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Abstract

Background: Active travel may be a means of integrating physical activity into an individual's routine. This analysis investigates the relationship between utilitarian walking and cycling and objectively measured physical activity and health-related outcomes in a nationally representative sample of Canadian adults.

Data and methods: Adults aged 20 to 79 who participated in the 2007-to-2011 Canadian Health Measures Surveys (n= 7,160) reported the weekly time spent in utilitarian walking and cycling, and also wore an Actical accelerometer for seven days. They underwent a series of tests to measure physical fitness, body composition, blood pressure, and biomarkers. Differences in physical activity and health-related outcomes across levels of utilitarian walking and cycling were assessed with ANCOVA analyses adjusted for age, sex, education, household income, self-reported usual daily physical activity, and the complex survey design.

Results: Utilitarian walking and cycling were associated with moderate-to-vigorous physical activity in a graded manner. Compared with respondents who reported walking 1 to 5 hours a week, those who walked more than 5 hours a week had lower skinfold thickness. Respondents who reported cycling 1 or more hours a week had greater aerobic fitness and lower body mass index (BMI), waist circumference, total cholesterol/HDL ratio, glycohemoglobin, C-reactive protein, and triglycerides than did those who did not cycle. They also had higher aerobic fitness and lower BMI and waist circumference than those who reported cycling less than an hour a week.

Interpretation: Cycling at least an hour a week was associated with improved fitness and reduced cardiovascular disease risk factors. Both utilitarian walking and cycling may be means of increasing adults' moderate-to-vigorous physical activity.

Keywords: Blood glucose, blood pressure, cholesterol, motor activity, obesity, physical fitness, transportation

Lack of physical activity is strongly associated with a range of negative health consequences for adults.[1-3] For instance, insufficient physical activity causes an estimated 9% of premature mortality worldwide and is related to 6% to 10% of the burden of diseases from coronary heart disease, type 2 diabetes, breast cancer and colon cancer.[2]

Canadian guidelines recommend that adults accumulate 150 minutes of moderate- to-vigorous-intensity physical activity each week.[4] However, according to accelerometry data from the 2007-to-2009 Canadian Health Measures Survey, only 15% of adults meet this recommendation.[5] Similarly, based on accelerometry data from the 2003/2004 National Health and Nutrition Examination Survey, fewer than 5% of American adults were sufficiently active.[6] Although these estimates may be biased by the cut-points used to measure moderate-to-vigorous physical activity,[7,8] a high prevalence of physical inactivity has also been observed based on self-reported data from 122 countries.[9]

During the last decade, active travel has received attention as a strategy to improve population health,[10-12] and at the same time, reduce exhaust and greenhouse gases emissions[13] and traffic congestion.[14] Active travel involves the use of non-motorized modes such as walking and cycling to reach destinations such as workplaces, schools, parks, and shops.

A recent systematic review found only two studies examining the relationship between active travel and objectively measured physical activity among adults.[15] Although some studies showed that active travel was associated with lower body weight and improved health outcomes, the quality of the evidence was questioned,[15,16] and concerns were raised about external validity and selection bias.[16] Furthermore, most studies considered only commuting to work, and many failed to distinguish between walking and cycling despite the greater physical intensity of the latter.[12,17]

This analysis examines associations between utilitarian walking and cycling and objective measures of physical activity, body composition, physical fitness and cardiovascular disease (CVD) risk factors in a nationally representative sample of Canadians aged 20 to 79. The hypotheses are that: 1) both utilitarian walking and cycling are associated with higher accelerometry-measured physical activity; and 2) cycling is more strongly associated with health-related outcomes than is walking.

Data and methods

Respondents

To maximize sample size, data from the 2007-to-2009 and 2010-to-2011 cycles of the Canadian Health Measures Survey (CHMS) were combined. From March 2007 through November 2011, the CHMS collected nationally representative data at

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33 sites across Canada from 11,387 respondents aged 3 to 79 who resided in private households.[18-20]

The survey consists of a home interview and a visit to a mobile examination centre (MEC) for a series of physical measurements.[18] Approximately 96% of Canadians are represented. Excluded from the survey are: residents of the three territories; people living on reserves and other Aboriginal settlements in the provinces; full-time members of the Canadian Forces; the institutionalized population; and residents of certain remote regions. Ethics approval was granted by Health Canada's Research Ethics Board, and written informed consent was obtained from all respondents.[19]

Of the households selected across both cycles, 72.7% provided the sex and date of birth of all household members. In each responding household, one or two members were selected to participate; 89.3% of the recruited respondents completed the household questionnaire, 83.3% of whom completed the MEC visit. The overall response rate was 53.5%; population weighting was adjusted for non-response bias.[20]

The present analysis is based on data from 7,160 respondents aged 20 to 79 (3,614 women and 3,546 men). Upon completion of their MEC visit, respondents were asked to wear an Actical accelerometer (Phillips – Respironics, Oregon, USA); 5,689 respondents provided valid data.[21] Respondents who visited the MEC in the morning were asked to fast overnight; 3,519 provided a fasting blood sample.

