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Comparison of self-reported and accelerometer-measured physical activity among Canadian youth

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Abstract

Background: Generally, correlation and agreement between self-reported and accelerometer-measured physical activity are low. The objective of this study is to compare estimates of physical activity from a newly developed Canadian questionnaire with measurements by accelerometer among 12- to 17-year-olds.

Data and methods: Physical activity was self-reported by domain (transportation, recreation, school, and occupational/household) as part of the new Physical Activity Youth Questionnaire (PAYQ) in the Canadian Health Measures Survey (CHMS; 2014–2017; n = 975) and the Canadian Community Health Survey (CCHS; 2015-2016; n=7,619). The CHMS also collected moderate-to-vigorous physical activity (MVPA) data using the Actical accelerometer. Descriptive statistics and correlation and agreement analyses were used to compare and contrast self-reported and accelerometer-measured physical activity variables. Linear regression was used to assess the association between physical activity and obesity.

Results: The average daily MVPA measured by accelerometry was 49.7 minutes per day. According to the PAYQ, Canadian youth reported an average of 78.2 minutes of physical activity per day from all domains, including recreation (31.3 minutes per day), transportation (15.5 minutes per day), school (25.8 minutes per day), and occupational/household (5.6 minutes per day). According to accelerometer-measured MVPA, 23.1% of youth met the physical activity guideline. The inclusion of all domains of self-reported physical activity resulted in a higher percentage of youth meeting the physical activity guideline (58.6%) than was the case for the recreation domain only (18.5%) or the sum of the recreation and school domains (34.0%). Overall, self-reported and accelerometer-measured physical activity estimates were poorly correlated (R < 0.2).

Interpretation: Population-level estimates of physical activity and the percentage of youth meeting the physical activity guideline were well-aligned between the Actical and the PAYQ; however, large differences were evident at the individual level. Therefore, caution should be exercised in using data from these two methods since their values may not be interchangeable.

Keywords: Data collection, direct measure, health surveys, movement, exercise
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Physical activity is positively associated with a wide range of physical, psychological, social and cognitive health outcomes in children and youth.[1,2] Self-report questionnaires are cost-efficient and provide important contextual information about physical activity, but are limited by recall bias and variation in reporting accuracy for different intensities and domains.[3] Accelerometers overcome some of these limitations. However, they do not capture certain types of movement accurately (e.g., cycling, load bearing). Nor do they provide any contextual information about the type or domain of physical activity participation.[4] This information is important for conducting surveillance as it identifies the types and domains of physical activity that are contributing the most and the least to overall physical activity levels. Capturing this contextual information may be particularly challenging in youth, given the more sporadic nature of how they accumulate physical activity throughout the day.[3]

Previous studies have reported low-to-moderate correlation between self-reported and accelerometer-measured physical activity among youth.[3,5,6,7] These differences between methods are important to understand given that they may lead to variation in the observed associations between physical activity and health.[5] In addition to differences between measurement methods, variation in analytical approach can also have a substantial effect on estimates. This is particularly relevant for youth given the recent change in the operationalization of the Canadian Physical Activity Guideline from at least 60 minutes **every day** to 60 minutes **on average**,[8] a change that shifts the percentage of Canadian children and youth meeting the current physical activity guideline from 7% to 33%.[9]

The Canadian Health Measures Survey (CHMS) was developed to overcome two important limitations of existing health research surveillance mechanisms in Canada: (1) some types of information cannot be ascertained via interview format (e.g., blood, urine and DNA markers), and (2) some health information obtained by means of self-report methods may be biased.[10] Since its inception, in 2007, the CHMS has collected both self-reported and accelerometer-measured physical activity data. This has created an opportunity to conduct comparative studies on how the data from these two methods relate to one another.[6,11,12] A more thorough understanding of how these measurement tools compare is important given that many large health surveillance surveys, including Canada's major health survey, the Canadian Community Health Survey (CCHS), rely solely upon questionnaire-based methods. The CCHS is the main surveillance tool for comparison between provinces, territories and health regions.

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Information needs for both surveillance and research have evolved over time, and there is an increased interest in not only quantifying the overall amount of physical activity done by youth, but also understanding the breakdown of physical activity by domain (i.e., transportation, school, recreation, and occupational/household),[13] so as to better understand any observed changes and to better target responses. Additionally, Canadian and global physical activity surveillance efforts often necessitate the measurement of adherence to Canadian and World Health Organization guidelines. Limitations of previous self-reporting and objective measurement tools to meet these needs led Statistics Canada to develop a new Physical Activity for Youth Questionnaire (PAYQ), which was subsequently implemented in both the CHMS (2014–2015) and the CCHS (2015–2016). The purpose of this study is to compare accelerometer-measured and self-reported physical activity from the new PAYQ among Canadian youth. Further, this paper examines the reliability and effect of mode (in-person versus telephone) of the PAYQ module by comparing estimates between cycles within each survey and between the CHMS and CCHS.

Methods

Data sources

The CHMS is an ongoing survey conducted by Statistics Canada that collects self-reported and measured health information from a representative sample of the Canadian household-dwelling population using mobile examination centres that travel to multiple sites across the country (resulting in a clustered sample).[14,15,16,17] The Labour Force Survey area frame, supplemented by the census, was used as the sampling frame. This analysis included data collected in cycles 4 (2014–2015) and 5 (2016–2017) from a sub-sample of youth aged 12 to 17 years who had complete accelerometer-measured MVPA and self-reported physical activity data (n = 975). Of the original 1,622 youth in the CHMS sample from both cycles, 1,527 had valid PAYQ data, and 975 of those had valid accelerometer data.

