Physical activity of Canadian children and youth, 2007 to 2015

by Rachel C. Colley, Valerie Carson, Didier Garriguet, Ian Janssen, Karen C. Roberts and Mark S. Tremblay

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Physical activity of Canadian children and youth, 2007 to 2015

by Rachel C. Colley, Valerie Carson, Didier Garriguet, Ian Janssen, Karen C. Roberts and Mark S. Tremblay

Abstract

Background: This study describes and compares the percentages of Canadian children and youth who adhere to different operational definitions of the moderate-to-vigorous physical activity (MVPA) recommendation of 60 minutes per day.

Data and methods: Data for 6- to 17-year-olds (n = 5,608) were collected from 2007 through 2015 as part of the Canadian Health Measures Survey. MVPA was measured using the Actical accelerometer. The MVPA recommendation was operationalized as accumulating 60 minutes of MVPA every day, on most days, and on average.

Results: Data from the most recent cycle of the Canadian Health Measures Survey indicate that 7% of children and youth accumulated at least 60 minutes of MVPA on at least 6 out of 7 days, and 33% achieved a weekly average of at least 60 minutes per day. Boys accumulated more MVPA than did girls, and 6- to 11-year-olds accumulated more MVPA than did 12- to 17-year-olds. Regardless of how adherence to the recommendation is operationalized, MVPA levels among Canadian children and youth did not change over the 9-year period from 2007 to 2015.

Interpretation: The majority of Canadian children do not meet the physical activity recommendation, regardless of the operational definition used. However, the discrepancies between results based on different interpretations of the 60-minutes-per-day recommendation highlight the importance of explicitly reporting how recommendations are operationalized to avoid misinterpreting trends and comparisons.

Keywords: Accelerometer, benchmarking, exercise, health surveys, moderate-to-vigorous physical activity, movement

Physical activity is associated with a range of physical, mental, and social health benefits for children and youth.1,2 Guidelines published by the World Health Organization and by several countries recommend that children and youth accumulate a minimum of 60 minutes of moderate-to-vigorous physical activity (MVPA) per day, and advocate engagement in vigorous-intensity physical activity, as well as muscle- and bone-strengthening activities, at least three times per week.3-6

Since 2007, the nationally representative Canadian Health Measures Survey (CHMS) has used accelerometers to measure MVPA. The first cycle of data, collected between 2007 and 2009, indicated that only 7% of Canadian children and youth met the recommended 60 minutes per day.7 Four cycles of CHMS data, collected across nine years (2007 to 2015), are now available and provide an opportunity to update statistics and examine temporal trends in the MVPA of Canadian children and youth.

The recently released Canadian 24-Hour Movement Guidelines for Children and Youth integrate recommendations for physical activity, sedentary behaviour, and sleep.8 The MVPA recommendation in these new Guidelines—60 minutes a day—is consistent with the previous Canadian stand-alone guideline4 and with guidelines from other countries and organizations.9 Despite between-country consistency in the MVPA recommendation, how this benchmark is assessed varies, thereby limiting comparisons between studies and across jurisdictions. Most notably, operationalization of the “daily” or “per day” aspect of the recommendation differs. Meeting the MVPA recommendation has been operationalized as: at least 60 minutes per day when averaged across a week9-14; at least 60 minutes on all 7 days of the week15-27; and at least 60 minutes on at least 58 or at least 6 days9 per week. The percentages of children and youth who meet the recommendation differ, based on how it is operationalized.28-31

