Sporadic and Bouted Physical Activity and the Metabolic Syndrome in Adults

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ABSTRACT

CLARKE, J., and I. JANSSEN. Sporadic and Bouted Physical Activity and the Metabolic Syndrome in Adults. *Med. Sci. Sports Exerc.*, Vol. 46, No. 1, pp. 76–83, 2014. **Purpose**: Physical activity guidelines recommend that adults accumulate at least 150 min of moderate-to-vigorous physical activity (MVPA) per week in bouts of at least 10 min. However, sporadic MVPA contributes significantly to total physical activity and may also affect health. The study objective was to determine, within adults age 18 to 64 yr, whether MVPA accumulated in bouts is more strongly associated with metabolic syndrome (MetS) than an equivalent volume of MVPA accumulated sporadically. **Methods**: The study sample included 1119 adults age 18 to 64 yr from the 2007–2009 Canadian Health Measures Survey, a nationally representative cross-sectional study. The energy expenditure from bouted (at least 10 consecutive minutes) and sporadic (<10 consecutive minutes) MVPA was measured for 7 d using Actical accelerometers. The presence of MetS was determined using established criteria. Associations were examined using logistic regression and controlled for covariates (age, sex, education, diet, and smoking). **Results**: After adjusting for the covariates and each other, bouted and sporadic MVPA were independently associated with the MetS. For each additional MET-hour per week of bouted MVPA, the relative odds of the MetS decreased by 9% (95% confidence interval, 3%–14%). For each additional MET-hour per week of sporadic MVPA, the relative odds of the MetS decreased by 11% (5%–16%). Overlapping confidence interval indicates no difference in the effect estimates for bouted and sporadic MVPA. Secondary analyses revealed that small bursts of sporadic MVPA (1–3 min) were meaningful when predicting the MetS. **Conclusion**: Within this representative sample of Canadian adults, sporadic MVPA was associated with the MetS to a similar order of magnitude as an equivalent volume of bouted MVPA. **Key Words:** CARDIOMETABOLIC RISK FACTORS, ACCELEROMETER, EXERCISE, GUIDELINES

EPIDEMIOLOGY

The role that regular moderate-to-vigorous physical activity (MVPA) has in the prevention of several chronic diseases is well accepted. A recent systematic review concluded that there is strong evidence that regular physical activity is important in the primary prevention of coronary artery disease, stroke, hypertension, colon cancer, breast cancer, type 2 diabetes, and osteoporosis (38).

The current physical activity guidelines of the World Health Organization (40) and several countries (3,12,35) recommend that adults accumulate at least 150 min of MVPA per week in bouts of at least 10 min (3,12,35,40). The notion that MVPA can be accumulated in brief, 10-minute bouts is based on evidence that a few short bouts of MVPA have comparable effects on fitness and health as a single longer bout (11,18,24,26,27). Although short and long bouts of MVPA are known to have important health benefits, there is currently limited evidence as to whether MVPA accumulated sporadically (in less than 10 consecutive minutes) has health benefits. The study of sporadic MVPA is important because it contributes significantly to total daily energy expenditure and therefore may play an important role in health (21,34,35). A recent study found that sporadic MVPA was associated with several cardiovascular risk factors and that, from a statistical standpoint, the associations for sporadic MVPA were similar to those for bouted MVPA (15). Although this and other (11,22,26,30,33) evidence provides support for the notion that sporadic MVPA benefits health, what remains uncertain is whether comparable volumes of sporadic MVPA and bouted MVPA influence health outcomes to a similar order of magnitude.

The purpose of this study was to determine whether bouted MVPA is more strongly associated with cardiometabolic risk factors, specifically with the metabolic syndrome (MetS), than an equivalent volume of sporadic MVPA. Secondary analyses assessed the duration of sporadic MVPA needed to influence the MetS. MetS is a highly prevalent (29) clustering of cardiometabolic risk factors that increase the relative risk of the developing cardiovascular disease and type 2 diabetes by approximately 50% (1,20).

