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ABSTRACT

Background

Data on meeting the Canadian 24-Hour Movement Guidelines for adults (24-H Guidelines) and associations with health indicators by body mass index (BMI) class are needed to support public health surveillance. The aim of this study was to describe the proportion of Canadian adults meeting individual and various combinations of the 24-H Guidelines by BMI class and their association with health indicators.

Data and methods

Data from the cross-sectional Canadian Health Measures Survey cycles 1 to 4 (2007 to 2015, n = 10,515 adults aged 18 to 79 years) were used. Daily time spent in moderate-to-vigorous physical activity (MVPA) and sedentary behaviour were assessed using accelerometry. Sleep duration, recreational screen time, chronic conditions, sociodemographic characteristics, and general and mental health were self-reported. The BMI, waist circumference, blood pressure and aerobic fitness were directly measured. Respondents were classified as meeting the 24-H Guidelines when

- the MVPA was 150 minutes per week or more
- sedentary time was nine hours or less per day
- recreational screen time was three hours or less per day
- sleep duration was seven to nine hours per day for individuals aged 18 to 64 years or seven to eight hours per day for individuals aged 65 years and older.

Results

Significantly fewer adults with overweight (6.1%) or class I (4.3%) and class II or III (3.9%) obesity met all three 24-H Guidelines compared with those with normal weight (9.5%). Meeting all three or two recommendations of the 24-H Guidelines was generally associated with a lower waist circumference, higher aerobic physical fitness and self-perceived general health regardless of BMI class.

Interpretation

Canadian adults living with overweight and obesity are less likely to meet the 24-H Guidelines. Most of the benefits associated with meeting the 24-H Guidelines are observed regardless of BMI status.

Keywords

Obesity, exercise, sleep, sedentary time, screen time, epidemiology, movement behaviours

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What is already known on this subject?

- High physical activity, low sedentary behaviour and sufficient sleep duration are associated with better health outcomes.
- The Canadian 24-Hour Movement Guidelines for adults (24-H Guidelines) were released in 2020 and provide evidence-based recommendations for a healthy day.
- A higher body mass index (BMI) is associated with physical inactivity, greater sedentary time and inadequate sleep.

What does this study add?

- The percentage of Canadian adults meeting all three 24-H Guidelines recommendations decreases as the BMI increases: normal weight (9.5%), overweight (6.1%), obesity class I (4.3%), and obesity classes II and III (3.9%).
- Canadian adults who meet all three or two out of three 24-H Guidelines recommendations had more favourable waist circumference, aerobic physical fitness, self-reported chronic conditions and self-perceived general health in all BMI classes compared with participants who did not meet them (except in obesity class II or III for fitness, chronic conditions and general health).
- Meeting moderate-to-vigorous physical activity, sleep or screen time recommendations resulted in better indicators of physical and perceived health across BMI classes. Additional studies in people with severe obesity are required to clarify whether this population has a specific pattern of associations.

A 24-hour day involves a continuum of movement progressing from the absence of movement (i.e., sleep) towards high-intensity movements (i.e., vigorous exercise).[1] While many studies have looked at the beneficial health effects of each movement behaviour in isolation (physical activity, sedentary behaviour and sleep), the concept of a 24-hour movement cycle has seen growing interest among researchers and public health authorities.[1] Indeed, evidence highlights that behaviours on the movement continuum are important, and achieving multiple recommendations within the 24-hour movement continuum is associated with better health.[1,2] In other words, "the whole day matters" for health and wellness, and the balance between each movement behaviour is important.[1] This paradigm shift resulted in the 2020 release of the Canadian 24-Hour Movement Guidelines for adults (24-H Guidelines)[3] for public health guidance, reporting benchmarks for moderate-to-vigorous physical activity (MVPA), sedentary behaviour and sleep duration.

Despite increasing evidence, recent systematic reviews underlined that research on 24-hour movement behaviours is still in its infancy, especially among adults.[1,2] In addition, authors underlined the need for studies to determine the adherence to such recommendations in the population, as well as potential moderators such as sociodemographic data and body mass index (BMI).[1,2] With the exception of a recent study by Rollo et al.,[4] previous research in adults has often focused on single movement behaviours[1,5-9] and did not use the 24-H Guidelines recommendations.[10] Moreover, although several studies showed that high BMI is associated with low levels of physical activity, high sedentary time and poor sleep,[10-13] recommendation adherence to specific combinations of movement behaviours by BMI class among Canadian adults is unknown, and it may be useful to support health surveillance efforts and public health messages. In 2018, approximately 36% of Canadians had overweight and 27% had obesity.[14] The prevalence of severe obesity (class II or III obesity) had been estimated at 6% in 2016, with the biggest increase since 1985 among classes II and III.[15] Depending on the BMI class, individuals may have different health profiles and may require different treatment options (i.e., public health, medical or surgical interventions), highlighting the importance of considering BMI classes separately.[16,17]

Thus, the objectives of the present study were to provide estimates for the proportion of Canadian adults meeting each movement behaviour recommendation (MVPA, sedentary behaviour and sleep duration), or multiple recommendations, across BMI classes and to examine the associations between meeting each movement behaviour recommendation, or multiple, and health indicators by BMI class.

Data and methods

Data source and study population

Data for this study were combined from cycles 1 (2007 to 2009), 2 (2009 to 2011), 3 (2012 to 2013) and 4 (2014 to 2015) of the Canadian Health Measures Survey (CHMS). More recent CHMS cycles were not included, because the sleep questions were not available.

The CHMS is a nationally representative repeated cross-sectional survey of Canadians aged 3 to 79 years across the 10

provinces.[18] Residents of Indigenous reserves, institutions, certain remote regions and the territories and full-time members of the Canadian Armed Forces were excluded from this survey.[18] Together, these exclusions represent 4% of the target population. Self-reported data were collected as part of a home interview, and direct measures were collected as part of a visit to a mobile examination centre. Ethics approval for the CHMS was obtained from Health Canada's Research Ethics Board.[19]

Data from 10,515 adults (aged 18 to 79 years) were used for analyses, after excluding data for those with severe mobility issues, such as requiring mechanical support, a wheelchair or help from people (n = 121 respondents); those with incomplete BMI information or underweight (BMI less than 18.5 kg/m^2) (n = 225 respondents); and pregnant women (n = 16 respondents). The overall response rates for the CHMS activity monitor subsample for cycles 1, 2, 3 and 4 were 41.8%, 42.4%, 38.8% and 37.7%, respectively.