Surveillance recommendations that accompanied the release of the new Guidelines suggest that adherence to the MVPA, screen time, and sleep components each be assessed using average daily time.8 This is a departure from the original approach to operationalizing the physical activity recommendation as accumulating 60 minutes of MVPA on at least 6 days per week.7 The authors of the new Guidelines suggested that both operational definitions be applied in the future in order to examine trends in MVPA over time.8 They also noted that use of an average rather than a daily measure is supported by the evidence that informed development of the Guidelines.2,32 This allows for consistency on how the different movement behaviour recommendations are operationalized (for example, avoid requiring 6 out of 7 days for MVPA, while requiring an average daily time for sleep and screen time).8 Findings from Cycles 2 and 3 of the CHMS (2009-to-2011 and 2011-to-2013) indicate that the difference between operationalizing 60 minutes per day as an average rather than requiring 60 or more minutes on at least 6 out of 7 days results in a difference in the percentage of children and youth who meet the guideline of 7% versus 36%.33 This discrepancy signals a need to reconcile how the two measures relate to one and another.

Evidence of a dose-response relationship between physical activity and health1 suggests that encouraging children and youth to increase their MVPA, regardless of their current baseline level, is warranted. Physical activity recommendations urge inactive children to “slowly increase their activity in small steps”10 and promote the idea that the “more physical

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activity children do, the more they will benefit.\textsuperscript{19} Therefore, examining MVPA below and above the 60-minutes-per-day benchmark provides complementary information about the percentage of children and youth who are close to achieving or exceeding the current guideline. These additional findings could inform whether strategies to increase physical activity should focus on frequency, duration, or both.

This study describes and compares the percentages of 6- to 17-year-old Canadians who adhere to the current MVPA recommendation, based on different operational definitions. The analysis presents an overview of the accelerometer-measured MVPA levels of Canadian children and youth from 2007 through 2015, using a range of benchmarks above, below, and including the 60-minutes-per-day recommendation. These comparisons help reconcile apparent changes in adherence to the recommendations resulting from the transition in the operational definition in the Canadian 24-Hour Movement Guidelines.

**Data and methods**

**Data source**

The Canadian Health Measures Survey (CHMS), an ongoing survey conducted by Statistics Canada, collects reported and measured health information from the household population aged 3 to 79. Residents of Indian Reserves, institutions, certain remote regions, and full-time members of the Canadian Forces are excluded.

The analysis pertains to 5,608 children and youth aged 6 to 17. The data were collected by the first four CHMS cycles: Cycle 1 (2007-to-2009; n = 1,473), Cycle 2 (2009-to-2011, n = 1,507), Cycle 3 (2012-to-2013, n = 1,328), and Cycle 4 (2014-to-2015, n = 1,300). Respondents answered an interviewer-administered questionnaire in their home, and within the next 6 weeks, visited a mobile examination centre (MEC) for a series of physical measurements. Ethics approval for the CHMS was obtained from Health Canada’s Research Ethics Board.\textsuperscript{34} Details about the CHMS are available in previous publications.\textsuperscript{35-39}

**Measurement of physical activity**

Upon completion of the MEC visit, ambulatory respondents were asked to wear an Actical accelerometer (Phillips – Respironics, Oregon, USA) over their right hip on an elasticized belt during their waking hours for 7 consecutive days. All data were blind to respondents while they wore the device. The Actical measures and records time-stamped acceleration in all directions, providing an index of physical activity intensity via a count value for each minute. A valid day was defined as 10 or more hours of wear time. A valid respondent was defined as a minimum of 4 valid days out of a possible 7.\textsuperscript{40} 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 1 to 2 minutes of counts between 0 and 100.\textsuperscript{40} An established movement intensity threshold was applied to the data to derive time spent in MVPA (at least 1,500 counts per minute).\textsuperscript{33} Complete descriptions of the accelerometer data reduction procedures are available elsewhere.\textsuperscript{37,38,40}

**Statistical analysis**

The statistical analyses were organized around four research questions:

1. How many minutes of MVPA do Canadian children and youth accumulate, and does this differ by sex and age group?
2. Have MVPA levels among children and youth changed over time?
3. How does the operational definition of the 60-minutes-per-day recommendation affect the percentage of children and youth meeting the benchmark?
4. Do more stringent (more than 60 minutes per day) or less stringent (up to 60 minutes per day) benchmarks offer additional and/or complementary information about temporal changes in MVPA habits among Canadian children and youth?

