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Prolonged sedentary time and physical fitness among Canadian men and women aged 60 to 69

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Abstract

Background: Evidence for associations between prolonged sedentary time and breaks in sedentary time and fitness is limited in older adults. This study examines associations between objectively measured and self-reported total sedentary time and breaks in sedentary time with cardiorespiratory and musculoskeletal fitness among Canadian men and women aged 60 to 69.

Data and methods: Data from cycles 1 and 2 of the Canadian Health Measures Survey were used for analysis. This is a nationally representative survey with an overall response rate of 53.5%. Men (n = 564) and women (n = 593) aged 60 to 69 were selected for analysis. Sedentary time, breaks in sedentary time, and moderate-to-vigorous physical activity were objectively measured with accelerometers. Leisure sedentary time was self-reported. Cardiorespiratory fitness was assessed with the modified Canadian Aerobic Fitness Test. Musculoskeletal fitness was based on grip strength and flexibility. Linear regression models were adjusted for age, sex, education, body mass index, smoking status and moderate-to-vigorous physical activity.

Results: The number of breaks in measured sedentary time (β:0.47, p = 0.02) and the percentage of measured sedentary time spent in bouts lasting at least 20 minutes (β:-0.53, p = 0.01) were associated with cardiorespiratory fitness. For men, grip strength was negatively associated with measured total sedentary time (β:-0.03, p = 0.03), and sit-and-reach was positively associated with breaks in measured sedentary time (β:0.15, p = 0.02). Self-reported sedentary time was not associated with any of the fitness outcomes.

Interpretation: Among Canadians aged 60 to 69, fitness may be influenced not only by total sedentary time, but also by patterns of sedentary time.

Key words: Aging, exercise, flexibility, functional autonomy, hand strength, physical activity, sitting

Cardiorespiratory fitness is a predictor of morbidity and all-cause mortality among middle-aged and older adults.[1,2] Musculoskeletal fitness, particularly grip strength, is also a predictor of cardiovascular mortality and all-cause mortality—an even stronger predictor than systolic blood pressure[3]—and is critical to functional autonomy and quality of life.[4]

Fitness is influenced by a combination of age, genetics and physical activity. Aging is associated with a decline in both cardiorespiratory and musculoskeletal fitness, but some of these changes can be attributed to decreased physical activity.[5] In fact, multicomponent exercise programs that include strengthening, balance and/or flexibility have been shown to significantly affect the physical and cognitive function of older adults.[6] However, objectively measured data reveal that only 4.5% of Canadians aged 60 to 79 accumulate 30 minutes per day of physical activity in the recommended 10-minute bouts.[7] More than 90% of men and women older than age 60 are sedentary for at least 8 hours a day.[8]

Even when physical activity levels are taken into account, sedentary time may influence health.[9] Among older adults, the amount of time spent sitting is associated with impaired glucose tolerance, dyslipidemia, high-risk waist circumference, coronary heart disease and poor perceived health.[8,10] Less is known about associations with measures of fitness, especially cardiorespiratory fitness.

In addition to total sedentary time, patterns of sedentary time may influence health outcomes. Prolonged sitting with few interruptions is associated with greater metabolic health risks compared with more fragmented sedentary periods.[11] Frequent interruptions may also positively influence lower extremity function and body composition in older adults.[12,13] However, little evidence is available on associations between patterns of sedentary time and cardiorespiratory and musculoskeletal fitness among older men and women.

Examining relationships between sedentary time and cardiorespiratory and musculoskeletal fitness, while accounting for physical activity levels, is critical for understanding the consequences of prolonged sitting for the health and autonomy of the older population. These associations are particularly important for people in their sixties, as targeted interventions may be able to slow declines in fitness. Based on data for 2007 through 2011 from the Canadian Health Measures Survey, this study analyzes associations between total sedentary time (self-reported and objectively measured) and breaks in sedentary time (objectively measured) and cardiorespiratory and musculoskeletal fitness among men and women aged 60 to 69.

Data and methods

Data from cycles 1 and 2 of the Canadian Health Measures Survey (CHMS) were used for analysis. The CHMS covers the Canadian population aged 3 to 79 living in private dwellings. Approximately 96% of the population is represented; residents of reserves, institutions and certain remote regions, and full-time members of the Canadian Forces are excluded.