Table 1
Sample characteristics

	Normal weight (n = 3,886)			Overweight (n = 3,966)			Obesity class I (n = 1,763)			Obesity classes II and III (n = 900)		
		95% Confidence interval			95% Confidence interval			95% Confidence interval			95% Confidence interval	
Variables	% or mean	Lower	Upper	% or mean	Lower	Upper	% or mean	Lower	Upper	% or mean	Lower	Upper
Sociodemographic data												
Age (years)	41.6	40.9	42.4	47.6	46.9	48.2	49.1	47.7	50.5	45.4	43.7	47.1
Sex (% female)	59.7	57.9	61.5	41.3	38.6	44.1	42.0	38.6	45.3	56.6	50.9	62.4
Household income quintile (%)												
1	14.8	12.7	16.9	11.3	9.3	13.3	11.1	8.5	13.7	16.9	11.1	22.7 [E]
2	17.5	15.3	19.8	17.9	15.2	20.6	16.0	13.4	18.7	15.7	11.6	19.8
3	18.4	15.8	21.0	19.0	16.6	21.4	20.8	17.4	24.2	20.1	15.6	24.6
4	20.0	17.1	23.0	19.4	17.1	21.8	19.8	16.7	22.9	22.0	17.4	26.7
5	29.3	25.7	32.8	32.4	28.6	36.2	32.3	27.2	37.4	25.2	19.3	31.2
Ethnicity (% White)	76.0	70.5	81.5	81.8	76.7	87.0	88.3	84.8	91.9	89.5	84.0	95.0
Health behaviours												
Smoking status (%)												
Non-smoker	55.0	51.0	59.0	49.2	45.7	52.8	46.5	42.1	50.8	49.0	44.0	54.0
Daily or occasional smoker	21.6	18.8	24.4	19.7	16.8	22.7	18.2	14.4	22.0	15.5	10.1	21.0 [E]
Former smoker	23.4	20.4	26.4	31.0	28.5	33.6	35.4	30.5	40.2	35.5	30.5	40.5
Fruit and vegetable consumption (number per day)	2.2	2.1	2.3	2.1	2.0	2.1	1.8	1.8	1.9	2.1	1.6	2.6
Soft drink consumption (number per day)	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.2	0.3	F	...	...
Movement behaviours												
Daily MVPA (minutes per day)	28.9	27.2	30.6	21.9	20.4	23.4	20.4	17.6	23.3	14.9	13.0	16.8
Daily sedentary time (hours per day)	9.7	9.6	9.8	9.7	9.6	9.8	9.8	9.6	9.9	9.8	9.6	9.9
Daily screen time (hours per day)	2.8	2.7	2.9	3.0	2.8	3.1	3.2	3.0	3.4	3.7	3.3	4.0
Daily sleep time (hours per day)	7.2	7.1	7.2	7.1	7.0	7.1	7.1	7.0	7.2	7.1	6.8	7.3
Health indicators												
BMI (kg/m^2)	22.4	22.3	22.5	27.3	27.2	27.4	32.1	32.0	32.2	39.2	38.7	39.8
Waist circumference (cm)[††]	80.6	80.2	81.1	94.8	94.4	95.3	106.2	105.5	106.9	120.4	119.0	121.8
Systolic blood pressure (mmHg)	106.2	105.3	107.0	113.0	112.2	113.7	115.5	114.0	116.9	116.9	114.9	118.9
Diastolic blood pressure (mmHg)	68.8	68.1	69.4	73.1	72.6	73.7	74.5	73.1	75.9	74.6	73.2	76.1
Aerobic fitness score	39.3	38.7	39.9	35.9	35.2	36.7	32.8	31.9	33.7	28.9	27.1	30.7
Has one or more chronic conditions (%)[‡]	6.4	5.2	7.7	10.6	8.8	12.4	15.5	12.3	18.6	24.6	18.0	31.1
Self-perceived general health (%)												
Excellent or very good	61.8	59.1	64.5	55.2	51.8	58.5	45.0	40.7	49.3	28.0	22.6	33.4
Self-perceived mental health (%)												
Excellent or very good	74.1	71.4	76.7	72.8	70.3	75.3	70.9	66.6	75.1	68.5	63.7	73.3

... not applicable

E use with caution

F too unreliable to be published

[‡] Has two or more of eight chronic diseases, excluding Alzheimer's and related dementias.

[††] The World Health Organization protocol was used in Cycle 1

Notes: BMI = body mass index; MVPA = moderate-to-vigorous physical activity. Data presented as means (95% CI) for continuous variables and percentages (95% CI) for categorical variables. [††] = The World Health Organization protocol was used in Cycle 1, and the National Institutes of Health (NIH) protocol was used in cycles 2 and 3. The following published equation was used to predict the NIH protocol results for Cycle 1.

Sources: Canadian Health Measures Survey cycles 1 to 4. Roberts KC, Rao DP, Bennett TL, Loukine L, Jayaraman GC. Prevalence and patterns of chronic disease multimorbidity and associated determinants in Canada. Health Promotion and Chronic Disease Prevention in Canada. 2015 Aug; 35(6): 87–94; Patry-Parisien J, Shields M, Bryan S. Comparison of waist circumference using the World Health Organization and National Institutes of Health protocols. Health Reports. 2012 Sep; 23(3): 53–60.

Table 2
Percentage estimates of Canadian adults meeting each recommendation or multiple recommendations within the Canadian 24-Hour Movement Guidelines for Adults and health indicators across body mass index classes

	Normal weight (n = 3,886)			Overweight (n = 3,966)			Obesity class I (n = 1,763)			Obesity classes II and III (n = 900)		
		95% Confidence interval			95% Confidence interval			95% Confidence interval			95% Confidence interval	
Meeting recommendation	percent	Lower	Upper	percent	Lower	Upper	percent	Lower	Upper	percent	Lower	Upper
Specific guideline met												
At least MVPA	51.7	47.9	55.5	39.8	35.8	43.7	32.0	27.0	37.1	23.9	18.0	29.7
At least sedentary behaviour	19.4	17.0	21.9	18.5	15.8	21.3	16.3	12.5	20.1	11.3	7.6	15.0
At least sleep	66.9	64.3	69.5	64.3	61.4	67.1	64.4	60.5	68.4	63.8	58.4	69.2
General combinations of movement behaviours												
All three	9.5	7.5	11.4	6.1	5.1	7.1	4.3	2.8	5.8 [E]	3.9	1.8	5.9 [E]
Two out of three	34.2	30.6	37.9	29.1	26.3	31.8	26.3	21.5	31.2	19.3	13.9	24.7
One out of three	41.2	38.0	44.4	46.2	43.3	49.0	47.0	43.2	50.8	48.8	41.7	55.9
None	15.1	12.9	17.2	18.7	16.3	21.1	22.4	18.3	26.4	28.0	22.4	33.6

E use with caution

Note: MVPA -= moderate-to-vigorous intensity physical activity.

