indicate sex.

Table 2. The Percentage (\pm SE) of Boys and Girls in Grades 3, 7, and 11 in Nova Scotia who Provided 0 to 7 Days of Accelerometer Data

	Grade 3		Grade 7		Grade 11	
	Boys	Girls	Boys	Girls	Boys	Girls
0 (no data)	5.2% \pm 1.36%	6.1% \pm 2.54%	8.8%* \pm 1.70%	6.9% \pm 1.78%	9.9% \pm 3.82%	9.0% \pm 2.05%
1 Day	2.4%* \pm 1.43%	0.5% \pm 0.53%	2.2%* \pm 2.05%	0.5% \pm 0.30%	0.7%* \pm 0.26%	1.3% \pm 1.56%
2 Days	1.4% \pm 0.71%	2.0% \pm 0.64%	2.2%* \pm 1.31%	1.0% \pm 0.51%	3.7%* \pm 1.80%	5.7% \pm 2.29%
3 Days	2.2% \pm 1.10%	2.9% \pm 0.78%	5.4%* \pm 1.43%	2.2% \pm 0.81%	3.8% \pm 2.61%	2.4% \pm 1.14%
4 Days	6.0% \pm 1.62%	4.6% \pm 1.30%	3.1%* \pm 1.44%	4.6% \pm 0.95%	4.4% \pm 1.63%	4.1% \pm 1.43%
5 Days	12.4% \pm 2.02%	13.7% \pm 2.53%	9.9% \pm 1.91%	8.8% \pm 1.40%	7.7% \pm 2.33%	9.2% \pm 2.68%
6 Days	17.4% \pm 2.96%	16.1% \pm 1.46%	21.9%* \pm 2.83%	18.8% \pm 2.00%	19.0% \pm 9.96%	19.5% \pm 3.46%
7 Days	52.9% \pm 4.50%	54.0% \pm 2.71%	46.5%* \pm 3.13%	57.2% \pm 3.41%	50.9% \pm 7.22%	48.8% \pm 4.09%

data presented in this table are weighted and accordingly representative of the population of students in grades 3, 7, and 11 living in Nova Scotia.

* indicates a significant difference between boys and girls within each grade where $p \leq 0.05$.

Between 14.0 and 22.6% of students were asked to take the accelerometer off at some point during the data collection period (Table 3). Individuals that asked the students to remove the accelerometer included teachers, coaches, friends, parents, and employers. Reasons given as to why the students were asked to remove the accelerometer included: playing sports, because we were told to take it off when in the water by the research team, I was sick, for safety reasons, and because it made me uncomfortable. Several students reported swimming (6.9 to 20.7%) while fewer reported other physical activity in water (0.6 to 6.4%). Physical activities in the water included games or activities such as diving, boating, swimming lessons, aquasize, and water polo.

Since accelerometers cannot be worn in the water, these sorts of physical activities cannot be objectively quantified using accelerometers. Data were also collected on biking, skateboarding, and skating; activities where the accelerometer may not as accurately register the intensity of the movements. Overall, 2.0 to 34.4% of students reported these activities, with generally fewer students in grade 11 indicating participation. Significantly more boys in grade 7 indicated participating in bike riding, skateboarding, and skating than girls (bike riding: $t = 10.69$; $df = 529.29$; $p < 0.0001$; skateboarding: $t = 8.63$; $df = 381.29$; $p < 0.0001$; skating: $t = 10.72$; $df = 548.42$; $p < 0.0001$).

Table 3. The Percentage [± SE] of Boys and Girls in grades 3, 7, and 11 in Nova Scotia. Who Self-Reported Wearing an Accelerometer for 7 Days, Being Asked to Remove the Accelerometer, Swimming, Physical Activity in the Water, Bike Riding, Skateboarding, or Skating

	Grade 3		Grade 7		Grade 11	
	Boys	Girls	Boys	Girls	Boys	Girls
7-Days Accelerometer	46.1%* ± 3.34%	51.5% ± 3.62%	35.9%* ± 4.05%	27.8% ± 2.22%	30.0%* ± 10.71%	14.2% ± 2.93%
Asked to Remove Accelerometer	21.1% ± 3.24%	22.6% ± 2.26%	16.4% ± 3.32%	14.0% ± 1.83%	17.0% ± 3.44%	20.3% ± 3.82%
Swimming	16.2%* ± 2.77%	20.7% ± 2.43%	20.6% ± 3.81%	19.4% ± 3.04%	8.6% ± 3.00%	6.9% ± 2.14%
Physical Activity in Water	2.8% ± 1.52%	3.1% ± 1.07%	6.4%* ± 1.88%	1.8% ± 1.12%	2.5%* ± 0.90%	0.6% ± 0.30%
Bike Riding	32.1% ± 3.63%	32.1% ± 3.94%	33.6%* ± 4.45%	18.9% ± 3.16%	17.2% ± 5.43%	14.6% ± 3.00%
Skateboarding	14.4%* ± 1.83%	1.5% ± 0.72%	8.7%* ± 1.73%	2.0% ± 1.10%	5.4%* ± 2.57%	2.4% ± 1.74%
Skating	33.8%* ± 4.14%	24.2% ± 3.27%	34.4%* ± 4.17%	18.1% ± 2.66%	13.9%* ± 7.13%	2.0% ± 0.86%

data presented in this table are weighted and accordingly representative of the population of students in grades 3, 7, and 11 living in Nova Scotia.

*indicates a significant difference between boys and girls within each grade where $p \leq 0.05$.

Table 4 presents the average minutes the accelerometer was worn per day for the boys and girls in grades 3, 7, and 11. Boys in grade 3 and 11 wore the accelerometer for significantly more minutes each day than the girls (grade 3: $t = 4.47$; $df = 612.44$; $p < 0.0001$; grade 11: $t = 4.00$; $df = 354.48$; $p < 0.0001$).

