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An examination of the associations between walkable neighbourhoods and obesity and self-rated health in Canadians

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Abstract

Background: Two-thirds of Canadian adults and one-third of Canadian children and youth are overweight or obese. There is increased interest in identifying features of the built environment—such as walkability—that facilitate lifestyle habits associated with reduced obesity and improved health. The purpose of this study is to examine how the associations between walkability and both obesity and self-rated health vary by age in Canadians using a new walkability dataset.

Data and methods: The 2016 Canadian Active Living Environments (Can-ALE) database was attached to Canadian Health Measures Survey (CHMS; 2009 to 2015) data. Moderate-to-vigorous physical activity (MVPA), light physical activity (LPA) and step counts were measured in the CHMS using the Actical accelerometer (n = 10,852; ages 3 to 79). Body mass index (BMI) and waist circumference were measured in a mobile clinic. Self-rated general and mental health were assessed using a questionnaire.

Results: The percentage of adults aged 40 to 59 classified as overweight or obese was 28 percentage points lower in the most walkable Can-ALE category than in the least walkable category (49.1% vs. 77.5%, $p < 0.0125$). There was a significant downward linear trend in measured BMI and waist circumference across Can-ALE categories (from least to most walkable) for adults aged 18 to 59, but not for children and youth or older adults aged 60 to 79. MVPA was a significant mediating factor in the association between the Can-ALE index and BMI in adults aged 40 to 79 (and in the waist circumference of respondents aged 40 to 59). Young adults (aged 18 to 39) were more likely than older adults (aged 60 to 79) to report very good or excellent general health as walkability increased.

Interpretation: Using a new and freely-available Canadian walkability index, this study observed a positive association between walkability and both measured obesity and self-rated general health in adults. Walkability is one of many built environment characteristics that should be considered when trying to understand the relative contribution of the built environment to a person's weight and overall health.

Keywords: exercise, walkability, built environment, walking, transportation
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Two-thirds of Canadian adults and one-third of Canadian children and youth are overweight or obese.[1,2] The modest success of individual-level programs and interventions (i.e., healthy eating and physical activity) aimed at altering the behaviours that contribute to obesity has led to increased interest in changing the physical environment in a way that helps individuals make better lifestyle choices.[3-4] The Chief Public Health Officer's Report on the State of Public Health in Canada 2017, *Designing Healthy Living*, drew attention to the potential impact of using the built environment to help Canadians make healthier choices. Similarly, one of the key tenets of the Ottawa Charter for Health Promotion is the need to create supportive environments to help individuals respond to a rapidly changing environment and increasing urbanization.[4,5] The activity friendliness of a neighbourhood is commonly assessed using walkability, which is a measure of how well a neighbourhood's built form promotes walking and generally consists of multiple subcomponents, including proximity to destinations of interest (e.g., shops, services, workplaces, schools), street connectivity (number of intersections, route options, directness of routes) and residential density (which can support destinations of interest). The Canadian Active Living Environments (Can-ALE) database is a new geography-based set of measures that represents the active living friendliness of Canadian communities.[6]

According to a recent systematic review and meta-analysis, there is strong evidence for a longitudinal association between neighbourhood walkability and obesity, hypertension and type 2 diabetes.[7] This work builds on a body of cross-sectional research that has reported evidence of a relationship between walkable features of the built environment and reduced obesity in adults[8-10] and children and youth.[11,12] Despite a general consensus that a link exists between the built environment and obesity, a clear causal pathway has yet to be described and likely consists of several environmental factors, including—but not limited to—walkability, access to healthy food, proximity to recreational facilities and services, and neighbourhood self-selection.[10,13-15] In Canada, research has shown that adults living in less walkable areas or areas with more urban sprawl are more likely to be overweight or obese.[16-19] However, another Canadian study reported no association between urban sprawl at the regional level and obesity in youth.[20] There is presently no national study in Canada that examines the association between walkability and obesity across a wide age range. Physical activity has been proposed as a key mediating factor in the association between walkability and obesity; however, conclusive evidence describing this effect has been identified as a gap in knowledge.[7,21]

Self-rated health is considered a powerful global indicator of health and mortality.[22] Given that self-rated health reflects both health behaviours (e.g., physical activity and related outcomes

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What is already known on this subject?

- Two-thirds of Canadian adults and one-third of Canadian children and youth are overweight or obese.
- Altering the built environment in a way that helps individuals make better lifestyle choices has been identified as a population health strategy.
- Walkability is positively associated with improved health and reduced obesity; however, the causal pathway is not clear.

What does this study add?

- There were less overweight or obese adults in the most walkable type of neighbourhood than in the least walkable type.
- The relationship between walkability and obesity was stronger in young adults than in youth or older adults.
- Young adults were more likely than older adults to report very good or excellent general health as walkability increased.

(e.g., obesity), it may be particularly useful to gain an overall sense of how the built environment is linked to health. Inactive people are more likely to report poor or fair general health,[23-25] while the link between physical activity and mental health is less clear. Using data from the Behavioral Risk Factor Surveillance System, Oishi and colleagues reported that Americans living in more walkable areas were healthier and had lower obesity rates; however, they were less satisfied with their lives.[26] Another study found that self-rated general health was higher in more walkable areas, but self-rated mental health was not linked to walkability.[27] In an examination of physical environmental factors that may be associated with depression, Rautio and colleagues reported that the links between poor housing, lack of green space, and noise and air pollution were more consistently associated with depression than walkability.[28]

The purpose of this study is to examine the association between walkability and obesity and self-rated general and mental health in a nationally representative sample of Canadian children and adults. The secondary purpose of this study is to examine and describe the mediating effect of physical activity in the association between walkability and obesity.