Descriptive statistics were used to calculate means and 95% confidence intervals overall and by age group and sex. Individual CHMS cycle accelerometer sample weights were used for analyses presenting individual cycle estimates.\textsuperscript{35-38} Pairwise contrasts were used to compare age groups (6 to 11 versus 12 to 17) and sex (boys versus girls).

Valid accelerometer data from each of the four CHMS cycles were stacked and weighted using combined accelerometer survey weights generated by Statistics Canada.\textsuperscript{42} The sample size...
for the combined analyses was 5,597 because of a lack of combined weights for a small number of children (n = 11) who turned 6 between the household and MEC visits. A trend analysis was performed on average daily minutes of MVPA allowing for linear, square, and cubic effects of time (survey cycle) to be estimated. Linear regression to assess the overall effect of time (survey cycle), while controlling for season, was also performed. Analyses controlled for age, body mass index, household income adjusted for household size quintiles, and highest level of parental education in the household (secondary graduation or less, postsecondary but below bachelor’s degree, bachelor’s degree or higher).

Achievement of 60 minutes of daily MVPA was measured several ways, reflecting the most common approaches to assessing adherence to the recommendation.

1. All days: Respondents were deemed adherent if they accumulated at least 60 minutes per day on all valid days of accelerometer data (4/4, 5/5, 6/6 or 7/7 days).

2. Most days: Respondents were deemed adherent if they accumulated at least 60 minutes per day on the number of days that corresponded most closely to 70% of days (3/4, 3/5, 4/6 or 5/7 days).

3. At least 6 out of 7 days: Bayesian statistics were used to determine the probability that a respondent would accumulate 60 minutes of MVPA on at least 6 out of 7 days a week based on their valid accelerometer data. The average of all probability values in the sample was then used to obtain the overall percentage of children and youth meeting the recommendation.

4. Average: Average daily minutes of MVPA were calculated using valid days for each respondent. If this value was at least 60 minutes per day, the respondent was deemed adherent.

The percentages of children and youth achieving an average MVPA of 15, 30, 45, 60, 75, or 90 minutes per day across valid days were also assessed. A betabinomial distribution was used to estimate the probability of accumulating 15, 30, 45, 60, 75 or 90 minutes of MVPA on 1 through 7 days a week. The estimated population prevalence of achieving each daily threshold was computed as the weighted average of those individual probabilities.

The data were analyzed using SAS 9.3 (SAS Institute, Cary, NC) and SUDAAN 11.0 (RTI International, NC) using appropriate denominator degrees of freedom (DDF) for each CHMS cycle in the SUDAAN procedure statements (DDF for Cycles 1, 3, 4 = 11, Cycle 2 = 13, all cycles = 46). To account for survey design effects, 95% confidence intervals were estimated with the bootstrap technique.