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Data were collected from March 2007 through February 2009 (cycle 1) and from August 2009 through November 2011 (cycle 2). Data collection occurred in two phases: a questionnaire on socio-demographic characteristics and health behaviours administered at the respondent's home, and a series of physical measurements, including fitness tests, during a subsequent visit to a mobile examination centre.

Of the households selected across both survey cycles, 72.7% provided the sex and date of birth of all household members. Within each responding household, one or two members were chosen to participate in the survey. Of these, 89.3% completed the household questionnaire, of whom 83.3% visited the mobile examination centre. The final response rate for the combined cycles, after adjusting for the sampling strategy, was 53.5% (53.2% for males and 53.8% for females).[14]

Ethics approval for the CHMS was obtained from the Research Ethics Board for Health Canada and the Public Health Agency of Canada, and informed, written consent was obtained from adult participants.[15]

After their mobile examination centre visit, ambulatory respondents received an Actical accelerometer to wear on an elasticized belt over their right hip during waking hours for seven days.[16,17] The Actical measures acceleration of movement in all directions. Movement is captured and recorded as a digitized value summed over one-minute intervals, resulting in a count per minute (cpm). Accelerometer data reduction followed published guidelines to identify and remove invalid data.[18] Total daily accelerometer wear time was determined by identifying non-wear time and subtracting it from 24 hours. Non-wear time was defined as periods of at least 60 consecutive minutes of zero counts, with allowance for 1 or 2 minutes of counts between 0 and 100 cpm.[18] A valid day was defined as at least 10 hours of wear time; only participants with at least four valid days were included in this analysis.

Total daily *measured* time (minutes) spent in sedentary and moderate-to-vigorous physical activity (MVPA) was determined based on values of 100 cpm or less and more than 1,535 cpm, respectively, on each valid day.[19,20] Daily average sedentary time and time spent in MVPA were calculated as the total number of minutes for all valid days, divided by the number of valid days. Daily average sedentary time spent in bouts of at least 20 minutes and the average number of bouts were determined. A bout was a continuous period of at least 20 minutes with 100 cpm or less (allowing for interruptions up to 2 minutes with cpm greater than 100).[21] The daily average number of breaks in sedentary time was determined. A break was any interruption (activity counts more than 100 cpm) of sedentary time lasting at least 1 minute. The percentage of total sedentary time spent in bouts of at least 20 minutes was calculated as average sedentary time in bouts divided by average sedentary time.[13]

Self-reported sedentary time was based on the combined number of hours per week respondents said they typically spent watching TV, playing video games, using computers and reading. In cycle 1, respondents selected from a list of pre-determined durations (none, less than 1 hour, 1 to 2 hours, 3 to 5 hours, 6 to 10 hours, 11 to 14 hours, 15 to 20 hours, or more than 20 hours). The derived variable for the total number of self-reported sedentary hours per week was the sum of the mid-point of the answer category for each question, which was grouped into the following categories (in hours): less than 5, 5 to less than 10, 10 to less than 15, 15 to less than 20, 20 to less than 25, 25 to less than 30, 30 to less than 35, 35 to less than 40, 40 to less than 45, or more than 45. In cycle 2, respondents provided an exact duration (to the nearest half hour) for each question. The derived variable for the total number of self-reported sedentary hours per week was the sum of all four responses. To allow for comparability between cycles, the derived variable in cycle 2 was grouped into the cycle 1 categories. The mid-point of each category was used to calculate average self-reported sedentary minutes per day.

Detailed descriptions of the eligibility criteria and measurement procedures for each CHMS fitness test are available elsewhere.[16,17,22] Briefly, at the beginning of the mobile examination centre visit, respondents answered a series of screening questions (including completing the Physical Activity Readiness Questionnaire (PAR-Q))[22] and had their resting blood pressure and heart rate measured to assess their risk of engaging in the tests.