Methods

Using the Postal Code Conversion File Plus (PCCF+), the 2016 Canadian Active Living Environments (Can-ALE) database was attached to Canadian Health Measures Survey (CHMS; 2009 to 2015) data. Of the original household and clinic CHMS sample aged 3 to 79 (n = 17,974), 13,133 respondents had valid accelerometer-measured physical activity and obesity data and, of these, Can-ALE data were available for 10,852. The CHMS is an ongoing cross-sectional survey conducted by Statistics Canada that collects measured and reported health information from a representative sample of the Canadian household-dwelling population aged 3 to 79 using mobile examination centres that travel to multiple sites across the country, except the territories.[29-31]

Canadian Active Living Environments (Can-ALE) database

The Can-ALE database is a geography-based set of measures that represents the active living friendliness of Canadian communities.[6,32] The z-scores of three factors were included in the 2016 Can-ALE database: intersection density, dwelling density and points of interest, which are hypothesized to increase walking behaviours by providing route options and decreased distances between homes and points of interest. A summarized index measure (the sum of z-scores for each ALE measure—the ALE index) and a categorical measure of the favourability of the active living environment (from 1, the least active living friendly and walkable, to 5, the most active living friendly and walkable—the ALE class) are also included in the database. The measures are based on one-kilometre buffers drawn from the centroids of dissemination areas (DAs). DAs are small geographic units defined by Statistics Canada that typically encompass a population of between 400 and 700 people. Intersection density was derived using road and footpath features from Statistics Canada's Road Network File and OpenStreetMap and represents the number of three-way (or more) intersections within a one-kilometre buffer around the DA centroid. Dwelling density was calculated using Statistics Canada census data and captures the average dwelling density of the DAs within the buffer area. The points of interest measure captures the number of potential walking destinations (e.g., parks, schools, shops, places of business and landmarks) within a one-kilometre buffer. Two versions of Can-ALE (2006 and 2016) are currently available. The present analysis used the 2016 database, as it was closer to the CHMS years used.

Postal Code Conversion File Plus (PCCF+)

The Postal Code Conversion File Plus (PCCF+) is a SAS© control program and set of associated datasets from the Postal Code Conversion File (PCCF), a postal code population weight file, the Geographic Attribute File, health region boundary files and other supplementary data. PCCF+ Version 7A[33] was used to assign a DA to each CHMS respondent's postal code to allow the Can-ALE measures to be attached. Because of precision issues with geocoding in rural areas,[33,34] respondents living in a rural area or small town were excluded from this analysis using the community size variable (CSize < 5). Community size is defined in terms of the 2016 Census population in each census metropolitan area (CMA) or census agglomeration (CA). Community size 1 includes Toronto, Montréal and Vancouver; community size 2 includes Ottawa–Gatineau, Edmonton, Calgary, Québec, Winnipeg and Hamilton; community size 3 includes all 18 other CMAs and seven of the larger CAs; community size 4 includes all 106 other CAs; and community size 5 includes all places not included in a CMA or CA and is representative of rural and small-town Canada.

Obesity and self-rated health

Body mass index (BMI) was calculated using measured weight in kilograms divided by measured height in metres squared ($kg{\cdot}m^2$). Height was measured to the nearest 0.1 cm using a ProScale M150 digital stadiometer (Accurate Technology Inc., Fletcher, United States), and weight was measured to the nearest 0.1 kg with a Mettler Toledo VLC with Panther Plus terminal scale (Mettler Toledo Canada, Mississauga, Canada). Waist circumference was measured to the nearest 0.1 cm using a flexible tape. Adults were classified as overweight or obese if their measured BMI was $\geq$ 25.0 kg/m^2. Children and youth were classified as overweight or obese according to the World Health Organization BMI-for-age Child Growth Standards. Young children (ages 3 to 4) were classified as overweight or obese if their BMI was greater than two standard deviations above the mean, while older children and youth (ages 5 to 17) were classified as overweight or obese if their BMI was greater than one standard deviation above the mean.[29-31] As part of the household questionnaire, respondents were asked to rate their general and mental health as poor, fair, good, very good or excellent. For this analysis, the response categories were collapsed into poor, fair or good and very good or excellent.

Accelerometer-measured physical activity

Upon completion of the mobile examination centre visit, ambulatory respondents were asked to wear an Actical accelerometer (Phillips Respironics, Oregon, United States) over their right hip on an elasticized belt during waking hours for seven consecutive days. All respondents were blind to the data while they wore the device. The Actical measures and records time-stamped acceleration in all directions, providing an index of physical activity intensity using a count value for each minute. A valid day was defined as having 10 or more hours of wear time and a valid respondent was defined as having a minimum of four valid days.[35] Wear time was determined by subtracting non-wear time from 24 hours. Non-wear time was defined as at least 60 consecutive minutes of zero counts, with allowance for one to two minutes of counts between 0 and 100. Published movement intensity thresholds were applied to the data to derive time spent in light physical activity (LPA) and moderate-to-vigorous physical activity (MVPA).[36-38] A complete description of the accelerometer data reduction procedures is available elsewhere.[35]

Statistical analysis

Descriptive statistics were used to calculate means and 95% confidence intervals. Pairwise contrasts were used to assess differences in BMI, waist circumference and percentage overweight or obese by walkability category. Because there were multiple comparisons (Can-ALE classes 2, 3, 4 and 5 vs. Class 1), a Bonferroni adjustment was applied to the p-values used in the pairwise contrasts (the p-values were divided by 4). Therefore, the results of the pairwise contrasts were presented as significant at the $p < 0.0125$ and $p < 0.00025$ levels. Trend analyses were used to assess upward or downward linear trends in measured obesity and percentage overweight or obese across the five categories of walkability. Regression models were used to assess the univariate associations between walkability (continuous variable), physical activity (MVPA, LPA and step counts) and obesity (BMI and waist circumference), and they were controlled for age, sex, household income and household education. The models for the preschool age group (ages 3 to 4) were controlled only for age and sex because of sample size constraints. Structural equation modelling was used to determine whether physical activity had a significant mediating (indirect) effect on the association between walkability and obesity. These models were also controlled for age, sex, household income and household education. Pairwise contrasts were used to assess the percentage difference in respondents reporting very good or excellent general and mental health by walkability category (like in the obesity analysis, a Bonferroni adjustment was applied to the p-values used in these pairwise contrasts). Trend analyses were used to assess upward or downward linear trends in the percentage of respondents reporting very good or excellent general and mental health. Logistic regression—controlled for age, sex, household income and household education—was used to determine whether walkability (ALE_index; continuous variable) had any impact on the likelihood of reporting less favourable general and mental health (i.e., poor, fair or good vs. very good or excellent).

