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ABSTRACT

Introduction

Accurate and ongoing assessments of physical activity (PA) and sedentary time (SED) are needed to support public health surveillance, evaluate interventions, and advance the understanding of how movement behaviours relate to health. After six cycles of data collection (2007 to 2019) using the Actical (AC) accelerometer, the Canadian Health Measures Survey (CHMS) transitioned to the ActiGraph wGT3X-BT (AG). To understand how estimates from the AC accelerometer may compare with those from the AG in the context of the CHMS, this study compares AC and AG accelerometer estimates of PA, step counts, and SED using CHMS protocols.

Methods

A convenience sample of 47 adults (aged 18 to 79 years) and 36 children and youth (aged 3 to 17 years) wore both AC and AG accelerometers on their waist for seven consecutive days. Estimates of PA and SED, step counts, and the percentage of those meeting PA recommendations were compared between the devices using descriptive, correlation, and agreement statistics.

Results

Agreement ranged from poor to excellent, with variability across PA intensities and age groups. Significant absolute differences in SED and light PA (LPA) were observed across all age groups, and in step counts among children and youth. Agreement was good to excellent across most age groups for moderate-to-vigorous PA (MVPA), and among adults for step counts. While the percentage of those meeting PA recommendations was higher with the AG, results were not statistically different. Similar comparisons could be made with the AG device when using the normal and low frequency extension filters.

Interpretation

The results of the present study provide data users and researchers with an indication of the expected differences between the devices across various movement behaviour outcomes in the context of the CHMS. Results suggest that comparisons between cycles 1 to 6 and Cycle 7 onward of the CHMS for MVPA are acceptable, but they should be carried out with caution. Comparisons of SED, LPA, vigorous PA, and step counts are not recommended.

Keywords

Accelerometry, physical activity, sedentary time, measurement, Canadian Health Measures Survey

AUTHORS

Janine Clarke, Aidan Gribbon, and Mélie St-Laurent are with the Centre for Health Data Integration and Direct Measures, Statistics Canada. Thomas Ferrao is with the Centre for Labour Market Information, Statistics Canada. Joel Barnes and Rachel Colley are with the Health Analysis and Modelling Division, Statistics Canada. Nicholas Kuzik is a student at the University of Alberta, formerly with the Centre for Health Data Integration and Direct Measures, Statistics Canada.

What is already known on this subject?

- Actical (AC) accelerometers were used in the first six cycles (2007 to 2019) of the Canadian Health Measures Survey (CHMS) to assess physical activity (PA) and sedentary time (SED). After considering CHMS data needs and device quality, ActiGraph wGT3X-BT (AG) accelerometers were used starting in Cycle 7 (2022 to 2024).
- The AC and AG accelerometers differ technically and mechanically in how they measure movement behaviour outcomes such as SED, light PA (LPA), moderate-to-vigorous PA (MVPA), and step counts.
- Previous studies have shown that while the output from the AC and the vertical axis output from the AG are well correlated, the devices are not directly comparable, with important differences in overall movement behaviour outputs.

What does this study add?

- To understand the impact on estimates in the CHMS, this study compares the AC and AG accelerometer estimates of PA, step counts, and SED in a convenience sample of people aged 3 to 79.
- The transition to the AG accelerometer substantially affects estimates of movement behaviour outcomes, especially for SED, LPA, vigorous PA, and step counts. Therefore, results for these outcomes from CHMS cycles 1 to 6 should not be directly compared with those from Cycle 7 onward.
- While the AG accelerometer typically recorded higher values than the AC, the differences were relatively stable across the range of MVPA, and directional bias was minimal. Comparisons of MVPA between cycles 1 to 6 and Cycle 7 onward of the CHMS are acceptable but should be carried out with caution.

From 2007 to 2019, Statistics Canada's Canadian Health Measures Survey (CHMS) used the Actical (AC) accelerometer (Philips Respironics, Oregon, United States) to measure physical activity (PA) and sedentary time (SED) among people living in Canada.[1-4] Accelerometer results have been widely used for conducting population health surveillance of PA in Canada,[5-7] informing the development of new PA recommendations in Canada and elsewhere,[8-10] and helping to better understand and interpret self-reported measures of PA.[11-14]

In 2017, Phillips Respironics decided to no longer support the AC accelerometer devices; therefore, a new device would be needed for future cycles of the CHMS. ActiGraph accelerometers have been widely used in research and surveillance.[15-17] After considering data needs and device quality, the CHMS team decided to proceed with the ActiGraph wGT3X-BT (AG) accelerometer (Ametris LLC [formerly ActiGraph LLC], Pensacola, Florida, United States), starting in Cycle 7 of the CHMS (2022 to 2024).

Transitioning to the AG accelerometer will increase the analytical potential of CHMS accelerometer data, as the AG provides outputs in raw mode, count values in each of three axes, and a combined three-dimensional output. However, the AC and AG accelerometers differ technically and mechanically in how they measure PA;[18,19] therefore, it is important for Statistics Canada to understand the differences between these devices. Previous studies have shown that although there is good correlation between the output from the AC and the vertical axis output from the AG, they are not directly comparable, and important differences exist in overall waking hours, SED, and PA outputs.[20-23]

To understand the impact that the change in accelerometer may have on the overall estimates of PA and SED in Cycle 7 of the CHMS, this study compared PA outcomes (light PA [LPA], moderate PA [MPA], vigorous PA [VPA], and step counts), adherence to PA recommendations, and SED as measured by the AG and the AC accelerometers in a sample of children and adults aged 3 to 79 years, using CHMS protocols. Results from this study will help in understanding and interpreting any differences observed between the results from Cycle 7 of the CHMS—and subsequent cycles—measured with the AG and those from earlier cycles measured with the AC.

Methods

Data source

Data for this study were collected from a convenience sample of Statistics Canada employees, friends, and family in Ottawa, Canada. Data were collected in three phases: May 2021, August 2021, and January 2022. Ethics approval was obtained from the Health Canada and Public Health Agency of Canada Research Ethics Board.

Participants were recruited through an email sent to Statistics Canada employees and shared with colleagues, friends, and family. Interested individuals contacted a study administrator, provided their age and sex, and completed a screening

questionnaire. Eligible participants received a package containing the AC and the AG accelerometers on an elasticized belt, consent and assent forms, a sleep log, and instructions. A virtual meeting was held to confirm consent and review procedures. Participants wore both accelerometers on an elasticized belt over their right hip 24 hours a day for seven days; returned the devices and forms by mail; and completed a follow-up questionnaire on PA, sedentary behaviour, and sleep.