Procedures

A detailed description of data collection procedures, screening guidelines, and eligibility criteria for the various measurements is provided online in the CHMS Data User's Guide.[22]

Active travel was assessed with two items (one for walking and one for cycling), as follows: "In a typical week in the past 3 months, how many hours did you usually spend walking [or bicycling] to work or to school or while doing errands?" Response options were: (1) none; (2) less than 1 hour; (3) 1 to 5 hours; (4) 6 to 10 hours; (5) 11 to 20 hours; (6) 20 or more hours. The present analysis used three categories for walking (less than 1 hour, 1 to 5 hours, and more than 5 hours) and for cycling (none, less than 1 hour, and 1 hour or more), based on the observed distributions.

An additional item assessed respondents' usual daily physical activity: "Thinking back over the past 3 months, which of the following best describes your usual daily activities or work habits?" Response options were: (1) usually sit during the day and don't walk around very much; (2) stand or walk quite a lot during the day but don't have to carry or lift things very often; (3) usually lift or carry light loads, or have to climb stairs or hills often; (4) do heavy work or have to carry very heavy loads.

Respondents were asked to wear an Actical accelerometer on an elasticized belt over their right hip during waking hours for seven consecutive days, except during water-based activities (swimming or bathing). Data were collected in 60-second epochs. The accelerometer has high technical reliability[23] and has been validated for measuring physical activity against indirect calorimetry in children and adults.[24] Estimates of adults' physical activity measured with Actical and Actigraph accelerometers are strongly correlated.[25]

The protocols used to assess body composition and physical fitness are described in detail elsewhere.[26] These tests were conducted by trained specialists with certification from the Canadian Society for Exercise Physiology.[26] Cardiovascular fitness (maximal oxygen consumption [VO_2max]) among respondents aged 20 to 69 was estimated using the modified Canadian Aerobic Fitness Test.[26] Grip strength was assessed twice with each hand using a Smedley III dynamometer (Takei Scientific Instruments, Japan), and the maximum scores for each hand were combined. Trunk flexibility was assessed with the sit-and-reach test. Body Mass Index (BMI) (kg/m^2) was computed from height and weight measured to the nearest 0.1 cm and 0.1 kg, respectively. Waist circumference was measured at the end of a normal expiration to the nearest 0.1 cm at the mid-point between the last rib and the top of the iliac crest. Harpenden skinfold calipers (Baty International, U.K.) were used to measure the triceps, biceps, subscapular, iliac crest and calf skinfolds, which were summed.[26]

Blood pressure was measured with an automated monitor.[27] Six measurements were taken at one-minute intervals. Average systolic and diastolic blood pressure were calculated from the last five measurements.

Blood samples were taken by a certified phlebotomist and analyzed at the Health Canada Laboratory following standardized protocols.[18] Fasting blood samples were obtained only from respondents who visited the MEC in the morning. Owing to differences between the two CHMS cycles in measurement protocols for many biomarkers, only fasting triglycerides were included in the present study. In addition, the following non-fasting blood markers were used: high-density lipoprotein (HDL) cholesterol, total cholesterol, total cholesterol/HDL ratio, glycohemoglobin (Hba1c), and C-reactive protein. Details about biospecimen sampling, storage and analysis procedures are available elsewhere.[18]

Data treatment

Accelerometry data were treated by Statistics Canada as described by Colley et al.[5,21,28] A valid day was defined as 10 or more hours of wear time; respondents with at least 4 valid days were included in the accelerometry subsample (n = 5,689). Daily wear time was obtained by subtracting non-wear time (periods of 60 or more minutes of consecutive zero counts, with allowance for 1 to 2 minutes of counts between 0 and 100) from 24 hours. The cut-points for physical activity intensity were: sedentary (fewer than 100 counts per minute);

light physical activity (100 to 1,534); moderate (1,535 to 3,961); and vigorous (3,962 or more).[28,29] Because the majority of respondents did not engage in vigorous activity, moderate and vigorous physical activity (MVPA) were combined. MVPA data were square-root-transformed given the skewness of the distribution.

Statistical analyses

All analyses were performed with Stata, version 13 (StataCorp, College Station TX), using survey weights for the combined surveys. Different sets of survey weights were developed by Statistics Canada to account for missing data for the accelerometry measures and for the fasting blood samples. To account for the complex survey design, 95% confidence intervals were estimated using the bootstrap technique,[30] and degrees of freedom were set to 24.[20] Respondents with missing data on education (n = 66), household income (n = 187), and/or usual daily physical activity (n = 4) accumulated less sedentary time (p = 0.005). However, no differences were noted for levels of utilitarian walking and cycling or for any other outcome of interest. Listwise deletion was used for subsequent analyses.