Table 5 presents the average minutes of light, moderate, hard and very hard intensity physical activity as well as minutes of sedentary time for the boys and girls in grades 3, 7, and 11. Boys in grade 3 obtained significantly more minutes of moderate and hard intensity physical activity; while girls obtained significantly more minutes of light and very hard intensity physical activity (light: $t = -6.38$; $df = 709.02$; $p < 0.0001$; moderate: $t = 7.20$; $df = 703.73$; $p < 0.0001$; hard: $t = 11.00$; $df = 512.01$; $p < 0.0001$; very hard: $t = -2.92$; $df = 679.16$; $p = 0.0036$)

In grade 7, boys obtained significantly more minutes of moderate ($t = 25.38$; $df = 513.60$; $p < 0.0001$) and hard intensity physical activity than girls ($t = 9.94$; $df = 479.32$; $p < 0.0001$).

Boys in grade 11 obtained significantly more minutes of all intensities of physical activity than girls (light: $t = 5.27$; $df = 293.06$; $p < 0.0001$; moderate: $t = 21.78$; $df = 292.62$; $p < 0.0001$; hard: $t = 11.33$; $df = 202.96$; $p < 0.0001$; very hard: $t = -2.89$; $df = 398.82$; $p = 0.0041$).

Table 4. The Average [\pm SE] Daily Minutes the Accelerometer was Worn by the Boys and Girls in Grades 3, 7, and 11 in Nova Scotia

Grade 3		Grade 7		Grade 11	
Boys	Girls	Boys	Girls	Boys	Girls
715.17 \pm 8.15*	698.13 \pm 8.33	721.02 \pm 7.41	717.77 \pm 6.85	704.56 \pm 15.43*	685.23 \pm 9.15

data presented in this table are weighted and accordingly representative of the population of students in grades 3, 7, and 11 living in Nova Scotia.

*indicates a significant difference between boys and girls within in each grade where $p \leq 0.05$.

Table 5. The Average Minutes [mean \pm SE] of Sedentary Time and Light, Moderate, Hard, and Very Hard Intensity Physical Activity in Boys and Girls in Grades 3, 7, and 11 in Nova Scotia

	Grade 3		Grade 7		Grade 11	
	Boys	Girls	Boys	Girls	Boys	Girls
Sedentary	319.93* \pm 5.81	304.82 \pm 6.27	390.27* \pm 5.99	410.37 \pm 5.84	425.46* \pm 7.88	437.55 \pm 6.06
Light	247.21* \pm 4.16	256.48 \pm 3.94	254.36 \pm 3.90	252.04 \pm 3.35	234.29* \pm 11.94	220.93 \pm 4.55
Moderate	135.08* \pm 2.53	126.39 \pm 2.37	68.85* \pm 2.18	49.73 \pm 1.85	40.61* \pm 2.35	24.90 \pm 1.18
Hard	11.37* \pm 0.63	8.56 \pm 0.45	6.30* \pm 0.70	4.34 \pm 0.36	3.52* \pm 1.02	1.42 \pm 0.18
Very Hard	1.59* \pm 0.23	1.90 \pm 0.23	1.24 \pm 0.29	1.29 \pm 0.19	0.67* \pm 0.16	0.44 \pm 0.09

data presented in this table are weighted and accordingly representative of the population of students in grades 3, 7, and 11 living in Nova Scotia.

*indicates a significant difference between boys and girls within each grade where $p \leq 0.05$.

Girls in grade 7 and 11 had significantly more minutes of sedentary time than boys; while girls in grade 3 had significantly fewer minutes of sedentary time (grade 3: $t = 4.92$; $df = 563.82$; $p < 0.0001$; grade 7: $t = -7.13$; $df = 578.92$; $p < 0.0001$; grade 11: $t = -3.27$; $df = 360.35$; $p < 0.0012$).

Table 6 presents the percentage of students in grades 3, 7, and 11 who obtained at least 60 minutes of moderate or more intense physical activity on 0, 1, 2, 3, 4, or 5 or more days of the week. Most ($> 80\%$) boys and girls in grade 3 obtained 60 minutes or more of moderate, hard, and very hard physical activity on at least 5 days of the week. Few students in grade 7 and 11 obtained 60 minutes or more of combined moderate, hard, and very hard physical activity on at least 5 days of the week with significantly more boys than girls obtaining this standard (grade 7: $t = 11.01$; $df = 502.30$; $p < 0.0001$; grade 11: $t = 4.53$; $df = 198.32$; $p < 0.0001$).

Table 6. The Percentage [\pm SE] of Boys and Girls in Grades 3, 7, and 11 in Nova Scotia that Obtained 60 Minutes or More of Moderate, Hard and Very Hard Intensity Physical Activity for 0, 1, 2, 3, 4, or 5 or More Days

	Grade 3		Grade 7		Grade 11	
	Boys	Girls	Boys	Girls	Boys	Girls
0 Days	0.5% \pm 0.42%	0.2% \pm 0.25%	5.4%* \pm 2.36%	15.7% \pm 2.11%	38.2%* \pm 7.29%	61.2% \pm 4.59%
1 Day	2.3%* \pm 1.52%	1.3% \pm 0.67%	8.5%* \pm 2.02%	20.4% \pm 3.62%	13.2%* \pm 3.25%	27.3% \pm 4.36%
2 Days	3.2% \pm 1.14%	2.9% \pm 0.80%	15.8%* \pm 2.58%	22.5% \pm 3.67%	16.8%* \pm 3.66%	6.1% \pm 2.20%
3 Days	3.6%* \pm 1.00%	6.4% \pm 1.22%	18.1% \pm 2.60%	17.7% \pm 2.23%	8.6%* \pm 3.35%	3.6% \pm 1.54%
4 Days	8.8% \pm 1.66%	8.9% \pm 1.57%	23.8%* \pm 3.57%	10.5% \pm 1.87%	18.6%* \pm 3.65%	0.9% \pm 0.38%
\geq 5 Days	81.6% \pm 2.69%	80.3% \pm 2.54%	28.4%* \pm 3.43%	13.2% \pm 2.66%	4.5%* \pm 2.25%	0.9% \pm 0.45%

data presented in this table are weighted and accordingly representative of the population of students in grades 3, 7, and 11 living in Nova Scotia.

*indicates a significant difference between boys and girls within each grade where $p \leq 0.05$.

Significantly more boys than girls in grade 7 obtained 60 minutes or more of moderate or more intense physical activity on 4 days of the week ($t = 10.05$; $df = 481.82$; $p < 0.0001$). Many girls (61.2%) and boys (38.2%) in grade 11 did not obtain at least 60 minutes of moderate or more intense activity on any day of the week.