The modified Canadian Aerobic Fitness Test (mCAFT) is a multi-stage sub-maximal test used to assess aerobic fitness. Stepping stages were completed until the respondent's heart rate reached 85% of maximum at the end of a stage (or until the respondent could no longer continue). Heart rate, the oxygen cost of the last stepping stage, and weight were used to calculate cardiorespiratory fitness.[22]

Sit-and-reach was measured with a flexometer (Fit Systems Inc., Calgary, Canada). Each respondent completed two trials; the best score (centimetres) was used.[22]

Grip strength was measured with a Smedley III dynamometer (Takei Scientific Instruments, Japan). Respondents completed two trials with each hand; the best scores from each hand were summed to calculate total grip strength (kilograms).

Covariates in the analysis were age, sex, education (postsecondary graduation, yes/no), body mass index, and smoking (smoker, yes/no).

The total sample consisted of 1,405 respondents aged 60 to 69. Of these, 14 were excluded from this analysis because they were screened out of the grip strength test (owing to an acute condition, a positive response to the PAR-Q or an unspecified reason). Another 234 were excluded because of incomplete grip strength or covariate data. The final study sample numbered 1,157, of whom 1,109 had complete sit-and-reach data, and 616 had complete mCAFT data. A total of 48 and 576 respondents were screened out of sit-and-reach and mCAFT, respectively, mainly because of medication use or a positive response to the PAR-Q.

Statistical analysis

Basic descriptive statistics were used to present characteristics of the sample, fitness scores, sedentary time (measured and self-reported), and physical activity levels by sex. Linear regression models were used to evaluate associations between the fitness outcomes and self-reported and measured sedentary time. Beta estimates, 95% confidence intervals, and p-values were calculated. Linear regression was also used to evaluate adjusted associations between fitness and the percentage of sedentary time spent in intervals lasting at least 20 minutes and the daily number of breaks in sedentary time. All models were adjusted for age, sex, education, body mass index and smoking. To evaluate independent associations with fitness, models were further adjusted for total MVPA. Statistical significance was set at $\alpha < 0.05$.

Analyses were completed using SAS v9.2 and SUDAAN v10. Results were weighted using the activity monitor subsample weights. Standard errors, coefficients of variation and 95% CI were calculated with the bootstrap technique. The CHMS combined cycle 1 and 2 study design requires that 24 degrees of freedom be specified in the software.[14]

Results

Characteristics of sample

The average age of respondents was 64 (Table 1). Three-quarters (74%) were married/common-law, and 55% were postsecondary graduates. According to accelerometer data, they accumulated a daily average of 595 minutes (95% CI: 589 to 601) of sedentary time, most of which (83% or 501 minutes, 95% CI: 491 to 510) were in bouts lasting at least 20 minutes. An estimated 12% of respondents aged 60 to 69 met the Canadian Physical Activity Guidelines of 150 minutes per week of MVPA.

Table 1
Characteristics of Canadian Health Measures Survey sample aged 60 to 69, by sex, Canada, 2007-to-2009 and 2009-to-2011 combined