To account for the complex survey design and non-response bias, all analyses were weighted using the combined cycle survey weights generated by Statistics Canada for cycles 2, 3 and 4 of the CHMS.[29-31] The data were analyzed with SAS 9.3 (SAS Institute, Cary, North Carolina) and SUDAAN 11.0 using denominator degrees of freedom (DDF = 35) in the SUDAAN procedure statements. Stata-MP64 (Version 14) was used for the structural equation modelling. The denominator degrees of freedom were defined to 35 using the svyset command in Stata. To account for survey design effects, variance (95% confidence intervals) was estimated using the bootstrap technique. Response rates were 40% for the CHMS (reflecting the analytical requirement of having at least four valid days of accelerometer data).[29-31]

Results

Descriptive physical activity and obesity characteristics of the sample are presented in Table 1. Table 1 also includes the distribution of the sample across the five Can-ALE categories and across the response categories for general and mental health. There was a significant downward trend in the prevalence of overweight and obesity across Can-ALE categories (from least to most walkable) in adults aged 18 to 59 only (Figure 1). There was a 28 percentage point difference in the percentage of 40 to 59 year old adults classified as overweight or

Table1
Distribution across Can-ALE classes and descriptive physical activity, obesity and self-rated health results

	Ages 3 to 4			Ages 5 to 11			Ages 12 to 17			Ages 18 to 39			Ages 40 to 59			Ages 60 to 79		
	n = 690	95% confidence interval		n = 2,416	95% confidence interval		n = 1,318	95% confidence interval		n = 2,277	95% confidence interval		n = 2,232	95% confidence interval		n = 1,919	95% confidence interval	
	Estimate	from	to	Estimate	from	to	Estimate	from	to	Estimate	from	to	Estimate	from	to	Estimate	from	to
Walkability Class 1 (%)	15.6^{E}	10.9	21.9	18.8	13.7	25.3	18.3^{E}	12.9	25.3	14.4	10.2	20.0	18.1	13.4	24.0	20.7	15.3	27.4
Walkability Class 2 (%)	33.1	25.9	41.1	37.4	31.3	44.0	32.9	27.0	39.4	31.1	25.3	37.7	34.7	28.3	41.8	32.8	27.4	38.7
Walkability Class 3 (%)	35.2	27.9	43.3	28.8	23.5	34.6	33.6	27.3	40.5	31.8	26.2	38.0	30.7	25.4	36.6	30.3	25.2	35.9
Walkability Class 4 (%)	F	...	...	F	...	...	F	...	...	12.8^{E}	8.8	18.1	11.2^{E}	7.3	16.9	11.7^{E}	7.2	18.6
Walkability Class 5 (%)	F	...	...	F	...	...	F	...	...	9.9^{E}	5.4	17.3	5.3^{E}	2.3	11.7	4.5^{E}	2.4	8.4
MVPA (minutes/day)	69.7	67.1	72.4	63.1	59.9	66.3	47.4	44.0	50.8	30.6	27.8	33.4	23.3	21.4	25.1	15.3	13.9	16.7
Light physical activity (minutes/day)	208.7	203.3	214.2	269.0	263.5	274.6	207.3	202.6	212.1	229.6	221.8	237.4	230.2	225.2	235.1	187.0	181.1	192.8
Step counts per day	10,283	9,855	10,711	11,579	11,178	11,979	9,669	9,207	10,132	8,956	8,583	9,330	8,536	8,220	8,853	6,898	6,664	7,132
Body mass index (kg/m^2)	16.2	16.0	16.5	17.4	17.2	17.6	21.9	21.5	22.3	26.2	25.5	26.9	28.0	27.5	28.5	27.8	27.3	28.2
Waist circumference (cm)	51.1	50.5	51.7	60.4	59.7	61.0	75.9	74.8	76.9	89.0	87.3	90.8	96.0	94.7	97.4	97.2	96.0	98.4
General health – poor, fair or good (%)	14.8^{E}	9.5	22.3	12.4	9.6	15.7	33.4	29.5	37.5	45.5	40.9	50.2	47.7	43.6	51.7	51.4	47.6	55.2
General health – very good or excellent (%)	85.2	77.7	90.5	87.6	84.3	90.4	66.6	62.5	70.5	54.5	49.8	59.1	52.3	48.3	56.4	48.6	44.8	52.4
Mental health – poor, fair or good (%)	...	...	...	...	...	...	21.8	18.4	25.6	27.5	23.1	32.4	30.7	27.3	34.4	29.0	25.7	32.5
Mental health – very good or excellent (%)	...	...	...	...	...	...	78.2	74.4	81.6	72.5	67.6	76.9	69.3	65.6	72.7	71.0	67.5	74.3