Chi-square analyses assessed differences in levels of utilitarian walking and cycling between sexes, age groups (20 to 39, 40 to 59, and 60 to 79), education (university, college, and less than college), annual household income (less than $40,000, $40,000 to $79,999, and $80,000 or more), and self-reported usual daily physical activity level ("usually sit" versus other). The association between levels of walking and cycling was also assessed with a chi-square test. Associations between levels of walking and cycling and measures of physical activity, body composition, physical fitness, and CVD risk factors were examined with ANCOVA analyses (using the generalized linear model procedure). These models were adjusted for the complex survey design, and respondents' age (entered as a continuous variable), sex, education, household income, usual daily physical activity, and levels of walking or cycling (when not the dependent variable). The results are reported as model-based regression coefficients (with 95% confidence intervals) for the pairwise comparisons of the three levels of utilitarian walking and cycling. Bonferroni adjustments were used to adjust p-values for multiple comparisons of the three levels of walking and cycling; thus, α was set at 0.0166.

Table 1
Selected characteristics, by sex, household population aged 20 to 79, Canada excluding territories, 2007 to 2011

Characteristics	Total (n = 7,160)			Men (n = 3,546)			Women (n = 3,614)		
	Number or %	95% confidence interval from	to	Number or %	95% confidence interval from	to	Number or %	95% confidence interval from	to
Mean age (years)	45.7	45.5	45.9	45.3	44.9	45.6	46.1	45.8	46.4
Education (%)									
Less than college	49.6	44.9	54.2	52.8	47.3	58.2	46.5	41.7	51.3
College	21.3	19.2	23.4	16.6	14.2	19.2	25.9	22.8	29.3
University	29.2	24.4	34.5	30.7	25.3	36.6	27.7	23.1	32.8
Household income (%)									
Less than $40,000	25.2	22.3	28.4	22.3	18.9	26.2	28.1	25.0	31.4
$40,000 to $79,999	34.2	31.5	37.0	32.4	28.3	36.7	36.0	33.5	38.7
$80,000 or more	40.6	37.2	44.1	45.3	41.0	49.8	35.9	32.4	39.5
Hours utilitarian walking per week (%)									
Less than 1	34.2	30.9	37.8	40.1	35.7	44.8	28.4	25.3	31.8
1 to 5	48.0	45.5	50.6	44.6	40.9	48.4	51.4	48.1	54.6
More than 5	17.8	15.5	20.2	15.2	13.1	17.7	20.2	17.4	23.4
Hours utilitarian cycling per week (%)									
None	94.0	92.4	95.2	91.6	89.1	93.6	96.3	94.7	97.4
Less than 1	2.0	1.8	3.1	3.2	2.3	4.4	1.6	0.9	2.9
1 or more	3.7	2.6	5.1	5.3	3.6	7.5	2.1	1.4	3.2
Physical activity minutes per day									
Sedentary	583.9	578.6	589.3	577.5	570.4	584.6	590.3	584.1	596.5
Light	239.6	232.3	246.9	246.7	236.3	257.1	232.6	226.4	238.9
Moderate-to-vigorous	22.7	20.8	24.6	26.1	23.8	28.5	19.3	17.5	21.2
Health-related measures									
BMI (kg/m^2)	27.3	26.9	27.7	27.6	27.2	28.0	27.0	26.6	27.5
Waist circumference (cm)	91.7	90.7	92.8	96.0	94.8	97.1	87.5	86.2	88.8
Sum of 5 skinfolds (mm)	74.5	73.0	76.0	61.5	59.8	63.2	87.2	85.2	89.2
Estimated VO_2max (mL $O_2 \cdot kg^{-1} \cdot min^{-1}$)	36.2	35.7	36.7	38.8	38.1	39.6	33.4	33.0	33.9
Sit and reach (cm)	25.9	25.3	26.5	23.0	22.1	23.8	28.9	28.2	29.5
Grip strength (kg)	70.5	69.3	71.8	89.3	87.6	91.0	52.2	51.2	53.2
Systolic blood pressure (mmHg)	112.6	111.5	113.6	114.8	113.6	116.0	110.3	109.3	111.4
Diastolic blood pressure (mmHg)	71.8	71.1	72.5	74.0	73.0	74.8	69.5	68.8	70.3
HDL cholesterol (mmol/L)	1.4	1.3	1.4	1.2	1.2	1.3	1.5	1.5	1.6
Total cholesterol (mmol/L)	5.0	4.9	5.1	5.0	4.9	5.1	5.0	5.0	5.1
Total cholesterol/HDL (mmol/L)	3.9	3.8	4.0	4.3	4.2	4.4	3.5	3.4	3.6
Glycohemoglobin (%)	5.7	5.6	5.8	5.7	5.6	5.8	5.6	5.6	5.7
C-reactive protein (nmol/L)	22.9	21.7	23.9	20.2	19.1	21.4	25.5	23.8	27.1
Triglycerides (mmol/L)	1.4	1.3	1.4	1.5	1.4	1.6	1.3	1.2	1.3