The CCHS is an ongoing cross-sectional survey conducted by Statistics Canada that collects information related to health status, health care utilization and determinants of health with respect to the Canadian population; it covers approximately 98% of Canadians aged 12 and older.[18] To assess the reliability of the PAYQ, this paper includes a comparison of estimates obtained in the CHMS to data collected in the 2015–2016 CCHS on respondents aged 12 to 17 years with complete PAYQ data (n = 7,619).

Physical activity measured by accelerometer, Canadian Health Measures Survey only

The CHMS consists of a household interview followed by a visit to a mobile examination centre, where respondents undergo about 2 to 2.5 hours of testing. Upon completion of the household and mobile examination centre visits, ambulatory respondents were asked to wear an Actical accelerometer (Phillips – Respironics, Oregon, USA) over their right hip on an elasticized belt during waking hours for seven consecutive days. It should therefore be noted that the accelerometer measurement of activity occurred in a different week to the household questionnaire, which included the PAYQ module. All respondents were blind to the data while they wore the device. The Actical measures and records time-stamped acceleration in all directions, providing an index of movement intensity via a count value for each minute (data were collected in 60-second epochs). A valid day was defined as having 10 or more hours of wear time, and a valid respondent was defined as having a minimum of four valid days.[14] Daily wear time was determined by subtracting non-wear time from 24 hours. Non-wear time was defined as at least 60 consecutive minutes of zero counts, with allowance for one to two minutes of counts from 0 to 100. Published movement intensity thresholds were applied to the data to derive time spent in light-intensity physical activity (LPA) and moderate-to-vigorous physical activity (MVPA).[19] Total physical activity (TPA) is the sum of MVPA and LPA. A complete description of the accelerometer data reduction procedures is available elsewhere.[14]

Physical activity measured by questionnaire, Canadian Health Measures Survey and Canadian Community Health Survey

As part of an in-person household interview, CHMS respondents were asked to provide estimates of time they spent in the last seven days engaged in transportation ($PAYQ_{TRA}$), recreational ($PAYQ_{REC}$), school-based ($PAYQ_{SCH}$) or other (occupational/household) physical activity ($PAYQ_{OTH}$) (see the PAYQ module in Appendix A). CCHS respondents provided the same information via a phone interview. The reported values by domain were summed to give total physical activity ($PAYQ_{TOT}$). Select combinations of domains were also tested (e.g., $PAYQ_{REC+SCH}$). Respondents were also asked to estimate the number of minutes in the last seven days during which they engaged in vigorous intensity physical activity. In order to be comparable to the accelerometer data, average daily values for each domain of physical activity were calculated.

Reliability and effect of mode of delivery

The PAYQ was administered in-person in the CHMS and over the phone in the CCHS. Physical activity estimates from the CHMS were compared to those obtained in the CCHS to determine whether the mode of delivery of the questionnaire had any effect. Reliability of the PAYQ was assessed across multiple cycles within the CHMS (e.g., 2014–2015 versus 2016–2017) and CCHS (2015 versus 2016).

What is already known on this subject?

- Self-reported and accelerometer-measured physical activity levels generally exhibit low correlation and agreement.
- Previous comparisons between self-reported and accelerometer-measured physical activity using Canadian Health Measures Survey (CHMS) data have exhibited low correlation between methods and large differences in the number of minutes of physical activity accumulated per day, and in adherence to physical activity guidelines.
- A new physical activity questionnaire module was adopted for the 2014–2015 CHMS and 2015-2016 CCHS. This new questionnaire asks youth to report physical activity accumulated by domain: transportation, recreation, school, and occupational/household.

What does this study add?

- On average, Canadian youth reported more physical activity than they accumulated on the accelerometer.
- The correlation between self-reported data from the new questionnaire module and accelerometer-measured physical activity was low. This finding is consistent with results observed for other questionnaire modules among this age group.
- About one in four respondents reported physical activity levels very close to the accelerometer measurements. The remaining respondents were split evenly between reporting more and reporting less physical activity than was measured by the accelerometer.
- Mode of delivery of the questionnaire (i.e., telephone versus in-person) appears to have an effect on physical activity estimates. On average, the estimates obtained over the phone were higher than those obtained in person.

Adherence to the physical activity guideline

Two analytical approaches were used to determine whether respondents adhered to the physical activity guidelines: (1) the **daily analytical method** requires that respondents reach or exceed 60 minutes per day of physical activity in order to be classified as adherent; and (2) the **average analytical method** requires that respondents' weekly average be equal to or exceed 60 minutes per day in order to be classified as adherent.

Obesity measures, Canadian Health Measures Survey only

To determine whether the measurement method affects the direction or strength of association with health, regression analyses were carried out by means of self-reported and accelerometer-measured physical activity estimates with measured obesity. Body mass index (BMI) was calculated as measured weight in kilograms divided by measured height in metres squared. Height was measured to the nearest 0.1 centimetre using a ProScale M150 digital stadiometer (Accurate Technology, Inc., Fletcher, North Carolina, USA). Weight, to the nearest 0.1 kilogram, was measured with a Mettler Toledo VLC with Panther Plus terminal scale (Mettler Toledo Canada, Mississauga, Ontario, Canada). Waist circumference was measured to the nearest 0.1 cm using a flexible tape. Regression coefficients were multiplied by 30 and therefore represent the effect on the outcome of increasing a given type of physical activity by 30 minutes (β_{30min}).