Source: Canadian Health Measures Survey cycles 1 to 4.

Independent variables

Movement behaviours and Canadian 24-Hour Guidelines recommendation adherence

As recommended in the 24-H Guidelines,[3] the specific components (e.g., sleep duration, sedentary time, recreational screen time and MVPA) were used to assess 24-H Guidelines recommendation adherence. The other components, such as breaking up prolonged sitting, doing light physical activity or doing muscle-strengthening activities, are not required when examining adherence to the overall 24-H Guidelines.

The CHMS respondents wore an omnidirectional accelerometer (Actical, Phillips Respironics, Oregon, United States) over their right hip for seven consecutive days while awake. Real-time movement data were not available to respondents while they were wearing the accelerometer. The Actical has been shown to be a valid device to assess physical activity among adults.[20] Only data from respondents with at least four valid wear days (defined as 10 hours or more of wear time per day) were included in the analysis.[21] Non-wear time was defined as a period of at least 60 consecutive minutes of zero counts, with allowance for one to two minutes of counts between 0 and 100. Standard values of counts per minute (cpm) were used to determine time spent sedentary (100 cpm or less)[22] and engaged in MVPA (1,500 cpm or more for respondents aged 18 to 19 years, and 1,535 cpm or more for respondents aged 20 to 79 years).[23,24] All MVPA minutes on valid days were divided by the number of valid days to obtain the average daily minutes of MVPA. If respondents spent an average of 21.43 minutes or more per day (150 minutes or more per week) in MVPA, they were categorized as meeting the MVPA recommendation.

The average daily screen time was calculated by summing respondents' answers to three questions: "In a typical week in the past 3 months, how much time did you usually spend" (1) on a computer, including using the Internet, playing computer games, emailing or chatting online?; (2) playing video games, such as on Xbox, Nintendo and PlayStation?; and (3) watching television, DVDs or videos? Given that answers to these questions in cycles 2 and 3 were continuous, categorical response options in Cycle 1 ("none," "less than 1," "1 to 2," "3 to 5," "6 to 10," "11 to 14," "15 to 20," "20 or more" hours) were converted into a continuous variable with the mid-point values of the six response options (0, 0.5, 1.5, 4, 8, 12.5, 17.5, 20).[25] Respondents were categorized as meeting the sedentary time recommendations when they spent three hours or less in recreational screen time per day and nine hours or less in total sedentary time per day.[3] The threshold of nine hours or less was used (instead of eight hours or less) to be consistent with surveillance recommendations when using accelerometer data to assess sedentary time.[4]

Average daily sleep duration was self-reported using the question: "How many hours do you usually spend sleeping in a 24-hour period, excluding time spent resting?" Respondents were categorized as meeting the sleep duration recommendation if their average daily sleep time was between seven hours and nine hours, 59 minutes (adults aged 18 to 64 years) or seven hours to eight hours, 59 minutes (adults aged 65 years and older).[3]

Respondents were categorized as meeting specific movement behaviour recommendations (e.g., meeting MVPA regardless of meeting other behaviour recommendations), specific combinations of movement behaviour recommendations (e.g., MVPA and sleep or sleep only) and general combinations of movement behaviours (all three, two out of three, one out of three or none).

Table 3
Associations between meeting each recommendation or multiple recommendations within the Canadian 24-Hour Movement Guidelines for Adults and continuous health indicators by body mass index class

	Log waist circumference			Log systolic blood pressure			Log diastolic blood pressure			Aerobic fitness		
		95% Confidence interval			95% Confidence interval			95% Confidence interval			95% Confidence interval	
Recommendation	β	Lower	Upper	β	Lower	Upper	β	Lower	Upper	β	Lower	Upper
Specific recommendations met												
At least MVPA												
Normal weight	-0.02	-0.03	-0.01	0.00	-0.01	0.02	0.00	-0.02	0.02	1.60	0.92	2.28
Overweight	-0.01	-0.02	0.00	0.00	-0.02	0.01	0.00	-0.02	0.02	1.05	0.34	1.77
Obesity class I	-0.02	-0.03	-0.01	0.00	-0.02	0.02	0.00	-0.03	0.02	2.02	0.62	3.42
Obesity classes II and III	-0.04	-0.06	-0.01	0.00	-0.03	0.03	0.00	-0.04	0.04	1.36	-0.56	3.29
At least sedentary behaviour												
Normal weight	-0.01	-0.02	0.00	0.01	-0.01	0.03	0.01	-0.01	0.03	1.72	0.91	2.52
Overweight	-0.01	-0.02	0.00	0.00	-0.02	0.01	0.01	-0.01	0.03	0.56	-0.24	1.37
Obesity class I	-0.01	-0.03	0.00	0.02	0.00	0.04	0.03	0.00	0.06	2.47	0.35	4.59
Obesity classes II and III	0.00	-0.03	0.04	0.00	-0.05	0.05	0.01	-0.04	0.06	0.42	-1.20	2.03
At least sleep												
Normal weight	0.00	-0.01	0.01	0.01	0.00	0.02	0.01	-0.01	0.03	0.17	-0.62	0.96
Overweight	0.00	-0.01	0.01	0.00	-0.01	0.02	-0.01	-0.02	0.01	0.33	-0.45	1.11
Obesity class I	0.00	0.00	0.01	0.00	-0.02	0.02	-0.01	-0.03	0.02	-0.72	-2.19	0.75
Obesity classes II and III	-0.02	-0.05	0.00	-0.03	-0.06	0.00	-0.03	-0.07	0.00	0.08	-1.80	1.96
General combinations of movement behaviours												
All three												
Normal weight	-0.02	-0.04	-0.01	0.01	-0.02	0.04	0.01	-0.03	0.05	3.43	2.06	4.79
Overweight	-0.02	-0.03	0.00	0.01	-0.02	0.03	0.01	-0.02	0.05	1.59	0.36	2.83
Obesity class I	-0.02	-0.05	0.02	0.02	-0.01	0.06	0.02	-0.02	0.06	3.15	0.29	6.02
Obesity classes II and III	-0.07	-0.11	-0.02	-0.04	-0.09	0.01	-0.03	-0.07	0.02	1.46	-2.09	5.01
Two out of three												
Normal weight	-0.01	-0.03	0.00	0.02	0.00	0.04	0.03	0.01	0.06	1.24	0.35	2.12
Overweight	-0.02	-0.02	-0.01	-0.01	-0.03	0.02	-0.01	-0.03	0.01	1.83	0.77	2.9
Obesity class I	-0.02	-0.03	0.00	0.00	-0.03	0.03	0.00	-0.04	0.04	2.26	0.37	4.14
Obesity classes II and III	-0.03	-0.07	0.00	-0.03	-0.07	0.01	-0.02	-0.07	0.02	0.38	-1.71	2.46
One out of three												
Normal weight	0.00	-0.02	0.01	0.02	-0.01	0.04	0.02	0.00	0.05	0.57	-0.21	1.36
Overweight	-0.01	-0.02	0.00	0.00	-0.02	0.02	0.00	-0.03	0.02	1.4	0.39	2.41
Obesity class I	0.00	-0.01	0.01	0.01	-0.02	0.03	-0.01	-0.04	0.03	1.38	0.02	2.75
Obesity classes II and III	-0.02	-0.04	0.01	-0.02	-0.06	0.03	-0.02	-0.06	0.02	-0.8	-3.24	1.65

