Physical activity of Canadian adults: Accelerometer results from the 2007 to 2009 Canadian Health Measures Survey

by Rachel C. Colley, Didier Garriguet, Ian Janssen, Cora L. Craig, Janine Clarke and Mark S. Tremblay

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Abstract

Background
Rising obesity rates and declining fitness levels have increased interest in understanding what underlies these trends. This article presents the first directly measured data on physical activity and sedentary behaviour on a nationally representative sample of Canadians aged 20 to 79 years.

Data and methods
Data are from the 2007 to 2009 Canadian Health Measures Survey (CHMS). Physical activity was measured using accelerometry. Data are presented as time spent in sedentary, light, moderate and vigorous intensity movement as well as steps accumulated per day.

Results
An estimated 15% of Canadian adults accumulate 150 minutes of moderate-to-vigorous physical activity (MVPA) per week; 5% accumulate 150 minutes per week as at least 30 minutes of MVPA on 5 or more days a week. Men are more active than women and MVPA declines with increasing age and adiposity. Canadian adults are sedentary for approximately 9.5 hours per day (69% of waking hours). Men accumulate an average of 9,500 steps per day and women, 8,400 steps per day. The 10,000-steps-per-day target is achieved by 35% of adults.

Interpretation
Before the CHMS, objective measures of physical activity and sedentary behaviour were not available for a representative sample of Canadians. The findings indicate that 85% of adults are not active enough to meet Canada’s new physical activity recommendation.

Keywords
Activity, exercise health measurement, motor activity, pedometer, physical fitness, public health, obesity, sedentary behaviour

Authors
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Regular physical activity is associated with a reduced risk of cardiovascular disease, some types of cancer, osteoporosis, diabetes, obesity, high blood pressure, depression, stress and anxiety. As well, strong evidence suggests that higher levels of physical activity are associated with health benefits; in fact, the more activity, the greater the health benefit. To determine whether Canadians are sufficiently active to obtain health benefits, the 2007 to 2009 Canadian Health Measures Survey (CHMS) used accelerometers to collect the first time-sequenced objective measures of physical activity for a nationally representative sample of 6- to 79-year-olds.

Before the CHMS, national trends in physical activity were derived from self-report surveys, the results of which suggested that the percentage of adults who perceive that they are active has been increasing. In 2009, 52.5% of Canadian adults reported that they were at least moderately active during their leisure time. Yet the prevalence of obesity has risen considerably in Canada over the past 25 years, with a quarter of adults now overweight or obese. Moreover, muscular strength and flexibility, typically maintained by regular physical activity, have declined since 1981.

If half of Canadians are, indeed, sufficiently active for health benefit, it is unlikely that such trends in obesity and fitness would be observed. These counterintuitive findings have increased interest in supplementing self-reported physical activity data with information from devices such as pedometers and accelerometers.

Canada is one of several countries that have recently, or are currently, revising their physical activity recommendations. Efforts have been made to harmonize the revision and recommendation processes among
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Countries (for example, Canada, United States, United Kingdom, Australia), as well as with the World Health Organization (WHO). This has led to a recommendation that adults should engage in at least 150 minutes per week of moderate-to-vigorous physical activity (MVPA), accumulated in bouts lasting at least 10 minutes. The 150 minutes can be accumulated in a variety of ways (for example 30 minutes, 5 days a week). Accelerometry data from the CHMS allow for an objective assessment of how many Canadians are meeting this recommendation.

Health promotion efforts have historically focused on encouraging leisure-time physical activity (LTPA) of at least moderate intensity. But LTPA represents only a small fraction of total daily movement, and attention is being directed toward the roles of sedentary behaviour and incidental movement in obesity and health. Time spent in sedentary pursuits is now recognized as not simply the absence of physical activity, but rather, a distinct set of behaviours with unique health effects independent of those associated with a lack of LTPA. The use of accelerometers in the CHMS makes it possible to quantify time spent at various movement intensities, including sedentary levels.