HDL = high-density lipoprotein
Notes: Moderate-to-vigorous physical activity data were square root-transformed for analyses. C-reactive protein and triglycerides were log-transformed, but non-transformed values are provided in the table.
Sources: 2007-to-2009 and 2009-to-2011 Canadian Health Measures Surveys, combined.

Table 2
Hours per week of utilitarian walking, by selected characteristics, household population aged 20 to 79, Canada excluding territories, 2007 to 2011

	Less than 1 hour (n = 2,451)			1 to 5 hours (n = 3,438)			More than 5 hours (n = 1,271)				
		95% confidence interval			95% confidence interval			95% confidence interval			
Characteristics	%	from	to	%	from	to	%	from	to	x^2	*p*
Sex										22.6	< 0.001
Men	40.1	35.7	44.8	44.6	40.9	48.4	15.2	13.1	17.7		
Women	28.4	25.3	31.8	51.4	48.1	54.6	20.2	17.4	23.4		
Education										4.2	0.009
Less than college	37.2	33.1	41.5	44.2	39.9	48.5	18.6	15.4	22.3		
College	32.0	27.8	36.6	49.0	44.3	53.7	19.0	16.0	22.4		
University	30.0	25.1	35.5	54.5	49.5	59.4	15.5	12.5	19.1		
Household income										5.0	0.003
Less than $40,000	33.6	28.9	38.6	44.5	40.3	48.7	21.9	18.4	25.9		
$40,000 to $79,999	36.1	31.9	40.6	47.7	44.7	50.8	16.2	13.7	19.0		
$80,000 or more	32.9	29.1	36.8	51.1	47.9	54.3	16.0	13.6	18.8		
Age group										8.6	< 0.001
20 to 39	28.7	24.3	33.5	51.6	48.4	54.8	19.8	16.4	23.7		
40 to 59	37.6	33.8	41.6	45.6	41.9	49.3	16.9	14.5	19.5		
60 to 79	37.6	34.4	41.0	46.4	43.4	49.5	15.9	13.8	18.4		
Daily physical activity										14.6	< 0.001
Usually sit	37.2	32.4	42.3	51.2	46.8	55.6	11.6	8.8	15.1		
Stand, walk, lift weights	32.9	29.4	36.6	46.6	44.1	49.2	20.5	17.9	23.2		

Notes: Chi-squared (x^2) values are adjusted for complex survey design and weighted to represent Canadian population.
Sources: 2007-to-2009 and 2009-to-2011 Canadian Health Measures Surveys, combined.

Table 3
Hours per week of utilitarian cycling, by selected characteristics, household population aged 20 to 79, Canada excluding territories, 2007 to 2011

	None (n = 6,726)			Less than 1 hour (n = 171)			More than 1 hour (n = 263)				
		95% confidence interval			95% confidence interval			95% confidence interval			
Characteristics	%	from	to	%	from	to	%	from	to	x^2	*p*
Sex										10.1	< 0.001
Men	91.6	89,1	93.6	3.2	2.3	4.4	5.3	3.6	7.5		
Women	96.3	94.7	97.4	1.6	0.9	2.9	2.1	1.4	3.2		
Education										1.8	0.168
Less than college	94.1	92.6	95.4	2.4	1.7	3.5	3.5	2.5	4.8		
College	95.9	91.5	98.1	1.6	0.8	3.1	2.5	1.0	6.4		
University	92.0	89.3	94.1	3.0	1.9	4.7	5.0	3.4	7.3		
Household income										0.4	0.780
Less than $40,000	94.2	91.5	96.1	2.0	1.4	2.7	3.8	2.2	6.6		
$40,000 to $79,999	94.3	92.5	95.6	2.4	1.6	3.5	3.4	2.3	4.9		
$80,000 or more	93.6	91.6	95.1	2.5	1.7	3.7	3.9	2.7	5.6		
Age group										11.6	< 0.001
20 to 39	91.5	88.6	93.7	3.3	2.2	4.7	5.3	3.4	8.0		
40 to 59	94.6	93.1	95.8	2.1	1.5	3.0	3.3	2.4	3.5		
60 to 79	97.1	96.1	97.8	1.4	0.9	2.0	1.6	1.1	2.3		
Daily physical activity										0.1	0.938
Usually sit	94.0	91.7	95.7	2.3	1.4	3.6	3.7	2.5	5.6		
Stand, walk, lift weights	93.9	92.1	95.3	2.5	1.8	3.3	3.7	2.5	5.4		

Notes: Chi-squared (x^2) values are adjusted for complex survey design and weighted to represent Canadian population.
Sources: 2007-to-2009 and 2009-to-2011 Canadian Health Measures Surveys, combined.