Actical accelerometer data

Data collection and reduction procedures for the AC accelerometer followed the same protocols as in previous CHMS cycles (cycles 1 to 6), as detailed in papers by Colley et al.[1,2,24] Devices were initialized to start recording at midnight with 15-second epochs for children aged 3 to 5 years and 1-minute epochs for participants aged 6 to 79 years. Once downloaded, the data were read into SAS 9.4 and cleaned by removing or imputing spurious values (20,000 counts per minute [cpm] or higher), identifying non-wear time (60 minutes or more with a movement allowance of 1 to 2 minutes),[15] and defining valid days (5 hours or more of wear time for participants aged 3 to 5 years and 10 hours or more for those aged 6 to 79 years). SED, LPA, MPA, VPA, and moderate-to-vigorous PA (MVPA) were classified using validated cut points and summarized for each valid day.[25-28] Average minutes of PA were calculated using valid days to assess adherence to age-specific PA recommendations. Data reduction specifications for the AC accelerometer are summarized in Text Table 1.

ActiGraph wGT3X-BT accelerometer data

The AG accelerometer was initialized to start collecting data at midnight at a sampling rate of 30 hertz. Raw data were downloaded and processed using the ActiLife software into 15-second epochs twice: once using the normal filter and once using the low frequency extension (LFE) filter. The LFE filter provides data that are more comparable to older AG accelerometer models,[29] while the normal filter is recommended for step count analysis. This analysis compares PA results

Text Table 1
Comparison of data reduction procedures for the Actical and the ActiGraph wGT3X-BT accelerometers

	Actical	ActiGraph wGT3X-BT
Sleep time removed	No	Yes
Spurious data treated	Yes (20,000 counts per minute or higher)	No
Preschool-aged children (3 to 4 years)		
Epoch length	15 seconds	15 seconds
Non-wear time criteria	60 minutes[2]	20 minutes[6]
Number of non-zeros allowed for non-wear	2	0
Number of hours per day for a valid day	5 or more	10 or more
Number of valid days	3 or more	4 or more
Cut points	Counts per 15 seconds:	Counts per 15 seconds:
Sedentary time	Fewer than 100[3]	Fewer than 25[7]
MVPA	288 or more[3]	420 or more[8]
School-aged children and youth (5 to 17 years)		
Epoch length	1 minute	15 seconds
Non-wear time criteria	60 minutes[1]	20 minutes[6]
Number of non-zeros allowed for non-wear	2	0
Number of hours per day for a valid day	10 or more	10 or more
Number of valid days	4 or more	4 or more
Cut points	Counts per minute:	Counts per 15 seconds:
Sedentary time	Fewer than 100[2]	Fewer than 25[7]
MPA	1,500 to 6,499[4]	574 to 1,002[7]
VPA	6,500 or more[4]	1,003 or more[7]
Adults (18 to 79 years)		
Epoch length	1 minute	Downloaded at 15 seconds but reintegrated into 1 minute epochs for analysis
Non-wear time criteria	60 minutes[1]	20 minutes[6]
Number of non-zeros allowed for non-wear	2	0
Number of hours per day for a valid day	10 or more	10 or more
Number of valid days	4 or more	4 or more
Cut points	Counts per minute:	Counts per minute:
Sedentary time	Fewer than 100[2]	Fewer than 100[1]
MPA	1,535 to 3,962[5]	2,020 to 5,998[1]
VPA	3,962 or more[5]	5,999 or more[1]

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Notes: MVPA = moderate-to-vigorous physical activity. VPA = vigorous physical activity. MPA = moderate physical activity. MPA and VPA are determined separately for 6- to 17-year-olds only, as there is no cut point for vigorous activity for 5-year-olds.

Source: Statistics Canada, Canadian Health Measures Survey crossover study, 2021.

obtained from both filters. No additional treatment of spurious data was required, as the software applies a built-in filter to exclude biologically implausible values.

Once extracted using the ActiLife software, the epoch-based data from the vertical axis (axis 1) and the inclinometer were read into SAS 9.4 for data reduction. LFE filter data were aggregated to one-minute epochs to identify and exclude sleep using an algorithm for waist-worn AG accelerometers published by Barreira et al.; detailed methods are available elsewhere.[30] Once sleep time was identified, it was removed from epoch-based data for the LFE and the normal filters. Despite the 24-hour wear protocol, sleep was not identified using the AC accelerometers, as there are currently no established methods for identifying sleep with this device.

The following steps were carried out on the remaining non-sleep minute data from each of the LFE and normal filters. First, non-wear time was identified as 20 consecutive minutes of zero counts, ending with any non-zero minute,[31] and valid days were defined as 10 hours or more (for participants aged 3 to 79 years). Second, SED and time spent in LPA, MPA, VPA, and MVPA were summarized using age- and device-specific cut points,[15,32,33] and step counts were summed for each valid day. This was done using the aggregated 1-minute epochs for adults and older adults and 15-second epochs for all children and youth. Finally, average minutes of PA were calculated using valid days to assess adherence to age-specific PA recommendations. Data reduction specifications for the AG accelerometer are summarized in Text Table 1. These procedures were used because they are, at the time of writing, expected to be those used to process and analyze respondent data from Cycle 7 of the CHMS.

Study sample

A total of 99 people aged 3 to 79 years agreed to participate and were provided accelerometers. Of those, 13 were excluded from the study because they did not wear the accelerometers during the requested period or there was an issue extracting data from one or more monitors. Another three were excluded because of too many spurious data points on the AC accelerometer (more than 15 data points of 20,000 cpm or higher). The final sample consisted of 83 participants who had the minimum required number of valid days on each device. The average age of the sample was 31.5 years (interquartile range: 8 to 53 years), and the sample was 53% female.