Table 7 presents the number of students that provided 5 or more and 4 or less days of accelerometer data while Table 8 presents a comparison of the average minutes per day of moderate, hard and very hard intensity physical activity for boys and girls in each grade who provided 5 or more and 4 or less days of accelerometer data. In grade 3, boys who provided 5 or more days of accelerometer data obtained significantly more minutes of moderate, hard and very hard intensity physical activity (moderate: $t = 6.13$; $df = 44.09$; $p < 0.0001$; hard: $t = 7.04$; $df = 73.33$; $p < 0.0001$; very hard: $t = 10.70$; $df = 206.08$; $p < 0.0001$) than the boys who provided 4 or fewer days of data.

There were no significant differences between the girls in grade 3 who provided 5 or more or 4 or less days of accelerometer data in the average daily minutes of moderate, hard, and very hard intensity physical activity. In grade 7, significantly more minutes of hard intensity physical activity were performed in boys and girls with 5 or more days of accelerometer data (boys: $t = 2.78$; $df = 57.07$; $p = 0.0073$; girls: $t = 2.37$; $df = 59.93$; $p = 0.021$) than in the boys and girls who provided 4 or fewer days of data. Further, girls in grade 7 with 5 or more days of accelerometer data obtained significantly more minutes of very hard intensity physical activity ($t = 19.66$; $df = 368.96$; $p < 0.0001$) than girls who provided 4 or less days of data.

Table 7. The Number of Boys and Girls in Grades 3, 7, and 11 Who Provided 5 or More and 4 or Less Days of Accelerometer Data

Days Worn	Grade 3		Grade 7		Grade 11	
	Boys	Girls	Boys	Girls	Boys	Girls
5 or More	273	347	226	352	131	182
4 or Less	37	51	34	42	25	40

Table 8. The Average [\pm SE] Minutes per Day of Moderate, Hard, and Very Hard Intensity Physical Activity for Boys and Girls in Grades 3, 7, and 11 who Provided 5 or More and 4 or Less Days of Accelerometer Data

	Days with Accelerometer Data	Grade 3		Grade 7		Grade 11	
		Boys	Girls	Boys	Girls	Boys	Girls
Moderate	5 or More	137.11* \pm 5.58	126.33 \pm 4.87	68.28 \pm 3.75	50.33 \pm 2.40	40.59* \pm 3.30	25.73* \pm 1.70
	4 or Less	117.75 \pm 22.69	126.25 \pm 30.26	66.70 \pm 16.24	49.62 \pm 11.93	30.69 \pm 7.00	20.38 \pm 4.12
Hard	5 or More	11.72* \pm 0.75	8.51 \pm 0.46	6.45* \pm 0.68	4.51* \pm 0.40	3.32* \pm 0.77	1.45 \pm 0.21
	4 or Less	8.33 \pm 1.68	8.95 \pm 1.98	5.29 \pm 1.33	3.86 \pm 1.14	5.02 \pm 1.62	1.40 \pm 0.41
Very Hard	5 or More	1.76* \pm 0.23	1.95 \pm 0.20	1.19 \pm 0.25	1.40* \pm 0.21	0.56* \pm 0.21	0.47 \pm 0.09
	4 or Less	0.50 \pm 0.11	1.61 \pm 0.35	1.03 \pm 0.26	0.24 \pm 0.05	2.35 \pm 0.71	0.25 \pm 0.09

* indicates a significant difference between 5 or more and 4 or less days of accelerometer data within sex and grade where $p \leq 0.05$.

In grade 11, significantly more minutes of moderate intensity physical activity were found in boys and girls with 5 or more days of accelerometer data (boys: $t = 7.65$; $df = 48.60$; $p < 0.0001$; girls: $t = 4.92$; $df = 59.45$; $p < 0.0001$) compared to those that provided 4 or less days of data. Boys in grade 11 with 4 or fewer days of accelerometer data had significantly more minutes of hard and very hard intensity physical activity (hard: $t = -2.83$; $df = 29.56$; $p = 0.0083$; very hard: $t = -5.95$; $df = 25.34$; $p < 0.0001$) than boys who provided 5 or more days of data. In grade 7, significantly more minutes of hard intensity physical activity were found in boys and girls with 5 or more days of accelerometer data (hard: $t = -2.83$; $df = 29.56$; $p = 0.0083$; very hard: $t = -5.95$; $df = 25.34$; $p < 0.0001$) compared to those who provided 4 or fewer days of data.

Table 9 presents the average minutes per weekday and weekend day the accelerometer collected data from the boys and girls in grades 3, 7, and 11.

Table 9. The Average [mean \pm SD] Daily Minutes the Accelerometer was Worn on Weekdays and Weekend Days for Boys and Girls with 7 Days of Accelerometer Data in Grades 3, 7, and 11

	Grade 3		Grade 7		Grade 11	
	Boys	Girls	Boys	Girls	Boys	Girls
Weekday	744.80* \pm 104.20	720.98* \pm 85.81	757.45 \pm 100.88	760.27* \pm 93.60	769.54* \pm 101.06	751.60* \pm 100.74
Weekend	712.94 \pm 163.52	666.48 \pm 145.63	734.60 \pm 157.37	691.15 \pm 136.15	736.43 \pm 165.34	700.32 \pm 144.72

* indicates a significant difference between weekday and weekend values within sex and grades where $p \leq 0.05$.