Statistical analysis

Descriptive statistics were used to calculate means and 95% confidence intervals. The percentage of respondents meeting the physical activity guidelines was assessed by means of measured (MVPA) and self-reported PAYQ variables under both the daily and average analytical approaches. Agreement between methods in adherence to the guideline was calculated. Pearson correlation coefficients were used to assess the relationship between measured and reported estimates of physical activity. The distribution of the mean difference (calculated as the measured estimate minus the self-reported estimate) between measured and self-reported physical activity variables was assessed on the basis of weighted histograms. Linear regression, controlling for age and sex, was used to assess the association with obesity measures.

To account for the complex survey design and non-response bias and to correctly estimate variance, all analyses were weighted using the survey weights generated by Statistics Canada for Cycles 4 and 5 of the CHMS[16,17] and the 2015–2016 CCHS.[18] SAS 9.3 (SAS Institute, Cary, North Carolina) and SUDAAN 11.0 were used to analyze the data; denominator degrees of freedom (DDF = 22) were used in the SUDAAN procedure statements for the CHMS analyses. To account for survey design effects, the bootstrap technique was employed to estimate the 95% confidence intervals.[16,17,18] Response rates were 40% for the CHMS[16,17] (reflecting the analytical requirement of at least four valid days of accelerometer data) and 57.5% for CCHS 2015–2016.[18]

Results

According to the PAYQ, Canadian youth reported an average of 78.2 minutes per day of physical activity from all domains ($PAYQ_{TOT}$), including recreation ($PAYQ_{REC}$: 31.3 minutes per day); transportation ($PAYQ_{TRA}$: 15.5 minutes per day); school ($PAYQ_{SCH}$: 25.8 minutes per day); and occupational/household ($PAYQ_{OTH}$: 5.6 minutes per day) (Table 1). According to the Actical, Canadian youth accumulated an average of 49.7 minutes per day of MVPA, 192.0 minutes per day of LPA, and 241.7 minutes per day of TPA. Boys were more active than girls; however, the difference was statistically significant only with respect to accelerometer-measured data. According to $PAYQ_{REC}$, $PAYQ_{SCH}$, $PAYQ_{OTH}$ and accelerometer-measured MVPA, 12- to 14-year- olds were more active than 15- to 17-year-olds. Weekday

Table 1
Average daily minutes of physical activity overall and by sex, age group and day of the week, household population aged 12 to 17 years

	All			Males†			Females			12- to 14-year-olds‡			15- to 17-year-olds		
		95% CI			95% CI			95% CI			95% CI			95% CI	
	Mean	from	to	Mean	from	to	Mean	from	to	Mean	from	to	Mean	from	to
Accelerometer-measured															
Moderate-to-vigorous physical activity	49.7	44.5	54.9	59.9	51.5	68.3	37.5**	34.3	40.7	56.1	47.7	64.5	42.5*	37.0	48.0
Light physical activity	192.0	187.0	197.1	196.8	190.0	203.5	186.3*	179.6	193.1	201.4	195.5	207.3	181.6*	174.1	189.0
Total physical activity	241.7	233.1	250.2	256.6	243.1	270.2	223.8*	216.2	231.4	257.5	244.8	270.3	224.0*	213.9	234.2
Questionnaire-measured (PAYQ)															
Transportation	15.5	13.1	17.9	17.0	13.7	20.2	13.8	9.9	17.8	13.4	10.9	15.8	18.0	13.6	22.3
Recreation	31.3	25.9	36.7	32.4	25.9	38.9	29.9	23.2	36.7	35.4	28.4	42.5	26.6*	21.3	32.0
School	25.8	21.7	29.9	26.6	21.3	31.8	24.9	19.5	30.3	30.1	24.8	35.4	21.0*	15.2	26.9
Household/Occupation	5.6E	3.6	7.6	7.2E	3.9	10.5	3.7E	2.0	5.4	2.9E	1.5	4.4	8.6E*	4.5	12.7
Total	78.2	70.8	85.6	83.1	74.5	91.7	72.4	62.0	82.8	81.8	72.3	91.4	74.2	65.3	83.1

E use with caution
* significantly different from reference category ($p < 0.05$)
** significantly different from reference category ($p < 0.001$)
† reference group (sex)
‡ reference group (age)
CI = confidence interval
Source: Statistics Canada, Canadian Health Measures Survey 2014-2015 and 2016-2017.

and weekend physical activity did not differ according to the accelerometer data. $PAYQ_{TOT}$ and $PAYQ_{TRA}$ were higher on weekdays than on weekends while $PAYQ_{REC}$ was higher on weekends.

When the daily analytical approach (i.e., accumulating 60 minutes of PA **every day**) was employed, 10% or less of Canadian youth met the physical activity guideline according to both the PAYQ and the accelerometer (Figure 1). Under the average analytical approach (i.e., accumulating 60 minutes of physical activity per day **on average**), 23.1% of Canadian youth met the PAG when accelerometer-measured MVPA was used, while various combinations of variables from the PAYQ yielded a result of 18.5% to 58.6%. A significantly larger proportion of boys than girls met the physical activity guideline according to measured MVPA only (10.6% versus 1.9%, daily analytical method; 32.1% versus 12.2%, average analytical method). A significantly greater proportion of 12- to 14-year-olds than 15- to 17-year-olds met the physical activity guideline for accelerator-measured MVPA (30.2% versus 15.1%) and self-reported $PAYQ_{REC}$ (22.9% versus 13.6%), $PAYQ_{REC+SCH}$ (42.3% versus 24.9%), and $PAYQ_{REC+SCH+TRA}$ (55.0% versus 40.8%) (all using the average analytical method).