Table 2
Number and distribution of valid days between the Actical and the ActiGraph wGT3X-BT accelerometers, by age group

	Actical			ActiGraph wGT3X-BT			
		95% confidence interval			95% confidence interval		
	percent or mean	from	to	percent or mean		from	to
Total number of participants (n = 83)							
Preschool-aged children (3 to 4 years) (n = 7)							
Average wear time across all valid days (hours)	14.2	12.8	15.6	13.3		12.8	13.8
Total number of valid days	45	…	…	45		…	…
Mean number of valid days	6.4	6.1	6.8	6.4		5.9	7.0
4 valid days (%)	0.0	…	…	0.0		…	…
5 valid days (%)	0.0	…	…	14.3		1.9	58.6
6 valid days (%)	57.1	22.7	85.83	28.6		7.1	67.7
7 valid days (%)	42.9	14.2	77.3	57.1		22.7	85.8
School-aged children and youth (5 to 17 years) (n = 29)							
Average wear time across all valid days (hours)	13.8	13.4	14.2	14.5	*	14.1	14.8
Total number of valid days	166	…	…	182		…	…
Mean number of valid days	5.9	5.6	6.3	6.5	**	6.2	6.8
4 valid days (%)	14.3	5.4	32.7	7.1		1.8	24.8
5 valid days (%)	7.1	1.8	24.8	7.1		1.8	24.8
6 valid days (%)	50.0	32.1	67.9	14.3	**	5.4	32.7
7 valid days (%)	28.6	14.9	47.8	71.4	**	52.2	85.1
Adults (18 to 64 years) (n = 38)							
Average wear time across all valid days (hours)	13.8	13.3	14.2	15.3	**	15.0	15.6
Total number of valid days	208	…	…	249		…	…
Mean number of valid days	5.8	5.4	6.1	6.9	**	6.8	7.0
4 valid days (%)	16.7	7.6	32.7	0.0	**	…	…
5 valid days (%)	19.4	9.5	35.7	2.8	*	0.4	17.6
6 valid days (%)	33.3	19.9	50.2	2.8	**	0.4	17.6
7 valid days (%)	30.6	17.7	47.4	94.4	**	80.1	98.6
Adults (65 to 79 years) (n = 9)							
Average wear time across all valid days (hours)	12.7	12.0	13.5	14.4	*	13.3	15.5
Total number of valid days	56	…	…	61		…	…
Mean number of valid days	6.2	5.8	6.6	6.8		6.4	7.2
4 valid days (%)	0.0	…	…	0.0		…	…
5 valid days (%)	11.1	1.5	50.5	11.1		1.5	50.5
6 valid days (%)	55.6	24.9	82.5	0.0	**	…	…
7 valid days (%)	33.3	11.0	67.0	88.9	**	49.5	98.5

… not applicable

* significant difference between Actical and ActiGraph estimates, $p < 0.05$

** significant difference between Actical and ActiGraph estimates, $p < 0.01$

Note: No differences were observed in the determined wear time or the number of valid days between the ActiGraph low frequency extension and normal filters.

Source: Statistics Canada, Canadian Health Measures Survey crossover study, 2021.

Table 3

Comparison of average daily wear time, sedentary time, light physical activity, moderate physical activity, vigorous physical activity, and step counts for the Actical accelerometer and the ActiGraph wGT3X-BT accelerometer (low frequency extension and normal filters)

	Actical			ActiGraph wGT3X-BT (low frequency extension filter)				ActiGraph wGT3X-BT (normal filter)			
		95% confidence interval			95% confidence interval				95% confidence interval		
	Mean	from	to	Mean	from	to	Delta (AG_{LFE}-AC)	Mean	from	to	Delta (AG_{NORMAL}-AC)
Preschool-aged children (3 to 4 years) (n = 41 days)											
Wear time (hours)	14.7	13.9	15.4	13.4	13.0	13.7	1.3 **	13.4	13.0	13.7	1.3 **
Sedentary time (minutes)	611	572	650	322	300	345	289 **	372	350	395	239 **
Light physical activity (minutes)	204	191	217	370	353	387	-166 **	332	316	347	-128 **
Moderate physical activity (minutes)	…	…	…	…	…	…	…	…	…	…	…
Vigorous physical activity (minutes)	…	…	…	…	…	…	…	…	…	…	…
Moderate-to-vigorous physical activity (minutes)	65	55	74	109	98	120	-44 **	98	87	108	-33 **
Steps	10,003	8,625	11,380	21,288	20,073	22,503	-11,286 **	9,004	8,239	9,769	998
Average counts (per minute)	310	270	349	740	672	808	-430 **	740	672	808	-430 **
School-aged children and youth (5 to 17 years) (n = 166 days [133 days[1]])											
Wear time (hours)	13.9	13.6	14.1	14.5	14.3	14.7	-0.6 **	14.5	14.3	14.7	-0.6 **
Sedentary time (minutes)	558	542	574	483	462	504	75 **	525	505	546	33 *
Light physical activity (minutes)	220	208	232	319	305	332	-99 **	282	269	295	-62 **
Moderate physical activity (minutes)[1]	47	41	52	39	36	42	8 *	35	32	38	12 **
Vigorous physical activity (minutes)[1]	3	2	4	20	16	23	-17 **	19	15	22	-16 **
Moderate-to-vigorous physical activity (minutes)	53	47	58	68	62	74	-15 **	62	56	67	-9 *
Steps	10,429	9,671	11,188	19,250	18,349	20,150	-8,820 **	9,106	8,535	9,677	1,323 **
Average counts (per minute)	319	292	346	560	521	599	-241 **	560	521	599	-241 **
Adults (18 to 64 years) (n = 213 days)											
Wear time (hours)	13.9	13.6	14.2	15.4	15.2	15.6	1.6 **	15.4	15.2	15.6	1.6 **
Sedentary time (minutes)	585	570	600	512	493	532	-73 **	552	533	571	-34 **
Light physical activity (minutes)	209	199	219	364	348	381	155 **	328	313	343	119 **
Moderate physical activity (minutes)	28	24	32	43	38	47	15 **	39	35	44	11 **
Vigorous physical activity (minutes)	9	7	12	6	4	8	-3 *	5	4	7	-4 *
Moderate-to-vigorous physical activity (minutes)	37	33	42	49	44	53	11 **	45	40	49	8 *
Steps	9,812	9,188	10,435	17,360	16,597	18,122	-7,548 **	9,503	8,918	10,087	-309
Average counts (per minute)	272	246	298	434	408	459	-162 **	434	408	459	" **
Older adults (65 to 79 years) (n = 54 days)											
Wear time (hours)	12.8	12.3	13.3	14.5	13.9	15.2	1.7 **	14.5	13.9	15.2	1.7 **
Sedentary time (minutes)	584	560	608	520	478	561	-64 **	578	543	613	-6
Light physical activity (minutes)	167	148	186	330	292	368	163 **	273	250	297	106 **
Moderate physical activity (minutes)	16	8	24	24	17	30	8	21	15	28	6
Vigorous physical activity (minutes)	2	0	4	0	0	0	-2	0	0	0	-2
Moderate-to-vigorous physical activity (minutes)	18	9	26	24	17	31	6	21	15	28	4
Steps	5,979	5,071	6,887	12,978	11,940	14,017	-6,999 **	6,388	5,565	7,211	409
Average counts (per minute)	151	113	188	273	240	306	-122 **	273	240	306	-122 **

… not applicable

* significantly different from estimate for the Actical accelerometer, $p < 0.05$

** significantly different from estimate for the Actical accelerometer, $p < 0.01$

1. Estimates include 6- to 17-year-olds only, as there is no vigorous activity threshold for 5-year-olds.

Notes: AC = Actical accelerometer. AG_{LFE} = ActiGraph wGT3X-BT using the low frequency extension filter. AG_{NORMAL} = ActiGraph wGT3X-BT using the normal filter. n = number of matched valid days between the AC and the AG.