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We have the opportunity to assess these associations within a large and representative sample of Canadian adults.

METHODS

Data source. The study is based on cycle 1 of the Canadian Health Measures Survey (CHMS). The CHMS covers the Canadian population age 6 to 79 yr living in private dwellings. The present study is limited to adults age 18–64 yr. Residents of Indian Reserves or Crown lands, institutions, certain remote regions, and full-time members of the Canadian Forces were excluded. Approximately 96% of the Canadian population is represented (14,31). Data were collected from March 2007 to February 2009. The survey consisted of two parts: 1) an in-home interview that collected information on sociodemographic characteristics and health behaviors and 2) a subsequent visit to a mobile clinic for a series of physical measurements, including anthropometric and fitness tests, and the collection of blood samples. Of the households selected for the survey, 69.6% provided the sex and date of birth of all household members. Within each responding household, one or two members were then selected to participate. Of those selected, 88.3% completed the household questionnaire, and 84.9% of those participated in the visit to the mobile clinic. The final response rate after adjusting for the sampling strategy was 51.7% (31). The sample for this article is based on 1119 respondents age 18–64 yr with valid physical activity and MetS data. Ethics approval for the CHMS was obtained from Health Canada's Research Ethics Board (10,31). Informed written consent was obtained.

Physical activity. At the mobile clinic, an Actical accelerometer was provided to ambulatory participants to wear on an elasticized belt over the right hip during all waking hours for 1 wk (31). Accelerometers were initialized to begin collection at midnight after the clinic visit and were mailed back to Statistics Canada after the 7-d collection period (31).

The Actical accelerometer measures the acceleration of movement in all directions (omnidirectional); movement is captured and recorded as a digitized value that is summed over 1-min intervals (epoch), resulting in 10,080 activity count per minute (cpm) values. Accelerometer data reduction followed published guidelines to identify and remove invalid data (6,7,36). Total daily accelerometer wear time was determined by identifying nonwear time and subtracting it from 24 h. Nonwear time was defined as periods of at least 60 consecutive minutes of zero counts, with an allowance for up to 2 min of counts between 0 and 100 (6,7,36). A nonwear period of 90 min was also explored following results of a recent validation study suggesting that a 90-min window is more appropriate in accurately identifying nonwear time (5). As the nonwear period of 90 min had no effect on the findings, a 60-min period was chosen to align with previously published accelerometer research from the CHMS and the National Health and Nutrition Examination Survey in the United States (7,36). A valid day was defined as having at least 10 h of wear time; a valid person was defined as having at least four valid days of data (6,7,36). Only participants with at least four valid days of data were included in this article.

A cut-point of ≥1535 cpm was used to denote epoch values of at least a moderate intensity (8). For each epoch above this value, the regression equation developed by Heil (17) was used to estimate energy expenditure ($kcal \cdot kg^{-1} \cdot min^{-1}$) as follows: activity energy expenditure ($kcal \cdot kg^{-1} \cdot min^{-1}$) = 0.02663 + (0.00001107 × cpm). The resulting value was converted to METs by multiplying by 60 and then adding 1 MET to account for resting energy expenditure, as the Heil equation predicts energy expenditure above rest. We chose to express MVPA in METs because this allowed us to merge the moderate and vigorous activity minutes and, when doing so, to account for the fact that more energy is expended for each minute of vigorous activity than for each minute of moderate activity. For each individual in the study, the total weekly MET-hours was determined by summing the MET-hour values for all bouted MVPA (i.e., MVPA accumulated in at least 10-min bouts) and sporadic MVPA (i.e., MVPA accumulated in period of 9 min or less) epochs. A bout of MVPA was defined as a period of at least 10 consecutive minutes above the moderate-intensity cut-point; a bout continued until 80% (i.e., 8 out of 10 min) was no longer above the cut-point. Because not all participants had seven valid days of data, each total was divided by the number of valid days to obtain a daily average, and then multiplied by 7 to obtain a weekly total. Thus, the final derived physical activity variables for each participant consisted of MET-hours per week of bouted MVPA and MET-hours per week of sporadic MVPA. Because this was an observational study, all participants had a bouted MVPA and a sporadic MVPA value, and these were not mutually exclusive groups.