In partnership with the Public Health Agency of Canada and Health Canada, Statistics Canada launched the CHMS in 2007. After a household interview, respondents went to a mobile examination centre where they underwent a series of direct health measures and received an accelerometer to wear for one week. Accelerometry data from the CHMS allow for an objective assessment of how many Canadians are meeting this recommendation.

Methods

Data source

The Canadian Health Measures Survey (CHMS), is a nationally representative survey that covers the

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>20 to 39</th>
<th>40 to 59</th>
<th>60 to 79</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total sample (number)</td>
<td>395</td>
<td>480</td>
<td>452</td>
</tr>
<tr>
<td>Age (years)</td>
<td>30.0</td>
<td>48.3</td>
<td>49.5</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>176.6</td>
<td>175.5</td>
<td>162.6</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>82.7</td>
<td>86.3</td>
<td>70.3</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>26.5</td>
<td>28.0</td>
<td>26.6</td>
</tr>
<tr>
<td>BMI category (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Healthy weight</td>
<td>39.8</td>
<td>21.1</td>
<td>47.2</td>
</tr>
<tr>
<td>Overweight</td>
<td>40.7</td>
<td>56.0</td>
<td>30.7</td>
</tr>
<tr>
<td>Obese</td>
<td>18.4</td>
<td>22.6</td>
<td>21.6</td>
</tr>
</tbody>
</table>

Excludes pregnant women
Use with caution
Table 2
Unweighted distribution of respondents, by valid days of accelerometer wear (10 or more wear hours), age group and sex, household population aged 20 to 79 years, Canada, March 2007 to February 2009

<table>
<thead>
<tr>
<th>Age group (years)/Sex</th>
<th>Number of valid days of accelerometer wear</th>
<th>% of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0† 1 2 3 4 5 6 7 1 or more 4 or more</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3.8 2.6 2.7 3.9 5.6 12.0 21.0 48.4 96.2 87.0</td>
<td></td>
</tr>
<tr>
<td>20 to 39 Men</td>
<td>5.0 3.7 2.3 7.4 9.1 15.1 19.6 37.8 95.0 81.6</td>
<td></td>
</tr>
<tr>
<td>20 to 39 Women</td>
<td>4.8 3.7 3.7 3.3 6.0 11.0 21.8 45.8 95.2 84.6</td>
<td></td>
</tr>
<tr>
<td>40 to 59 Men</td>
<td>2.8 2.0 2.4 3.4 5.0 11.4 23.6 49.3 97.2 89.4</td>
<td></td>
</tr>
<tr>
<td>40 to 59 Women</td>
<td>3.4 1.5 2.8 3.1 4.1 9.0 22.2 54.0 96.6 89.2</td>
<td></td>
</tr>
<tr>
<td>60 to 79 Men</td>
<td>2.6 2.4 2.6 3.2 3.8 15.6 19.8 50.2 97.4 89.3</td>
<td></td>
</tr>
<tr>
<td>60 to 79 Women</td>
<td>4.1 2.3 2.3 3.7 5.8 11.3 18.3 52.0 95.9 87.5</td>
<td></td>
</tr>
</tbody>
</table>

† agreed to wear accelerometer, but returned device with no valid data


The monitors were returned in a prepaid envelope to Statistics Canada, where the data were downloaded and the monitor was checked to determine if it was still within the manufacturer’s calibration specifications.

The Actical (dimensions: 2.8 x 2.7 x 1.0 centimetres; weight: 17 grams) measures and records time-stamped acceleration in all directions, thereby indicating the intensity of physical activity. The digitized values are summed over a user-specified interval of 1 minute, resulting in a count value per minute (cpm). Accelerometer signals are also translated into steps accumulated per minute. The Actical has been validated to measure physical activity in adults31 and children32,33 and step counts in adults and children.34 All data are blind to respondents while they are wearing the device.

Biologically implausible data were assessed to determine if files should be included in final analyses; the procedures applied to manage such data are described elsewhere.30 Published guidelines were followed to identify and remove days with incomplete (invalid) accelerometer wear time.30,38,39 A valid day was defined as 10 or more hours of wear time; respondents with 4 or more valid days were retained for analyses.38 Wear time was defined by subtracting nonwear time from 24 hours. Nonwear time was defined as at least 60 consecutive minutes of zero counts, with allowance for 1 to 2 minutes of counts between 0 and 100.