Table 10 presents the average minutes per weekday or weekend day of sedentary time, light, moderate, hard, and very hard intensity physical activities. All students, except the boys in grade 7 provided significantly more minutes of accelerometer data on the weekdays compared to the weekend days (grade 3 boys: $t = 3.42$; $df = 165$; $p = 0.00078$; grade 3 girls: $t = 6.34$; $df = 229$; $p < 0.0001$; grade 7 girls: $t = 7.96$; $df = 235$; $p < 0.0001$; grade 11 boys: $t = 2.00$; $df = 86$; $p = 0.049$; grade 11 girls: $t = 4.46$; $df = 114$; $p < 0.0001$). Girls in grades 3, 7, and 11 and boys in grade 11 obtained significantly more minutes of sedentary time on weekdays compared to the weekend days (grade 3 girls: $t = 3.72$; $df = 229$; $p < 0.00025$; grade 7 girls: $t = 7.03$; $df = 235$; $p < 0.0001$; grade 11 girls: $t = 6.14$; $df = 114$; $p < 0.0001$; grade 11 boys: $t = 2.70$; $df = 86$; $p = 0.0084$). Boys and girls in grade 3 obtained significantly more minutes of light, moderate, and hard intensity physical activity on the weekdays versus the weekend days (boys light: $t = 4.54$; $df = 165$; $p < 0.0001$; boys moderate: $t = 2.60$; $df = 165$; $p < 0.010$; boys hard: $t = 5.84$; $df = 165$; $p < 0.0001$; girls light: $t = 6.82$; $df = 229$; $p < 0.0001$; girls moderate: $t = 2.85$; $df = 229$; $p = 0.0048$; girls hard: $t = 5.53$; $df = 229$; $p < 0.0001$). There were no significant differences in the average minutes obtained on the weekdays or weekend days in any intensity of physical activity for boys in grade 7. Girls in grade 7 obtained significantly more minutes of light, moderate, and hard intensity physical activity on the weekdays (light: $t = 2.85$; $df = 235$; $p = 0.0048$; moderate: $t = 7.09$; $df = 235$; $p < 0.0001$; hard: $t = 2.74$; $df = 235$; $p = 0.0067$) than the weekend days. Boys and girls in grade 11 obtained significantly more minutes of moderate intensity physical activity on the weekdays (boys: $t = 3.58$; $df = 86$; $p = 0.00057$; girls: $t = 3.17$; $df = 114$; $p = 0.0019$) compared to the weekend days. Boys in grade 11 also obtained significantly more minutes of very hard intensity physical activity on the weekdays ($t = 2.81$; $df = 86$; $p = 0.0061$) compared to the weekend days.

The data in Tables 11, 12, 13, 14, and 15 present the average minutes of sedentary time and light, moderate, hard, and very hard intensity physical activity for specific time periods: before school (6:00 – 8:44 a.m.), during the school day (8:45 a.m. – 3:00 p.m.), lunch time (12:00 and 12:55 p.m.), after school (3:01 and 6:00 p.m.) and in the evening (6:01 – 11:00 p.m.). Boys accumulated significantly more minutes of moderate intensity physical activity before school than girls in all grades (Table 11: grade 3: $t = 9.75$; $df = 655.11$; $p < 0.0001$; grade 7: $t = 7.95$; $df = 579.33$; $p < 0.0001$; grade 11: $t = 12.49$; $df = 214.70$; $p < 0.0001$).

Table 10. The Average Minutes [mean \pm SD] per Day of Sedentary Time and Light, Moderate, Hard, and Very Hard Intensity of Physical Activity in Boys and Girls in Grades 3, 7, and 11 with 7 Days of Accelerometer Data

		Grade 3		Grade 7		Grade 11	
		Boys	Girls	Boys	Girls	Boys	Girls
Sedentary	Weekday	324.78 \pm 92.45	308.81* \pm 70.61	413.12 \pm 89.61	438.93* \pm 76.88	463.13* \pm 76.59	488.90* \pm 83.38
	Weekend	323.56 \pm 131.56	287.44 \pm 109.12	400.78 \pm 118.81	394.90 \pm 111.90	429.45 \pm 124.23	435.30 \pm 112.00
Light	Weekday	261.60* \pm 41.05	270.00* \pm 42.50	266.51 \pm 52.62	262.61* \pm 48.32	258.03 \pm 60.59	233.47 \pm 49.88
	Weekend	243.75 \pm 55.18	246.21 \pm 60.51	259.52 \pm 70.97	250.80 \pm 64.35	269.90 \pm 83.62	240.00 \pm 80.41
Moderate	Weekday	142.88* \pm 35.28	130.64* \pm 33.74	70.06 \pm 24.25	52.85* \pm 20.96	43.66* \pm 20.48	26.68* \pm 14.32
	Weekend	133.79 \pm 56.91	123.16 \pm 47.05	67.54 \pm 42.41	40.67 \pm 29.78	33.79 \pm 24.79	20.94 \pm 20.82
Hard	Weekday	13.64* \pm 10.43	9.39* \pm 6.12	6.61 \pm 7.94	4.51* \pm 4.79	3.81 \pm 5.59	1.75 \pm 2.74
	Weekend	9.43 \pm 10.27	7.09 \pm 6.78	5.56 \pm 9.51	3.31 \pm 7.35	2.94 \pm 5.38	1.46 \pm 2.79
Very Hard	Weekday	1.90 \pm 3.42	2.14 \pm 3.34	1.15 \pm 2.52	1.37 \pm 2.48	0.90* \pm 2.24	0.80 \pm 2.76
	Weekend	2.41 \pm 7.29	2.58 \pm 6.75	1.20 \pm 4.31	1.49 \pm 4.88	0.35 \pm 1.13	0.61 \pm 2.82

*indicates a significant difference between weekday and weekend values within sex and grade where $p \leq 0.05$.

Boys accumulated significantly more moderate and hard intensity physical activity than girls in all grades during the school day (Table 12: grade 3, moderate: $t = 11.14$; $df = 660.51$; $p < 0.0001$; grade 7, moderate: $t = 25.99$; $df = 479.77$; $p < 0.0001$; grade 11, moderate: $t = 21.12$; $df = 265.02$; $p < 0.0001$; grade 3, hard: $t = 13.73$; $df = 541.60$; $p < 0.0001$; grade 7, hard: $t = 12.66$; $df = 489.84$; $p < 0.0001$; grade 11, hard: $t = 10.07$; $df = 273.42$; $p < 0.0001$).

During lunch time of the school days, boys in all grades accumulated significantly more moderate and hard intensity physical activity than girls (Table 13: grade 3, moderate: $t = 8.92$; $df = 645.60$; $p < 0.0001$; grade 7, moderate: $t = 11.36$; $df = 515.73$; $p < 0.0001$; grade 11, moderate: $t = 15.63$; $df = 224.91$; $p < 0.0001$; grade 3, hard: $t = 12.11$; $df = 520.87$; $p < 0.0001$; grade 7, hard: $t = 7.22$; $df = 479.24$; $p < 0.0001$; grade 11, hard: $t = 5.83$; $df = 233.34$; $p < 0.0001$).