### Table 1

<table>
<thead>
<tr>
<th>Sex and age group</th>
<th>2007 to 2009</th>
<th>2009 to 2011</th>
<th>2012 to 2013</th>
<th>2014 to 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average minutes per day</td>
<td>95% confidence interval</td>
<td>Average minutes per day</td>
<td>95% confidence interval</td>
</tr>
<tr>
<td></td>
<td>Cycle 1 (n = 1,473)</td>
<td>from to</td>
<td>from to</td>
<td>from to</td>
</tr>
<tr>
<td>Total</td>
<td>57  51  62</td>
<td>49  45  53</td>
<td>57  51  63</td>
<td>55  49  61</td>
</tr>
<tr>
<td>6 to 11</td>
<td>63  56  70</td>
<td>54  50  59</td>
<td>65  58  72</td>
<td>62  56  69</td>
</tr>
<tr>
<td>12 to 17</td>
<td>51  47  56</td>
<td>44  40  48</td>
<td>50  43  57</td>
<td>48  42  55</td>
</tr>
<tr>
<td>Boys</td>
<td>64  57  70</td>
<td>55  49  60</td>
<td>63  55  71</td>
<td>63  55  71</td>
</tr>
<tr>
<td>Total</td>
<td>69  60  78</td>
<td>61  55  68</td>
<td>72  62  81</td>
<td>72  62  81</td>
</tr>
<tr>
<td>6 to 11</td>
<td>59  53  65</td>
<td>49  43  56</td>
<td>56  47  65</td>
<td>55  47  64</td>
</tr>
<tr>
<td>Girls</td>
<td>44  44  54</td>
<td>42  39  46</td>
<td>50  45  54</td>
<td>46  41  51</td>
</tr>
<tr>
<td>Total</td>
<td>57  51  63</td>
<td>47  43  51</td>
<td>58  52  63</td>
<td>52  47  58</td>
</tr>
<tr>
<td>6 to 11</td>
<td>42  37  48</td>
<td>39  35  42</td>
<td>43  36  49</td>
<td>40  35  45</td>
</tr>
</tbody>
</table>


### Figure 1

Weighted distribution of average daily minutes of moderate-to-vigorous physical activity (MVPA), by Canadian Health Measures Survey cycle, household population aged 6 to 17, Canada, 2007 to 2015

The percentages of children and youth achieving an average MVPA of 15, 30, 45, 60, 75, or 90 minutes per day across valid days were also assessed. A betabinomial distribution was used to estimate the probability of accumulating 15, 30, 45, 60, 75 or 90 minutes of MVPA on 1 through 7 days a week. The estimated population prevalence of achieving each daily threshold was computed as the weighted average of those individual probabilities.

The data were analyzed using SAS 9.3 (SAS Institute, Cary, NC) and SUDAAN 11.0 (RTI International, NC) using appropriate denominator degrees of freedom (DDF) for each CHMS cycle in the SUDAAN procedure statements (DDF for Cycles 1, 3, 4 = 11, Cycle 2 = 13, all cycles = 46). To account for survey design effects, 95% confidence intervals were estimated with the bootstrap technique.
Results

Boys, younger children most active
Average daily MVPA for children and youth ranged from a low of 49 minutes in Cycle 2 to a high of 57 minutes in Cycles 1 and 3 (Table 1). In all cycles, boys accumulated more MVPA than did girls (p < .001), and 6- to 11-year-olds accumulated more MVPA than did 12- to 17-year-olds (p < .001). Average wear time (range: 13.3 to 13.7 hours per day) and number of valid days (range: 5.8 to 6.1) remained stable across cycles (data not shown).

Trends over time
No significant linear trend in average daily minutes of MVPA was evident across CHMS cycles (Table 1, Figure 1). There was a significant cubic trend in average minutes per day of MVPA (p = 0.02), reflecting lower average daily MVPA in Cycles 2 and 4, compared with Cycles 1 and 3.

In a linear regression model that controlled for season, age, sex, body mass index, household income and parental education, the only significant effect of time (survey cycle) was a drop in Cycle 2 (-7 minutes per day, p < .05). The effect of season was significant in the model (p < 0.0001) and reflected more MVPA in spring, than in winter (-16 minutes per day), summer (-13 minutes per day), and fall (-12 minutes per day).

Adherence depends on operational definition
Figure 2 illustrates differences in the prevalence of adherence based on the four operational definitions of the 60-minute MVPA recommendation. When the “all days,” “most days,” or “6/7 days” operational definitions were used, adherence was below 12% in all CHMS cycles. By contrast, when the “daily average” operational definition was used, adherence ranged between 29% and 41% across cycles.