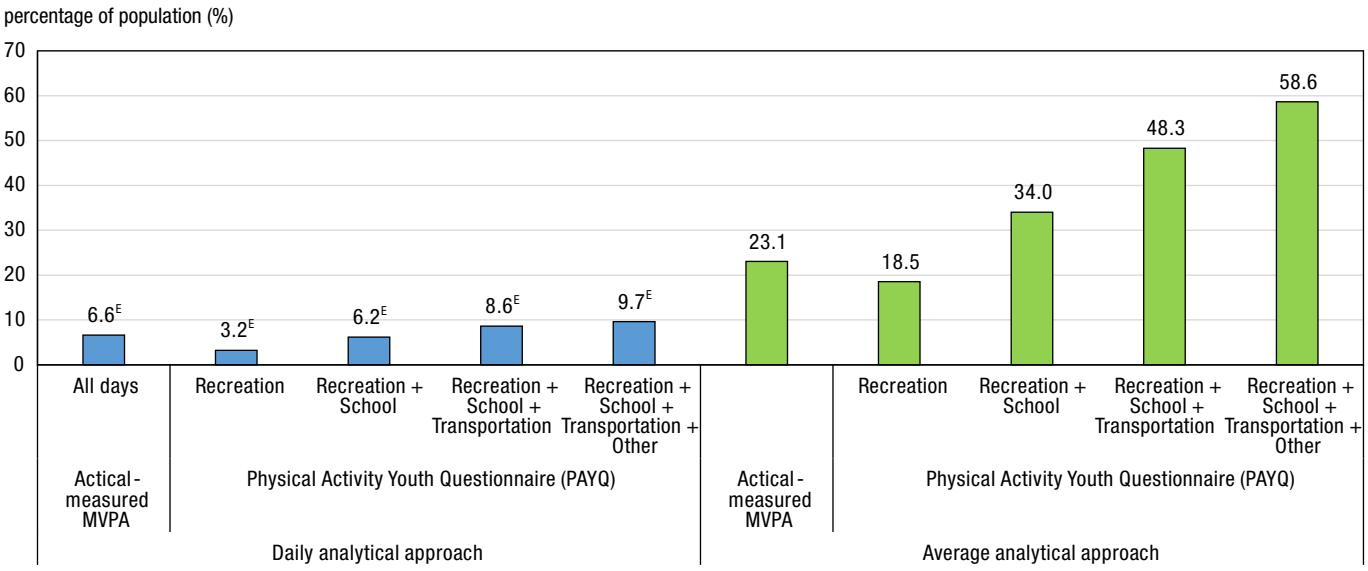
Under the average analytical approach, the measurement methods were in agreement (i.e., both classified respondents as either meeting or not meeting the PAG) among 54% ($PAYQ_{TOT}$) to 73% ($PAYQ_{REC}$) of respondents. Under the daily analytical approach, the measurement methods were in agreement (i.e., both classified respondents as either meeting or not meeting the PAG) among 85% ($PAYQ_{TOT}$) to 90% ($PAYQ_{REC+SCH}$) of respondents. However, almost all of this agreement was attributable to both methods classifying respondents as non-adherent.

Accelerometer-measured MVPA was weakly correlated with $PAYQ_{REC}$, $PAYQ_{SCH}$ and $PAYQ_{TRA}$ (Figure 2). LPA and TPA were both correlated with all domains except $PAYQ_{TRA}$. The correlation increased when multiple domains of physical activity were summed together. The highest correlation observed was that between measured TPA and $PAYQ_{TOT}$ ($R = 0.18$, $p < .0001$). The strength of correlation was consistent between boys and girls (data not shown). Examining the correlations between measurement methods separately for weekdays and weekends did not appreciably change the strength of correlation (data not shown). Vigorous physical activity from the two measurement methods was not correlated (data not shown).

The mean difference between accelerometer-measured MVPA and $PAYQ_{TOT}$ (-28.5 minutes per day, 95% confidence interval [CI]: -19.0 to 9.6) was greater than the mean difference between accelerometer-measured MVPA and $PAYQ_{REC+SCH}$ (0.02 minutes per day, 95% CI: -8.8 to +8.8). Differences between methods at the individual level were large and went in both directions (Figure 3). For one-quarter of respondents, the difference between measured MVPA and $PAYQ_{TOT}$ and $PAYQ_{REC+SCH}$ was within +/- 12.5 minutes per day. When $PAYQ_{TOT}$ was used, 50% of respondents reported values higher than measured values while 25% of respondents had measured values higher than those reported. When $PAYQ_{REC+SCH}$ was used, roughly the same percentage of respondents reported more or less than was measured (34% versus 41%). These results contributed to an overall mean difference close to zero.

Measured MVPA and TPA were not associated with BMI or waist circumference. LPA was positively associated with BMI ($\beta_{30min} = 0.19$, 95% CI: 0.03 to 0.35). Self-reported $PAYQ_{REC}$ was negatively associated with BMI ($\beta_{30min} = -0.23$ kg·m^{-2}, 95% CI: -0.45

Figure 1
Percentage of Canadian youth meeting the physical activity guidelines according to the accelerometer and questionnaire data, household population aged 12 to 17 years



[E] use with caution
MVPA: moderate-to-vigorous physical activity
Source: Statistics Canada, Canadian Health Measures Survey, 2014-2015 and 2016-2017.

to -0.012) and waist circumference (β_{30min} = -0.79 cm, 95% CI: -1.42 to -0.16), and $PAYQ_{SCH}$ was negatively associated with waist circumference (β_{30min} = -0.97 cm, 95% CI: -1.69 to -0.26).

