Title: Associations between neighbourhood built characteristics and sedentary behaviours among Canadian men and women: findings from Alberta's Tomorrow Project

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Abbreviations: ATP: Alberta's Tomorrow Project, b: beta-coefficient, CI: Confidence Interval, HLQ: Health and Lifestyle Questionnaire, IPAQ-LF: International Physical Activity Questionnaire Long Form, NDVI: Normalized Difference Vegetation Index, SD: Standard Deviation

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Funding: This work was supported by the Canadian Institutes of Health Research [FDN-154331] and a Seed Grant from the Diabetes, Obesity, and Nutrition Strategic Clinical Network (Alberta Health Services). VN has received an O'Brien Institute of Public Health Postdoctoral Scholarship and a Cumming School of Medicine Postdoctoral Scholarship (University of Calgary).

Word count: Abstract (221); main text excluding abstract, tables, and references (4216); references (73); Table count: 5.

ABSTRACT

Evidence of associations between neighbourhood built characteristics and sedentary behaviours is mixed. The study aim was to investigate the associations between objectively-derived neighbourhood built characteristics and self-reported sedentary behaviours among Canadian men and women. This study sourced survey data from Alberta's Tomorrow Project (2008; n=14,785), in which sitting and motor vehicle travel times during the last 7 days was measured. Geographic Information System was used to calculate neighbourhood built characteristics within a 400m buffer of participant's home and a *walkability* score was estimated. To estimate the associations between neighbourhood characteristics and sedentary behaviours, covariate-adjusted generalized linear regression models were used. *Walkability*, *3-way intersections,* and *population count* were positively associated with sitting time. *Business destinations* and *greenness* were negatively associated with sitting time. *Walkability*, *3-way*, and *4-way intersections* were negatively associated with motor vehicle travel time. Sex-specific associations between neighbourhood characteristics and sedentary behaviour were found. Among men, *business destinations* were negatively associated with sitting time, and *3-way intersections, population count,* and *walkability* were negatively associated with motor vehicle travel time. Among women, *Normalized Difference Vegetation Index* was negatively associated with sitting time. Interventions to reduce sedentary behaviours may need to target neighbourhoods that have built characteristics which might support these behaviours. More research is needed to disentangle the complex relationships between different neighbourhood built characteristics and specific types of sedentary behaviour.

Keywords: neighbourhood, built environment, walkability, sedentary behaviour, sitting time, motor vehicle travel time

INTRODUCTION

Sedentary behaviour is distinct from physical inactivity (1). Sedentary behaviour is defined as "any walking behaviour characterized by an energy expenditure ≤1.5 metabolic equivalents while in sitting or reclining posture" (2). Theoretically, sedentary behaviour comprises activities that promote sitting such as watching television, using computers, and driving motor vehicles (3). Sedentary behaviour is associated with several adverse outcomes, including type 2 diabetes mellitus, cardiovascular diseases, overweight, obesity, anxiety, depression, cancers, all-cause mortality and cardiovascular disease mortality (4-8). Evidence suggests that adverse outcomes associated with sedentary behaviour persist even after physical activity is taken into consideration (9). In recent years, the prevalence rate of sedentary behaviour has increased - in Canada, during 2007, around 29% of adults watch television for at least 15 hours/week and around 15% of adults use computers for at least 11 hours/week (10). Most recent estimates of sedentary behaviour for Canadians adults spend 9.6 hours per day in sedentary behaviour activities (11).