Source: Statistics Canada, Canadian Health Measures Survey crossover study, 2021.

The number and distribution of valid days with the AC and the AG accelerometers by age group are presented in Table 2. Wear time was the same for the AG accelerometer using the LFE filter (AG_{LFE}) and the normal filter (AG_N).

Statistical analysis

To compare the averages for SED, LPA, MPA, VPA, MVPA, and step counts derived from each device, the analysis was limited to paired valid days (i.e., days that were identified as valid on both devices). Estimates from the two devices were compared using paired t-tests, with significant differences assessed by examining the 95% confidence intervals (CIs) and considering p-values of < 0.05 and < 0.01.

Adherence to the age-specific PA recommendations from Canada's 24-Hour Movement Guidelines was also compared.[34-37] For this comparison, average daily MVPA (calculated from valid days) was used to classify each person as either meeting or not meeting the age-specific recommendations (at least 60 minutes per day for children and youth aged 3 to 17 years and at least 150 minutes per week for adults aged 18 to 79 years) for each device.

Intraclass correlation coefficients (ICCs) were used to assess the agreement and the consistency of SED, LPA, MPA, VPA, MVPA, and step count estimates between devices. The two-way random-effects ICC (i.e., ICC [2,1]), based on absolute agreement, was used to assess whether the devices could be considered interchangeable at the population level, that is, whether the change is expected to affect population-level estimates. This is the primary purpose of this study. The two-way mixed-effects ICC (i.e., ICC [3,1]), based on consistency, is also presented, as it helps assess whether the devices rank individuals similarly, providing insight into how consistently each monitor detects between-person differences. ICC results

were interpreted as follows: an ICC of 0.90 or higher was considered excellent, 0.75 to 0.89 was good, 0.50 to 0.74 was moderate, and below 0.50 was poor.[38]

To further evaluate differences between monitors, Bland–Altman plots with limits of agreements are presented for selected results.

Results were disaggregated by age group only, as data reduction procedures are age- but not sex-specific. All analyses were conducted using SAS 9.4 and SAS-callable SUDAAN 11.0.3, except for the ICCs and the Bland–Altman plots, which were done in R. The psych package[39] was used to generate the ICCs and the ggplot2 package[40] was used to generate the Bland–Altman plots in RStudio 4.1.3.

Results

Wear time and valid days

Wear time and the number of valid days were significantly higher with the AG accelerometer than with the AC across all age groups, except for preschool-aged children (Table 2).

Among adults and older adults, the proportion of the sample with seven valid days was more than twice as high with the AG device as with the AC (94% versus 31% for adults; 89% versus 33% for older adults).

The average SED, LPA, MPA, VPA, MVPA, and step counts from the AG_{LFE}, the AG_N and the AC devices are presented in Table 3. ICCs are presented in Table 4.

Table 4
Intraclass correlation coefficients between the Actical accelerometer and the ActiGraph wGT3X-BT accelerometer (low frequency extension and normal filters) for movement behaviour outcomes

	ActiGraph wGT3X-BT (low frequency extension filter)						ActiGraph wGT3X-BT (normal filter)					
		95% confidence interval			95% confidence interval			95% confidence interval			95% confidence interval	
	ICC (2,1)	from	to	ICC (3,1)	from	to	ICC (2,1)	from	to	ICC (3,1)	from	to
Preschool-aged children (3 to 4 years)												
Sedentary time (minutes)	0.00 [2]	-0.05	0.08	0.00 [2]	-0.30	0.31	0.00 [2]	-0.07	0.12	0.02 [2]	-0.29	0.32
Light physical activity (minutes)	0.04 [2]	-0.04	0.18	0.28 [2]	-0.03	0.54	0.09 [2]	-0.05	0.31	0.39 [2]	0.10	0.62
Moderate physical activity (minutes)	...	...	...	...	...	...	...	...	...	...	...	...
Vigorous physical activity (minutes)	...	...	...	...	...	...	...	...	...	...	...	...
Moderate-to-vigorous physical activity (minutes)	0.37 [2]	-0.10	0.71	0.70 [3]	0.50	0.83	0.46 [2]	-0.09	0.76	0.70 [3]	0.50	0.83
Steps	0.18 [2]	-0.03	0.53	0.81 [4]	0.67	0.89	0.76 [4]	0.57	0.87	0.79 [4]	0.64	0.88
School-aged children and youth (5 to 17 years)												
Sedentary time (minutes)	0.33 [2]	0.13	0.50	0.40 [2]	0.26	0.52	0.39 [2]	0.25	0.51	0.40 [2]	0.26	0.52
Light physical activity (minutes)	0.35 [2]	-0.09	0.64	0.59 [3]	0.48	0.68	0.45 [2]	0.07	0.67	0.58 [3]	0.47	0.68
Moderate physical activity (minutes)[1]	0.61 [3]	0.47	0.71	0.63 [3]	0.52	0.72	0.55 [3]	0.34	0.69	0.60 [3]	0.48	0.70
Vigorous physical activity (minutes)[1]	0.22 [2]	-0.05	0.46	0.37 [2]	0.21	0.51	0.24 [2]	-0.04	0.47	0.38 [2]	0.23	0.52
Moderate-to-vigorous physical activity (minutes)	0.72 [4]	0.48	0.83	0.78 [4]	0.71	0.83	0.75 [4]	0.65	0.83	0.78 [4]	0.71	0.83
Steps	0.35 [2]	-0.06	0.70	0.79 [4]	0.73	0.84	0.81 [4]	0.65	0.89	0.84 [4]	0.79	0.88
Adults (18 to 64 years)												
Sedentary time (minutes)	0.17 [2]	0.04	0.30	0.20 [2]	0.07	0.33	0.22 [2]	0.09	0.34	0.23 [2]	0.10	0.35
Light physical activity (minutes)	0.29 [2]	-0.09	0.61	0.62 [2]	0.53	0.70	0.41 [2]	-0.10	0.72	0.71 [3]	0.64	0.77
Moderate physical activity (minutes)	0.76 [4]	0.33	0.89	0.84 [4]	0.80	0.88	0.80 [4]	0.54	0.89	0.85 [4]	0.81	0.89
Vigorous physical activity (minutes)	0.84 [4]	0.76	0.89	0.86 [4]	0.82	0.89	0.82 [4]	0.73	0.88	0.84 [4]	0.80	0.88
Moderate-to-vigorous physical activity (minutes)	0.84 [4]	0.61	0.92	0.89 [4]	0.85	0.91	0.88 [4]	0.78	0.93	0.90 [5]	0.87	0.92
Steps	0.39 [2]	-0.07	0.74	0.81 [4]	0.75	0.85	0.92 [5]	0.90	0.94	0.92 [5]	0.90	0.94
Older adults (65 to 79 years)												
Sedentary time (minutes)	0.17 [2]	-0.08	0.40	0.18 [2]	-0.09	0.43	0.32 [2]	0.06	0.54	0.32 [2]	0.05	0.54
Light physical activity (minutes)	0.21 [2]	-0.09	0.50	0.43 [2]	0.18	0.62	0.42 [2]	-0.09	0.76	0.78 [3]	0.65	0.87
Moderate physical activity (minutes)	0.81 [4]	0.63	0.90	0.84 [4]	0.74	0.90	0.83 [4]	0.71	0.90	0.85 [4]	0.75	0.91
Vigorous physical activity (minutes)	0.00 [2]	-0.25	0.25	0.00 [2]	-0.27	0.26	0.00 [2]	-0.25	0.26	0.00 [2]	-0.27	0.26
Moderate-to-vigorous physical activity (minutes)	0.78 [4]	0.64	0.87	0.79 [4]	0.66	0.87	0.80 [4]	0.67	0.88	0.80 [4]	0.68	0.88
Steps	0.27 [2]	-0.06	0.64	0.76 [4]	0.62	0.85	0.94 [5]	0.88	0.96	0.94 [5]	0.90	0.97