Results

A third (34.2%) of respondents reported that they engaged in utilitarian walking less than an hour a week; 48.0% reported 1 to 5 hours a week; and 17.8% reported more than 5 hours a week (Table 1). Reports of more than 5 hours a week were more prevalent among women, younger adults, people who did not have a university degree, those who earned less than $40,000 annually, and those with more active occupations (Table 2).

Most respondents (94.0%) reported no utilitarian cycling; 2.4% reported less than an hour a week, and 3.7% reported at least an hour a week (Table 3). Men and younger adults were much more likely than women and older adults to report at least an hour a week. Hours of utilitarian cycling were not associated with education, household income, or self-reported usual daily physical activity. A significant positive association was observed between reported levels of utilitarian walking and cycling ($\chi^2_{[4 \text{ df}]} = 4.3$; $p = 0.008$, data not shown).

Utilitarian walking was positively associated with daily MVPA in a graded manner—respondents who walked more than 5 hours a week accumulated an additional 9.3 minutes of MVPA each day ($p < 0.001$) (Table 4). However, respondents who reported walking 1 to 5 hours a week accumulated less light physical activity than did those who walked the least (-17.6 minutes a day; $p = 0.001$). Compared with respondents who walked 1 to 5 hours a week, those who walked more than 5 hours a week had lower skinfold thickness (-4.1 mm; $p = 0.010$). In a sensitivity analysis (data not shown) that excluded self-reported usual daily physical activity from the control variables, the model-based coefficients and their statistical significance were unchanged.

A gradient was also evident between utilitarian cycling and MVPA (Table 5), but differences were significant only between adults who reported cycling at least an hour a week and those reporting no cycling. Compared with respondents who did not cycle, those who cycled less than an hour a week

Table 4
Relationship between utilitarian walking and measures of physical activity and health indicators, household population age 20 to 79, Canada excluding territories, 2007 to 2011

Physical activity and health indicators	Weekly utilitarian walking								
	1 to 5 hours (n = 3,438) versus less than 1 hour (n = 2,451)			More than 5 hours (n = 1,271) versus 1 to 5 hours (n = 3,438)			More than 5 hours (n = 1,271) versus less than 1 hour (n = 2,451)		
		95% confidence interval			95% confidence interval			95% confidence interval	
	b	from	to	b	from	to	b	from	to
Sedentary time (min/day)	6.7	-2.7	16.1	-4.6	-17.4	8.1	2.1	-12.2	16.4
Light physical activity (min/day)	-17.6†	-27.6	-7.7	0.9	-15.4	17.3	-16.7	-33.0	-0.5
Moderate-to-vigorous physical activity (min/day)	3.7†	1.2	6.2	5.6†	2.4	8.8	9.3†	5.4	13.2
BMI (kg/m^2)	-0.2	-0.6	0.3	0.0	-0.6	0.6	-0.2	-0.9	0.5
Waist circumference (cm)	-0.3	-1.5	0.8	0.1	-1.3	1.5	-0.3	-2.0	1.5
Sum of 5 skinfolds (mm)	1.6	-0.7	3.8	-4.1†	-7.1	-1.1	-2.5	-5.6	0.6
Estimated VO_2max (mL $O_2 \cdot kg^{-1} \cdot min^{-1}$)	0.0	-0.7	0.7	0.4	-0.2	1.1	0.4	-0.5	1.3
Sit and reach (cm)	-0.3	-1.5	0.9	0.1	-1.0	1.2	-0.2	-1.5	1.1
Grip strength (kg)	-1.2	-2.9	0.4	0.8	-0.8	2.3	-0.5	-2.5	1.5
Systolic blood pressure (mmHg)	0.5	-0.6	1.6	-0.9	-2.6	0.9	-0.4	-2.0	1.2
Diastolic blood pressure (mmHg)	-0.2	-1.0	0.5	-0.5	-1.6	0.5	-0.8	-1.7	0.1
HDL cholesterol (mmol/L)	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1
Total cholesterol (mmol/L)	-0.1	-0.2	0.0	0.0	-0.1	0.1	-0.1	-0.2	0.0
Total cholesterol/HDL (mmol/L)	-0.1	-0.2	0.1	-0.1	-0.3	0.0	-0.2	-0.4	0.0
Glycohemoglobin (%)	0.0	-0.1	0.1	-0.1	-0.1	0.0	-0.1	-0.2	0.0
C-reactive protein (nmol/L)	0.7	-1.7	3.1	1.2	-2.3	4.7	1.9	-1.9	5.7
Triglycerides (mmol/L)	0.0	-0.1	0.1	-0.1	-0.2	0.0	-0.1	-0.3	0.0