The average daily MVPA of children and youth who accumulated 60 minutes of MVPA on all or 6/7 days ranged from 107 to 127 minutes; the average daily MVPA of those who accumulated 60 minutes on most days or on average was lower, ranging from 82 to 91 minutes (Table 2). An estimated 35% of children and youth with an average daily MVPA of at least 60 minutes accumulated 60 minutes on 7/7 days of the week (data not shown).

Beyond a single benchmark
The percentages of children and youth in each CHMS cycle whose average daily MVPA was at least 15, 30, 45, 60, 75, or 90 minutes are presented in Figure 3, with the percentages accumulating 60 minutes on 6/7 days a week included for comparison. The percentages accumulating 60 minutes on 6/7 days a week (range: 5% to 8%) most closely aligned with the
Figure 3
Percentage accumulating average moderate-to-vigorous physical activity (MVPA) of 15, 30, 45, 60, 75 or 90 minutes per day compared with percentage accumulating 60 minutes at least 6 out of 7 days, by Canadian Health Measures Survey cycle, household population aged 6 to 17, Canada, 2007 to 2015

Figure 4
Percentage accumulating at least 60 minutes of moderate-to-vigorous physical activity (MVPA) on 1 through 7 days per week compared with percentage with average daily MVPA at least 60 minutes, household population aged 6 to 17, Canada, 2007 to 2015

Discussion
This study examines trends in MVPA levels among Canadian children and youth over a 9-year period, and discusses the implications of a shift in the operational definition of the recommendation. Regardless of how the recommendation was operationalized or the analytical approach used, MVPA levels did not change markedly between 2007 and 2015. Fewer than 10% of children and youth accumulated 60 minutes of MVPA every day, and a third accumulated an average of 60 minutes a day. The findings highlight the low percentage meeting the recommendation, and the importance of explicitly reporting how it is operationalized.

The lack of a temporal trend in this analysis is consistent with a pedometer-based study by Cameron et al., who collected data on 43,806 Canadian children aged 5 to 19 between 2005 and 2015. That study found a modest decline (-6.1%) in median steps per day. The researchers noted that their results indicated that the national goal set by the Federal-Provincial-Territorial Ministers responsible for sport, physical activity and recreation to increase mean step counts per day from 11,500 to 14,500 by 2015 had not been met. While not reported in the present analysis, step-count values for 6- to 17-year-olds from the CHMS exhibited a similar decrease (-8% from Cycle 1 to Cycle 4). This mirrors the lack of substantive change in average daily minutes of MVPA between Cycle 1 and Cycle 4 (57 to 55 minutes per day or -3.2%). The present study, therefore, adds to the evidence presented by Cameron et al. that the physical activity levels of Canadian chil-
dren and youth have been stable over the past decade.

The discrepancy observed in the percentages of children and youth who meet the 60-minutes-per-day recommendation, depending on the operational definition, is consistent with other research.29-31 This result is intuitive given that achieving a daily average of 60 minutes is easier than accumulating 60 minutes every day of the week. By examining multiple MVPA levels below and above 60 minutes per day, it was possible to estimate the frequency and duration of MVPA required to achieve a weekly average of at least 60 minutes per day. The percentage achieving an average daily MVPA of 60 minutes (33%) is a better reflection of those who accumulate 60 minutes of MVPA on 4 out of 7 days per week (35%) (Figure 4). Only about a third of those who achieve an average daily MVPA of 60 minutes accumulate 60 minutes every day. Further evidence of the mismatch between operational definitions can be seen by comparing the average daily MVPA of those accumulating 60 minutes on 6/7 days per week (35%) (Table 2). Only about a third of those who achieve an average daily MVPA of 60 minutes accumulate 60 minutes every day. Further evidence of the mismatch between operational definitions can be seen by comparing the average daily MVPA of those accumulating 60 minutes on 6/7 days per week (35%) (Table 2).