	Total (n = 1,157)			Men (n = 564)			Women (n = 593)		
		95% confidence interval			95% confidence interval			95% confidence interval	
Characteristic	estimate	from	to	estimate	from	to	estimate	from	to
Average age (years)	64	64	64	64	64	64	64	64	64
Marital status (%)									
Married or common-law	74.1	69.9	77.9	81.5	75.7	86.2	67.2*	60.8	73.0
Widowed, separated or divorced	20.6	17.5	24.0	14.0E	9.8	19.6	26.7*	22.3	31.7
Single, never married	5.3E	3.7	7.6	4.5E	3.0	6.8	6.1E	3.8	9.5
Education (%)									
Postsecondary graduation	55.1	49.7	60.4	57.5	50.7	64.0	52.8	45.8	59.7
Less than postsecondary	44.9	39.6	50.3	42.5	36.0	49.3	47.2	40.3	54.2
Body mass index (kg/m^2)	28.3	27.8	28.8	28.6	27.9	29.4	27.9	27.2	28.6
Normal weight (%)	27.8	22.9	33.3	23.6	17.6	30.9	31.7*	25.7	38.3
Overweight (%)	40.1	35.2	45.3	42.5	34.7	50.8	37.9	32.5	43.6
Obese (%)	32.1	27.5	37.0	33.9	27.4	41.0	30.4	24.7	36.8
Fitness outcomes									
Aerobic score (cardiorespiratory fitness; ml/kg/min)	25.5	25.1	26.0	27.1	26.3	28.0	24.1*	23.6	24.7
Grip strength (kg)	64	62	66	81	79	83	48*	46	49
Sit-and-reach (cm)	22.1	21.4	22.9	17.4	16.6	18.2	26.8*	25.7	27.9
Physical activity									
Average daily leisure sedentary time† - self-reported (minutes)	221	209	233	222	207	238	220	210	231
Average daily sedentary time - measured (minutes)	595	589	601	590	580	600	600*	588	611
Average daily sedentary time in bouts - measured (minutes)	501	491	510	500	485	515	501	482	521
Average daily number of sedentary bouts of at least 20 minutes	9	8	9	9	8	9	8*	8	9
Average daily number of breaks (at least 1 minute) in sedentary time	44	43	45	44	43	45	44	42	46
Average daily sedentary time in bouts (%)	83.2	82.2	84.3	83.8	82.4	85.3	82.7	80.7	84.6
Average daily TPA - measured (minutes)	224	216	232	231	220	241	218	205	231
Average daily MVPA - measured (minutes)	15	13	18	18	14	21	13*	11	15
Physical Activity Guidelines for Older Adults (% meeting)	12.0	9.0	16.0	13.2E	9.2	18.7	10.9	7.9	14.9

E use with caution
* significantly different from men ($p < 0.05$)
† watching TV, playing video games, using computer and reading
TPA = total physical activity (light and moderate-to-vigorous)
MVPA = moderate-to-vigorous physical activity
Note: A sedentary “break” was any movement above the sedentary threshold lasting at least 1 minute.
Source: 2007-to-2009 and 2009-to-2011 Canadian Health Measures Survey (combined).

Sedentary time and fitness

In the fully adjusted models, no fitness measures were associated with the amount of *self-reported* TV/video game/computer/reading time among men or women (Table 2).

For *measured* total sedentary time, a significant and negative association was noted for cardiorespiratory fitness in the combined sample of men and women in the fully adjusted model b (β:-0.1283, $p < 0.01$). The association between grip strength and measured sedentary time was also significant in the combined sample of men and women in the fully adjusted model (β: -0.017, p = 0.03) (Table 2).

In the combined sample of men and women, cardiorespiratory fitness was significantly and negatively associated with the percentage of sedentary time spent in bouts lasting at least 20 minutes (β:-0.581, $p < 0.01$) (Table 3). After adjustment for total MVPA, the relationship remained significant (β:-0.529, p = 0.01). No significant associations were evident between sedentary time in bouts of at least 20 minutes and grip strength or sit-and-reach.

The association between the number of breaks in sedentary time and cardiorespiratory fitness was positive and significant in the combined sample of men and women, even when adjusted for MVPA (β:0.468, p = 0.02) (Table 4). However, the association reflected the situation among women; the number of breaks in sedentary time was not significantly related to men's cardiorespiratory fitness. The number of breaks in sedentary time was positively and significantly associated with sit-and-reach among men (β:0.145, p = 0.02). Breaks in sedentary time were not associated with the grip strength of either sex.

Discussion

This study examined associations between sedentary time and fitness among Canadians in their sixties. The main findings were that, after adjusting for MVPA: 1) objectively measured sedentary time was inversely associated with cardiorespiratory fitness and grip strength; 2) the number of breaks in sedentary time was positively associated with cardiorespiratory fitness; 3) the percentage of sedentary time spent in bouts of at least 20 minutes was inversely associated with cardiorespiratory fitness; 4) associations between sedentary time in bouts of at least 20 minutes and breaks in sedentary time and cardiorespiratory fitness were not consistent between sexes, nor were associations between sedentary time and grip strength; and 5) self-reported sedentary time was not related to any fitness variable. The last

Table 2
Association of self-reported and measured sedentary time with selected fitness outcomes, by sex, Canada, 2007-to-2009 and 2009-to-2011 combined