† significant difference after Bonferroni adjustment
HDL = high-density lipoprotein
Notes: ANCOVA models were fitted with Generalized Linear Model procedure in Stata, version 13. Analyses were adjusted for complex survey design, sex, age, self-reported usual daily physical activity (usually sit versus others), education and household income. Model-based coefficients (b) show relationship between physical activity and health-related measures and weekly hours of utilitarian walking; for example, compared with those who reported walking less than 1 hour per week, those who reported more than 5 hours per week accumulated an additional 9.3 minutes of moderate-to-vigorous activity per day. Moderate-to-vigorouss physical activity data were square root-transformed for analyses; C-reactive protein and triglycerides were log-transformed (non-transformed coefficients are provided for ease of interpretation, but p-values were calculated with the transformed data).
Sources: 2007-to-2009 and 2009-to-2011 Canadian Health Measures Surveys, combined.

had lower glycohemoglobin (-0.1%; $p = 0.015$); those who cycled an hour or more a week accumulated more MVPA (15.6 min/day; $p < 0.001$), and had higher aerobic fitness (+3.3 mL $O_2 \cdot kg^{-1} \cdot min^{-1}$, $p < 0.001$) and lower BMI (-1.9 kg/m^2; $p < 0.001$), waist circumference (-6.0 cm; $p < 0.001$), total cholesterol/HDL ratio (-0.3; $p = 0.016$), glycohemoglobin (-0.1%; $p= 0.012$), C-reactive protein (-6.7 nmol/L; $p = 0.004$), and triglycerides (-0.3 mmol/L; $p = 0.013$). As well, those who cycled an hour or more a week had higher aerobic fitness (+2.7 mL $O_2 \cdot kg^{-1} \cdot min^{-1}$; $p = 0.001$), lower BMI (-1.8 kg/m^2; $p = 0.013$), and smaller waist circumference (-5.6 cm; $p = 0.003$) than those who cycled less than an hour a week.

Discussion

Consistent with the first hypothesis, adults who reported greater amounts of active travel—utilitarian walking and cycling—accumulated more daily MVPA. Those who cycled at least an hour a week had greater aerobic fitness and lower BMI, waist circumference, total cholesterol/HDL ratio, glycohemoglobin, C-reactive protein and triglycerides than did those who did not cycle. This supports the second hypothesis, suggesting that cycling is more strongly associated with reduced CVD risk factors than is walking.

Studies have shown that when physical activity increases in one domain, individuals tend to reduce it in others.[31] Therefore, it is important to determine if people who engage in active travel are more active overall. The present study is among the first to examine relationships between active travel and objective measures of physical activity in a large, nationally representative sample of adults. Active travel was associated with higher MVPA, consistent with studies that largely relied on self-reported physical activity.[15] However, in this analysis, adults who reported walking 1 to 5 hours a week accumulated significantly less light physical activity. In addition, no association was observed between active travel and sedentary behaviour, suggesting that active travel is not sufficient to reduce the amount of time (more than 9 hours a day) during which Canadian adults are sedentary.

When potential confounders were taken into account, few associations emerged between utilitarian walking and health-related outcomes. The sensitivity analysis suggests that the findings are not due to the inclusion of self-reported usual daily physical activity as a control variable. These results contrast with a meta-analysis of randomized controlled trials of leisure-time walking, which indicated favourable changes in measures of aerobic fitness, body composition, and blood pressure.[32] In follow-ups to the Nurse's Health Study and the Women's Health Initiative Observational Study,[33,34] leisure-time walking was associated with a reduced risk of cardiovascular events. However, a critical review[12] noted that studies that showed

Table 5
Relationship between utilitarian cycling and measures of physical activity and health indicators, household population aged 20 to 79, Canada excluding territories, 2007 to 2011