The change in the operational definition of the 60-minutes-per-day recommendation without a corresponding change in the amount of MVPA being recommended creates a challenging transition period in the reporting of prevalence, trends and comparisons. Variation in how the recommendation has been operationalized has led to calls for harmonization and accurate reporting of how the recommendation is interpreted in analyses.29-31 In the context of the CHMS, the difference in the percentages of children and youth meeting the 60-minute recommendation varies fivefold between the daily (6/7 days) and the average approaches: 7% versus 33%. The average approach recognizes day-to-day variations in MVPA, which may not be harmful as long as the total weekly volume remains sufficient.1

Although the gap between operational definitions is large, the take-home message is the same: the majority of Canadian children and youth do not meet the recommendation, a situation that has not changed since 2007. Further, the finding that 33% accumulate an average of at least 60 minutes of MPVA is only part of a broader picture—far fewer (17.5%) meet all aspects of the Canadian 24-Hour Movement Guidelines.33 Recent studies have reported that health outcomes improve as more components of the Guidelines are achieved.33,46 As the new operational definition is adopted, it will be important for researchers to describe their methods carefully (which operational definition was used) and be prudent in making comparisons with other studies.

**Strengths and limitations**

A strength of the present analysis is examination of MVPA levels below and above the 60-minutes-per-day benchmark. This provides information about levels that the entire population is achieving, not just the percentage who meet the single recommendation. For example, CHMS findings suggest that the percentages of children and youth who accumulate modest amounts of MVPA (15 or 30 minutes per day, for instance) have not changed over time.

Assessing adherence to the MVPA recommendation alongside a series of complementary measures (for example, average daily minutes of MVPA and number of days that children exceed 60 minutes) creates the context required to understand the overall trend and identify targets for intervention and messaging. With CHMS accelerometer data (the only nationally representative Canadian dataset), it is possible to track changes in physical activity over time. Accelerometers yield objective information about intensity of movement, and thus, overcome some of the limitations associated with self-reports.47 However, accelerometers may underestimate MVPA, as they do not accurately measure the intensity of movement associated with activities such as swimming, cycling, and load-bearing. Further, use of 60-second epochs may not accurately capture the intermittent nature of children’s physical activity.48

This analysis does not include results or discussion specific to the “vigorous” component of MVPA. This is an important limitation, given that the Guidelines recommend vigorous physical activity at least 3 days per week. The overall response rate to the accelerometer measurement across the four

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**Table 3**

<table>
<thead>
<tr>
<th>Minutes of MVPA accumulated</th>
<th>1 or more days</th>
<th>3 or more days</th>
<th>6 or more days</th>
<th>7 days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cycle 1</td>
<td>Cycle 2</td>
<td>Cycle 3</td>
<td>Cycle 4</td>
</tr>
<tr>
<td>At least 15</td>
<td>99</td>
<td>99</td>
<td>99</td>
<td>99</td>
</tr>
<tr>
<td>At least 30</td>
<td>95</td>
<td>93</td>
<td>93</td>
<td>94</td>
</tr>
<tr>
<td>At least 45</td>
<td>86</td>
<td>80</td>
<td>86</td>
<td>84</td>
</tr>
<tr>
<td>At least 60</td>
<td>75</td>
<td>64</td>
<td>74</td>
<td>68</td>
</tr>
<tr>
<td>At least 75</td>
<td>60</td>
<td>48</td>
<td>59</td>
<td>53</td>
</tr>
<tr>
<td>At least 90</td>
<td>46</td>
<td>36</td>
<td>46</td>
<td>41</td>
</tr>
</tbody>
</table>

CHMS cycles was about 40%. Despite adjustments to the sampling weights to compensate, estimates may be biased by systematic differences between respondents and non-respondents.

**Conclusion**

These findings highlight the importance of precise explanations of how guidelines and recommendations are operationalized to be able to conduct between-study comparisons and tracking of trends over time. Nonetheless, regardless of the operational definition employed, MVPA levels of Canadian children and youth have not changed markedly since 2007, and remain lower than recommended.
References