Because of the error involved in converting accelerometer counts to energy expenditure, we also considered MVPA in minutes per week in addition to MET-hours per week. For the calculations, we assumed that the energy expended for each minute of vigorous intensity activity would be twice that expended for moderate-intensity activity (12). Thus, total weekly minutes of MVPA was obtained by multiplying the vigorous intensity minutes by two and adding them to moderate-intensity minutes. Because the results for the analyses based on MVPA in minutes per week were comparable with those for MVPA in MET-hours per week, we have only presented the findings on the basis of the latter MVPA variable throughout the article.

MetS. MetS was defined on the basis of the 2009 Joint Interim Statement (1) and was present if three or more of the following conditions were met: high blood pressure (≥130/85 mm Hg) or drug treatment; high triglycerides (≥1.7 $mmol \cdot L^{-1}$ for men and women) or drug treatment; low HDL cholesterol (<1.0 $mmol \cdot L^{-1}$ for men, <1.3 $mmol \cdot L^{-1}$ for women) or drug treatment; high fasting blood glucose

(≥5.6 mmol·L^{-1}) or drug treatment; and high waist circumference (≥102 cm for men, ≥88 cm for women). Lower waist circumference cutoffs have been proposed in the definition of MetS; however, there is limited evidence supporting either cutoffs (1,29). The cutoffs used in the present analysis were chosen because they are those currently recommended by Health Canada (16).

Measurement procedures for the MetS components are described briefly here. Greater detail is provided elsewhere (2,31). Waist circumference was measured to the nearest 0.1 cm at the midpoint between the last floating rib and the top of the iliac crest, at the end of a normal expiration, using a Gulick tape measure. Resting blood pressure was measured electronically using a BPTruTM BP-300 device (BpTRU Medical Devices Ltd., Coquitlam, British Columbia). After resting quietly for 5 min, a minimum of six measurements was then taken automatically, 1 min apart, and the average systolic and diastolic blood pressure was determined using the last five of the six measurements. Venous blood samples were collected after a 10-h fasting period: glucose levels were measured in plasma, whereas triglycerides and HDL cholesterol were measured in serum. Blood samples were analyzed at the Health Canada Laboratory (Bureau of Nutritional Sciences, Nutrition Research Division). Glucose, HDL cholesterol, and triglycerides were all measured on the Vitros 5,1FS (Ortho Clinical Diagnostics). Results below the limit of detection were included in analysis by imputing a value of the limit of detection divided by 2. For medication use, respondents provided all prescription and over-the-counter products taken in the past month (32). Drug identification numbers were coded using the Anatomical Therapeutic Chemical Classification System (39).

Covariates. Covariates include age, sex, education (postsecondary graduate, yes/no), smoking status (current smoker or nonsmoker), diet, health utility index (HUI), and total accelerometer wear time. Dietary information was obtained through a food frequency questionnaire (32). Principal component analysis was used to create a single diet quality index variable on the basis of the yearly frequency of consumption of the following food items: brown bread, fruit, lettuce, spinach, salt water and fresh water fish, shellfish, and nuts. These food items were identified as being part of a healthy diet and are known to have a positive association with the MetS risk factors (20). Therefore, the diet index was included in the regression models as a means of adjusting for a good diet, and higher scores indicated a more healthy diet. The HUI is a summary score of an individual's overall functional health based on vision, hearing, speech, mobility, dexterity, cognition, emotion, and pain and discomfort, which are attributes that are associated with physical activity and the MetS. The index ranges in value from −0.360 (a state considered worse than death) to 1 (perfect health). More information on the index has been published elsewhere (13). Finally, total accelerometer wear time was included as a covariate to account for differences in wear time. Time spent in light physical activity and time spent sedentary were also considered as possible covariates; however, preliminary analysis indicated that neither variables were related to the MetS, and they were therefore not included as covariates.