According to ecological models, the built environment is an important determinant of physical activity (12). Evidence suggests that neighbourhood built characteristics, including pedestrian and street connectivity, land use and destination diversity, density, greenspaces, buildings, and walkability are associated with physical activity in adults (13-15). Given that neighbourhood characteristics are associated with different types of physical activity, it is expected that certain neighbourhood characteristics will also be associated with specific sedentary behaviours. Previous findings on the associations between neighbourhood characteristics and sedentary behaviour are mixed (16-29). In a Canadian study, objectively-derived *walkability* (including *network buffer area, total population, proportion of neighbourhood greenness, path/cycleway length, number of businesses, number of bus stops, length of sidewalk, mix of park types* and *mix of recreational facilities*) was negatively associated with leisure-based screen time (20). In another Canadian study, Koohsari et al. (27) found negative associations between objectively-derived characteristics (*population density, intersection density,* and *business destinations*) and self-reported car driving time. In contrast, among Belgian adults, Van Dyck et al. (25) found objectively-estimated *walkability* to be positively associated with both self-reported and accelerometer-derived sitting time. Yet, among Dutch and Belgian adults, Compernolle et al. (16) found no association between objectively-derived neighbourhood characteristics and objectively-derived total sedentary time.

Koohsari et al. (28) conducted a systematic review of 17 studies (no Canadian studies were included) on the associations between neighbourhood characteristics and sedentary behaviours. They examined 89 associations and found 25 significant associations in the expected, negative direction. (28). In their systematic review, O'Donoghue et al. (29) found higher density and proximity of green space was associated with less sedentary behaviour time. The researchers also found inconsistent findings between studies regarding associations between neighbourhood walkability and safety and sitting and leisure screen time (29).

Associations between the built environment and sedentary behaviours may be sex-specific. For example, men spend more time in sedentary activities than women (17, 18, 26), but evidence suggests that the associations between neighbourhood built characteristics and sedentary behaviours may be stronger for women. In an Australian study, women residing in high walkable neighbourhoods were found to spend less time watching television than women residing in low walkable neighbourhoods (24). In another Australian study, the presence of *community infrastructure* (*count of business destinations*) was negatively associated with weekday sitting time among women but not men. In addition, *residential density* and *presence of transit stops* were negatively associated with weekday sitting time among women only (17). Moreover, Owen et al. (21) found perceived *aesthetics* and *safety from crime* to be negatively associated with sedentary time among women, while *land use mix diversity* negatively associated with sedentary time among men. In a US study, perceived neighbourhood characteristics such as *litter in streets*, *safety of walking after dark*, and *lack of places to shop* were positively associated with television viewing time among women only (23). Perceived *neighbourhood safety* was also positively associated with overall sitting time among German women only (26). Hinckson et al. (18) found negative associations between objectively-derived *retail footprint area ratio* and average daily minutes of accelerometer-based sedentary time among New Zealand women only. These previous studies, while relying mainly on self-reported built environment measures, suggest that associations with sedentary behaviour are both behaviour- and sex-specific.

The new Canadian 24-hour movement guidelines recognize the importance of encouraging adults to accumulate more physical activity and less sedentary time (30). A better understanding of the determinants of sedentary behaviour is needed to inform interventions that discourage sedentary behaviour. The aim of our study was to: 1) estimate the associations between objectively-derived neighbourhood built characteristics and specific self-reported sedentary behaviours including overall sitting and motor vehicle travel times, and; 2) estimate sex-specific associations between neighbourhood characteristics and sedentary behaviours among men and women.

METHODS

Data source

In this study, a secondary analysis of data was conducted using data from the Alberta's Tomorrow Project (ATP). The study design and recruitment procedures for ATP have been described elsewhere (31, 32). To summarize, from 2000 to 2008 participants aged 35-69 years residing in Albertan urban and rural households were recruited using a random digit dialling method (31, 32). Each eligible participant received a consent form and a baseline health and lifestyle questionnaire (HLQ). The HLQ elicited information within socio-demographic, personal health, and lifestyle domains. In 2008, ATP participants were mailed a follow-up HLQ to update information on socio-demographic characteristics, personal and family health history, and lifestyle behaviours. On the 2008 questionnaire participants also reported new information on lifestyle behaviours such as physical activity and sedentary behaviour as well as the perceived built environment characteristics (31).

In this study, data from participants who completed the 2008 follow-up survey and resided in urban areas pertaining to second digit in the residential postal code (n=15,342) was used. In Canada, a postal code is designated as 'rural' if the second digit is 0 (e.g., T012A2) or 'urban' if the second digit is a number from 1 to 9 (e.g., T1H2A2)(33). The University of Calgary Conjoint Health Research Ethics Board approved this secondary analysis.