1. Estimates include 6- to 17-year-olds only, as there is no vigorous activity threshold for 5-year-olds.
2. Poor (ICC below 0.50)
3. Moderate (ICC from 0.50 to 0.74)
4. Good (ICC from 0.75 to 0.89)
5. Excellent (ICC of 0.90 or higher)

Notes: ICC = intraclass correlation coefficient. The two-way random-effects ICC (i.e., ICC [2,1]), based on absolute agreement, and the two-way mixed-effects ICC (i.e., ICC [3,1]), based on consistency, are presented.

Source: Statistics Canada, Canadian Health Measures Survey crossover study, 2021.

Sedentary time

The AG_{LFE} consistently resulted in significantly fewer minutes of SED for all age groups (322 versus 611 minutes for preschool-aged children, $p < 0.0001$; 483 versus 558 minutes for school-aged children and youth, $p < 0.0001$; 512 versus 585 minutes for adults, $p < 0.0001$; and 520 versus 584 minutes for older adults, $p = 0.0086$).

Compared with the AC, the AG_N also recorded significantly fewer minutes of SED among preschool-aged children (372 versus 611 minutes, $p = 0.0026$), school-aged children and youth (525 versus 558 minutes, $p = 0.0135$), and adults (552 versus 585 minutes, $p = 0.0067$).

Agreement and consistency were poor across all age groups, regardless of the AG filter used (Table 4).

Light physical activity

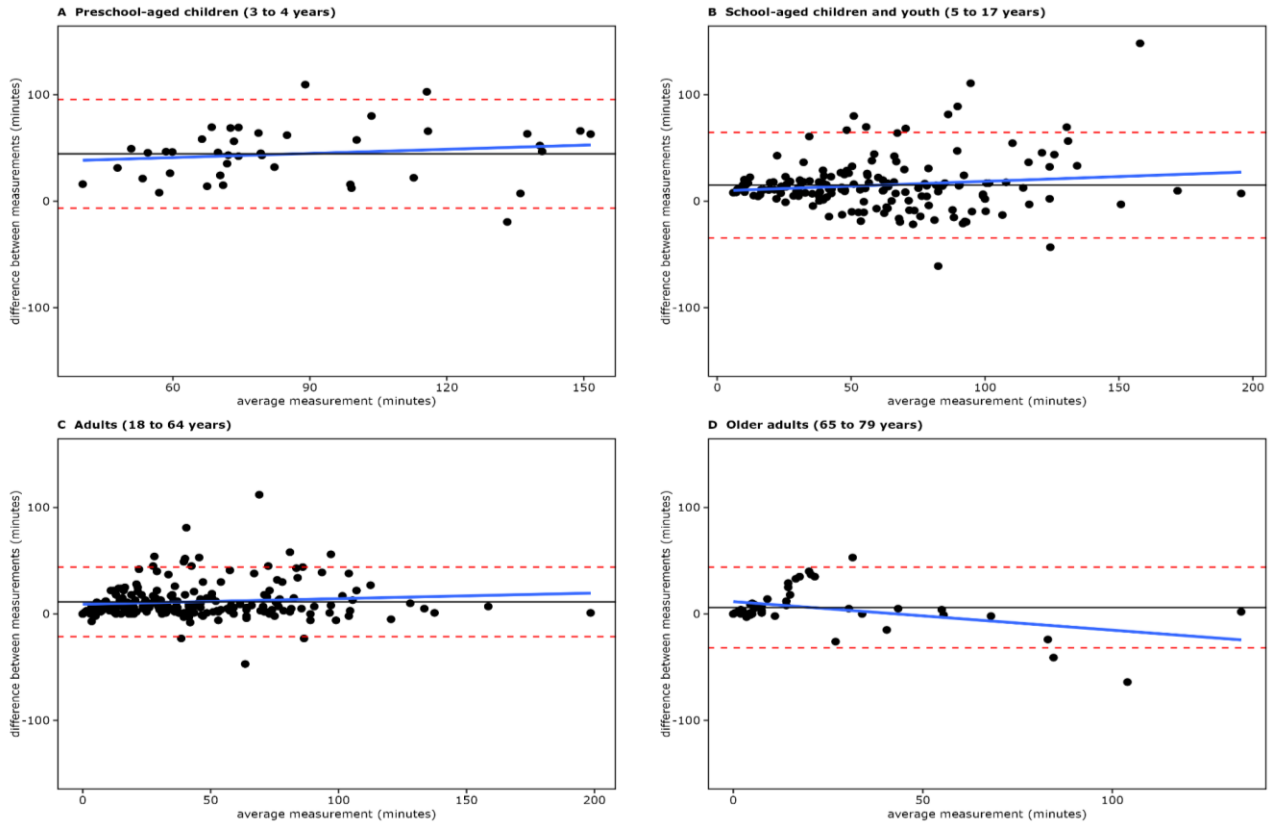
LPA was significantly higher with the AG_{LFE} than with the AC across all age groups (370 versus 204 minutes for preschool-aged children, $p < 0.0001$; 319 versus 220 minutes for school-aged children and youth, $p < 0.0001$; 364 versus 209 minutes for adults, $p < 0.0001$; and 330 versus 167 minutes for older adults, $p < 0.0001$). Agreement and consistency were poor in all age groups, except for school-aged children and youth, where agreement was poor but consistency was moderate.