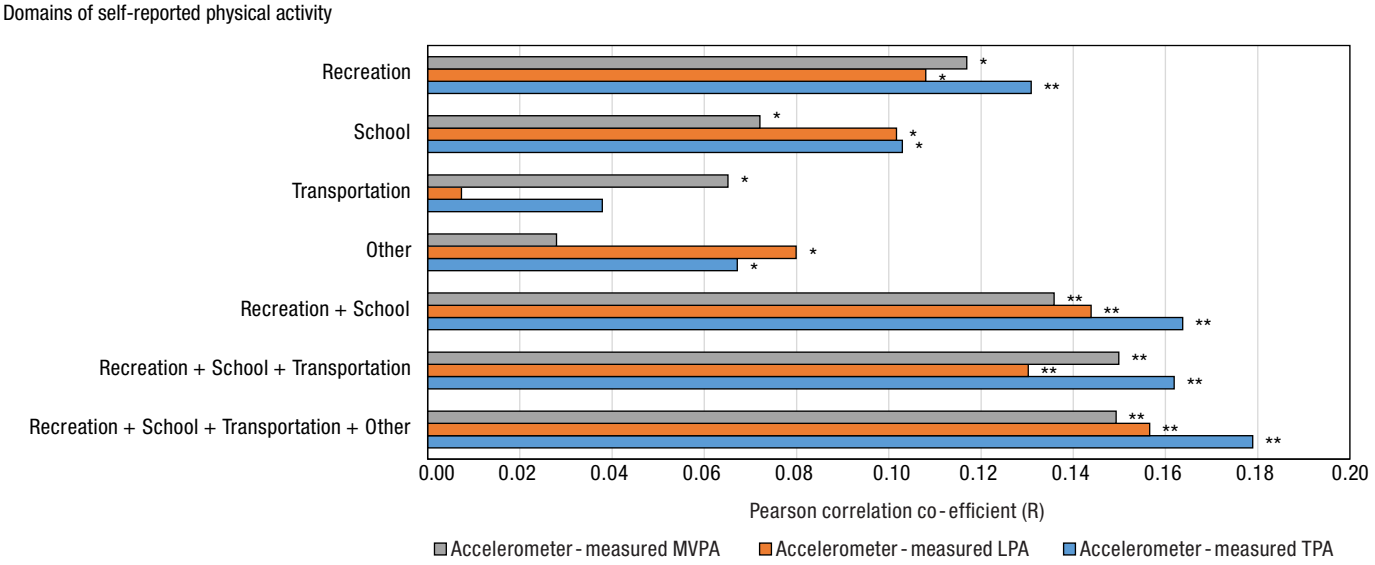
Self-reported physical activity estimates were higher according to the CCHS than the CHMS (Figure 4). This was true across all domains with an average difference between surveys for $PAYQ_{TOT}$ of about 20 minutes per day. A higher percentage of CCHS respondents met the physical activity guideline ($PAYQ_{TOT}$: 63.0%, 95% CI: 61.5% to 64.5%; $PAYQ_{REC+SCH}$: 46.4%, 95% CI: 44.8% to 47.9%) than was observed when PAYQ data from the CHMS was used ($PAYQ_{TOT}$: 58.6%, 95% CI: 52.5% to 64.5%; $PAYQ_{REC+SCH}$: 34.1%, 95% CI: 28.1% to 40.6%). No significant differences were evident between the 2015 and 2016 CCHS samples or between the 2014–2015 and 2016–2017 CHMS samples (with the exception of a significant difference between CHMS cycles for $PAYQ_{OTH}$).

Discussion

This study found that overall population-level estimates of physical activity and the percentage meeting the physical activity guideline were similar between the PAYQ and accelerometer; however, individual-level differences were evident, and physical activity estimates were weakly correlated. This study is consistent with many previous studies that have shown that different measurement tools[3,5,20] and different analytical approaches[9,21] lead to differences in physical activity estimates and the percentage of youth meeting the physical activity guideline. These sources of variation create an obvious surveillance challenge. However, a thorough understanding of how the various tools and analytical techniques relate to one another remains important given that measurement tools and approaches are rarely consistent between studies.