Table 11. The Average Minutes [mean \pm SE] of Sedentary Time and Light, Moderate, Hard, and Very Hard Intensity of Physical Activity per School Day before School (6:00 – 8:44 a.m.) in Boys and Girls in Grades 3, 7, and 11 in Nova Scotia

	Grade 3		Grade 7		Grade 11	
	Boys	Girls	Boys	Girls	Boys	Girls
Sedentary	31.00 \pm 2.23*	28.24 \pm 2.24	25.08 \pm 1.41*	28.84 \pm 1.89	19.90 \pm 1.71*	25.28 \pm 1.50
Light	29.54 \pm 2.09*	28.39 \pm 2.52	22.66 \pm 1.37*	25.52 \pm 1.34	15.87 \pm 1.08*	16.87 \pm 1.03
Moderate	13.42 \pm 1.00*	10.88 \pm 0.89	5.25 \pm 0.31*	4.23 \pm 0.42	3.28 \pm 0.60*	1.64 \pm 0.20
Hard	0.71 \pm 0.08*	0.37 \pm 0.05	0.43 \pm 0.11*	0.25 \pm 0.05	0.10 \pm 0.03	0.10 \pm 0.03
Very Hard	0.05 \pm 0.01*	0.04 \pm 0.01	0.03 \pm 0.01*	0.01 \pm 0.01	0.00 \pm 0.00	0.01 \pm 0.00

data presented in this table are weighted and accordingly representative of the population of students in grades 3, 7, and 11 living in Nova Scotia.

*indicates a significant difference between boys and girls within in grades where $p \leq 0.05$.

Table 12. The Average Minutes [mean \pm SE] of Sedentary Time and Light, Moderate, Hard, and Very Hard Intensity of Physical Activity per School Day during School (8:45 a.m. to 3:00 p.m.) in Boys and Girls in Grades 3, 7, and 11 in Nova Scotia

	Grade 3		Grade 7		Grade 11	
	Boys	Girls	Boys	Girls	Boys	Girls
Sedentary	132.65 \pm 2.74*	135.62 \pm 3.37	166.96 \pm 4.34*	185.61 \pm 4.65	190.57 \pm 10.45*	186.11 \pm 5.52
Light	116.45 \pm 3.08*	119.14 \pm 3.79	105.78 \pm 2.22*	97.86 \pm 2.17	83.64 \pm 3.85*	68.84 \pm 2.38
Moderate	62.89 \pm 1.82*	55.50 \pm 1.68	30.03 \pm 0.90*	21.11 \pm 0.74	20.57 \pm 1.33*	11.14 \pm 0.70
Hard	6.64 \pm 0.58*	4.41 \pm 0.23	2.62 \pm 0.24*	1.57 \pm 0.13	1.12 \pm 0.19*	0.43 \pm 0.11
Very Hard	0.48 \pm 0.08*	0.61 \pm 0.08	0.28 \pm 0.06*	0.20 \pm 0.02	0.25 \pm 0.06	0.19 \pm 0.06

data presented in this table are weighted and accordingly representative of the population of students in grades 3, 7, and 11 living in Nova Scotia.

*indicates a significant difference between boys and girls within grades where $p \leq 0.05$.

Between 3:01 and 6:00 p.m., or the afterschool time frame, boys in grades 3, 7, and 11 accumulated significantly more minutes of moderate (only grade 7 and 11) and hard intensity physical activity than girls. (Table 14: grade 7, moderate: $t = 11.72$; $df = 577.19$; $p < 0.0001$; grade 11, moderate: $t = 11.60$; $df = 280.99$; $p < 0.0001$; grade 3, hard: $t = 2.31$; $df = 499.60$; $p = 0.021$; grade 7, hard: $t = 4.36$; $df = 429.80$; $p < 0.0001$; grade 11, hard: $t = 6.36$; $df = 251.95$; $p < 0.0001$). Boys in grade 7 and 11 accumulated significantly more moderate and hard intensity physical activity than girls after 6:00 p.m. (Table 15: grade 7, moderate: $t = 11.67$;

df = 495.29; $p < 0.0001$; grade 11, moderate: $t = 7.04$; $df = 279.48$; $p < 0.0001$; grade 7, hard: $t = 5.71$; $df = 500.69$; $p < 0.0001$; grade 11, hard: $t = 7.56$; $df = 190.70$; $p < 0.0001$).

The data in Table 16 presents the average minutes of sedentary time and light, moderate, hard, and very hard intensity physical activity for recess or between 10:15 and 10:30 a.m. for the boys and girls in grade 3. Boys obtained significantly more minutes of moderate ($t = 6.33$; $df = 634.66$; $p < 0.0001$) and hard intensity physical activity ($t = 11.16$; $df = 528.72$; $p < 0.0001$) in this time frame compared to the girls.

Table 13. The Average Minutes [mean \pm SE] of Sedentary Time and Light, Moderate, Hard, and Very Hard Intensity of Physical Activity per School Day during lunch time (12:00 – 12:55 p.m.) in Boys and Girls in Grades 3, 7, and 11 in Nova Scotia

	Grade 3		Grade 7		Grade 11	
	Boys	Girls	Boys	Girls	Boys	Girls
Sedentary	15.79 \pm 0.63*	16.29 \pm 0.69	22.41 \pm 0.97*	25.57 \pm 0.82	27.05 \pm 1.06	27.58 \pm 0.90
Light	15.91 \pm 0.48*	17.68 \pm 0.54	17.13 \pm 0.40*	16.72 \pm 0.50	14.98 \pm 0.77*	12.26 \pm 0.67
Moderate	14.68 \pm 0.78*	12.93 \pm 0.57	6.77 \pm 0.58*	5.02 \pm 0.39	5.21 \pm 1.10*	2.64 \pm 0.28
Hard	1.97 \pm 0.31*	1.19 \pm 0.10	0.69 \pm 0.14*	0.42 \pm 0.06	0.17 \pm 0.06*	0.05 \pm 0.02
Very Hard	0.11 \pm 0.03	0.13 \pm 0.03	0.07 \pm 0.02*	0.05 \pm 0.01	0.02 \pm 0.01	0.03 \pm 0.02

data presented in this table are weighted and accordingly representative of the population of students in grades 3, 7, and 11 living in Nova Scotia.