Time spent in various levels of movement intensity—sedentary, light, moderate, vigorous—is based on the application of intensity cut-points corresponding to each intensity level (Table 3).

Table 3
Physical activity intensity cut-points for Actical accelerometer35-37

<table>
<thead>
<tr>
<th>Intensity</th>
<th>Metabolic Equivalent (METs)</th>
<th>Example</th>
<th>Accelerometer count range (counts per minute)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sedentary</td>
<td>1 to less than 2</td>
<td>Car travel, sitting, reclining, standing</td>
<td>Less than 100*</td>
</tr>
<tr>
<td>Light</td>
<td>2 to less than 3</td>
<td>Walking less than 3.2 km/h, light household cleaning, cooking</td>
<td>100 to less than 1.505</td>
</tr>
<tr>
<td>Moderate</td>
<td>3 to less than 6</td>
<td>Walking more than 3.2 km/h, cleaning (vacuuming, washing car), bicycling for pleasure</td>
<td>1.535 to less than 5.962</td>
</tr>
<tr>
<td>Vigorous</td>
<td>6 or more</td>
<td>Jogging, competitive team sport participation</td>
<td>3.962 or more</td>
</tr>
</tbody>
</table>

* including wear-time zeros

Adherence to various physical activity targets was examined:
1. New Canadian and Global WHO recommendation: 150 minutes of MVPA per week accumulated in 10-minute bouts. To count as a bout, 10 consecutive minutes of observations had to exceed the moderate intensity cut-point, with allowance for a maximum of two observations falling below the cut-point during that period (8 out of 10 minutes had to be above the cut-point).5,12-14
   a) Adherence defined as a weekly sum of 150 or more minutes of MVPA per week. If respondents had 4 to 6 valid days, their average daily MVPA was multiplied by 7 to obtain a weekly sum.
   b) Adherence defined as the probability of accumulating at least 30 minutes of MVPA on at least 5 days of the week.
2. 10,000 steps per day.40-42

To determine the probability that adults accumulate at least 30 minutes (or 15 minutes) of MVPA on at least 5 days per week, the analytical approach was harmonized with that used in the analysis of the 2003-2004 NHANES accelerometry data.38 To maximize the sample size (important because only 48.4% of the sample aged 20 to 79 years who wore accelerometers had 7 valid days of wear), a Bayesian approach was used to incorporate the information from all respondents with 4 or more valid days. An individual’s probability of being adherent (active at least 5 out of 7 days) was estimated using a Beta distribution for its observed combination...
of active and wear days. The estimated population prevalence of adherence is the weighted average of these individual probabilities. Further detail is available elsewhere (http://riskfactor.cancer.gov/tools/nhanes_pam).\textsuperscript{39}

Compared with other accelerometer models, the Actical has better instrument reliability,\textsuperscript{43} and its omni-directional capability allows it to capture a wider range of movement than a uni-axial device such as the Actigraph used in NHANES. The Actical is also waterproof, which may have helped with compliance as respondents did not have to remove the device so often throughout the day.

**Statistical analysis**

All analyses were conducted with SAS Version 9.1 and were based on weighted data using respondents with 4 or more valid days. To account for the survey design of the CHMS, standard errors, coefficients of variation and 95% confidence intervals were estimated with the bootstrap technique.\textsuperscript{44} Comparisons of physical activity among age and sex groupings were made with pairwise contrasts. Differences between estimates were tested for statistical significance, which was established at \( p < 0.05 \).

**Results**

**Age, sex and BMI**

The majority of Canadian adults’ waking hours—68% for men and 69% for women—are sedentary. Total average daily sedentary time is 575 minutes (9.6 hours) for men and 585 minutes (9.8 hours) for women (Table 4). Overall, men and women engage in about 4 hours per day of light physical activity.