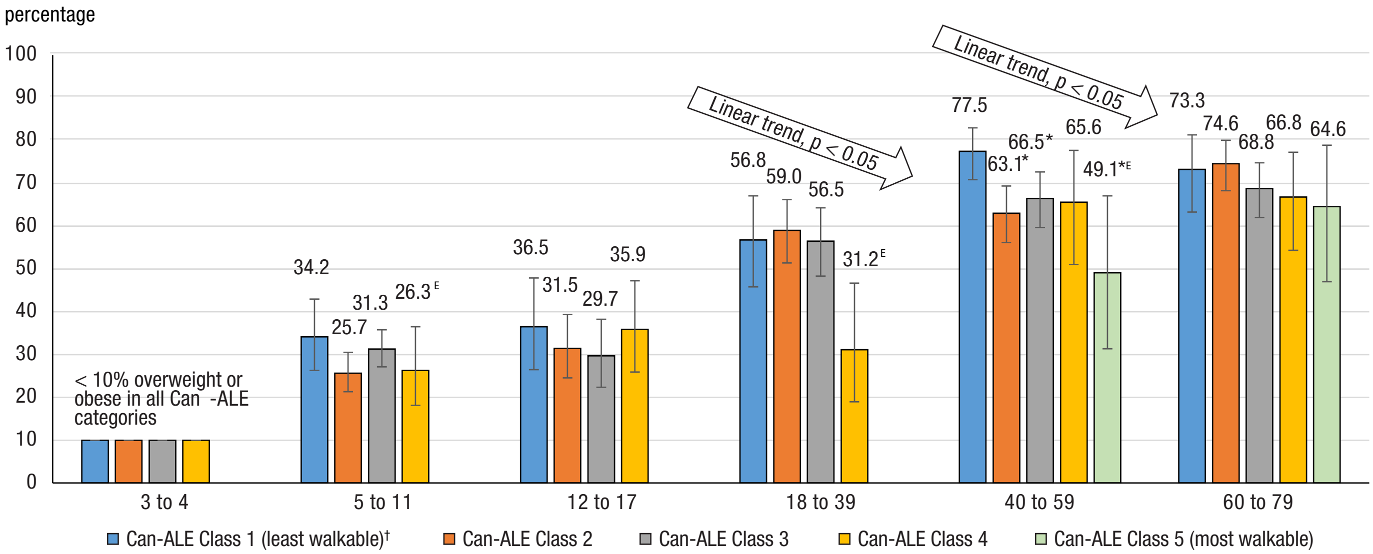
... not applicable
^{E} use with caution
F too unreliable to be published
Note: MVPA: moderate-to-vigorous physical activity.
Source: Canadian Health Measures Survey, 2009 to 2015.

obese between the most and least walkable categories. There was a significant downward linear trend in both measured BMI and waist circumference across Can-ALE categories (from least to most walkable) for adults aged 18 to 59, but not for children and youth or older adults aged 60 to 79 (figures 2 and 3). Pairwise contrasts between percentage overweight or obese, BMI and waist circumference in Can-ALE classes 2, 3, 4 and 5 and Class 1 (least walkable) are noted in figures 1, 2 and 3.

A summary of the univariate associations between the Can-ALE walkability index, physical activity (MVPA, LPA and step counts) and BMI, as well as between the walkability index, physical activity (MVPA, LPA and step counts) and waist circumference, is provided in figures 4 and 5. The indirect effect (path) of physical activity (MVPA, LPA and step counts) is also noted in figures 4 and 5. Walkability was associated with MVPA in youth and adults aged 18 to 79, but not in children aged 3 to 11. Walkability was negatively associated with LPA in youth and older adults (ages 60 to 79) and was associated with step counts in adults aged 40 to 59 only. MVPA was negatively associated with BMI in children aged 5 to 11 and adults aged 40 to 79, and with waist circumference in children and adults of all ages. LPA was negatively associated with BMI in adults aged 40 to 59 and with waist circumference in adults aged 40 to 79. Step counts were negatively associated with BMI in adults aged 40 to 79 and with waist circumference in adults of all ages. Walkability was negatively associated with BMI and waist circumference in adults aged 18 to 59 (figures 4 and 5). MVPA was a significant mediating factor (indirect effect) in the association between the Can-ALE index and BMI in adults aged 40 to 79, and step counts per day was a significant mediating factor for adults aged 40 to 59 (Figure 4). MVPA was a significant mediating factor in the association between the Can-ALE index and waist circumference in adults aged 40 to 59 (Figure 5).

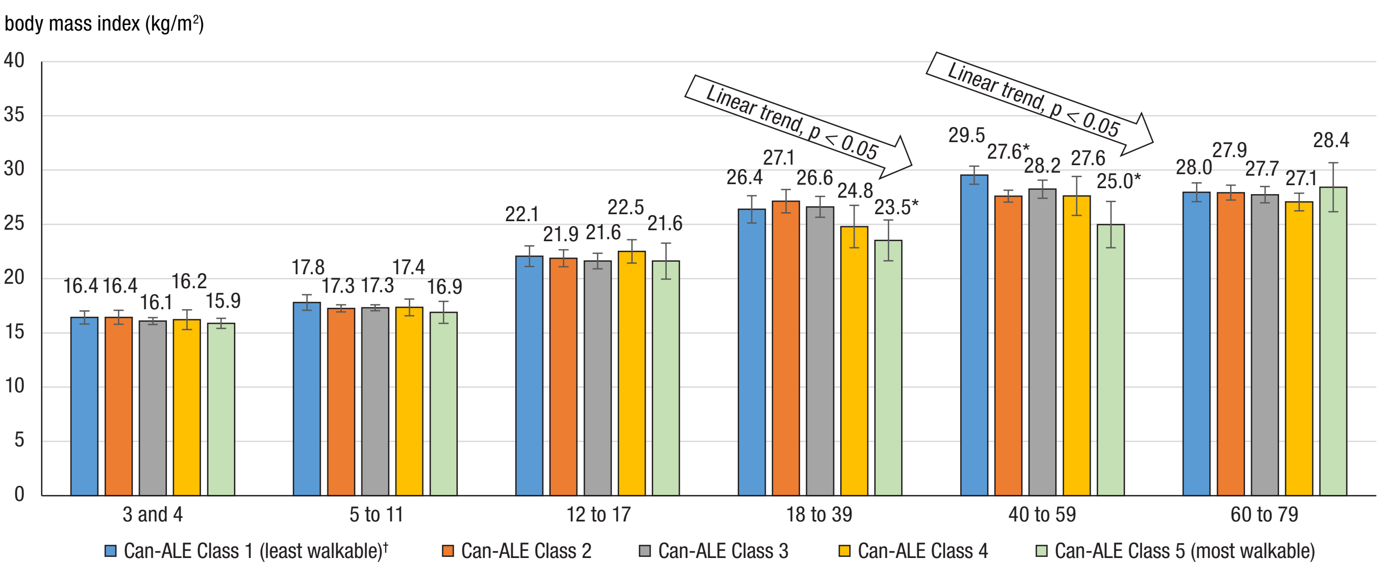
The percentage of respondents reporting very good or excellent general and mental health is presented by Can-ALE category and age group in figures 6 and 7. There was a significant upward trend in the percentage of respondents reporting very good or excellent general health across Can-ALE categories (from least to most walkable) for adults aged 18 to 39. There was a significant downward trend in the percentage reporting very good or excellent general health across Can-ALE categories (from least to most walkable) for adults aged 60 to 79. According to logistic regression models (controlling for age, sex, household income and education), there was a decreased likelihood (odds ratio: 0.883, $p < 0.05$) of reporting poor, fair or good general health (as opposed to very good or excellent) as the walkability index increased in young adults (ages 18 to 39). There was an increased likelihood (odds ratio: 1.063, $p < 0.05$) of reporting poor, fair or good general health (as opposed to very good or excellent) in older adults aged 60 to 79. The percentage reporting