Exposure variables

Objectively-derived neighbourhood built characteristics

We used Geographical Information Systems to estimate neighbourhood characteristics within a 400m Euclidean buffer around each participant's home. Just as there is no universally agreed upon set of built characteristics that should be included in walkability indices (34), so to there is no agreed upon buffer shape (e.g., network vs. Euclidean polygon) or size for estimating neighbourhood built characteristics in relation to health behaviours, including sedentary behaviour (28, 35, 36). Nevertheless, Koohsari et al. (28) suggests that the built environment close to home may be more relevant for leisure-time sedentary behaviour. Moreover, in the North American context, motor vehicle travel distances are often shorter among those residing in neighbourhoods with built characteristics that support walking (37-39). A 400m buffer was used to capture the built characteristics within close proximity to homes (i.e., within about a 5-minutes walking distance) (36, 40) and to reduce any overlap between buffer boundaries that might occur when larger buffers are used. In the development phase of creating our walkability index, which included creating the index for all Alberta urban postal codes (400m Euclidean buffer), we found that it was highly correlated with Walk Score® (r=0.69), which itself has been validated against other walkability indices (41, 42) but may be positively associated with sedentary behaviour (43, 44).

A street network file (the median or centre line) was used to calculate *number of street intersections* (*3-way* and *4-way*) and an enhanced point of interest file used to calculate *number of business destinations*. Note that different types of *business destinations* were estimated (e.g., hardware stores, department stores, grocery stores, restaurants, banks, libraries, laundry stores, stationary stores, liquor stores, jewellery stores, barbershops, museums, schools, colleges, and universities). Using Statistics Canada 2006 census dissemination block level data, *population count* was estimated. The dissemination block and 400m Euclidean buffer polygons were overlayed to account for the geometric overlap as they are different sizes and shapes. Population counts from the fragments of dissemination blocks which overlapped with the buffer polygon were summed to obtain the buffer population count (the population count of each dissemination block was weighted according to the amount its area overlapped with the buffer polygon).

Like previous studies (45, 46), normalized difference vegetation index (NDVI) was used as an indicator of amount of neighbourhood greenness. To estimate *NDVI*, Landsat 5 satellite imagery for the Alberta region was obtained from the Canadian Urban Environmental Health Research Consortium (47). The satellite imagery for Alberta was captured between May and August of 2008 at a spatial resolution of 30m by 30m. To determine pixel based mean NDVI values, Google Earth

Engine® and MATLAB® software were utilized (48, 49). The average NDVI of all pixels within each 400m buffer was estimated.

Informed by previous studies (50, 51), a walkability score was created for each participant by standardizing neighbourhood characteristics and summing their z scores. Our walkability score reflected qualities associated with the 3Ds of urban design (i.e., Density, Diversity, and Design) (52) as it was originally developed to explain neighbourhood walking. Correlations between built characteristics are presented in Table 1. Apart from *NDVI*, all neighbourhood characteristics were used to construct a walkability score.

The operational definition of intersections used in walkability index formulas varies (53), however, 3-way intersections generally contribute to less neighbourhood connectivity than 4-way intersections (53, 54). Thus, prior to summing z scores, 3-way intersection was down-weighted (multiplied by 0.5):

Walkability score = [0.5 x z(3-way intersection count)] + z(4-way intersection count) + z(business destination count) + z(population count)

Outcome variables

Self-reported sedentary behaviours

Participants self-reported their overall sitting and motor vehicle travel times within the last 7 days by using International Physical Activity Questionnaire Long Form (IPAQ-LF)(31), which produces reliable and valid estimates of sedentary behaviour (55). For this study, overall sitting time was defined as time spent sitting at work, at home, doing course work, and during leisure time and included time spent sitting at a desk, visiting friends, reading, or sitting, or lying down to watch television, and did not include time spent travelling in a motor vehicle (56). Motor vehicle travel time referred to time spent in a motor vehicle while travelling to workplaces, shopping centers, movie theatres and other destinations by train, car, tram, or other vehicle type (56). The IPAQ-LF questions captured usual sitting time (minutes) per day spent on a weekday, weekend, and traveling in a motor vehicle during the last 7 days. To estimate total weekly non-vehicle sitting time, we summed daily weekday (multiplied x 5) and weekend (multiplied x 2).