	Weekly utilitarian cycling								
	Less than 1 hour (n = 171) versus none (n = 6,726)			1 or more hours (n = 263) versus less than 1 hour (n = 171)			1 or more hours (n = 263) versus none (n = 6,726)		
		95% confidence interval			95% confidence interval			95% confidence interval	
Physical activity and health indicators	b	from	to	b	from	to	b	from	to
Sedentary time (min/day)	-21.7	-52.1	8.7	12.5	-24.7	49.7	-9.2	-28.7	10.3
Light physical activity (min/day)	7.8	-9.6	25.1	-1.6	-31.4	28.3	6.2	-15.8	28.2
Moderate-to-vigorous physical activity (min/day)	5.0	-1.8	11.7	10.6	1.5	19.8	15.6†	8.3	22.9
BMI (kg/m^2)	-0.1	-1.5	1.3	-1.8†	-3.1	-0.4	-1.9†	-2.6	-1.1
Waist circumference (cm)	-0.4	-4.2	3.4	-5.6†	-9.0	-2.2	-6.0†	-8.2	-3.8
Sum of 5 skinfolds (mm)	-0.6	-5.7	4.4	-5.0	-11.8	1.8	-5.6	-10.5	-0.7
Estimated VO_2max (mL $O_2 \cdot kg^{-1} \cdot min^{-1}$)	0.6	-0.6	1.8	2.7†	1.2	4.2	3.3†	2.3	4.4
Sit and reach (cm)	2.3	0.3	4.3	0.4	-3.2	3.9	2.7	-0.2	5.5
Grip strength (kg)	0.0	-3.9	3.9	0.9	-4.2	5.9	0.8	-3.1	4.8
Systolic blood pressure (mmHg)	-2.9	-5.9	0.0	1.7	-2.1	5.4	-1.3	-3.1	0.6
Diastolic blood pressure (mmHg)	-2.1	-4.3	0.0	2.7	-0.1	5.5	0.6	-0.9	2.0
HDL cholesterol (mmol/L)	0.1	0.0	0.1	0.0	-0.1	0.1	0.1	0.0	0.1
Total cholesterol (mmol/L)	0.2	-0.1	0.4	-0.3	-0.6	0.0	-0.1	-0.4	0.1
Total cholesterol/HDL (mmol/L)	-0.1	-0.4	0.2	-0.2	-0.5	0.2	-0.3†	-0.5	-0.1
Glycohemoglobin (%)	-0.1†	-0.2	0.0	0.0	-0.1	0.1	-0.1†	-0.2	0.0
C-reactive protein (nmol/L)	0.8	-8.0	9.5	-7.4	-16.4	1.5	-6.7†	-9.5	-3.8
Triglycerides (mmol/L)	-0.2	-0.4	0.0	-0.1	-0.4	0.2	-0.3†	-0.5	-0.1

† significant difference after Bonferroni adjustment
HDL = high-density lipoprotein
Notes: ANCOVA models were fitted with the Generalized Linear Model procedure in Stata, version 13. Analyses were adjusted for complex survey design, sex, age, self-reported usual daily physical activity (usually sit versus others), education, and household income. Model-based coefficients (b) show relationship between physical activity and health-related measures and weekly hours of utilitarian cycling; for example, compared with those reporting no cycling, those reporting at least 1 hour per week accumulated an additional 15.6 minutes of moderate-to-vigorous physical activity per day. Moderate-to-vigorous physical activity data were square root-transformed for analyses while C-reactive protein and triglycerides were log-transformed (non-transformed coefficients are provided for ease of interpretation, but p-values were calculated with the transformed data).
Sources: 2007-to-2009 and 2009-to-2011 Canadian Health Measures Surveys, combined.

cardiovascular benefits of walking typically involved older adults who walked considerable distances at a higher intensity and without compensatory reductions in other activities. Utilitarian walking may not be intense enough to trigger cardiovascular benefits, particularly in young adults who tend to have higher aerobic fitness.[12]

Another possible explanation for the present findings is that respondents who reported more hours of utilitarian walking may be less active in the remainder of the day.[31] The observation that respondents who walked 1 to 5 hours a week accumulated less light physical activity than did those who walked less than an hour a week provides some support for this explanation. In addition, utilitarian walking was associated with lower socioeconomic status (SES). Despite adjustment for education and household income, residual confounding from SES may remain. For instance, the analyses did not control for diet quality, which may be inferior among individuals with lower SES, thereby increasing their CVD risk.[35] Finally, measurement error may have limited the ability to detect significant differences across levels of walking.

Notwithstanding the lack of significant associations with health-related outcomes, utilitarian walking may yield environmental benefits including reduced emissions of greenhouse gases and vehicle exhaust gases.[13,14] Also, a large shift from driving to active travel could reduce exposure to airborne particulate matter, which is known to increase cardiovascular risk.[36]

Strong associations emerged between utilitarian cycling for at least an hour a week and MVPA, aerobic fitness, and CVD risk factors. For example, the mean difference in MVPA between these respondents and those reporting no cycling amounts to 109.2 minutes a week (more than 70% of recommended weekly MVPA[4]). Similarly, the mean difference in aerobic fitness corresponds to almost one metabolic equivalent. Mean differences in BMI (-1.9 kg/m^2), waist circumference (-6.0 cm), triglycerides (-0.3 mmol/L) and C-reactive protein (-6.7 nmol/L) were also large. Such measures have been shown to be important predictors of subsequent cardiovascular diseases.[1] The strong association between cycling at least an hour a week and MVPA, despite the limited ability of accelerometers to capture physical activity during cycling,[37] suggests that adults who engage in utilitarian cycling may also be more active during the remainder of the day.