Results were similar for the AG_N compared with the AC, although the differences were smaller (332 versus 204 minutes for preschool-aged children, $p < 0.0001$; 282 versus 220 minutes for school-aged children and youth, $p < 0.0001$; 328 versus 209 minutes for adults, $p < 0.0001$; and 273 versus 167 minutes for older adults, $p < 0.0001$). Agreement was poor across all age groups, while consistency was moderate, except for preschool-aged children, where it was poor.

Moderate-to-vigorous physical activity

Results for MPA, VPA, and MVPA varied somewhat by age group. In preschool-aged children, MVPA was significantly higher with the AG_{LFE} (109 minutes, $p < 0.0001$) and the AG_N (98 minutes, $p < 0.0001$) than with the AC device (65 minutes) (Table 3). While agreement was poor, consistency was moderate, regardless of the AG filter used. The difference between the AG_{LFE} and the AC increased slightly as MVPA increased (Figure 1A).

Figure 1
Bland–Altman plots moderate-to-vigorous physical activity differences (minutes) between devices, by age group



Notes: Each plot shows the mean bias (solid line) and 95% limits of agreement (dashed red lines) for the difference in step counts between the Actical and the ActiGraph using the normal filter.
Source: Statistics Canada, Canadian Health Measures Survey crossover study, 2021.

Among school-aged children and youth, MVPA was significantly higher with the AG_{LFE} (68 minutes, p = 0.0003) and the AG_N (62 minutes, p = 0.0243) than with the AC (53 minutes). With the AG_{LFE} and the AG_N, MPA was lower than with the AC (39 versus 47 minutes, p = 0.0179, and 35 versus 47 minutes, p = 0.0004, respectively) but VPA was more than six times higher (20 versus 3 minutes, p < 0.0001, and 19 versus 3 minutes, p < 0.0001, respectively). With both filters, agreement and consistency were good for MVPA, moderate for MPA, and poor for VPA in this age group. The difference between the AG_{LFE} and the AC appeared to increase with higher values, particularly above 80 minutes (Figure 1B).

Among adults, MVPA was significantly higher with the AG accelerometer than with the AC (AG_{LFE}: 49 versus 37 minutes, p = 0.0008; AG_N: 45 versus 37 minutes, p = 0.0223), MPA was higher (AG_{LFE}: 43 versus 28 minutes, p < 0.0001; AG_N: 39 versus 28 minutes, p = 0.0001), but VPA was lower (AG_{LFE}: 6 versus 9 minutes, p = 0.0298; AG_N: 5 versus 9 minutes, p = 0.0188). Regardless of the AG filter used, agreement and consistency were at least good for MPA, VPA, and MVPA. The Bland–Altman plot shows good agreement and very little evidence of bias for adults (Figure 1C).

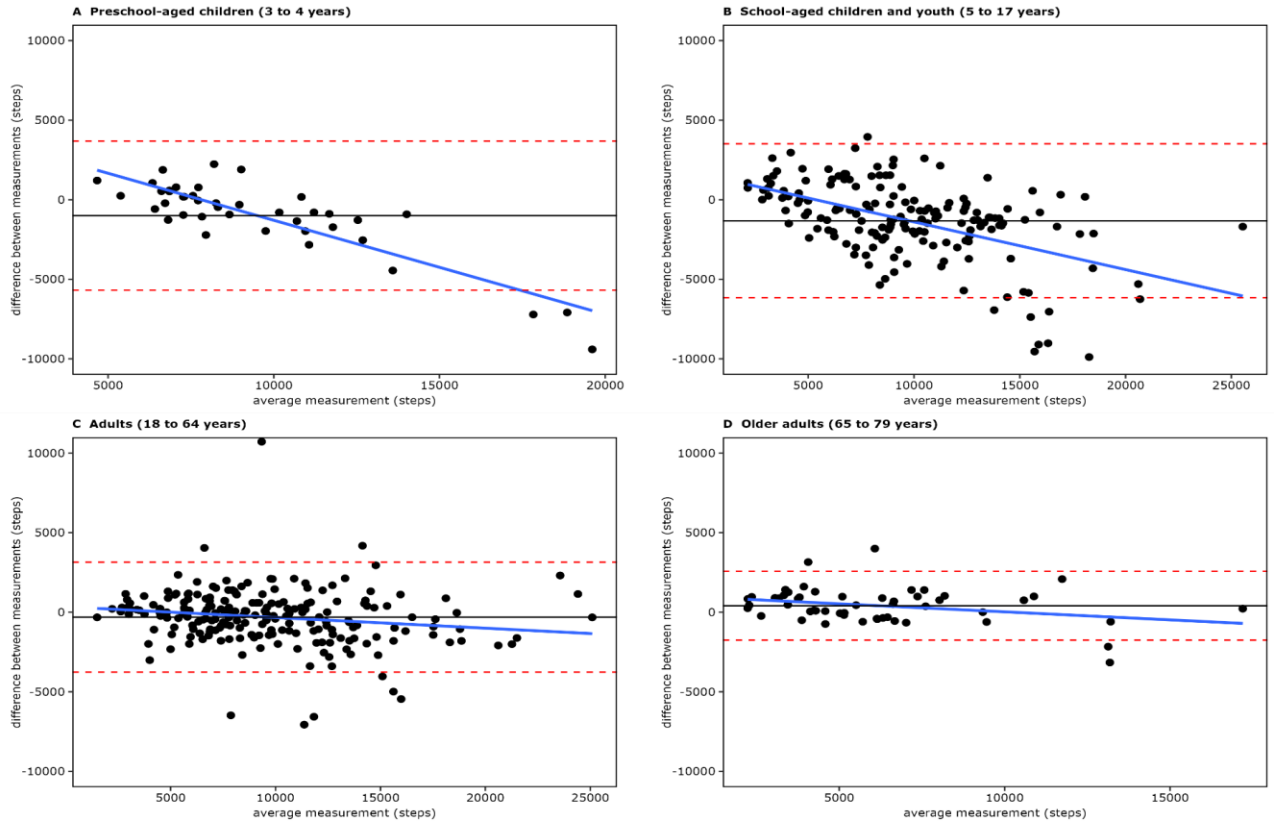
Among older adults, MVPA with the AG was not significantly different compared with the AC (AG_{LFE}: 24 versus 18 minutes, p = 0.2863; AG_N: 21 versus 18 minutes, p = 0.4983). MPA and VPA were also not significantly different, although no minutes of VPA were accumulated with the AG (using either filter), compared with two minutes with the AC. Agreement and consistency were good for MVPA and MPA but poor for VPA. The Bland–Altman plot shows good agreement with very low MVPA (below 15 minutes) but poor agreement at higher levels (Figure 1D).