Notes: β (95% CI) = unstandardized beta coefficient (95% confidence interval); MVPA -= moderate-to-vigorous intensity physical activity. All models were adjusted for age, sex, household income quintile, ethnicity, data collection season, smoking status, fruit and vegetable intake, and soft drink consumption. In addition, 1,886 participants who took medication to lower blood pressure (16.1%) were excluded from the systolic and diastolic analyses. The reference group is "not meeting recommendation" for all models.
Source: Canadian Health Measures Survey cycles 1 to 4.

Dependent variables

Health indicators

Height, body mass, waist circumference, blood pressure and aerobic physical fitness were measured during the mobile examination centre visit.[26-28] The BMI was calculated by dividing body mass in kilograms by height in metres squared ($kg.m^2$). BMI classes were coded as normal weight (18.5 $kg.m^2$ to 24.9 $kg.m^2$), overweight (25.0 $kg.m^2$ to 29.9 $kg.m^2$), obesity class I (30 $kg.m^2$ to 34.9 $kg.m^2$), and obesity classes II and III (35 $kg.m^2$ and over). Waist circumference was measured following the National Institutes of Health protocol. For Cycle 1, waist circumference was measured using the World Health Organization protocol, then converted to the National Institutes of Health protocol using a validated prediction equation to allow for comparability across cycles.[29] Systolic and diastolic blood pressures were measured by trained health professionals following a five-minute rest period, using an oscillometric blood pressure measurement device. Several blood pressure measurements were taken at one-minute intervals, and the last five were used to average systolic and diastolic blood pressures. Aerobic physical fitness was assessed in cycles 1 and 2 using the modified Canadian Aerobic Fitness Test, a progressive submaximal step test validated in Canadian adults against peak VO_2 values measured during a maximal treadmill protocol[30-32] The Canadian Society for Exercise Physiology Physical Activity Training for Health (CSEP-PATH) equation was used to predict VO_{2max}: VO_{2max} ($mL.kg^{-1} \cdot min^{-1}$) = 17.2 + (1.29 x oxygen cost at the final stage) - (0.09 x weight in kg) - (0.18 x age in years).[33,34]

Chronic conditions were self-reported by respondents. Participants were examined as those without a chronic condition, compared with those with one or more of the following conditions: arthritis, mental disorders, asthma,

Table 4
Associations between meeting each recommendation or multiple recommendations within the Canadian 24-Hour Movement Guidelines for Adults and odds of having a poor health outcome by body mass index class

	One or more chronic conditions			Excellent or very good self-perceived general health			Excellent or very good self-perceived mental health		
		95% Confidence interval			95% Confidence interval			95% Confidence interval	
Recommendation	Odds ratio	Lower	Upper	Odds ratio	Lower	Upper	Odds ratio	Lower	Upper
Specific recommendations met									
At least MVPA									
Normal weight	0.83	0.62	1.11	1.42	1.10	1.82	1.03	0.74	1.44
Overweight	0.80	0.61	1.05	1.31	0.99	1.72	1.05	0.78	1.42
Obesity class I	0.96	0.58	1.59	1.61	1.01	2.56	0.98	0.54	1.77
Obesity classes II and III	0.62	0.27	1.41	0.56	0.25	1.26	1.25	0.60	2.60
At least sedentary behaviour									
Normal weight	0.82	0.51	1.33	1.47	1.00	2.16	1.05	0.66	1.67
Overweight	0.68	0.50	0.94	1.25	0.91	1.70	0.90	0.64	1.28
Obesity class I	0.51	0.30	0.87	1.23	0.69	2.22	0.75	0.40	1.39
Obesity classes II and III	0.74	0.26	2.12	1.13	0.50	2.55	1.13	0.36	3.50
At least sleep									
Normal weight	0.56	0.39	0.79	1.74	1.27	2.39	1.23	0.89	1.70
Overweight	0.84	0.64	1.09	1.53	1.20	1.96	1.49	1.10	2.01
Obesity class I	0.61	0.40	0.92	1.78	1.25	2.53	2.07	1.38	3.12
Obesity classes II and III	0.72	0.42	1.22	0.82	0.43	1.57	1.00	0.56	1.79
General combinations of movement behaviours									
All three									
Normal weight	0.40	0.22	0.72	3.62	1.83	7.15	1.57	0.81	3.05
Overweight	0.32	0.19	0.55	2.66	1.57	4.51	1.63	0.69	3.89
Obesity class I	0.34	0.10	1.11	2.18	0.83	5.74	1.50	0.54	4.15
Obesity classes II and III	0.19	0.02	1.55	1.95	0.36	10.39	2.74	0.58	12.97
Two out of three									
Normal weight	0.44	0.29	0.68	2.23	1.56	3.19	1.08	0.69	1.71
Overweight	0.74	0.44	1.23	2.02	1.47	2.78	1.34	0.87	2.08
Obesity class I	0.48	0.29	0.78	2.91	1.62	5.24	1.66	0.87	3.16
Obesity classes II and III	0.73	0.28	1.88	0.33	0.13	0.87	0.94	0.37	2.43
One out of three									
Normal weight	0.53	0.33	0.85	1.70	1.09	2.65	1.12	0.74	1.71
Overweight	0.76	0.49	1.17	1.79	1.31	2.46	1.33	0.87	2.04
Obesity class I	0.51	0.31	0.84	1.86	1.25	2.77	1.58	1.02	2.43
Obesity classes II and III	0.40	0.21	0.77	0.75	0.40	1.41	0.95	0.51	1.77

Notes: All models were adjusted for age, sex, household income quintile, ethnicity, data collection season, smoking status, fruit and vegetable intake, and soft drink consumption. The reference group is "not meeting recommendation" for all models.
Source: Canadian Health Measures Survey cycles 1 to 4.

diabetes mellitus, heart disease, chronic obstructive pulmonary disorder, cancer and stroke, as described in previous work.[35]

Self-perceived general and mental health were assessed by asking respondents to rate their general health and mental health as "excellent," "very good," "good," "fair" or "poor." The proportions of respondents who reported "very good" or "excellent" physical and mental health were compared with those of respondents who reported "good," "fair" or "poor" health.