*indicates a significant difference between boys and girls within grades where $p \leq 0.05$.

Table 14. The Average Minutes [mean \pm SE] of Sedentary Time and Light, Moderate, Hard, and Very Hard Intensity Physical Activity per School Day between 3:01 and 6:00 p.m. in Boys and Girls in Grades 3, 7, and 11 in Nova Scotia

	Grade 3		Grade 7		Grade 11	
	Boys	Girls	Boys	Girls	Boys	Girls
Sedentary	65.02 \pm 1.89*	61.37 \pm 1.42	81.03 \pm 1.53*	84.76 \pm 1.44	81.85 \pm 2.67*	89.09 \pm 1.62
Light	54.26 \pm 1.54*	62.07 \pm 1.17	58.13 \pm 1.22*	60.73 \pm 0.90	56.65 \pm 3.60	57.90 \pm 1.63
Moderate	35.07 \pm 1.21	35.40 \pm 1.05	17.05 \pm 0.73*	13.43 \pm 0.58	10.48 \pm 1.11*	7.08 \pm 0.60
Hard	2.91 \pm 0.26*	2.61 \pm 0.18	1.70 \pm 0.28*	1.28 \pm 0.11	0.89 \pm 0.25*	0.50 \pm 0.11
Very Hard	0.52 \pm 0.12*	0.69 \pm 0.10	0.49 \pm 0.16*	0.37 \pm 0.06	0.23 \pm 0.07*	0.10 \pm 0.04

data presented in this table are weighted and accordingly representative of the population of students in grades 3, 7, and 11 living in Nova Scotia.

*indicates a significant difference between boys and girls within grades where $p \leq 0.05$.

Table 15. The Average Minutes [mean \pm SE] of Sedentary Time and Light, Moderate, Hard, and Very Hard Intensity Physical Activity per School Day after 6:00 p.m. (6:01 – 11:00 p.m.) in Boys and Girls in Grades 3, 7, and 11 in Nova Scotia

	Grade 3		Grade 7		Grade 11	
	Boys	Girls	Boys	Girls	Boys	Girls
Sedentary	65.76 \pm 2.73	65.53 \pm 2.60	108.74 \pm 2.51*	112.36 \pm 1.43	125.74 \pm 6.60	128.95 \pm 4.00
Light	46.09 \pm 1.74*	50.88 \pm 1.52	67.34 \pm 2.54*	69.41 \pm 1.17	66.63 \pm 6.41	67.16 \pm 2.72
Moderate	24.74 \pm 1.39*	26.02 \pm 0.99	17.36 \pm 1.22*	13.13 \pm 0.78	8.63 \pm 1.48*	6.25 \pm 0.55
Hard	1.89 \pm 0.20	1.81 \pm 0.14	1.97 \pm 0.36*	1.43 \pm 0.15	1.52 \pm 0.74*	0.47 \pm 0.08
Very Hard	0.36 \pm 0.07*	0.52 \pm 0.10	0.50 \pm 0.15	0.58 \pm 0.12	0.24 \pm 0.09*	0.14 \pm 0.05

data presented in this table are weighted and accordingly representative of the population of students in grades 3, 7, and 11 living in Nova Scotia.

*indicates a significant difference between boys and girls within grades where $p \leq 0.05$.

Table 16. The Average Minutes [mean \pm SE] of Sedentary Time and Light, Moderate, Hard, and Very Hard Intensity of Physical Activity per School Day during Recess (10:15 to 10:30 a.m.) in Boys and Girls in Grade 3 in Nova Scotia

	Boys	Girls
Sedentary	3.43 \pm 0.42	3.52 \pm 0.32
Light	3.87 \pm 0.27*	4.34 \pm 0.19
Moderate	4.04 \pm 0.51*	3.47 \pm 0.34
Hard	0.65 \pm 0.15*	0.34 \pm 0.06
Very Hard	0.03 \pm 0.01*	0.05 \pm 0.02

data presented in this table are weighted and accordingly representative of the population students in grade 3 living in Nova Scotia.

*indicates a significant difference between boys and girls where $p \leq 0.05$.

DISCUSSION

The purpose of this chapter was to present the methodology used to collect physical activity data using the Actigraph GT1M accelerometer in three surveillance studies (PACY 2001; PACY 2005; Keeping Pace 2009) conducted four years apart in cross sectional samples of students in grades 3, 7, and 11 from Nova Scotia, Canada. Since population estimates were only made for the data from the Keeping Pace project to enable representativeness of the Nova Scotia population of boys and girls in grades 3, 7, and 11, it would be inappropriate to make comparisons among the findings of the three surveillance projects. Instead, this chapter focuses primarily on the extensive physical activity results from the Keeping Pace surveillance study.

Thus, when methodology is discussed in this section and elsewhere in this chapter, reflections are made upon all three studies, but when results are discussed, they come only from the latter study. This section discusses the sample that volunteered to participate in the surveillance studies, the percentage of boys and girls in grades 3, 7, and 11 living in Nova Scotia who obtained the standard (i.e., recommended level of physical activity), suggestions based on the percentage who obtained the standard to promote physical activity, the potential for bias in the sample, weekday versus weekend physical activity, time of day activity and sedentary time. This section concludes with a reflection on our experiences with data collection and analysis with a focus on the benefits and barriers to using accelerometers to collect physical activity data on children and youth.

In each of the surveillance studies, more girls than boys volunteered to participate. Although there is a slight favoring in the population number towards females, this does not account for the substantive difference in the number of female participants in these studies. The use of active parental consent procedures appears to bias a sample towards white, middle income, females [16]. Further, in each of the surveillance studies substantively more students in grade 11 had to be invited to participate in the study in order to reach the sample target. There are likely a variety of factors related to the recalcitrance of students in grade 11 to participate including: (a) it may not have been the ‘cool’ thing to do, (b) it may not have been fashionable, (c) even though the accelerometer is small, once in a pouch and attached to a belt, it is often noticed and some students may have been uncomfortable with that at school and at work, (d) the mistaken thought that there was a GPS (global position system) inside the accelerometer which would show where they were during the day and evening, (e) embarrassment over their lack of physical activity participation, etc.