Step counts

Step counts were not comparable between the two AG filters. Step counts were approximately twice as high with the AG_{LFE} than with the AG_N across all age groups. While agreement was poor with the AG_{LFE}, consistency was good across all age groups. With the AG_N, results varied somewhat by age group.

For preschool-aged children and school-aged children and youth, agreement and consistency were good; however, the absolute difference in the number of average daily steps was 999 for preschool-aged children (9,004 versus 10,003 steps, p = 0.2139) and 1,323 for school-aged children and youth (9,106 versus 10,429 steps, p = 0.0063).

Figure 2
Bland–Altman plots of step count differences between devices, by age group



Notes: Each plot shows the mean bias (solid line) and 95% limits of agreement (dashed red lines) for the difference in step counts between the Actical and the ActiGraph using the normal filter.
Source: Statistics Canada, Canadian Health Measures Survey crossover study, 2021.

For adults and older adults, agreement and consistency were excellent, and absolute differences were much smaller (9,503 versus 9,812 steps, p = 0.4784, and 6,388 versus 5,979 steps, p = 0.5126, respectively). In all age groups, the difference in steps between the AG_N and the AC devices decreased markedly with increasing steps, particularly among children and youth, where differences were as high as 10,000 steps per day (Figure 2).

Adherence to physical activity recommendations

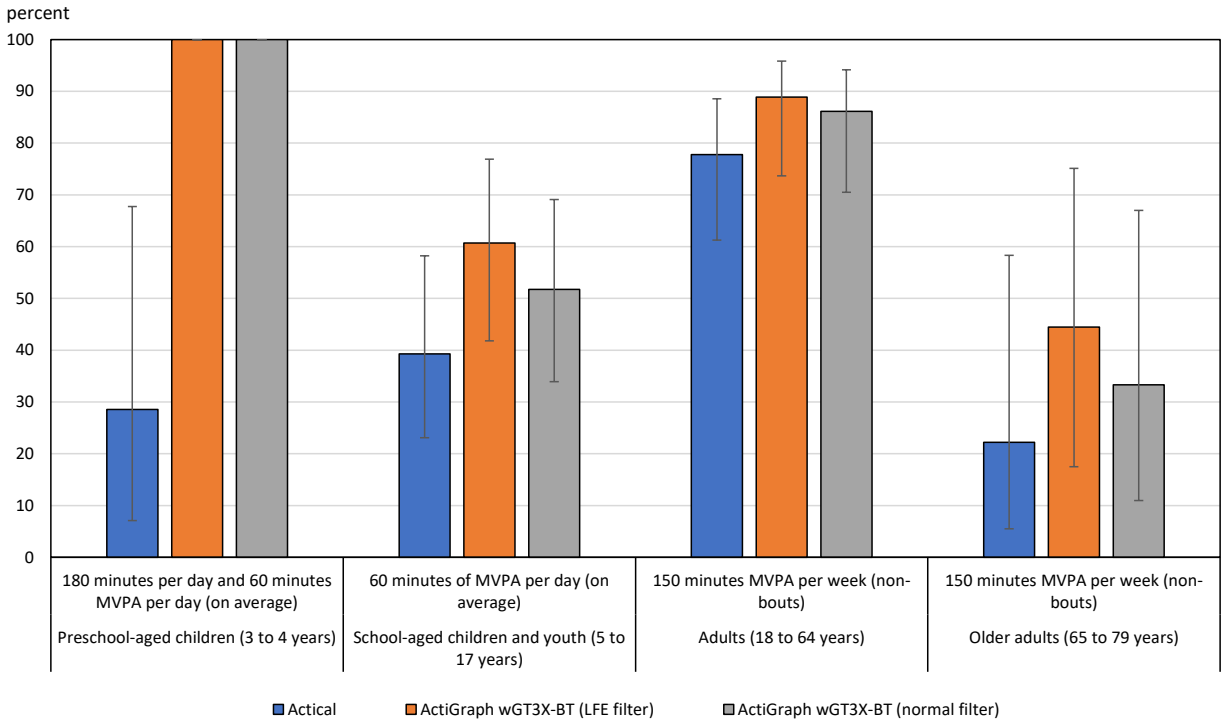
The percentages of those meeting age-specific PA recommendations are presented in Chart 1. The only statistically significant differences were found in the preschool-aged group, where adherence was more than three times higher with the AG accelerometer, regardless of the filter used, than with the AC (AC: 28.6% [95% CI: 7.1 to 67.7]; AG: 100%, p < 0.0001). While results were not statistically significant among school-aged children and youth, adherence was about 1.5 times higher with the AG than with the AC (AC: 39.3% [95% CI: 23.1 to 58.2]; AG_{LFE}: 61.7% [95% CI: 41.8 to 76.9]; AG_N: 51.7% [95% CI: 33.9 to 69.1]). Similarly, among older adults, results were not statistically significant; however, adherence was also 1.5 to 2 times higher with the AG (AC: 22.2% [95% CI: 5.5 to 58.3]; AG_{LFE}: 44.4% [95% CI: 17.5 to 75.1]; AG_N: 33.3% [95% CI: 11.1 to 67.0]). Results were most comparable among adults (AC: 77.8% [95% CI: 61.3 to 88.6]; AG_{LFE}: 88.9% [95% CI: 73.7 to 95.8]; AG_N: 86.1% [95% CI: 70.5 to 94.2]).