Type of sedentary time, fitness outcome and sex	Number	β estimate†	95% confidence interval from	95% confidence interval to	p-value	β estimate‡	95% confidence interval from	95% confidence interval to	p-value
Self-reported leisure sedentary time§									
Cardiorespiratory fitness									
Total	616	-0.014	-0.063	0.035	0.57	-0.014	-0.061	0.034	0.56
Men	294	-0.018	-0.100	0.064	0.66	-0.018	-0.101	0.066	0.66
Women	322	-0.016	-0.061	0.028	0.45	-0.001	-0.043	0.041	0.96
Grip strength									
Total	1,157	-0.009	-0.022	0.004	0.15	-0.009	-0.022	0.004	0.15
Men	564	-0.008	-0.029	0.013	0.44	-0.008	-0.029	0.013	0.43
Women	593	-0.010	-0.022	0.002	0.10	-0.010	-0.022	0.003	0.12
Sit-and-reach									
Total	1,106	-0.003	-0.012	0.005	0.43	-0.003	-0.012	0.005	0.43
Men	541	-0.001	-0.014	0.011	0.86	-0.001	-0.014	0.012	0.88
Women	558	-0.005	-0.016	0.007	0.41	-0.004	-0.015	0.006	0.40
Measured sedentary time									
Cardiorespiratory fitness									
Total	616	-0.135	-0.184	-0.086	<0.01	-0.128	-0.185	-0.072	0.00
Men	294	-0.119	-0.224	-0.013	0.03	-0.134	-0.244	-0.024	0.02
Women	322	-0.150	-0.224	-0.075	0.00	-0.108	-0.174	-0.043	0.00
Grip strength									
Total	1,157	-0.014	-0.028	-0.000	0.04	-0.017	-0.032	-0.002	0.03
Men	564	-0.025	-0.049	-0.001	0.04	-0.031	-0.058	-0.003	0.03
Women	593	-0.007	-0.027	0.012	0.44	-0.007	-0.026	0.012	0.47
Sit-and-reach									
Total	1,106	-0.008	-0.024	0.009	0.36	-0.009	-0.028	0.010	0.35
Men	541	-0.011	-0.028	0.006	0.19	-0.016	-0.037	0.006	0.14
Women	558	-0.002	-0.025	0.020	0.83	-0.001	-0.023	0.021	0.90

† adjusted for age, sex, education, body mass index, smoking status and accelerometer wear time.
‡ adjusted for age, sex, education, body mass index, smoking status, accelerometer wear-time and measured moderate-to-vigorous physical activity
§ watching TV, playing video games, using computer and reading
Source: 2007-to-2009 and 2009-to-2011 Canadian Health Measures Survey (combined).

Table 3
Association of percentage of total sedentary time spent in bouts of at least 20 minutes with selected fitness outcomes, by sex, Canada, 2007-to-2009 and 2009-to-2011 combined

Fitness outcome and sex	number	β estimate†	95% confidence interval from	95% confidence interval to	p-value	β estimate‡	95% confidence interval from	95% confidence interval to	p-value
Cardiorespiratory fitness									
Total	616	-0.581	-0.965	-0.198	0.00	-0.529	-0.938	-0.120	0.01
Men	294	-0.534	-1.277	0.210	0.15	-0.534	-1.298	0.230	0.16
Women	322	-0.625	-1.088	-0.161	0.01	-0.479	-0.904	-0.055	0.03
Grip strength									
Total	1,157	-0.064	-0.148	0.021	0.13	-0.066	-0.153	0.021	0.13
Men	564	-0.111	-0.266	0.045	0.16	-0.114	-0.278	0.050	0.16
Women	593	-0.059	-0.157	0.038	0.22	-0.057	-0.149	0.036	0.22
Sit-and-reach									
Total	1,106	-0.056	-0.159	0.048	0.28	-0.057	-0.163	0.050	0.28
Men	541	-0.097	-0.226	0.031	0.13	-0.101	-0.239	0.036	0.14
Women	558	-0.019	-0.146	0.108	0.76	-0.016	-0.136	0.104	0.79

† adjusted for age, sex, education, body mass index and smoking status
‡ adjusted for age, sex, education, body mass index, smoking status and total minutes of measured moderate-to-vigorous physical activity
Source: 2007-to-2009 and 2009-to-2011 Canadian Health Measures Survey (combined).