Statistical analysis. Conventional descriptive statistics were used to describe the sample. Partial correlations (adjusted for age and sex) were used to examine relations between the MVPA variables. Relations between the MVPA and MetS variables were determined using logistic regression. An initial model (model 1) that included all covariates was run separately for the sporadic and bouted MVPA variable. A second model (model 2) that included both the sporadic and bouted MVPA variables and the covariates was run so that the independent effects of sporadic and bouted MVPA could be examined. The MVPA variables were included in the logistic regression models as continuous variables; thus, the odds ratios (OR) and associated 95% confidence intervals (CI) are expressed per each 1 MET-hour per week difference in MVPA. The variance inflation factors were calculated for each of the covariates in model 2 to determine whether multicollinearity was an issue (25).

In a second set of analyses, participants were divided into three groups for both sporadic and bouted MVPA using cut-points that are equivalent to the physical activity guidelines: inactive (0–249 MET·min), somewhat active (250–499 MET·min or meeting 50% of the guideline), and active (≥500 MET·min or meeting 100% of the guideline). The grouped variable was included in the logistic regression models, and OR and associated 95% CI are expressed using the inactive group as the referent. Finally, the c-statistic was determined for each logistic regression model to assess the overall fit of the model. The c-statistic is identical with the area under the receiver operating characteristic curve, with values ranging from 0.5 (no better discrimination than chance alone) to 1.0 (perfect discrimination).

In secondary analyses, different lengths of sporadic MVPA were assessed to determine the minimum duration of sporadic MVPA needed to influence the MetS. Sporadic MVPA in lengths of 7–9, 4–9, and 1–9 min was determined. In a series of logistic regression models, we considered whether adding shorter sessions of sporadic MVPA to the sporadic MVPA variable resulted in a model that was better able to predict the MetS (e.g., did the volume of sporadic MVPA accumulated in 1–9 min predict MetS better than sporadic MVPA accumulated in 4–9 min). The Akaike information criterion (AIC) was calculated to compare the goodness of fit between the regression models. A difference in AIC values of between 2 and 7 indicates a moderate difference in fit of the models, whereas a difference of 7 or more indicates a large difference in model fit (4). The Akaike weight was calculated to indicate the probability that each regression model was the best choice among the set of candidate models based on model fit (4).

All analyses were completed using SAS v9.2 and SUDAAN v10. All results were weighted using the activity monitor subsample weights (31). SE, coefficients of variation,

and 95% CI were calculated using the bootstrap technique. The CHMS study design requires that 11 degrees of freedom be specified in the software (31), and this limits the number of variables that can be included in the regression models to 11.

RESULTS

Descriptive characteristics of the 1119 participants are presented in Table 1. The mean age of the sample was 41.1 yr, and 49.1% were male. Approximately 12.7% had high fasting glucose, 18.9% had high blood pressure, 22.9% had high triglycerides, 29.5% had a high waist circumference, 31.2% had low HDL cholesterol, and 15.2% had MetS.

The average total, bouted, and sporadic MVPA energy expenditure values were 13.5, 6.4, and 7.2 MET·h·wk^{-1}, respectively (Table 1). Partial correlation analysis showed that total MVPA was highly correlated with bouted MVPA ($r = 0.91$, $P < 0.0001$), but less so with sporadic MVPA ($r = 0.63$, $P < 0.0001$). Bouted MVPA was modestly correlated with sporadic MVPA ($r = 0.25$, $P < 0.0001$).