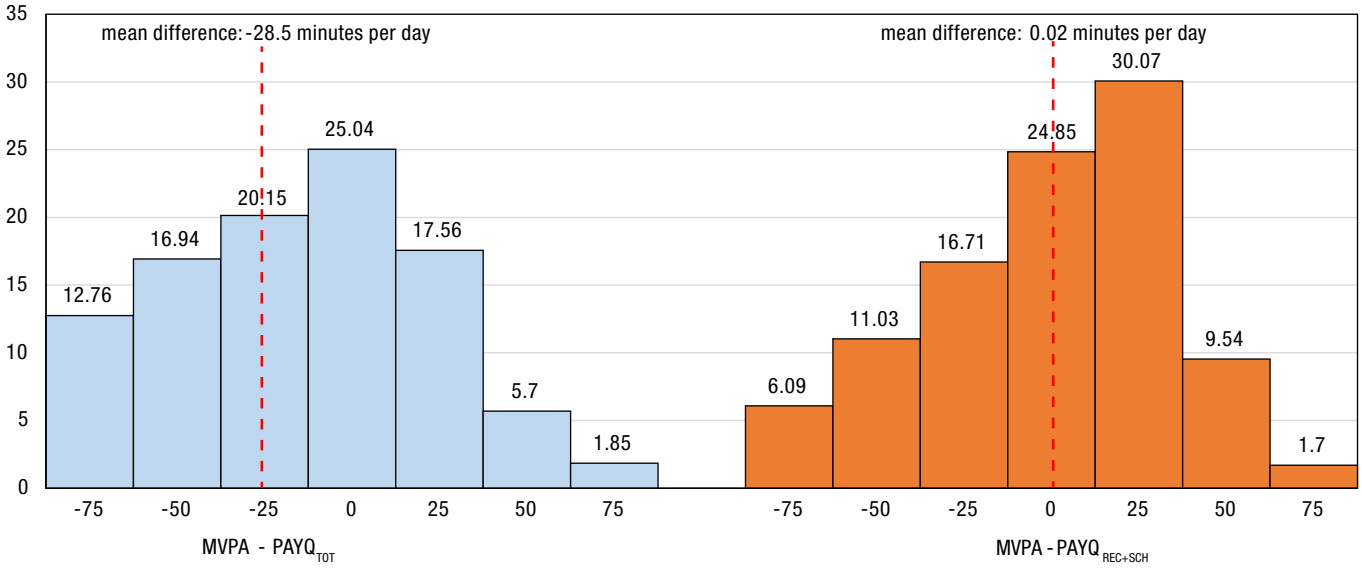
Accelerometers and questionnaires capture different aspects of physical activity. Accelerometers record values in response to movement and numerical thresholds are applied to the data to determine how much time was spent in MVPA, whereas questionnaires attempt to get at a similar construct by asking people to report minutes of activity that "*made you sweat at least a little and breathe harder*." The ambiguity of this statement and risk for misinterpretation combined with the inherent bias and recall difficulties make it easy to understand why estimates are so different between methods. Further, some activities (e.g., cycling, skating, load-bearing) are not captured accurately by accelerometers. All of these aforementioned differences between methods are evident in comparative studies that show wide variation and poor correlation in physical activity estimates between accelerometers and questionnaires.[3,5,20,22,23] The low correlations (i.e., R = < 0.20) observed between accelerometer-measured and self-reported physical activity observed in this study are also consistent with these previous studies as well as with another CHMS study comparing accelerometer-measured physical activity estimates with those obtained using the Minnesota Leisure-Time Physical Activity Questionnaire (R range: 0.22 to

Figure 2
Correlation between accelerometer- and questionnaire-measured physical activity data, household population aged 12 to 17 years



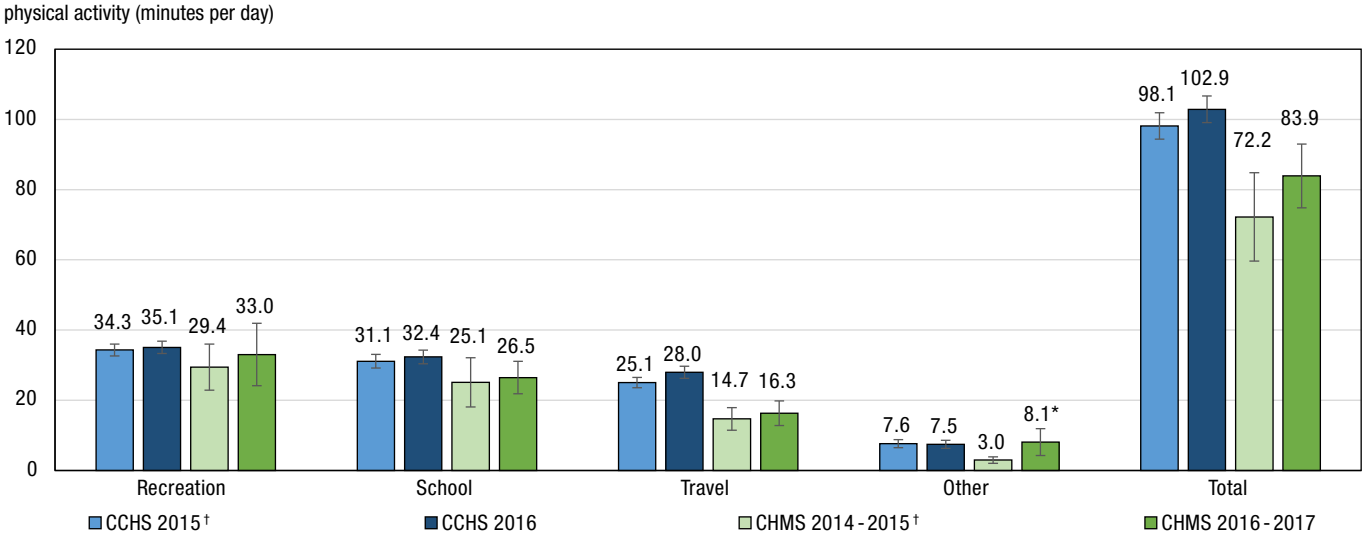
* significantly different from 0 ($p < 0.05$)
** significantly different from 0 ($p < 0.0001$)
LPA: light physical activity
MVPA: moderate-to-vigorous physical activity
TPA: total physical activity
Source: Statistics Canada, Canadian Health Measures Survey, 2014-2015 and 2016-2017.