Statistical analyses

All statistical analyses were conducted in SAS EG version 7.1 (SAS Institute Inc., Cary, North Carolina, United States). SAS survey procedures were used to incorporate accelerometer subsample survey and bootstrap weights with 46 degrees of freedom to account for non-response bias and the complex survey design. Twenty-four degrees of freedom were used for analyses with the aerobic fitness variable, because it was available only in cycles 1 and 2. The weighting allows for estimates to be nationally representative of the Canadian population living in the 10 provinces.

Descriptive statistics were generated for all variables as means or percentages, with 95% confidence intervals (CIs). Significant differences in descriptive characteristics between groups were identified when the 95% CIs did not overlap.

Multivariate regression models were used to assess associations between health indicators (waist circumference, systolic and diastolic blood pressure, and aerobic physical fitness) and meeting the various combinations of the 24-H Guidelines recommendations by BMI class. Multivariate regression models for blood pressure were performed among participants who did not

Supplemental Table 5

Percentage estimates of Canadian adults meeting specific and multiple recommendations within the Canadian 24-Hour Movement Guidelines for Adults and health indicators across body mass index classes

	Normal weight (n = 3,880)			Overweight (n = 3,964)			Obesity class I (n = 1,759)			Obesity classes II and III (n = 898)		
		95% Confidence interval			95% Confidence interval			95% Confidence interval			95% Confidence interval	
Meeting recommendation	percent	Lower	Upper	percent	Lower	Upper	percent	Lower	Upper	percent	Lower	Upper
Specific combinations of movement behaviours												
MVPA, SB and sleep	9.5	7.5	11.4	6.1	5.1	7.1	4.3	2.8	5.8 E	3.9	1.8	5.9 E
MVPA and SB only	3.2	2.1	4.3 E	3.1	2.0	4.3 E	3.9	1.5	6.3 E	F	…	…
MVPA and sleep only	26.0	22.4	29.5	20.3	17.7	22.9	16.5	12.4	20.7	13.6	8.2	19.1 E
SB and sleep only	5.1	3.7	6.5	5.6	4.1	7.2	5.9	4.1	7.7	5.4	2.9	7.9 E
MVPA only	13.1	11.1	15.2	10.2	7.7	12.8	7.2	4.8	9.6	6.1	3.5	8.7 E
SB only	1.7	0.9	2.4 E	3.7	2.4	4.9	2.2	0.7	3.6 E	1.8	0.8	2.8 E
Sleep only	26.4	23.8	29.0	32.2	29.2	35.2	37.7	34	41.3	40.9	34.6	47.2
None	15.1	12.9	17.2	18.7	16.3	21.1	22.4	18.3	26.4	28.0	22.4	33.6

… not applicable

E use with caution

F too unreliable to be published

Notes: MVPA = moderate-to-vigorous intensity physical activity; SB = sedentary behaviour.

Source: Canadian Health Measures Survey cycles 1 to 4.

report taking medication to control blood pressure (N = 1,886 respondents [16.1%]). Waist circumference and blood pressure were log-transformed for all regression models to meet the assumption of normality, and the unstandardized beta coefficients as the 95% CIs for each model were reported. Associations between the various combinations of the 24-H Guidelines recommendations and having one or more chronic conditions, as well as self-reported general and mental health, were assessed using multivariate logistic regression models with "failing to meet the recommendation" used as the reference group. All models were adjusted for age (in years), sex (male vs. female), household income quintile (adjusted for household size), ethnicity (White vs. non-White), data collection season (summer, fall, winter, spring), smoking status (regular or occasional smoker vs. former smoker vs. non-smoker), fruit and vegetable intake (number per day), and soft drink consumption (number per day). Regression results were considered statistically significant at $p < 0.05$.

Results

Population characteristics

Of the 10,515 respondents included in this study, 37% (n = 3,886) were classified with normal weight, 38% (n = 3,966) with overweight, 17% with class I obesity (n = 1,763) and 9% (n = 900) with class II or III obesity. The descriptive characteristics for the full sample and by BMI class are presented in Table 1. The mean age of respondents was 45.4 years (95% CI: 45.2 to 45.6), and 50.3% (95% CI: 49.9 to 50.6) were female. Adults with overweight and obesity classes I, II or III were significantly older and accumulated less MVPA than those with normal weight. Adults with class II or III obesity also accumulated less MVPA compared with adults with overweight and class I obesity. Adults with class I obesity reported significantly more daily recreational screen time compared with those with normal weight, and adults with class II or III obesity reported more recreational screen time compared with those with normal weight and overweight.

Meeting the Canadian 24-Hour Movement Guidelines recommendations

The proportion of Canadian adults meeting the 24-H Guidelines recommendations is presented in Table 2 and Supplemental Table 5. Regarding the prevalence of those who met all three movement guideline recommendations, adults with overweight (6%), class I obesity (4%) and class II or III obesity (4%) were less likely to meet them compared with those with a normal weight (10%). Adults with class II or III obesity (19%) were less likely to meet two out of three movement guideline recommendations, compared with those with a normal weight (34%) or overweight (29%). It is worth noting that most respondents who met two out of three movement guideline recommendations did so by meeting the MVPA and sleep duration recommendations (Supplemental Table 5). Regarding the proportion of adults who met one specific movement behaviour, between-group differences were found with normal-weight adults (52%) being more likely to meet the MVPA recommendation compared with those with overweight (40%), class I obesity (32%) and class II or III obesity (24%). Adults with class II or III obesity were less likely to meet the sedentary time recommendation (11%), compared with adults with normal weight (19%) and overweight (19%).