The OR (95% CI) for MetS and its component risk factors per each 1 MET·h·wk^{-1} difference in total, bouted, and sporadic MVPA are presented in Table 2. After adjusting for the covariates (model 1), total, bouted, and sporadic MVPA were all related to the MetS. A comparison of the c-statistic values for model 1 indicates that the bouted and sporadic MVPA measures had a similar ability to distinguish between participants with and without MetS. The findings for model 2 indicate that bouted and sporadic MVPA were also related to MetS after adjusting for each other. The OR of 0.91 (0.86–0.97) for bouted MVPA indicates that for each additional MET-hour per week of bouted MVPA, the relative odds of the MetS decreased by 9%. The OR of 0.89 (0.84–0.95) for sporadic MVPA indicates that for each additional MET-hour per week of sporadic MVPA, the relative odds of the MetS decreased by 11%. The 95% CI for the effect estimates for the bouted and sporadic MVPA variables overlapped, indicating that these estimates were not statistically different from each other. The variance inflation factors for sporadic (1.23) and bouted (1.11) were both <5, implying that multicollinearity was not an issue for the primary exposure variables. The relation between

TABLE 1. Participant characteristics (mean ± SE or percentage).

Variable	Total (n = 1119)	Males (n = 532)	Females (n = 587)
Age (yr)	41.1 ± 0.4	40.6 ± 0.7	41.6 ± 0.7
Sex (%)		49.1	50.9
Race (%)			
White	81.7	80.6	82.8
Other	18.3 E	19.4 E	17.2 E
Current daily smoker (%)			
Yes	18.1	20.1	16.2
No	81.9	79.9	83.8
Postsecondary graduation (%)			
Yes	65.0	64.6	65.3
No	35.0	35.4	34.7
Income quartile (%)			
Lower income quartile	18.7	16.0	21.3
Lower-middle income quartile	22.3	21.9	22.6
Upper-middle income quartile	25.5	24.7	26.3
Upper income quartile	28.9	34.5	23.4
No income reported	4.7	2.9 E	6.5 E[a]
Physical activity			
Total MVPA (total MET·h·wk^{-1})	13.5 ± 0.9	14.8 ± 1.0	12.3 ± 1.0[a]
Bouted MVPA (total MET·h·wk^{-1})	6.4 ± 0.6	6.5 ± 0.7	6.4 ± 0.7
Sporadic MVPA (total MET·h·wk^{-1})	7.2 ± 0.4	8.6 ± 0.4	6.1 ± 0.5[a]
Cardiometabolic risk factors			
Waist circumference			
Mean (cm)	89.1 ± 0.8	93.4 ± 0.9	84.9 ± 1.3[a]
High waist circumference (%)	29.5	23.9	35.0
Blood pressure			
Mean systolic (mm Hg)	109 ± 1	112 ± 1	106 ± 1[a]
Mean diastolic (mm Hg)	71 ± 1	73 ± 1	68 ± 1[a]
High blood pressure (%)	18.9	20.0	17.8
HDL cholesterol			
Mean (mmol·L^{-1})	1.3 ± 0.0	1.2 ± 0.0	1.5 ± 0.0[a]
Low HDL cholesterol (%)	31.2	25.4	36.8[a]
Triglycerides			
Mean (mmol·L^{-1})	1.28 ± 0.04	1.39 ± 0.05	1.18 ± 0.05[a]
High triglycerides (%)	22.9	27.1	18.9[a]
Fasting glucose			
Mean (mmol·L^{-1})	5.01 ± 0.03	5.16 ± 0.04	4.86 ± 0.03[a]
High fasting glucose (%)	12.7	16.6	9.0[a]
MetS (%)	15.2	13.1 E	17.3

E Interpret with caution (coefficient of variation between 16.6% and 33.3%).
[a]Significantly different from estimate for males ($P < 0.05$).

TABLE 2. OR (95% CI) for MetS and its component risk factors according to total, bouted, and sporadic MVPA (MET-hours per week).