Figure 3
Weighted distribution of mean difference between accelerometer- and questionnaire-measured physical activity, household population aged 12 to 17 years



MVPA: moderate-to-vigorous physical activity
$PAYQ_{TOT}$: total physical activity derived using the Physical Activity Youth Questionnaire
$PAYQ_{REC+SCH}$: recreation + school physical activity derived using the Physical Activity Youth Questionnaire
Source: Statistics Canada, Canadian Health Measures Survey, 2014-2015 and 2016-2017.

Figure 4
Physical activity across the various domains in the Canadian Community Health Survey and the Canadian Health Measures Survey, household population aged 12 to 17 years



* significantly different from reference category
† reference category
Source: Statistics Canada, Canadian Community Health Survey 2015-2016 and Canadian Health Measures Survey 2014-2015 and 2016-2017.

0.26).[6] A notable limitation of the current study, which may explain, in part, the low correlation, is that the accelerometer and questionnaire measures did not take place during the same week. This is an unavoidable reality of this particular survey and means that any comparison between methods relies on the assumption that both methods are capturing **typical** physical activity behaviour that is at least somewhat comparable from week to week. It is probable that the strength of correlation is underestimated in this study as compared to the results that would have been obtained had the measures been taken simultaneously.

In addition to conceptual differences between accelerometers and questionnaires are differences in estimates caused by variation in analytical approaches. When the PAYQ was being designed (2012), the Canadian physical activity guideline for children and youth was operationalized as meeting the 60 minute target on all seven days of the week.[15] Since then, the new Canadian 24-Hour Guidelines for Children and Youth were published, and recommend that children and youth be classified as adherent to the 60 minute per day physical activity recommendation if they accumulated enough MVPA throughout the week to have an average daily MVPA value greater than or equal to 60 minutes per day.[8] This less strict approach results in an upward shift in the number of respondents classified as adherent. Large differences in the percentage adherent to the physical activity guideline have been reported between the daily and average analytical approaches both in Canada (6.8% versus 33.2% meeting the physical activity guideline)[9] using accelerometers and in the United Kingdom (22.6% versus 54.3%) using questionnaires.[21] When the daily analytical approach was applied to both the PAYQ and Actical data in the present study, both tools indicated that 10% or less of Canadian youth were meeting the physical activity guideline. When the average analytical approach was applied to both methods, the range in percentage meeting the physical activity guideline was less narrow (18.5% to 58.6%). This alignment in population-level estimates of adherence shows that the PAYQ and Actical appear to be capturing a similar overall story; however, the results also highlight the importance of harmonizing the analytical approach when attempting to reconcile differences in physical activity estimates attributable to the measurement method itself.

Recall of physical activity is a complex process that is affected by social desirability bias (e.g., recalling greater physical activity because it may be viewed more favourably by others), recall bias (e.g., inability of respondent to accurately recall physical activity levels), and a misunderstanding of movement intensities.[3,24] It is also important to consider that youth may not possess the cognitive maturity to recall a variety of specific physical activity events.[24,25] While physical activity generally becomes more structured (and arguably easier to recall) with age, youth still engage in many unstructured physical activity pursuits, such as spontaneous play, that are difficult to remember and/or quantify accurately.[26] Some domains of the PAYQ may not be capturing physical activity that is equivalent in intensity to accelerometer-measured MVPA exclusively, and may include physical activity that would be classified as LPA by the accelerometer. This is evident in Figure 2, which shows a

lower correlation between the transportation and occupational/household domains with measured variables, than for the recreation and school domains. When individual domains or a limited combination of domains were compared to measured MVPA (49.7 minutes per day), the estimates were closer (e.g., $PAYQ_{REC+SCH}$ 57.1 minutes per day). Similarly, the percentage meeting the physical activity guideline was also closer to those obtained using measured MVPA (23.1%) when fewer domains were included (e.g., $PAYQ_{REC+SCH}$: 34.0% and $PAYQ_{REC}$: 18.5%). The lack of correlation between the occupational/household domain and MVPA is consistent with a similar analysis on adults that found that the occupational/household domain was more correlated with accelerometer-measured LPA than MVPA.[11] Both studies appear to indicate that some domains seem to capture MVPA more exclusively (e.g., school, recreation) while others appear to capture a combination of LPA and MVPA (e.g., other). MVPA occurs more frequently in structured situations, such as sport participation, workouts, and physical education classes, than does LPA. This type of physical activity is therefore easier to recall than LPA, which tends to occur more sporadically throughout the day in short bursts. This reality may explain, in part, the stronger correlations observed between the recreation and school domains with measured MVPA. Alternatively, the incongruence observed may be a result of poor transfer of intensity thresholds developed under controlled laboratory conditions to population surveillance, which looks to quantify free-living activity.

Another approach to comparing physical activity measurement tools is to examine whether they are similarly associated with health outcomes. Measured MVPA was not associated with obesity whereas self-reported recreational physical activity was negatively associated with both BMI and waist circumference. This result is in contrast to a similar analysis done on adults,[11] which found the opposite (i.e., measured and not reported physical activity was negatively associated with obesity). The adult analysis[11] combined with the current investigation demonstrate the importance of acknowledging that different methods may not tell a consistent story when it comes to understanding links between behaviours and health.

A previous comparison of in-person and telephone interviewing in the CCHS found that the interview mode affected the answers on physical activity (obtained using the Minnesota Leisure-Time Physical Activity Questionnaire) such that there were significantly more inactive persons when interviews were conducted in person than when interviews were conducted over the phone.[27] The results of the present study agree with this finding given that higher physical activity estimates were obtained through the telephone approach (CCHS) than the in-person-interview approach (CHMS). Comparisons made in the current analysis between cycles for each separate survey show that the PAYQ appears to be reliable at the population level (Figure 4). A more detailed examination of reliability of the PAYQ at the individual level is recommended.