Consistent with the present findings, a systematic review noted that small randomized controlled trials have demonstrated the efficacy of cycling to work in increasing adults' aerobic fitness.[17] Similarly, lower odds of overweight and obesity have been reported among adults who commuted by bicycle.[38,39] Prospective studies have also shown that cycling to work was associated with a reduced risk of all-cause mortality,[40,41] although no reduction was noted in a cohort of U.K. adults who reported lower levels of cycling.[42]

The present study extends current evidence by considering a broader range of destinations. While an individual's workplace may be too far away to commute by bicycle, other destinations may provide opportunities for utilitarian cycling.

Overall, 3.7% of respondents reported cycling at least an hour a week; the percentage was much higher among men and in younger adults. Similar disparities by age and gender have been noted in large surveys of adults in Australia, Canada, the United Kingdom, and the United States.[43] By contrast, no gender differences were observed in Denmark, Germany and the Netherlands, where cycling is more prevalent and safer.[43]

What is already known on this subject?

- Among adults, active travel is associated with higher self-reported physical activity.
- Some evidence indicates that people who engage in active travel have lower body weight and more favourable health outcomes, but the quality of this evidence was rated low.
- Earlier studies tended to focus only on commuting to work, and many did not distinguish between walking and cycling despite the higher intensity of cycling.

What does this study add?

- Utilitarian walking and cycling were both associated with accelerometry-measured physical activity in a graded manner among Canadian adults.
- After adjustment for potential confounders, few associations persisted between utilitarian walking and health-related outcomes.
- Utilitarian cycling for an hour or more a week was associated with greater cardiovascular fitness and reduced cardiovascular disease risk factors.

Limitations and strengths

The main limitation of this study is the cross-sectional design, which makes it impossible to determine the direction of observed relationships. Second, statistical adjustment was limited by the survey design which allowed only 24 degrees of freedom,[20] rendering the analyses more conservative. Third, the analysis did not control for MVPA because accelerometers do not indicate if it was accumulated through active travel or other activities. Nevertheless, the models were adjusted for self-reported usual daily physical activity (a common measure in large-scale epidemiological studies[44]) and for levels of utilitarian walking or cycling when it was not the dependent variable. Fourth, self-reported walking and cycling are subject to recall and social desirability biases,[45] a limitation compounded by the use of a single question that is potentially cognitively challenging. Fifth, the reliability and validity of the active travel questions are not known, although previous research suggests that adult-reported travel modes and duration have high test-retest reliability.[46] Objective assessments of physical activity in adults might have been more strongly associated with health-related outcomes, but the use of global positioning systems or direct observation to assess active travel is cost-prohibitive for large, nationally representative surveys. Data were collected throughout the year, so adults who cycled only during warmer months may have been categorized as non-cyclists because they did not cycle in the three months before their survey interview and MEC visit. Such seasonal variations in active travel may have led to regression towards the mean.[47]

This study is one of the first to investigate associations between active travel (not restricted to commuting to work) and objective measures of physical activity, physical fitness, body composition, and CVD risk factors in a large, nationally representative sample of adults. Direct measurement of all outcome variables likely avoided social desirability and recall bias that are associated with self-reported physical activity and body composition indicators.[45,48] Unlike most North American studies, this study analyzed utilitarian walking and cycling separately rather than combined. Furthermore, the active travel questions in the CHMS made it possible to examine the effects of different "doses" of walking and cycling.

Conclusion

The findings, based on a large, nationally representative sample of Canadian adults, show a graded association between both utilitarian walking and cycling and accelerometry-measured MVPA. Few differences in health-related outcomes across levels of walking were apparent, but cycling at least an hour a week was strongly associated with greater aerobic fitness and lower BMI, waist circumference, total cholesterol/HDL ratio, glycohemoglobin, C-reactive protein, and triglycerides. These findings suggest that cycling may be associated with a more consistent pattern of health benefits than walking.

Given the low prevalence of active travel, particularly cycling, future prospective studies might examine determinants of change in travel behaviour. Moreover, studies that include measures of physical activity in all four domains—leisure, transportation, occupation and household—would be able to assess the effect of an increase in active travel on physical activity in the other domains. Finally, future research could examine the shape of the dose-response relationship between active travel and health-related outcomes.

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