Condition	Physical Activity (MET-Hours per Week)	Model 1[a]		Model 2[b]	
		OR[c] (95% CI)	C-statistic	OR[c] (95% CI)	C-statistic
MetS	Total (sporadic + bouts)	0.90 (0.86–0.94)	0.79		
	Bouts	0.89 (0.84–0.95)	0.77	0.91 (0.86–0.97)	0.79
	Sporadic	0.86 (0.81–0.92)	0.78	0.89 (0.84–0.95)	0.79
High blood pressure	Total (sporadic + bouts)	1.00 (0.96–1.03)	0.80		
	Bouts	1.00 (0.95–1.04)	0.80	1.00 (0.95–1.05)	0.80
	Sporadic	0.99 (0.91–1.07)	0.80	0.99 (0.91–1.08)	0.80
High WC	Total (sporadic + bouts)	0.96 (0.94–0.98)	0.73		
	Bouts	0.95 (0.93–0.98)	0.72	0.96 (0.94–0.98)	0.73
	Sporadic	0.95 (0.90–1.00)	0.71	0.96 (0.91–1.02)	0.73
High glucose	Total (sporadic + bouts)	0.97 (0.96–0.99)	0.77		
	Bouts	0.96 (0.93–0.99)	0.77	0.96 (0.93–1.00)	0.77
	Sporadic	0.98 (0.94–1.02)	0.76	1.07 (1.04–1.11)	0.77
High triglycerides	Total (sporadic + bouts)	0.97 (0.94–1.01)	0.69		
	Bouts	0.97 (0.92–1.03)	0.68	0.98 (0.92–1.04)	0.69
	Sporadic	0.96 (0.91–1.01)	0.69	0.97 (0.91–1.02)	0.69
Low HDL	Total (sporadic + bouts)	0.98 (0.96–1.00)	0.61		
	Bouts	0.98 (0.95–1.00)	0.60	0.98 (0.96–1.00)	0.61
	Sporadic	0.97 (0.93–1.01)	0.61	0.97 (0.94–1.01)	0.61

[a]Model 1: adjusted for age, sex, education, diet, smoking status, total accelerometer wear time, and HUI.
[b]Model 2: adjusted for age, sex, education, diet, smoking status, total accelerometer wear time, HUI, and the other physical activity variables (bouts or sporadic MVPA).
[c]OR presented per 1 unit change in MET-hours per week of physical activity.

sporadic and bouted MVPA with the MetS, based on model 2 in Table 2, are further illustrated in Figure 1, with MVPA expressed in MET-minutes per week.

The associations between total, bouted, and sporadic MVPA with the individual components of the MetS were not as strong or consistent as they were for the MetS *per se* (Table 2). Irrespective of the MetS component, the c-statistic values for the models that included bouted or sporadic MVPA were comparable with each other. Furthermore, the 95% CI for the effect estimates for the bouted and sporadic MVPA variables overlapped.

The OR (95% CI) for MetS according to three different levels of sporadic and bouted MVPA is shown in Table 3. After adjusting for covariates and bouted MVPA, participants who were active (e.g., ≥500 MET·min·wk^{-1}) based on their sporadic MVPA were only 0.36 (0.15–0.86) times as likely to have the MetS by comparison with participants who were inactive (e.g., <250 MET·min·wk^{-1}) based on their sporadic MVPA. Similarly, after adjusting for covariates and sporadic MVPA, participants who were active based on their bouted MVPA were only 0.32 (0.13–0.80) times as likely to have the MetS by comparison with participants who were inactive based on their bouted MVPA. A comparison of the c-statistic values for model 2 indicates that the bouted and sporadic MVPA measures had a similar ability to distinguish between participants with and without MetS.

The OR (95% CI) for MetS according to bouted MVPA and different durations of sporadic MVPA are presented in Table 4. As shown in models 2 to 4, sporadic MVPA accumulated in 7–9, 4–9, and 1–9 min predicted the MetS independent of bouted MVPA and the covariates. The AIC-related values comparing the goodness of fit between regression models are also included in Table 4. Sporadic MVPA of 1 to 9 min (model 4) had the lowest AIC value, and there was a 95.9% probability that this model provided the best fit among all the models. Thus, even the shorter bursts of sporadic MVPA (e.g., 1–3 min) were relevant in the prediction of the MetS.