Supplemental Table 6

Associations between meeting specific and multiple recommendations within the Canadian 24-Hour Movement Guidelines for Adults and continuous health indicators by body mass index class

	Log waist circumference			Log systolic blood pressure			Log diastolic blood pressure			Aerobic fitness		
		95% Confidence interval			95% Confidence interval			95% Confidence interval			95% Confidence interval	
Recommendation	β	Lower	Upper	β	Lower	Upper	β	Lower	Upper	β	Lower	Upper
Specific combinations of movement behaviours												
MVPA, SB and sleep												
Normal weight	-0.01	-0.03	0.00	0.00	-0.02	0.02	-0.01	-0.04	0.02	2.64	1.35	3.93
Overweight	-0.01	-0.02	0.01	0.01	-0.01	0.02	0.02	-0.01	0.04	0.26	-0.84	1.36
Obesity class I	-0.01	-0.04	0.02	0.02	-0.01	0.05	0.02	-0.01	0.06	1.67	-0.84	4.17
Obesity classes II and III	-0.05	-0.09	-0.01	-0.02	-0.06	0.02	-0.01	-0.05	0.03	1.75	-1.48	4.97
MVPA and SB only												
Normal weight	-0.02	-0.04	0.00	0.03	0.00	0.05	0.05	0.02	0.08	1.51	-0.34	3.37
Overweight	-0.01	-0.04	0.01	0.00	-0.04	0.03	0.01	-0.03	0.04	2.11	0.77	3.45
Obesity class I	-0.03	-0.08	0.02	0.01	-0.04	0.06	-0.03	-0.10	0.04	5.61	-1.26	12.48
Obesity classes II and III	-0.02	-0.13	0.09	-0.09	-0.20	0.01	-0.07	0.17	0.03	2.18	-4.45	8.81
MVPA and sleep only												
Normal weight	-0.01	-0.02	0.00	0.01	-0.01	0.02	0.01	-0.01	0.03	0.04	-0.63	0.71
Overweight	-0.01	-0.02	0.00	0.00	-0.01	0.02	0.00	0.02	0.02	0.34	-0.77	1.44
Obesity class I	-0.01	-0.03	0.00	-0.01	-0.04	0.02	-0.01	-0.06	0.04	0.03	-1.57	1.62
Obesity classes II and III	-0.04	-0.07	-0.01	-0.01	-0.05	0.02	-0.01	-0.07	0.04	1.21	-0.57	2.98
SB and sleep only												
Normal weight	-0.01	-0.03	0.01	0.01	-0.02	0.03	0.02	-0.01	0.04	-0.28	-1.53	0.96
Overweight	0.00	-0.02	0.02	-0.03	-0.05	-0.01	-0.03	-0.05	0.00	0.52	-1.00	2.03
Obesity class I	0.00	-0.04	0.03	0.00	-0.03	0.04	0.04	-0.01	0.10	-0.36	-2.37	1.66
Obesity classes II and III	0.03	-0.02	0.08	-0.01	-0.08	0.05	0.01	-0.05	0.08	-0.78	-2.73	1.17
MVPA only												
Normal weight	0.00	-0.02	0.01	-0.01	-0.04	0.01	-0.02	-0.04	0.01	0.30	-0.59	1.20
Overweight	0.00	-0.02	0.01	-0.02	-0.04	0.01	-0.01	-0.04	0.02	1.18	0.00	2.36
Obesity class I	-0.01	-0.02	0.01	0.00	-0.03	0.04	0.01	-0.04	0.05	1.68	-0.68	4.04
Obesity classes II and III	0.00	-0.06	0.07	0.04	-0.03	0.10	0.05	-0.04	0.14	-1.09	-3.95	1.76
SB only												
Normal weight	-0.03	-0.07	0.00	0.05	0.00	0.10	0.04	-0.01	0.09	-1.20	-2.08	-0.31
Overweight	0.00	-0.02	0.02	0.02	-0.02	0.06	0.04	0.00	0.09	-0.26	-1.24	0.72
Obesity class I	-0.01	-0.03	0.01	0.04	-0.02	0.10	0.06	-0.04	0.17	-0.94	-2.18	0.30
Obesity classes II and III	0.05	-0.01	0.12	0.07	-0.03	0.18	0.06	-0.05	0.17	-1.33	-3.63	0.98
Sleep only												
Normal weight	0.02	0.01	0.03	0.00	-0.01	0.01	0.01	-0.01	0.02	-1.20	-2.08	-0.32
Overweight	0.00	0.00	0.01	0.01	-0.01	0.03	0.00	-0.02	0.02	-0.21	-1.18	0.76
Obesity class I	0.01	0.00	0.02	0.00	-0.02	0.02	-0.02	-0.04	0.01	-1.09	-2.44	0.27
Obesity classes II and III	0.00	-0.03	0.02	-0.02	-0.05	0.01	-0.02	-0.06	0.01	-0.95	-2.84	0.95
None												
Normal weight	0.01	0.00	0.02	-0.02	-0.04	0.00	-0.02	-0.05	0.00	-1.17	-1.93	-0.41
Overweight	0.01	0.00	0.02	0.00	-0.02	0.02	0.00	-0.02	0.02	-1.59	-2.47	-0.71
Obesity class I	0.00	-0.01	0.01	-0.01	-0.03	0.02	0.00	-0.03	0.03	-1.80	-3.22	-0.38
Obesity classes II and III	0.02	0.00	0.05	0.02	-0.02	0.06	0.02	-0.02	0.06	0.23	-1.92	2.38

Notes: β (95% CI) = unstandardized beta coefficient (95% confidence interval); MVPA -= moderate-to-vigorous intensity physical activity; SB = sedentary behaviour. All models were adjusted for age, sex, household income quintile, ethnicity, data collection season, smoking status, fruit and vegetable intake, and soft drink consumption. In addition, 1,886 participants who took medication to lower blood pressure (16.1%) were excluded from the systolic and diastolic analyses. The reference group is "not meeting recommendation" for all models.

Source: Canadian Health Measures Survey cycles 1 to 4.

Physical health indicator associations

Associations between health indicators and meeting the 24-H Guidelines recommendations are reported in Table 3 and Supplemental Table 6.

Meeting all three or two out of three recommendations was negatively associated with waist circumference (nonsignificant in adults with overweight and class I obesity for meeting all three recommendations) and positively associated with aerobic physical fitness in all BMI classes (except in adults with class II or III obesity for physical fitness).

A negative association was found for all BMI classes between meeting the MVPA recommendation and waist circumference, and a positive association was found between meeting the MVPA recommendation and aerobic physical fitness (except for adults with class II or III obesity). Among adults with normal weight, a negative association was found between meeting the sedentary behaviour recommendation and waist circumference, and a positive association was found between meeting the sedentary behaviour recommendation and aerobic physical fitness (except in adults with overweight and class II or III obesity). Meeting the sleep duration recommendation was negatively associated with waist circumference, as well as

diastolic and systolic blood pressure, in adults with class II or III obesity.

Associations with self-reported health

Table 4 and Supplemental Table 7 display the odds of self-reported presence of a chronic condition and excellent or very good self-perceived general and mental health by meeting the 24-H Guidelines recommendations across BMI classes.