One of the main objectives of the three surveillance studies was to determine the percentage of boys and girls in each grade who obtained 60 minutes or more of moderate or more intense physical activity on at least five days of the week. This level of physical activity, termed the standard was established for the first PACY project based upon the available evidence at that time [9]. This standard was met by more than 80% of the students in grade 3; by 28.4% of the boys and 13.2% of the girls in grade 7, and by 4.5% of the boys and 0.9% of the girls in grade 11. Comparison can be made to Canadian children and youth – though not directly as the sample size and ‘standard’ are different. Only 9% of Canadian boys and 4% of Canadian girls between the ages of 6 to 19 years obtained at least 60 minutes of moderate or more intense physical activity on 6 days of the week [17]. The physical activity data from the Keeping Pace project are used by various individuals working in the physical activity sector to direct their initiatives aimed at increasing physical activity in children and youth. There is an obvious and dramatic drop in the percentage of students achieving the standard between grades 3 and 7; with another decline between grades 7 and 11. The decrease is more dramatic in girls than boys, so much so that by grade 11, few girls achieve the standard. This decrease in physical activity during childhood and difference in boy and girl participation levels in physical activity are also noted by others [17-20].

Two aspects from the data presented in this chapter may be helpful in planning physical activity promotion initiatives. First, as children age, there is a need to address the lack of physical activity differently for girls than boys. A significantly higher percentage of girls (15.7 and 61.2% of girls in grades 7 and 11, respectively) than boys in grades 7 and 11 did not obtain even one day of at least 60 combined minutes of moderate, hard, and very hard intensity physical activity.

Second, it is worth noting the substantive minutes of light intensity physical activity were obtained by the participants. This leads to the suggestion that in the promotion of physical activity the message might be better phrased as “keep moving, but do so a little faster” or “step up the intensity of what you are doing” vs. “you need to get moving”. Similarly, there are significantly more boys than girls in grades 7 and 11 who already obtain at least 60 minutes of moderate or more intense physical activity on 4 days of the week. These individuals (23.8 and 18.6% of the boys in grades 7 and 11, respectively) only need one more day per week to meet the standard.

A potential bias may exist in the estimation of the percentage that met the standard in these surveillance studies as it may be that the more physically active participants were more compliant and wore the accelerometer for the duration of the study. In the Keeping Pace surveillance study, 52.9% of the students provided seven days and 90.7% provided three or more days of accelerometer data. Though not directly comparable, 79% of the United States population-based sample of individuals 6 to 85 years of age provided three or more days of at least 10 hours of accelerometer data in the National Health and Nutrition Examination Survey [21]. The average minutes of accelerometer data provided by the boys and girls in grades 3, 7, and 11 ranged between 685 to 721 minutes equivalent to 11 or 12 hours of data. Compliance in the Keeping Pace study may be related to the attention given to participants during data collection; that is, reminder calls were made mid-week to the participants’ guardians. Compliance can also be effectively increased by providing compensation contingent upon the number of complete days of data provided [22].

To examine the potential for bias for a more physically active sample that provided more complete data, a comparison of accelerometer data from those who provided 5 or more versus 4 or fewer days of accelerometer data was undertaken. This analysis provides some evidence – though not conclusive – to suggest that the boys and girls who provided at least 5 days of data also obtained significantly more minutes of moderate, hard and very hard intensity physical activity data. Specifically, the data from the boys in grade 3 indicates that those with 5 or more days of accelerometer data also had significantly more minutes per day of moderate, hard and very hard intensity physical activity than those who provided 4 or fewer days of accelerometer data. This difference was not found in the girls in grade 3. Compared to the girls who provided 4 or fewer days of accelerometer data, the girls in grade 7 with 5 or more days of data obtained significantly more minutes of hard and very hard intensity physical activity per day with no similar significant differences found within the boys in grade 7. There also were no significant differences between the boys and girls in grade 7 in the minutes of moderate intensity physical activity obtained. In grade 11, both the boys and girls with 5 or more days of data obtained significantly more minutes per day of moderate intensity physical activity than those who provided 4 or less days of accelerometer data with no significant differences in the minutes of hard or very hard intensity physical activity obtained.

As previously noted, on average there were more than 10 hours or 600 minutes of accelerometer data for weekdays and weekend days with all students with seven days of accelerometer data except boys in grade 7 provided significantly more minutes of accelerometer data on the weekdays versus the weekend days. Keeping this difference in mind, there were substantively and significantly more minutes of moderate intensity physical activity in boys and girls in all grades except boys in grade 7 on the weekdays versus the weekend days. Further, there were significantly more minutes of sedentary time in girls in all grades and boys in grade 11 on weekend versus weekdays. Similar results regarding a higher

accumulation of physical activity on weekdays and higher levels of sedentary time on weekend days were found in the Canadian Health Measures survey of children and youth between the ages of 6 to 19 years [23]. These results seem surprising given the assumption that boys and girls have more free time available for physical activity on weekend days versus weekdays. These results can be used to inform physical activity promotion strategies regarding the timing for implementation.

Various time periods were examined in the Keeping Pace study to get a better understanding of when children and youths physical activity occurred. For the weekday physical activity data for the boys and girls in grades 3, 7, and 11, it was further analyzed according to before school, during school, at lunch time, after school, and in the evening. An additional time frame of recess was included for boys and girls in grade 3. Regardless of the timeframe, the majority of minutes recorded were spent in sedentary time except for boys and girls in grade 3 for recess and lunch time. Comparison to Canadian data from the Canadian Health Measures survey of 6 to 19 year olds can be made for the 3:01 to 6:00 p.m. time frame [23]. In the Canadian study, the children and youth accumulated on average only 14 minutes of moderate or more intense physical activity in the 180 minute time frame [23]. In the Keeping Pace surveillance study with the data combined for the boys and girls in grades 3, 7, and 11, the average minutes of moderate or greater intensity physical activity during the afterschool time frame (3:01 to 6:00 p.m.) was 22.9 ± 2.3 min, with as little as 8 minutes of moderate or more intense physical activity in the girls in grade 11 to as high as 39 minutes in the boys in grade 3.