DISCUSSION

The purpose of this study was to determine whether equivalent amounts of bouted and sporadic MVPA are associated with the MetS to a similar order of magnitude. The key finding was that for every additional weekly MET-hour of MVPA, which is equivalent to approximately 20 min of moderate or 10 min of vigorous activity, the odds of MetS were approximately 10% lower, regardless of whether the MVPA was accumulated in bouts or sporadically (Table 2). This finding suggests that the total amount of MVPA accumulated throughout the week is important, but that the nature

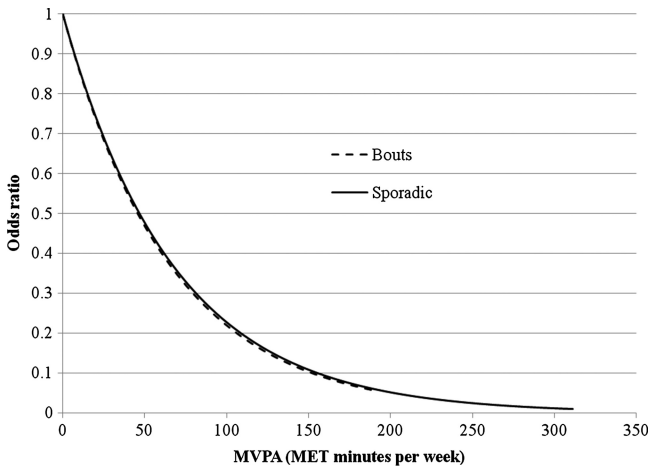

FIGURE 1—Association between sporadic and bouted MVPA and the MetS. OR is plotted from 0 (referent) to values that correspond to the 98th percentile of the sample for MVPA (MET-minutes per week). OR was adjusted for age, sex, education, diet, smoking, total accelerometer wear time, HUI, and the other physical activity variables (sporadic or bouted).

TABLE 3. OR (95% CI) for MetS according to bouted and sporadic MVPA levels.

Condition	Model 1[a]		Model 2[b]	
	OR (95% CI)	C-statistic	OR (95% CI)	C-statistic
Sporadic MVPA				
Inactive (referent)	1.00	0.77	1.00	0.78
Somewhat active	0.73 (0.35–1.52)		0.85 (0.44–1.64)	
Active	0.27 (0.11–0.65)[c,d]		0.36 (0.15–0.86)[c,d]	
Bouted MVPA				
Inactive (referent)	1.00	0.77	1.00	0.79
Somewhat active	0.32 (0.12–0.86)[c]		0.39 (0.15–1.02)	
Active	0.25 (0.11–0.58)[c]		0.32 (0.13–0.80)[c]	

[a]Estimates adjusted for age, sex, education, diet, smoking status, total accelerometer wear time, and HUI.
[b]Estimates adjusted for age, sex, education, diet, smoking status, total accelerometer wear time, HUI, and the other physical activity variables (bouts or sporadic).
[c]Significantly different from referent ($P < 0.05$).
[d]Significantly different from "somewhat active" group ($P < 0.05$).

in which that MVPA is accumulated (e.g., sporadically or in bouts) is not. Secondary analyses confirmed that even small bursts of sporadic MVPA (1–3 min) were meaningful when predicting the MetS (Table 4).

Recent work has suggested that sporadic physical activity contributes significantly to total daily energy expenditure and therefore has the potential to play an important role in health (21,34,35). The advent of accelerometers in physical activity assessment allows for sporadic physical activity levels to be measured accurately in natural settings and permits the independent effects of sporadic and bouted MVPA on health to be assessed. Previous studies have found associations between bouted (33) and sporadic (15,22,30,33) MVPA, as measured by accelerometry, and various cardiometabolic risk factors. Strath et al. (33) used accelerometer data from the 2003–2004 US National Health and Nutrition Examination Survey to compare the relations between bouted and sporadic MVPA and markers of obesity in adults. The volumes of both bouted and sporadic MVPA were negatively associated with waist circumference, but the association was significantly stronger for bouted MVPA. However, consistent with the present study, there was no difference in the association with waist circumference between bouted and sporadic MVPA, after the authors controlled for physical activity intensity. McGuire and Ross (22) collected accelerometer data from a sample of 126 obese middle-age adults who did not engage in bouted MVPA. They found that sporadic MVPA was negatively associated with visceral adipose tissue but not cardiometabolic risk factors such as glucose and insulin resistance (23). Also consistent with the present study are recent findings by Glazer et al. (15), who collected accelerometer data from a sample of the Third Generation Cohort of the Framingham Heart Study. They found that there was no difference in the strength of associations with cardiovascular risk factors when comparing MVPA accumulated in shorter (<10 min) versus longer (≥10 min) bouts.