Figure 1
Weighted percentage of CHMS sample classified as overweight or obese, by Can-ALE category and age group



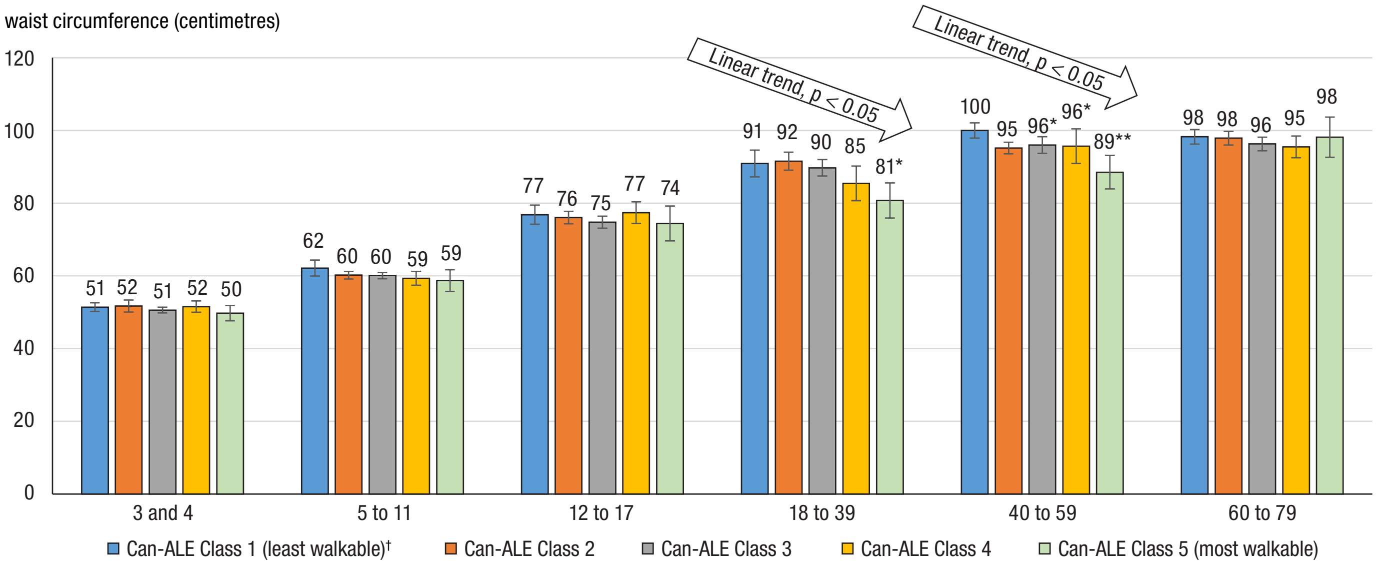
E use with caution
* significantly different from reference category (p < 0.0125)
† reference category
Notes: Can-ALE classes 4 and 5 were collapsed for children, youth and young adults because of sample size limitations.
For children aged 3 to 4, the percentage overweight or obese could not be presented by Can-ALE class because of sample size limitations.
CHMS stands for Canadian Health Measures Survey, and Can-ALE stands for Canadian Active Living Environments.
Source: Canadian Health Measures Survey, 2009 to 2015.

Figure 2
Measured body mass index, by Can-ALE category and age group



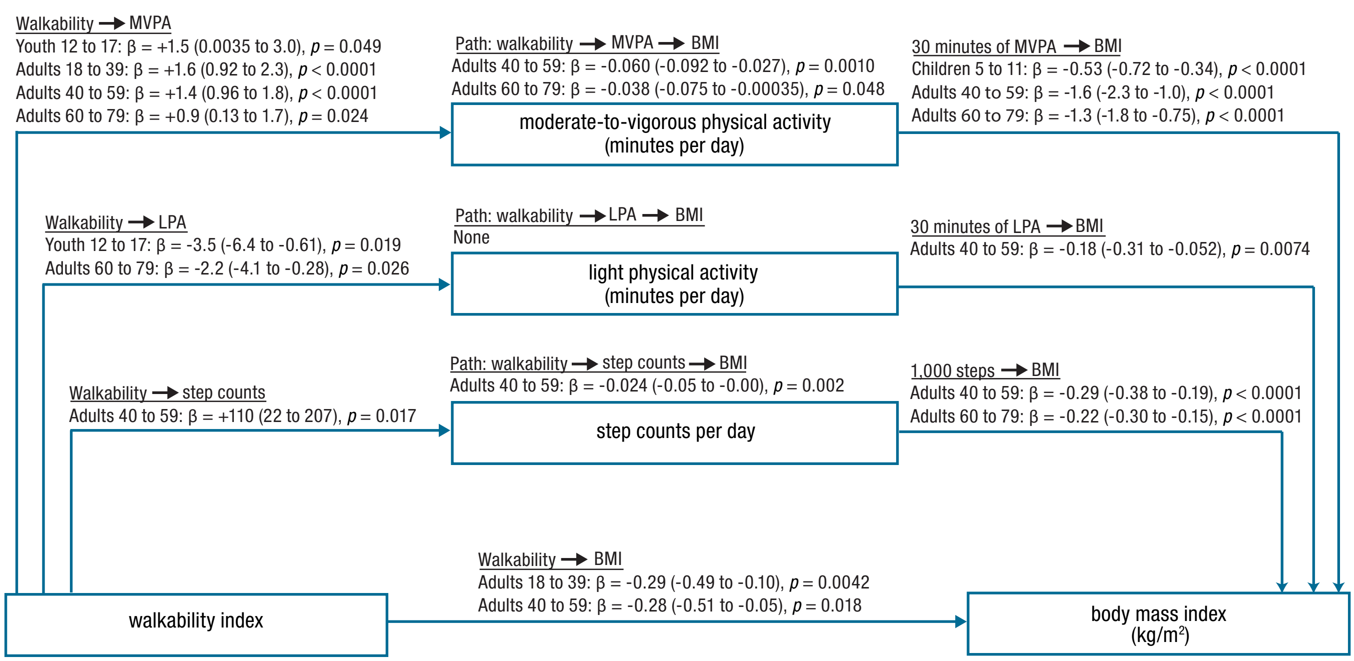
* significantly different from reference category (p < 0.0125)
† reference category
Note: Can-ALE stands for Canadian Active Living Environments.
Source: Canadian Health Measures Survey, 2009 to 2015.