With each successive surveillance study in Nova Scotia, more in-depth attempts have been made to better understand the times when the participants removed the accelerometer as well as the reasons for its removal. The most recent non-use log used in the Keeping Pace surveillance project asked specific questions regarding who asked the student to take off the accelerometer as well as questions regarding activities that the accelerometer may not measure well. The response to who asked and why the accelerometer was removed included internal as well as external reasons. Anecdotal reports from the first two surveillance studies informed the researchers that the participants were not allowed to wear the accelerometers in athletic competition (e.g., basketball or hockey games). This was confirmed in the results of the Accelerometer Non-Use Log from the Keeping Pace surveillance project with many students reporting removing the accelerometer because of competition. Internal reasons reported for removing the accelerometer were because the student was sick or felt uncomfortable wearing it.

One strength of the data collection and analysis of the Keeping Pace surveillance project is the inclusion of sedentary time. Sedentary time was also included in the PACY 2005 surveillance project because of an interest in better understanding the relationship between body mass index (BMI) and level of physical activity participation [24]. An intensity cut point of 100 counts was chosen to identify sedentary behavior for the PACY 2005 and Keeping Pace surveillance projects which is considered the cut point that clearly differentiates accelerometer non-use and sedentary behaviors [2].

Sedentary time is different than inactivity as noted by the recent clarification made in the 2012 Active Healthy Kids Canada Report Card: "Sedentary behavior should be defined as any waking behavior characterized by an energy expenditure of ≤ 1.5 METs (metabolic equivalent of task) while in a sitting or reclining posture. In contrast the term "inactive" should be used to describe those who are performing insufficient amounts of MVPA (i.e. not

meeting specified physical activity guidelines).” (25; p 35). Examples of sedentary behaviors include sitting, lying down, watching television, working or playing on the computer, reading, and sleeping [26] It has recently been recognized that high levels of sedentary time, regardless of whether or not the physical activity guidelines are met result in increased health risk [26, 27]. This realization led to the development of sedentary guidelines for Canadian children and youth which recommend no more than 2 hours of recreational screen time for children and youth between the ages of 5 to 17 years [27]. Further, it is recommended that children and youth between the ages of 5 to 17 years limit sedentary forms of transportation as well as extended sitting time and time spent indoors each day [27].

Overall our experience with using accelerometers to collect data in the PACY 2001, PACY 2005, and Keeping Pace 2009 surveillance projects has been positive. We believe we have collected and analyzed valid, useful data to inform policies and strategies to improve the level of participation in physical activity of children and youth in Nova Scotia. The ability to collect an objective measure of physical activity including not only the minutes of physical activity accumulated over a day, but also the intensity of the physical activity accumulated over the day and for specific time periods as well as weekday and weekend participation has been useful in better understanding the current reality of physical activity participation among children and youth living in Nova Scotia.

Our experience with the objective surveillance of physical activity over three separate cross sectional provincial surveillance projects has also made us aware of a number of barriers or difficulties associated with the use of accelerometers. First, it should be noted the benefit of being able to partition the physical activity data to various levels of intensity (i.e., sedentary, light, moderate, hard, very hard) and for various time points in the day as well as for the whole day results in a large amount of data. This has been noted as a challenge by others as well [3]. In this regard and also in managing partial or incomplete data, Eslinger [8] provides useful guidelines regarding how the resultant data may be used or not used. Another methodological issue that requires consideration relates to the choice of intensity related cut points for children and youth [18]. Currently there are five different choices to make [12, 28-31] each developed based on a different age group and using different activities. Recent validation research of the accelerometer cut points for children and youth using a large sample and age range of participants as well as 12 standardized activity trials ranging from sedentary behaviors such as hand writing to very hard intensity physical activities such as aerobic dance [2] suggests that the equations developed by Evenson [28] and Freedson [29] are best for all physical activity intensity levels.

Although accelerometers provide excellent physical activity data, including the intensity of participation and when participation occurs, the data still cannot sufficiently address all physical activity research questions for all populations and all situations [4]. The rationale for participation – or lack thereof cannot be determined, nor can location of participation [3]. That said, recent advances have combined accelerometry with global positioning. For example, in a study of children in New Zealand, Quigg et al. [32] reported that overall 1.9% of recorded activity occurred in a city park for 5 to 10 year children who provided 7 days of accelerometer data. Our difficulty in getting students in grade 11 to volunteer to participate in our surveillance studies with a 12.8% participation rate raises a ‘red flag’ regarding the inclusion of GPS monitoring with the collection of physical activity data collection.

We also anticipate significant challenges obtaining ethical approval for the inclusion of GPS monitoring of our participants. Further, the addition of GPS data – if possible – in a

surveillance study would add to the barrier of a significant, almost overwhelming data base. Rationale for participation or lack thereof in physical activity can be best determined using a different tool for data collection as well as a different research methodology; specifically, qualitative methods using open ended questions whether in a self-report questionnaire, one-on-one or focus group interview would be required to better understand why a child or youth choose to do or not do certain physical activities.

In conclusion, given the goal to monitor the physical activity participation of boys and girls in grades 3, 7, and 11 in Nova Scotia, the Actigraph accelerometer has been an effective tool for data collection. In fact, the accelerometer data collected with each surveillance study has been used more extensively than simply to describe the minutes of physical activity students achieved over the time period measured. It has also been used to determine the percentage of boys and girls in grades 3, 7, and 11 who obtained the standard or recommended level of physical activity (i.e., at least 60 minutes of moderate or more intense physical activity on at least 5 days of the week). These results clearly identified that girls are less active than boys and that activity levels are much lower in the students in the higher grades compared to the students in the younger grades. The time of day data is particularly useful for targeting time periods where students are believed to have 'free' time but do not engage in much physical activity whether on the weekdays or weekend days. Combining the physical activity findings from accelerometers with an open-ended approach to questions whether in a written or interview format could further strengthen the understanding of children and youths participation in physical activity. For example one-on-one or focus group interviews could be conducted with participants with high and low levels of participation with questions designed to better understand their motivations towards their physical activity participation or lack thereof. Regardless of the particular methodology chosen to better understand children and youths participation in physical activity, the objective assessment of physical activity participation obtained via accelerometry in children and youth is a valued and worthwhile practice.

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