Discussion

Using the AG and AC accelerometers across multiple age groups, this study compared SED, LPA, and MVPA estimates; step counts; and adherence to PA recommendations. Differences in PA and SED estimates were expected because of known differences in measurement technology and data processing protocols. The results of the present study confirm that between-device differences are substantial for several key waking movement behaviours.

For preschool-aged children, agreement and consistency between devices was particularly poor across most movement behaviours. Absolute differences exceeded four hours for SED, more than one hour for LPA, and approximately 1,000 steps per day. These discrepancies indicate that the devices are capturing fundamentally different aspects of movement in this age group and cannot be used interchangeably. As a result, national estimates of movement behaviours among preschool-aged children are not directly comparable across CHMS cycles that use different devices.

Chart 1
Percentage meeting the physical activity recommendations of the Canadian 24-hour Movement Guidelines with the Actical accelerometer versus the ActiGraph wGT3X-BT accelerometer (low frequency extension and normal filters), by age group



Notes: LFE= low frequency extension. MVPA = moderate-to-vigorous physical activity.
Source: Statistics Canada, Canadian Health Measures Survey crossover study, 2021.

Among school-aged children and youth and adults, the pattern differed. Again, estimates of SED showed poor agreement, consistent with previous research suggesting that the devices identify different individuals or days as sedentary, even when overall mean values are similar at the population level. This highlights that while population-level averages may align, caution is required when interpreting individual-level estimates of SED across devices.

In contrast, agreement and consistency in the MVPA estimates were moderate to good. While the AG_N typically recorded higher values than the AC, the differences were relatively stable across the range of MVPA, and directional bias was minimal. As a result, population-level prevalence estimates—such as the percentage of children or youth or adults meeting PA guidelines—were broadly similar between devices. Although the AG_N and AC may not be considered interchangeable at the individual level, they appear to provide sufficiently comparable estimates to support population-level surveillance of MVPA across past and future CHMS cycles.

The observed differences are likely the result of several well-known methodological factors. First, non-wear time algorithms influence SED estimates. The AC accelerometer used a 60-minute non-wear period, while the AG used 20 minutes, resulting in higher SED estimates for the AC, consistent with earlier research.[21,22,41,42] Second, the use of different cut points for classifying intensity levels can lead to substantial differences, even when validated cut points are applied to each device, even within the same device.[43,44] Cut points are intended to mitigate variability arising from differences in accelerometer hardware and signal-processing algorithms; however, they do not fully harmonize data across devices because they are usually developed from different studies that use different methodologies.

Epoch length also plays a role, as shorter epochs allow short bursts of activity to be captured, while counts averaged over a full minute are less likely to surpass intensity cut points. AG data were extracted using shorter epochs (15 seconds) for all ages, while the AC recorded at 60-second epochs across most age groups. This contributed to large discrepancies in MVPA, particularly among school-aged children and youth, where the AG recorded six times more VPA than the AC. In adults and older adults, AG data were reintegrated into one-minute epochs, but the original short-epoch collection may still influence comparisons.

Although using identical data reduction procedures could have diminished between-device differences, this study intentionally applied the protocols used in previous and upcoming CHMS cycles. AC data were processed using the same approach applied in all previous CHMS cycles, while AG data were processed following widely accepted protocols used in large-scale studies, including the International Study of Childhood Obesity, Lifestyle and the Environment. These protocols are the same as those that will be applied to CHMS cycles 7 and 8 onward. As such, this study provides practical insight into how historical and future CHMS accelerometer data may differ.

The results of the present study have implications for population surveillance of waking movement behaviours in Canada. Past CHMS accelerometer data, based on AC outputs, have been used to inform national surveillance reports and policies by organizations such as the Public Health Agency of Canada and ParticipACTION.[5-7] Without appropriate interpretation, comparisons between earlier (AC-based) and newer (AG-based) CHMS cycles may lead to inaccurate conclusions about changes in PA and SED levels among people living in Canada. Caution is therefore recommended when carrying out comparisons between cycles 1 to 6 and cycle 7 of the CHMS across most movement behaviours. While agreement was generally good for MVPA, and comparisons are likely appropriate, comparisons for SED, LPA, and VPA should be avoided. Comparing step counts is likely appropriate for adults, but not for preschool-aged children or school-aged children and youth. Although agreement was good, the difference of approximately 1,000 steps per day—a value that is large for these age groups—is concerning.

Results comparing the AG_N and the AG_{LFE} were similar for most daytime behaviours; however, step counts were approximately twice as high with the AG_{LFE}. This has practical implications. In 24-hour monitoring protocols, extracting separate data using both filters—the AG_N filter for daytime activity and the AG_{LFE} filter for sleep, as well as LPA in older adults—is recommended.[45] This approach increases data processing time and storage demands, particularly in large-scale surveys. The similarity in daytime estimates between the AG_N and the AG_{LFE} suggests that using a single filter may be sufficient for many outcomes, as seen in other studies. While step count differences remain a limitation, a prediction equation is under development to estimate AG_N-equivalent steps from AG_{LFE} data in future CHMS cycles. This would allow the CHMS to rely solely on the AG_{LFE}, greatly increasing operational efficiencies, with little to no impact on outcomes.

Limitations

This study has several limitations. The overall sample size was small, particularly for the youngest and oldest age groups. While the comparison of the main outcomes (SED, LPA, MVPA, step counts) was done at a per-day level, increasing the statistical power, assessing adherence to guidelines had to be done at the person level. As such, there may have been insufficient power to detect any significant differences in the estimates of adherence between the devices. By applying device-specific protocols, real-world practices are reflected, but the ability to conduct fully standardized comparisons is limited. The analysis focused on group-level outcomes and did not explore individual-level variability.

Conclusion

With the CHMS transitioning from the AC to the AG accelerometer starting in Cycle 7, it is important to understand how this change affects estimates of accelerometer-measured movement behaviours across survey cycles. Differences in outcomes between the accelerometers were expected given the lack of harmonization of methods and the inherent technical and mechanical differences between them. While some consideration was given to better align results through standardized data reduction approaches or the development of correction equations, priority was given to following device-specific recommendations and aligning with other large-scale studies to ensure greater global generalizability. Results indicate that comparisons between CHMS cycles for most outcomes should be avoided because of poor agreement. An important exception is for MVPA and adherence to PA recommendations, where agreement was good. The results of this study provide data users and researchers with an indication of the expected differences between the devices across various movement behaviour outcomes and underscore the importance of methodological transparency and consistency in movement behaviour surveillance. These differences can influence prevalence estimates and trend analyses. The findings provide important context for accurately interpreting the CHMS results and communicating trends in Canadians' movement behaviours.

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