Figure 3
Measured waist circumference, by Can-ALE category and age group



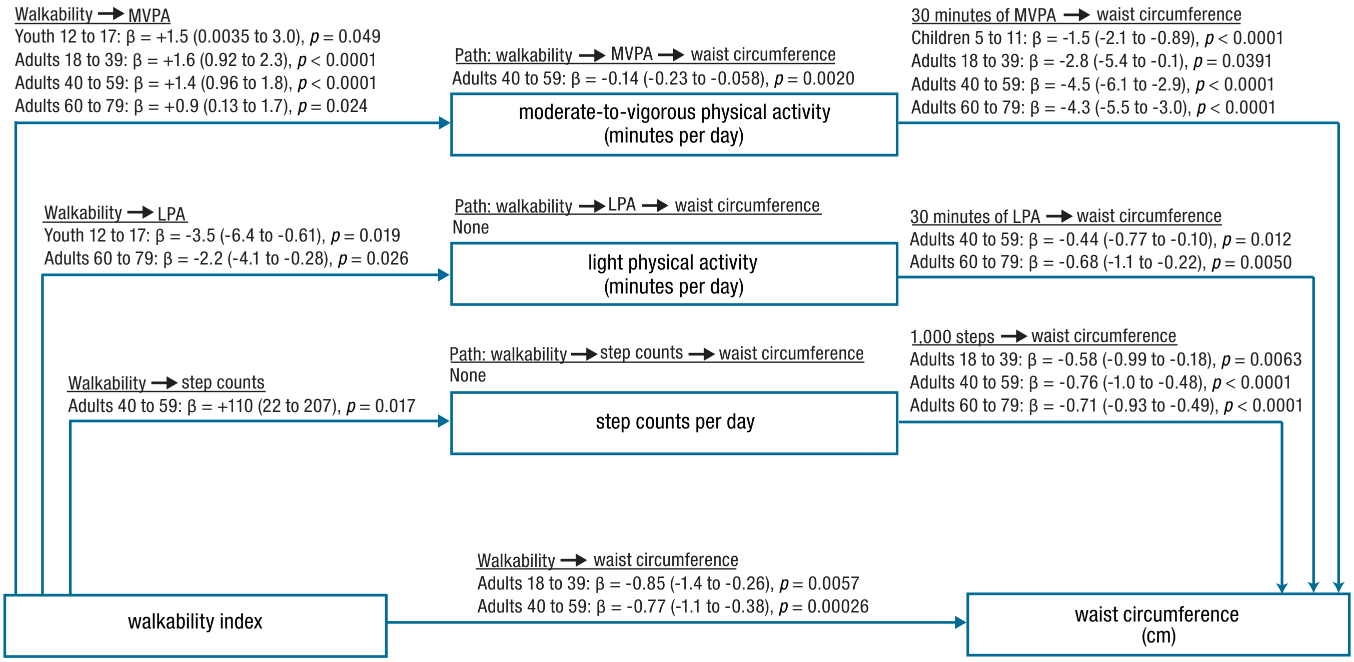
* significantly different from reference category (p < 0.0125)
** significantly different from reference category (p < 0.00025)
† reference category
Note: Can-ALE stands for Canadian Active Living Environments.
Source: Canadian Health Measures Survey, 2009 to 2015.

Figure 4
Summary of linear regression and structural equation modelling between the walkability index, physical activity (MVPA, LPA and step counts) and measured body mass index



Notes: Age groups not listed did not have statistically significant associations.
All models displayed were controlled for age, sex, household income and education.
The beta values represent the effect of increasing the walkability index by a unit of 1 on physical activity or waist circumference.
The beta values provided for the associations between physical activity and body mass index were multiplied by 30 (minutes of MVPA and LPA) or 1,000 (steps) to facilitate interpretation.
MVPA stands for moderate-to-vigorous physical activity, LPA stands for light physical activity and BMI stands for body mass index.

Figure 5
Summary of linear regression and structural equation modelling between the walkability index, physical activity and waist circumference



Notes: Age groups not listed did not have statistically significant associations.
All models displayed were controlled for age, sex, household income and education.
The beta values represent the effect of increasing the walkability index by a unit of 1 on physical activity or waist circumference.
The beta values provided for the associations between physical activity and waist circumference were multiplied by 30 (minutes of MVPA and LPA) or 1,000 (steps) to facilitate interpretation.
MVPA stands for moderate-to-vigorous physical activity, LPA stands for light physical activity and BMI stands for body mass index.