At ages 20 to 39, men accumulate more MVPA than do women: 33 versus 24 minutes per day; a sex difference is not evident at ages 40 to 79 years. Healthy weight men average 35 minutes a day of MVPA, while overweight and obese men average significantly less: 26 and 19 minutes, respectively. Healthy weight women accumulate an average of 25 minutes of MVPA a day, while overweight women accumulated 20 minutes, and obese women, 13 minutes.

**Meeting recommendations**

According to the CHMS data, 15% of adults (17% of men and 14% of women) accumulate 150 minutes per week of MVPA in 10-minute bouts (Table 5). The percentage of adults accumulating 150 minutes on a regular basis—at least 30 minutes on at least 5 days a week—is 5%. Overall, about half (53%) are accumulating at least 30 minutes of MVPA 1 or more days per week, but almost as many (47%) do so less than one day a week (Table 6).

**Step counts**

Men average 9,500 steps per day, and women, 8,400 (Table 4). The daily average is significantly lower at ages 60 to 79 years: 7,900 steps for men and 7,000 steps for women. A significant sex difference is evident only in the 40-to-59-year age group (10,000 versus 8,700 steps per day). Obese men and women accumulate significantly fewer steps per day than do healthy weight adults. Just over a third (35%) of adults accumulate an average of 10,000 steps per day; older adults are significantly less likely than 20- to 39-year-olds to do so (Table 5).

**Discussion**

This article provides an overview of the physical activity levels of Canadians aged 20 to 79 years, based on the first objectively measured physical activity data collected for a representative sample of Canadians. The most important finding is that 15% of adults are meeting the revised physical activity recommendation. The majority—69%—of Canadian adults’ waking hours are spent in sedentary pursuits.
To obtain substantial health benefits, new WHO and Canadian guidelines recommend that adults should accumulate at least 150 minutes of MVPA a week, a level achieved by 17% of men and 14% of women, according to the CHMS data.

A considerable amount of the evidence in support of the 150-minutes-per-week recommendation suggests that frequent physical activity is important for health. The percentage of Canadian adults reaching the 150-minutes-per-week recommendation by accumulating at least 30 minutes of MVPA on at least 5 days per week is about 5%.

CHMS data may provide insight into how the physical activity recommendations could be translated into practical messages. While the finding that 5% of Canadian adults accumulate 30 minutes of MVPA on 5 out of 7 days is informative, further insight can be obtained by examining how close the remaining 95% come to this recommendation. Many adults are getting some physical activity, as 63% accumulate 15 minutes of MVPA at least one day a week. However, this means that more than a third (37%) do not reach even this modest level of activity. These findings provide targets for intervention and suggest a need to encourage a substantial share of Canadian adults to increase both the duration and frequency of their MVPA.

Objectively measured physical activity data from the 2005-2006 National Health and Nutrition Examination Survey (NHANES) show that 3% of Americans aged 20 to 59 years were accumulating at least 30 minutes of MVPA in 10-minute bouts on 5 out of 7 days. CHMS data for the same age range show that the estimated prevalence is slightly higher in Canadian men (20 to 59 years: 6%), similar in Canadian women aged 20 to 39 years (3%), and higher in Canadian women aged 40 to 59 years (5%). The United States and Canada are both struggling with disturbing trends in obesity and chronic disease. Harmonization in health surveillance between countries...
What is already known on this subject?

- Over the past 25 years, the prevalence of obesity has increased among Canadian adults.
- According to self-report estimates, 52.5% of Canadian adults are physically active.
- Moderate-to-vigorous physical activity (MVPA) is associated with health benefits.
- Sedentary behaviour is emerging as a negative contributor to health.

What does this study add?

- An estimated 15.4% of Canadian adults accumulate 150 or more minutes of moderate-to-vigorous MVPA in 10-minute bouts per week, and 4.8% do so at least 30 minutes on at least 5 days.
- A third of Canadian adults accumulate an average of 10,000 or more steps per day.
- On average, men accumulate 27 minutes a day of MVPA, and women, 21 minutes.
- Regardless of age group, men engage in more MVPA than do women.
- Men and women spend about 9.5 of their waking hours being sedentary.

may increase the efficiency with which efforts to encourage physical activity can be evaluated and implemented.