The results of this study and other studies (15,22,30,33) provide important findings on the role that sporadic MVPA plays in health and have important implications for public health guidelines and the way the MVPA is prescribed and promoted. Current physical activity guidelines of the World Health Organization (40) and several countries (e.g., Australia, Canada, and United States) (3,12,35) recommend that the weekly dose of 150 min of MVPA be accumulated in bouts of at least 10 min (3,12,35,40). However, an important finding of the present study is that sporadic MVPA is important in the prediction of MetS. These and other findings (15,22,30,33) suggest that the weekly dose of MVPA can be accumulated sporadically in periods of 9 min or less. Given that only 15% of Canadian adults (7) and <10% of American adults (36) meet the current guidelines, and that a lack of time is the most often cited reason for physical inactivity (37), the current study supports promoting sporadic MVPA as another way for individuals to accumulate a sufficient weekly dose of MVPA. Sporadic MVPA could be accumulated through lifestyle-embedded activities such as stair climbing and household chores (9).

Strengths of this study include the use of a large, nationally representative sample of Canadian adults and the use of accelerometers, which provide an objective and unbiased measure of physical activity (9,17). As with any study, this study is not void of limitations. The cross-sectional nature

TABLE 4. OR (95% CI) for the MetS according to bouted (≥10 min) MVPA and different lengths of sporadic MVPA.

Model[a]	Physical Activity (MET-Hours per Week)	OR[b] (95% CI)	ΔAIC[c]	Relative AIC	Akaike Weight (%)
1	Bouts (≥10 min)	0.89 (0.84–0.95)	18.61	0.0001	<0.01
2	Bouts (≥10 min)	0.90 (0.84–0.95)	20.49	0.0000	<0.01
	Sporadic (7–9 min)	0.95 (0.70–1.29)			
3	Bouts (≥10 min)	0.93 (0.89–0.98)	6.29	0.0431	4.13
	Sporadic (4–9 min)	0.82 (0.72–0.94)			
4	Bouts (≥10 min)	0.91 (0.86–0.97)	0.00	1.0000	95.86
	Sporadic (1–9 min)	0.89 (0.84–0.95)			
			Total	1.0432	100

[a]All models adjusted for age, sex, education, diet, smoking status, total accelerometer wear time, and HUI.
[b]OR presented per 1 unit change in MET-hours per week of physical activity.
[c]Difference in AIC vs the optimal model (model 4).

does not allow for assumptions to be made regarding causality. However, it is likely that low MVPA preceded the MetS on the basis of previous randomized controlled trials, and prospective cohort studies have found that MVPA has a positive influence on cardiometabolic risk factors and is effective in the prevention of MetS (19,38). Several limitations also exist in the use of accelerometers. Accelerometers are unable to accurately capture non–step-based activities (e.g., swimming, cycling, and weightlifting) (9,28). Accelerometers are also unable to account for the added energy expenditure associated with load-bearing activities or added incline (9,17). Furthermore, it must be assumed that the accelerometer data collected over the 4- to 7-d measurement period are representative of an individual's normal physical activity behavior. Finally, the survey design requires that 11 degrees of freedom be specified in the statistical software (31), which also limited the number of covariates that were included in the regression models.

In conclusion, this study found comparable associations between equivalent doses of sporadic and bouted MVPA and the relative odds of MetS. This study adds to the dearth of information that currently exists on the relation between sporadic MVPA and MetS. Additional studies based on randomized controlled trials are needed to confirm the cross-sectional associations found in the present study.

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