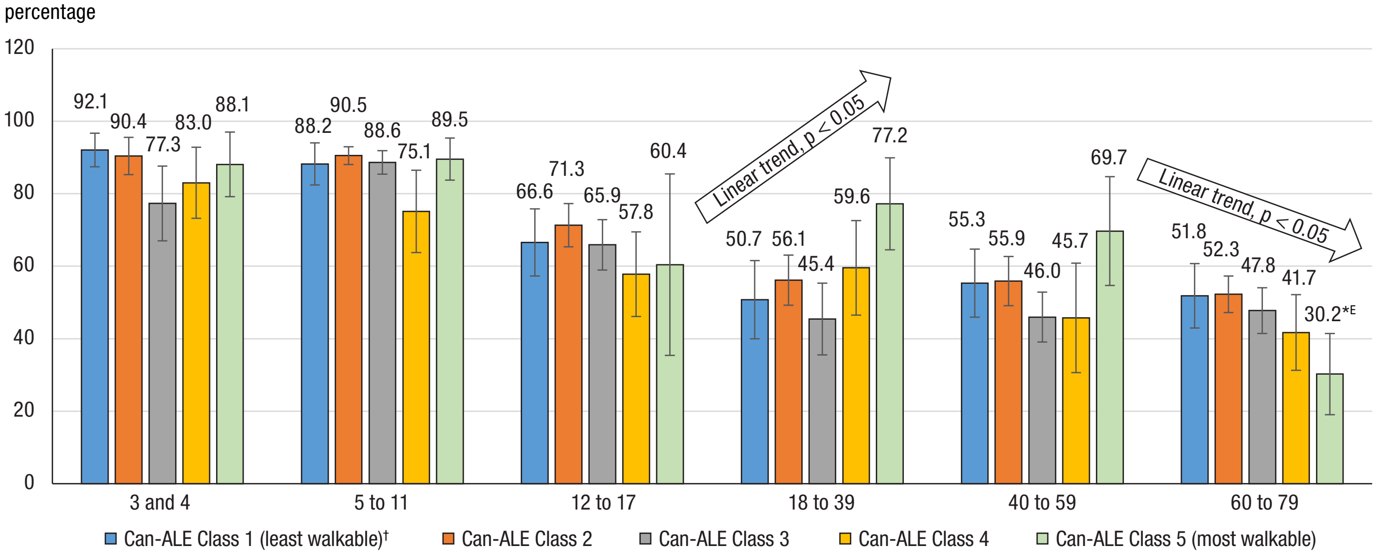
very good or excellent mental health did not vary by Can-ALE category for any age group (Figure 7). The logistic regression models indicated that walkability did not have an effect on the likelihood of reporting favourable mental health.

Discussion

Using the new Canadian Can-ALE measure, this study found an association between walkability and measured obesity in adults, but not in children or youth. This study also observed a relationship between walkability and self-rated general health; however, this association was present only in adults and the direction varied by age. No association was observed between walkability and mental health. The limited associations observed between walkability and obesity and health in this study are similar to what has been reported previously and must be considered in context among a wide range of other factors that influence a person's health and weight.

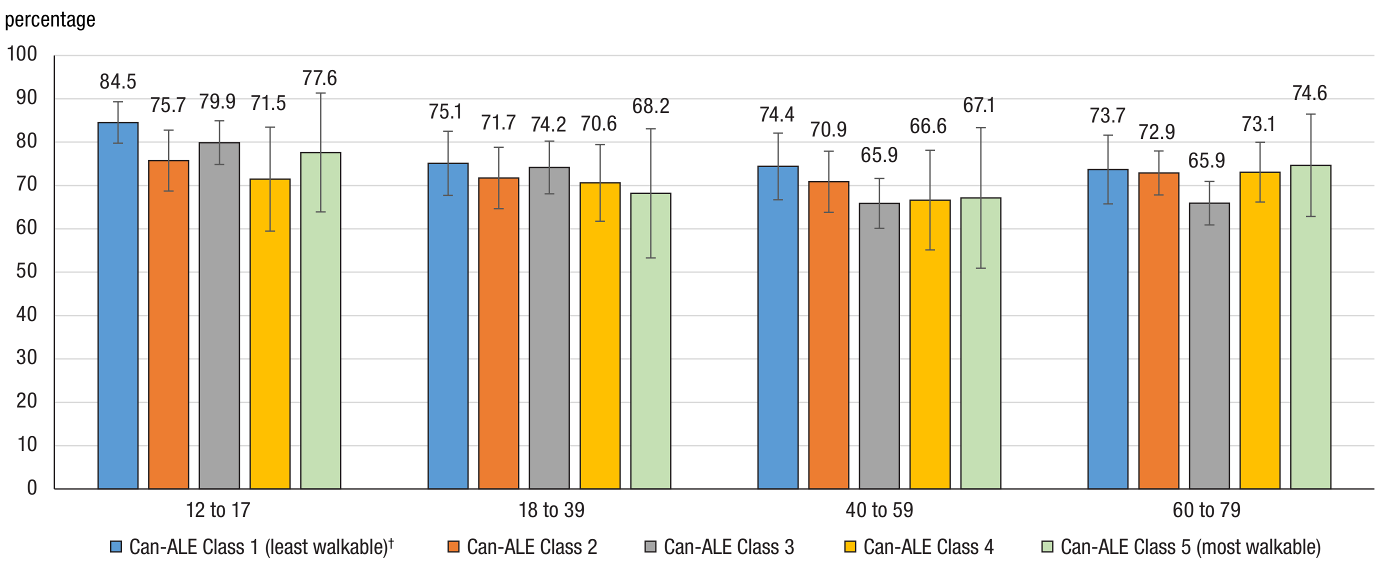
To date, Canadian research examining the association between walkability and obesity has typically focused on a single province or city, and most studies have used BMI data based on self-reported height and weight. Three different studies using different measures of walkability all reported about a 10 percentage point difference in the prevalence of overweight and obesity (BMI $\geq$ 25 kg/m^2) between the least walkable and most walkable categories: adults aged 30 to 64 from Toronto (49.7% vs. 41.3%[18]), adults aged 30 to 64 from southern Ontario (53.5% vs. 43.3%[17]) and adults from Ontario aged 20 and older (52.4% vs. 42.4%).[16] Another study on adults aged 20 and older from Toronto and Vancouver reported a lower average BMI among individuals living in more walkable areas compared with those living in less walkable areas (0.04 to 0.06 kg/m^2); however, the overall relationship between walkability and BMI was marginally significant.[39] The present study found a more dramatic difference in the prevalence of overweight and obesity between the least and most walkable categories (e.g., a 30 percentage point difference in adults aged 18 to 59). Similarly, the difference in average BMI between the least and most walkable Can-ALE categories was greater than those previously reported (-2.9 kg/m^2 in adults aged 18 to 39 and -4.5 kg/m^2 in adults aged 40 to 59), but was more consistent with another Toronto-based study that used measured BMI data and found a difference of 2.6 kg/m^2 between the least and most walkable neighbourhoods.[40] The overall prevalence of overweight and obesity was higher in the study done by Loo and colleagues and in the present study, which likely reflects the previously documented bias that exists between self-reported and measured height and weight data.[41] The finding in the present study that there was no association between obesity and walkability in adults aged 60 to 79 is difficult to compare with previous Canadian studies that typically examined adults as a single age group or excluded those