Meeting one, two or all three of the guideline recommendations was significantly associated with increased odds of reporting very good or excellent self-perceived general health among adults with normal weight, overweight and class I obesity (except all three in obesity class I). Meeting two out of three guideline recommendations was significantly associated with reduced odds of reporting very good or excellent self-perceived general health among adults with class II or III obesity.

Supplemental Table 7

Associations between meeting specific and multiple recommendations within the Canadian 24-Hour Movement Guidelines for Adults and odds of having a poor health outcome by body mass index class

	One or more chronic conditions			Excellent or very good self-perceived general health			Excellent or very good self-perceived mental health		
		95% Confidence interval			95% Confidence interval			95% Confidence interval	
Recommendation	Odds ratio	Lower	Upper	Odds ratio	Lower	Upper	Odds ratio	Lower	Upper
Specific combinations of movement behaviours									
MVPA, SB and sleep									
Normal weight	0.72	0.45	1.15	2.09	1.25	3.52	1.45	0.85	2.46
Overweight	0.41	0.25	0.66	1.57	0.97	2.54	1.29	0.59	2.80
Obesity class I	0.59	0.18	1.88	1.13	0.43	2.92	1.03	0.37	2.88
Obesity classes II and III	0.32	0.04	2.31	2.96	0.55	16.01	2.85	0.38	21.28
MVPA and SB only									
Normal weight	0.99	0.25	3.86	0.72	0.24	2.15	0.67	0.22	2.05
Overweight	0.84	0.43	1.66	1.66	0.86	3.20	0.62	0.30	1.29
Obesity class I	1.11	0.26	4.77	2.01	0.66	6.12	0.55	0.11	2.67
Obesity classes II and III	F	…	…	F	…	…	F	…	…
MVPA and sleep only									
Normal weight	0.74	0.51	1.07	1.34	1.02	1.76	0.98	0.71	1.36
Overweight	0.97	0.63	1.49	1.20	0.86	1.69	1.28	0.87	1.89
Obesity class I	1.21	0.76	1.93	1.74	1.06	2.86	1.54	0.78	3.03
Obesity classes II and III	1.20	0.48	3.02	0.33	0.11	1.03	1.00	0.32	3.13
SB and sleep only									
Normal weight	0.84	0.41	1.74	1.47	0.84	2.55	1.09	0.47	2.50
Overweight	1.10	0.60	2.01	0.99	0.53	1.85	0.89	0.45	1.76
Obesity class I	0.27	0.13	0.54	1.38	0.47	4.03	1.20	0.40	3.63
Obesity classes II and III	1.94	0.39	9.56	0.56	0.14	2.23	0.73	0.17	3.11
MVPA only									
Normal weight	1.30	0.64	2.64	0.86	0.56	1.32	0.96	0.61	1.53
Overweight	1.10	0.71	1.71	0.86	0.56	1.32	0.77	0.52	1.14
Obesity class I	0.81	0.33	2.01	0.90	0.44	1.85	0.67	0.32	1.40
Obesity classes II and III	0.33	0.09	1.20	0.49	0.11	2.16	1.02	0.23	4.42
SB only									
Normal weight	1.22	0.55	2.67	0.69	0.28	1.68	0.56	0.24	1.27
Overweight	0.71	0.36	1.43	0.81	0.39	1.71	0.85	0.36	2.00
Obesity class I	0.93	0.34	2.60	0.36	0.07	1.88	0.30	0.07	1.22
Obesity classes II and III	0.35	0.06	2.17	0.74	0.07	7.79	0.71	0.03	19.05
Sleep only									
Normal weight	0.77	0.54	1.10	0.99	0.74	1.32	1.10	0.76	1.57
Overweight	1.01	0.74	1.38	1.24	0.95	1.60	1.27	0.94	1.73
Obesity class I	0.83	0.52	1.34	1.14	0.82	1.58	1.60	1.03	2.49
Obesity classes II and III	0.69	0.39	1.21	1.17	0.63	2.16	0.94	0.53	1.67
None									
Normal weight	2.08	1.38	3.13	0.50	0.33	0.74	0.87	0.59	1.29
Overweight	1.40	0.93	2.11	0.52	0.39	0.69	0.74	0.49	1.10
Obesity class I	2.03	1.32	3.14	0.46	0.31	0.69	0.63	0.41	0.97
Obesity classes II and III	2.19	1.16	4.13	1.53	0.83	2.81	1.01	0.56	1.82

… not applicable

F too unreliable to be published

Notes: MVPA = moderate-to-vigorous physical activity; SB = sedentary behaviour. All models were adjusted for age, sex, household income quintile, ethnicity, data collection season, smoking status, fruit and vegetable intake, and soft drink consumption. The reference group is "not meeting recommendation" for all models.

Source: Canadian Health Measures Survey cycles 1 to 4.

Meeting all three of the recommendations was significantly associated with reduced odds of having one or more chronic conditions among adults with normal weight and overweight, while reduced odds were observed for meeting two out of three recommendations among adults with normal weight and class I obesity.

Meeting the sleep duration recommendation was significantly associated with reduced odds of having one or more chronic conditions (normal and obesity class I) and increased odds of reporting very good or excellent self-perceived general health (except class II or III obesity) and mental health (overweight and class I obesity). Meeting the MVPA recommendation was associated with increased odds of reporting very good or excellent self-perceived general health among adults with normal weight and class I obesity. Meeting the sedentary behaviour recommendation reduced the odds of having one or more chronic conditions (overweight and class I obesity) and increased the odds of reporting very good or excellent general health in adults with normal weight.

To verify the impact of removing respondents with severe mobility issues from the analysis, a sensitivity analysis was conducted. When those with severe mobility issues were added in the analysis, negligible changes in associations with self-reported health and physical health indicators were identified.

Discussion

The aim of the present study was to estimate the prevalence of Canadian adults meeting the 24-H Guidelines and each recommendation in the guidelines by BMI class. Furthermore, this study aimed to examine the associations between meeting individual and various combinations of the recommendations in the 24-H Guidelines with health indicators. Two-thirds of Canadian adults have overweight or obesity,[14] and excess weight is associated with a myriad of negative health consequences.[17] The present study, therefore, contributes important new information on how the prevalence of Canadian adults meeting the 24-H Guidelines varies by BMI class.