The CHMS finding that 15% of adults are meeting the 150 minutes of MVPA per week recommendation differs markedly from self-reported data. According to the Canadian Community Health Survey, more than half of adults are at least “moderately active” in their leisure time.1,6,7 As population surveillance efforts such as the CHMS implement objective measures of physical activity, expected and substantive differences between self-reported and objective measures need to be examined and understood. Self-reported data are subject to bias,8-49 typically resulting from social desirability and recall difficulties. Accelerometers are limited by their inability to capture some types of movement (for example, upper body, swimming), potential bias via the application of walking-based intensity cut-points, and the lack of contextual information about how physical activity is accumulated. Population surveillance that exploits the unique advantages of each methodology is desirable.

The CHMS data show that roughly a third of Canadian men and women achieved the well-known pedometer target of 10,000 steps per day. The average man takes approximately 9,500 steps per day, and the average woman, 8,400 steps. These figures are close to results of the 2005-2006 NHANES, which found that American adults averaged about 9,700 steps per day.50 Collecting and reporting data from the pedometer function of the Actical offers some distinct advantages. Pedometers are now widely available and relatively economical for individuals to purchase. Furthermore, pedometer results are conceptually easier to understand than counts per minute data, and therefore, might lend themselves more easily to use in a variety of health and fitness settings.

“Sedentary” is increasingly being defined as a distinct subset of activities, rather than simply a lack of volitional physical activity of moderate or vigorous intensity.23 Sedentary behaviour encompasses a broad range of activities (for instance, occupational sitting, TV watching, eating) that occur intermittently throughout the day.17 According to the CHMS data, the majority (69%) of Canadian adults’ accelerometer wear time was sedentary. This is higher than values observed in American analyses of the 2003-200441 and 2005-2006 NHANES,45 which reported ranges of 50% to 60% of the day being spent in sedentary activities. With the sedentary end of the movement spectrum accounting for such a large share of a Canadian adult’s day,15 ongoing monitoring of this behaviour is needed. The CHMS sedentary time data constitute an objective baseline against which changes resulting from interventions and policy initiatives can be tracked and assessed.

Limitations

Accelerometers have several important limitations, notably, potential underestimation of overall activity because they cannot accurately capture activities that are not step-based (for example, swimming, cycling). In addition, accelerometers do not measure the added energy expenditure associated with upper body movement (for example, weight-lifting, shoveling snow), load carrying, or walking up an incline. However, walking is far more common than swimming, cycling, and weight training among Canadian adults.52

Current understanding of the appropriate amount of physical activity required to obtain health benefit is based on epidemiological evidence from self-report surveys. The gap between self-reported LTPA and accelerometer-measured MVPA is poorly understood and is an important area of future research. For example, a survey respondent who reports participation in a 60-minute hockey game may accumulate only 20 to 30 minutes of MVPA on the accelerometer. To transform raw accelerometry data into usable information, intensity cut-points must be applied to separate the activity data into sedentary, light, moderate and vigorous. Because of the paucity of published literature available to set adult cut-points for the Actical, the cut-points used in the present analysis were based on a small number of studies.36,37

The overall response rate to the accelerometry component of CHMS was 42.2%. Although adjustments were made to the sampling weights to compensate, estimates could be biased by systematic differences between respondents and non-respondents. For example, given that non-respondents tended to be younger, male, and more obese than
people who wore the accelerometer for 4 or more days, these individuals might be less active. Thus, the physical activity data in this analysis could be slightly overestimated.

Conclusions
The CHMS accelerometry data indicate that Canadians are less active than self-reported estimates suggest. In light of this new measurement capability, relationships between physical activity and health will need to be re-examined. The broad range of health outcomes assessed in the CHMS will allow researchers to study the impact physical activity and sedentary behaviour on health more objectively than has ever been possible. Exploration of these relationships is needed to inform the design, delivery and priority of healthy active living initiatives. Ongoing collection of physical activity measures will also allow for assessments of the efficacy of health interventions.

References
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36. Colley RC, Tremblay MS. Moderate and vigorous physical activity intensity cut-points for the Actical accelerometer. (submitted and under review)