Table 4
Association of number of breaks in sedentary time with selected fitness outcomes, by sex, Canada, 2007-to-2009 and 2009-to-2011, combined

Fitness outcome and sex	number	β estimate†	95% confidence interval from	95% confidence interval to	p-value	β estimate‡	95% confidence interval from	95% confidence interval to	p-value
Cardiorespiratory fitness									
Total	616	0.547	0.196	0.898	0.00	0.468	0.098	0.838	0.02
Men	294	0.609	-0.112	1.331	0.09	0.540	-0.214	1.294	0.15
Women	322	0.547	0.175	0.920	0.01	0.423	0.076	0.770	0.02
Grip strength									
Total	1,157	0.068	-0.011	0.147	0.09	0.056	-0.023	0.136	0.16
Men	564	0.103	-0.035	0.240	0.14	0.069	-0.056	0.195	0.27
Women	593	0.067	-0.034	0.168	0.18	0.078	-0.020	0.177	0.11
Sit-and-reach									
Total	1,106	0.063	-0.035	0.161	0.20	0.065	-0.031	0.160	0.17
Men	541	0.139	0.020	0.258	0.02	0.145	0.025	0.266	0.02
Women	558	-0.002	-0.111	0.108	0.97	-0.010	-0.122	0.102	0.86

† adjusted for age, sex, education, body mass index and smoking status
‡ adjusted for age, sex, education, body mass index, smoking status, total measured sedentary time and total minutes of measured moderate-to-vigorous physical activity
Note: A sedentary "break" was any movement above the sedentary threshold lasting at least 1 minute.
Source: 2007-to-2009 and 2009-to-2011 Canadian Health Measures Survey (combined).

conforms with previous work showing measured sedentary time to be more consistently related to health outcomes than are self-reported measures.[8] Together, these results indicate that prolonged sedentary time may affect age-related losses in cardiorespiratory and musculoskeletal fitness, and that breaking it up with with light-intensity activity could positively influence fitness levels in older adults, regardless of moderate-to-vigorous physical activity levels.

Earlier research indicates that sedentary time and patterns of sedentary time are associated with older adults' health and functional fitness.[8,10,23] In the present study, the percentage of total sedentary time spent in bouts of at least 20 minutes was inversely associated with cardiorespiratory fitness, and a greater number of breaks in sedentary time was associated with better cardiorespiratory fitness. These findings are important because cardiorespiratory fitness is a strong predictor of morbidity and all-cause mortality.[2] In 2015, Oudegeest-Sander et al. demonstrated that non-exercising older adults with higher cardiorespiratory fitness have better vascular function and lower cardiovascular risk.[24] They suggested that greater amounts of non-exercise activity, such as activities of daily living, may partly explain the fitness and vascular health of some older individuals who do not engage in purposeful physical actvity.[24] It is possible that adaptations in the vasculature, and likely other components such as muscle oxidative capacity, are stimulated by light intensity activities. While mechanistic studies are required, the present results support the potential importance of non-exercise activity by demonstrating that breaks in prolonged sitting may influence cardiorespiratory fitness in older adults. Frequent interruptions of sedentary periods may be particularly important for older adults, who tend to accumulate considerable daily sedentary time.[7,8] However, the CHMS data are cross-sectional, so it is possible that older adults with lower cardiorespiratory fitness find it more difficult to break up their sedentary time. Intervention research is needed to determine the impact that breaking up sedentary time has on cardiorespiratory fitness.

Total sedentary time was inversely related to grip strength in men and women, even after adjusting for MVPA. As well, the association between breaks in sedentary time and sit-and-reach scores was positive among men. Therefore, sedentary time may also influence musculoskeletal fitness, which is crucial for independent living and autonomy.

A study by Santos et al. found that sedentary time was significantly related to functional fitness in older adults.[23] Similarly, Davis et al. reported that more breaks in sedentary time were associated with better physical function.[12] Both of these studies used functional performance tests to measure fitness in contrast to the more traditional fitness tests employed in the CHMS. It is possible that, similar to cardiorespiratory fitness, breaking up sedentary time with light-intensity weight-bearing activities provides a stimulus for adaptations in the working muscle. However, the CHMS does not include a lower body measure of muscular strength or endurance. Research is needed to assess associations between breaks in sedentary time and measures of lower body strength at older ages.