Figure 6
Weighted percentage of CHMS sample reporting very good or excellent general health, by walkability category and age group



E use with caution
* significantly different from reference category (p < 0.0125)
† reference category
Note: CHMS stands for Canadian Health Measures Survey, and Can-ALE stands for Canadian Active Living Environments.
Source: Canadian Health Measures Survey, 2009 to 2015.

Figure 7
Weighted percentage of CHMS sample reporting very good or excellent mental health, by walkability category and age group



† reference category
Notes: There were no significant differences.
CHMS stands for Canadian Health Measures Survey, and Can-ALE stands for Canadian Active Living Environments.
Source: Canadian Health Measures Survey, 2009 to 2015.

older than 65. While walkability was not associated with obesity in adults aged 60 to 79 in this study, walkability was positively associated with MVPA in this age group, which is consistent with previous Canadian research that reported a positive association between walkability and self-reported physical activity in older adults.[42,43] The present study observed that the association between walkability and both obesity and self-rated health was different for adults aged 60 to 79 compared with younger adults. This, combined with the suggestion that older adults may be particularly vulnerable to environmental influences,[43] suggests that future research should consider examining this age group separately.

Compared with adults, there is less research focused on examining the associations between features of the built environment and obesity in children and youth. The lack of association between walkability and obesity observed in youth in the present study is consistent with the work of Seliske and colleagues, who reported no association between urban sprawl and obesity in Canadian youth.[20] However, it is important to note that urban sprawl and walkability are not directly comparable built environment measures. In contrast, American research on youth has reported lower odds of being overweight or obese for those living in more walkable communities[45] and a positive association between urban sprawl and obesity.[12] The lack of association observed between walkability and both obesity and health in children and youth in this study adds to previous studies that have suggested there are many other features of the built environment that should be considered when attempting to explain the variance in the physical activity and health of children and youth, including—but not limited to—access to recreational facilities and park space, parental perceptions of safety, pedestrian infrastructure, and crime rates.[46-49] There is also some indication that highly walkable neighbourhoods may be detrimental to the physical activity levels of young children.[47,51]

Obesity is a complex health concern and its etiology cannot be explained without considering influences across the individual, social, environmental and policy levels of the socioecological model of health. The goal of the present study was not to determine the relative contribution of walkability to obesity among the long list of other predictors, but rather to examine the association between a new Canadian walkability measure and obesity across the lifespan (ages 3 to 79) and to consider the mediating effect of physical activity. Other studies that have taken a broader approach have confirmed that the built environment has an important role to play in explaining obesity and health in adults beyond demographic, socioeconomic and behavioural characteristics.[39] A key contribution of the present study is that it demonstrates that the association between walkability and obesity observed previously in Canadian adults persists with a new measure of walkability. Furthermore, the results of this study demonstrate that the influence of walkability on obesity and general health varies by age and that walkability has a greater influence on young adults (ages 18 to 59) than on children, youth and older adults.

Strengths and limitations

The Can-ALE dataset is a new Canadian geography-based set of measures that incorporates high-quality data sources that are open and free to use. Descriptive epidemiology work using this new walkability measure with obesity and self-rated health is not yet available in the published literature. This study provides a broad overview of how the new measure of walkability relates to obesity and self-rated health in Canadians. Notable strengths of the current study include its national scope and the use of BMI data based on measured height and weight. Furthermore, the physical activity data used in the mediation analysis were obtained using accelerometers. Part of the underlying rationale for the development of the CHMS was the ability to examine differences between measured and self-reported health characteristics, behaviours and conditions. Numerous studies using CHMS data have confirmed that differences do exist between measured and self-reported obesity and physical activity data and that these differences matter when examining interrelationships between health predictors and outcomes.[41,42,50-52] The discordance observed between this study and others in the prevalence of BMI between less walkable and highly walkable neighbourhoods also highlights the gap between self-reported and measured data.

This study was limited in the breadth of covariates included in the regression modelling. Future work should explore additional individual-level and neighbourhood-level variables that affect the relationship between the built environment and a person's health. Key limitations of both this study and previous work are the cross-sectional design and lack of adjustment of residential self-selection.[53] If people choose to live in a neighbourhood that supports their existing lifestyle habits, this may lead to an overestimation of the strength of association between walkability, physical activity and obesity. Longitudinal research that follows people who move from less walkable to highly walkable areas (and vice versa) would help to shed light on this issue. It is also important to note that rural areas of Canada are not well represented in this study, and further research designed to accommodate the unique environmental context of rural Canada is needed. Another important limitation of examining the etiology of obesity is the lack of information included in this study about the food environment.[15] Future research using structural equation modelling (path analysis) should examine paths to obesity and their interactions: walkability → physical activity → obesity and health and the food environment → dietary intake → obesity and health.

Conclusion

Obesity interventions focused on individual-level behaviours (e.g., physical activity and dietary intake) may fail to address key factors that can either support or hinder an individual's attempts to adopt healthier lifestyle habits. Considering a person's environmental context is consistent with the Chief Public Health Officer's Report on the State of Public Health in Canada 2017, *Designing Healthy Living*, as well as with the Ottawa Charter for Health Promotion, which both call for the creation of supportive environments to improve population health.[4,5] The present study provides a platform for future work that may explore a broader spectrum of health outcomes. More work is needed to identify and understand the many other built environment characteristics beyond walkability that support healthy lifestyles, particularly in children and older adults. ■

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