The findings show that the prevalence of Canadian adults meeting the MVPA (150 minutes or more per week) or sedentary behaviour (three hours or less of recreational screen time per day and nine hours or less of total sedentary time per day) recommendations is low, particularly in adults with overweight and obesity compared with those with normal weight. The results corroborate those from previous studies showing that physical inactivity and sedentary time increase across BMI classes.[10,13,36-39] The association between obesity and physical inactivity has previously been identified as bidirectional, where physical inactivity can be a risk factor for obesity or a consequence of excess weight.[40] However, the available evidence does not suggest a causal relationship between sedentary behaviours and obesity in adults.[41] Only breaks in sedentary time seem beneficial for BMI.[41] Considering that half of the population or less meets the MVPA and sedentary behaviour recommendations, studies have identified alternative approaches to improve movement profiles,[10,36,42] such as breaking up sedentary time and increasing light-intensity physical activity.

The present study also observed that the prevalence of Canadian adults meeting the sleep duration recommendation (over 63%) is higher, compared with the MVPA and sedentary behaviour recommendations. Sleep duration in the CHMS is self-reported by respondents, and future studies using device-based measures of sleep are needed to better capture the sleep characteristics of Canadians at the population level.[43] No significant difference in the percentage of Canadian adults meeting the sleep duration recommendation was noted across BMI classes, while both short and long sleep durations have been associated with higher BMI in epidemiological studies.[10-12] However, evidence on the association between obesity and sleep duration in adults is inconsistent.[44] These discrepancies across studies may be explained by differences in sleep and obesity measurements, in different adjustments for potential confounders, and in population characteristics (e.g., age, socioeconomic status, depression). This further highlights the need to have more studies with device measures of sleep in people with obesity.

To better support the importance of the new 24-H Guideline recommendations, studying the associations between recommendations and health indicators is essential, as well as knowing their direction and strength in different subgroups. Although the number of significant associations for physical health indicators in the normal weight class is higher compared with the overweight and obesity classes, the pattern of associations is similar across BMI classes and reinforces the importance of promoting healthy behaviours regardless of body size.

The results also show that meeting all three or two out of three recommendations is associated with lower waist circumference in almost all BMI classes, and higher aerobic physical fitness, except in obesity classes II and III. Given the literature on the topic[36,42] and the present results, it seems obvious that MVPA is the main contributor of these benefits rather than sleep and consequently should be favoured to improve aerobic physical fitness and waist circumference. The absence of association between MVPA, sedentary behaviour and aerobic fitness in adults with class II or III obesity could be explained by statistical power issues, the step aerobic test used not being adapted for populations with severe obesity or the absence of CSEP-PATH equations validated in this population.

Concerning blood pressure, the findings of this study are consistent with a previous study in adults that used compositional data analysis showing no association between MVPA and blood pressure.[45] However, given physical activity is well known to improve blood pressure in normal and hypertensive people,[46] the low number of associations found for these outcomes in the present results could be explained in part by the good average blood pressure across the different groups and low variability within groups. Additional studies using a

longitudinal design and considering these variables are needed to better elucidate this relationship, especially among people with severe obesity, where a negative association was found.

Results regarding self-reported health outcomes showed that meeting all three or two of the three recommendations was significantly associated with increased odds of reporting very good or excellent self-perceived general health among adults with normal weight, overweight and class I obesity (except all three in class I obesity). Inverse results were found for these variables among adults with class II or III obesity, and this should be further explored in future studies. Several factors such as statistical power issues attributable to dichotomization or the prominent association between severe obesity and mood disorder could explain these results.[47]

In addition, the important role of sleep in the 24-hour movement continuum was illustrated by the results showing that meeting the sleep duration recommendation was associated with lower odds of having one or more chronic conditions and poor self-perceived general and mental health, except in obesity classes II and III. Excluding mental health, where systematic reviews are lacking or find no significant association with incident depression, the available evidence supports the results of the present study by showing positive associations between meeting sleep duration recommendations and reduction in the incidence of several cardiometabolic diseases.[12] In obesity classes II and III, the absence of significant association could be explained by a lack of statistical power or sleep being less of an issue than other factors in this population for perceiving their health to be very good or excellent.

Of note, few significant associations were observed between meeting recommendations and self-perceived mental health. Cross-sectional studies on the association of physical activity, sedentary time and sleep time with mental health showed mixed and divergent results.[36,48,49] Systematic reviews have also underlined a lack of evidence on this topic[12,50,51] However, the high percentage of respondents reporting very good or excellent mental health across all BMI classes (over 68%), the potential low variability of self-reported mental health, and the type of analysis and variables (categorical) used could partially explain these results.

The main strengths of this study are the large representative Canadian sample (excluding people with severe mobility limitations) and the objective assessment of MVPA and sedentary time across obesity classes. Nonetheless, some limitations should be noted to better interpret the results. Firstly, the cross-sectional design prevents causal inferences between behaviours, BMI and health indicators. Secondly, sleep and screen time are self-reported, resulting in potential recall bias and measurement error. Another limitation concerning the generalization of the results is the assessment period (2007 to 2015). However, sleep questions are not available in the more recent CHMS cycles. In addition, only one cpm cut-off was used to classify time spent sedentary and in MVPA among respondents, when energy cost per cpm differs between people of different BMIs, and consequently could lead to disparities in movement intensity classification across BMI classes. The reduced efficiency of gait among individuals with overweight and obesity means that they expend greater energy at lower intensities of movement (e.g., light-intensity physical activity).[52] Future research on the relative importance of light-intensity movement for health, particularly among individuals with obesity, is needed to better understand these issues. Finally, although several potential covariates were used to adjust associations, other variables not measured could have influenced associations and resulted in residual confounding (e.g., medication, environmental factors).

Conclusion

The prevalence of Canadian adults meeting all three movement behaviour recommendations (MVPA, sedentary behaviour and sleep duration) is low, especially in adults with obesity. Most beneficial associations between the 24-H Guidelines recommendations and health indicators—particularly waist circumference, aerobic physical fitness, self-perceived general health and self-reported chronic conditions—were observed among all BMI classes. Thus, all adults would benefit from meeting the 24-H Guidelines, regardless of weight status. This further supports the importance of promoting movement behaviour changes for all, rather than specifically for people with obesity. This public health approach is also well aligned with a desire to reduce stigma, weight bias and discrimination towards people with obesity.[19] Future studies should use a longitudinal design, objective measures of sleep, and validated tools and equations for physical activity and sedentary time among people with obesity to better understand associations. Additional studies in people with severe obesity are also required to clarify findings.

Declarations

Ethics approval and consent to participate

Approval for conducting the CHMS was obtained from Health Canada's Research Ethics Board. Participants provided consent to participate.

Disclaimer

The content and views expressed in this article are those of the authors and do not necessarily reflect those of the Government of Canada.

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