The two studies mentioned above[12,23] examined participants who were significantly older and had lower fitness than the CHMS sample. This makes the present findings noteworthy, as even among the sample, who were younger and healthier, an inverse association was apparent between both cardiorespiratory fitness and musculoskeletal fitness and sedentary time.

Relationships between the sedentary variables and cardiorespiratory fitness and musculoskeletal fitness were not consistent for men and women. Among women, the percentage of sedentary time spent in bouts of at least 20 minutes and breaks in sedentary time were associated with cardiorespiratory fitness; no significant associations were found among men. By contrast, for men, associations were noted between measured sedentary time and grip strength, and between breaks in sedentary time and sit-and-reach; similar associations were not observed for women.

At any given age, men's cardiorespiratory fitness exceeds that of women. For example, in this sample, according to the mCAFT score, which was used to estimate cardiorespiratory fitness in ml/kg/min, the cardiorespiratory fitness for men was 27.1, compared with 24.1 for women (Table 1). Moreover, at ages 60 to 70, women fall in a critical range (15 to 20 ml/kg/min), where functional autonomy may become compromised.[25] It is possible that sedentary time influences cardiorespiratory fitness once it falls below a certain level. Due to screening restrictions placed on performing the aerobic test, the CHMS sample was also fitter and healthier than the general population. Thus, the association between patterns of sedentary time and cardiorespiratory fitness may be stronger in less fit women. Similarly, with regard to the differences in associations with sit-and-reach, it is possible that because women tend to have better flexibility than men,[26,27] men are more susceptible to the effects of sedentary time on flexibility, as prolonged sitting is associated with muscle stiffness.[28]

The results for patterns of sedentary time are of particular interest as they suggest that breaking up sedentary time may positively influence cardiorespiratory fitness among women but not men, while such breaks affect flexibility in men but not in women. This may indicate that in household, leisure, transportation and occupation domains, men and women interrupt their sedentary time with different types of activity. It is clear that sex needs to be considered when assessing associations between sedentary time and fitness among older adults, as they point to a possible need for differences in intervention strategies.

What is already known on this subject?

- Older adults spend a considerable amount of time sitting.
- Functional fitness has been shown to be lower among older adults who are sedentary for prolonged periods.

What does this study add?

- Based on data for 2007 through 2011 from the Canadian Health Measures Survey, this study found that among Canadians aged 60 to 69, total accelerometer-measured sedentary time was significantly associated with cardiorespiratory fitness.
- Among women, the percentage of sedentary time spent in bouts of at least 20 minutes was negatively associated with cardiorespiratory fitness, but the association with the number of breaks in sedentary time was positive.
- Among older men, total sedentary time was negatively associated with grip strength, and the number of breaks in sedentary time was positively associated with flexibility.
- Self-reported sedentary leisure time was not related to cardiorespiratory or musculoskeletal fitness among 60- to 69-year-olds.

Strengths and limitations

The strengths of the current analysis are the use of a large, nationally representative sample, and standardized, objective measurements of sedentary time, cardiorespiratory fitness and musculoskeletal fitness. However, the results should be interpreted in the context of several limitations. First, as a result of rigorous screening for CHMS fitness testing, the final sample was fitter and healthier than the population overall. Consequently, the findings may not be generalizable to all people in their sixties. In fact, associations between sedentary time and fitness might be even stronger among those with functional restrictions or chronic conditions. Second, the cross-sectional study design precludes drawing conclusions about the direction of observed relationships. Less-fit people may spend more time in sedentary activities, a possibility that could be explored in future studies.

Conclusion

These data demonstrate a significant relationship between directly measured sedentary time, breaks in sedentary time, and fitness among Canadians in their sixties. Given the long-established associations between fitness and both health and functional autonomy for older adults, this study underscores the importance of minimizing total sedentary time and breaking up sedentary time, in addition to increasing physical activity. Differences in the results for men and women suggest that sex is a factor to consider when developing and evaluating intervention studies of older adults. ■

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