As part of this study, a range of analyses were conducted to compare accelerometer-measured and questionnaire-derived physical activity estimates among youth. While the inclusion of multiple domains of physical activity is important from a surveillance perspective, the results of this study demonstrate that data users may want to limit the inclusion of domains to recreation and school in order to obtain physical activity estimates closer to those obtained by accelerometry. The results herein suggest that the transportation and other domains capture a combination of MVPA and LPA, and that this may be contributing to low correlation and agreement with accelerometer-derived estimates. This presents a challenge for future questionnaire development as it appears as though respondents are not always clear on what intensity of movement they are meant to report. Further, determining a mechanism to differentiate between light and moderate intensity within questionnaires is challenging, but would contribute to better understanding of the relative contributions of light and moderate-to-vigorous movement to health.

The results of the present study add to a growing body of literature[4,11] that suggests accelerometer-measured and self-reported physical activity are assessing different aspects of the same behaviour and that adopting multiple complementary approaches at the same time may be the optimal approach to providing a more complete profile of physical activity behaviour.[28] Despite the challenges and limitations associated with self-reported physical activity data in youth, the reality for many large-scale health surveys is that this methodology is the only feasible option given cost and logistical constraints. Although accurate recall of physical activity is difficult, self-reported levels of physical activity have been shown to associate strongly with health and, therefore, provide important proxy-level information of this behaviour. Furthermore, because of their cost-effectiveness, self-report surveys are of key importance in international and sub-jurisdictional surveillance. Currently the CCHS offers the ability to report on smaller geographic areas, such as provinces and territories, and health regions, whereas the CHMS offers national estimates. Comparisons like the current one are therefore important to reconcile and understand the differences that will inevitably be observed when physical activity estimates for different measurement tools are compared. ■

Appendix A: Physical Activity Youth Questionnaire (PAYQ)

Adapted from: Canadian Health Measures Survey documentation

Preamble: The following questions are about various types of physical activities that you have done each day in the past week.

1. Transportation

a. In the last seven days, did you use active ways like walking or cycling to get to places such as [school, the bus stop, the shopping centre, work/school] or to visit friends?

INTERVIEWER: Do not include walking, cycling or other activities done purely for leisure. These activities will be asked about later.

i. Yes
ii. No

b. How much time did you spend using active ways to get to places?

i. Yesterday: ___minutes or hours
ii. 2 days ago: ___minutes or hours
iii. 3 days ago: ___minutes or hours
iv. 4 days ago: ___minutes or hours
v. 5 days ago: ___minutes or hours
vi. 6 days ago: ___minutes or hours
vii. 7 days ago: ___minutes or hours

2. School

a. In the last seven days, did you do sports, fitness or recreational physical activities while at [school or day camp, including during physical education classes, during your breaks and any other time you played indoors or outdoors]?

i. Yes
ii. No

b. Did any of these activities make you sweat at least a little and breathe harder?

i. Yes
ii. No

c. How much time did you spend doing these activities at school/day camp that made you sweat at least a little and breathe harder?

i. Yesterday: ___minutes or hours
ii. 2 days ago: ___minutes or hours
iii. 3 days ago: ___minutes or hours
iv. 4 days ago: ___minutes or hours
v. 5 days ago: ___minutes or hours
vi. 6 days ago: ___minutes or hours
vii. 7 days ago: ___minutes or hours

3. Leisure-Time Recreation

a. In the last seven days, did you do physical activities in your leisure time, including exercising, playing an organized or non-organized sport or playing with your friends?

i. Yes
ii. No

b. Did any of these recreational physical activities make you sweat at least a little and breathe harder?

i. Yes
ii. No

c. How much time did you spend doing these leisure-time activities that made you sweat at least a little and breathe harder?

i. Yesterday: ___minutes or hours
ii. 2 days ago: ___minutes or hours
iii. 3 days ago: ___minutes or hours
iv. 4 days ago: ___minutes or hours
v. 5 days ago: ___minutes or hours
vi. 6 days ago: ___minutes or hours
vii. 7 days ago: ___minutes or hours

4. Occupational/Household

a. In the last seven days, did you do any other physical [activities you have not already reported], for example, while you were doing paid or unpaid work or were helping your family with chores?

i. Yes
ii. No

b. Did any of these other physical activities make you sweat at least a little and breathe harder?

i. Yes
ii. No

c. How much time did you spend doing these other physical activities that made you sweat at least a little and breathe harder?

i. Yesterday: ___minutes or hours
ii. 2 days ago: ___minutes or hours
iii. 3 days ago: ___minutes or hours
iv. 4 days ago: ___minutes or hours
v. 5 days ago: ___minutes or hours
vi. 6 days ago: ___minutes or hours
vii. 7 days ago: ___minutes or hours

5. Vigorous Physical Activity

a. You have reported a total of ___ minutes of physical activity (insert sum of transportation, school, recreation, occupational/household). Of these activities, were there any of vigorous intensity, meaning they caused you to be out of breath?

i. Yes
ii. No

b. In the last seven days, on which days did you do these vigorous activities that caused you to be out of breath?

i. Yesterday
ii. 2 days ago
iii. 3 days ago
iv. 4 days ago
v. 5 days ago
vi. 6 days ago
vii. 7 days ago

c. How much time in total did you spend doing vigorous activities that caused you to be out of breath?

i. ____ hours (min: 0, max: 168)

Or

ii. ____minutes (min:0, max: 9995)

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