Socio-demographic covariates

Socio-demographic covariates were sourced from the ATP dataset using the 2008 HLQ data (56) including age, sex, self-reported health, marital status, number of children in the household, highest education level, employment status, household income, and season participant returned the questionnaire.

Statistical analysis

The proportion of missing data within variables was low (<4%; n=557), therefore we performed a complete case analysis. Before performing data analysis, neighbourhood characteristics were rescaled to aid in interpretation (*street intersections* and *business destinations* divided by 10, *population count* divided by 100, and *NDVI* was divided by the interquartile range). Descriptive statistics (means, standard deviations (SD), and frequencies) were computed for the sample. Each of the sedentary behaviour outcomes were almost normally distributed. Subsequently, a covariate-adjusted generalized linear model with a normal distribution and identity link function was used to estimate the associations between neighbourhood characteristic and sedentary behaviour. Effect estimates were presented as unstandardized slope coefficients (b) and 95% confidence intervals (CIs). To circumvent model collinearity, only one neighbourhood characteristic was introduced into each regression model. To estimate sex-specific associations between neighbourhood characteristics and sedentary behaviour, the data was tested for significant interaction terms and slope coefficients were further computed, separately for men and women. An alpha of $p<0.05$ was considered statistically significant. Analysis was undertaken in Stata Version 15 (Stata Corp LLC, Texas, USA).

RESULTS

Sample characteristics

The analysis included complete data on 14,785 participants. About two-third of the participants were middle-aged (mean age= 55.2 years; SD=9.2 years). Approximately, two-thirds of the sample was female (62%), 41% reported very good general health status, 77% were either married or had live-in partners, 73% reported no children living in the household, 77% had completed some or entire post-secondary education, 54% were full-time employed, and 42% reported annual household incomes of >$100,000/year (Table 2). There were significant ($p<.05$) differences in socio-demographic, health-related, and neighbourhood characteristics as well as sedentary behaviours between men and women. On average, the count of *business destinations* within each buffer was higher for women than men (Table 3). On average, men spent more time than women sitting on weekdays and weekends and travelling in a motor vehicle (Table 3).

Associations between neighbourhood characteristics and sedentary behaviours (pooled analysis)

Sitting

Adjusting for covariates, *walkability* was positively associated with time sitting on a weekday (b 2.10; 95% CI 0.72, 3.50) and on weekdays and weekends combined (b 13.00; 95% CI 4.25, 21.66). Moreover, count of *3-way intersections* were positively associated with time sitting on a weekday (b 4.11; 95% CI 1.50, 6.71) and on weekdays and weekends combined (b 23.70; 95% CI 7.50, 39.92). *Population count* was also positively associated with time sitting on a weekday (b 1.86; 95% CI 1.40, 2.31), weekend day (b 1.08; 95% CI 0.65, 1.50), and time sitting on weekdays and weekends combined (b 11.43; 95% CI 8.60, 14.31). However, count of *business destinations* was negatively associated with time sitting on a weekday (b -5.54; 95% CI -10.53, -0.55) as was *NDVI* which was negatively associated with time sitting on a weekday (b -3.20; 95% CI -6.35, -0.002), weekend days (b -5.10; 95% CI -7.90, -2.22), and weekdays and weekends combined (b -26.00; 95% CI -45.75, -6.24) (Table 4).

Motor vehicle travel

Adjusting for covariates, *walkability* (b -0.68; 95% CI -1.21, -0.15) and count of *3-way and 4-way intersections* were negatively associated with motor vehicle travel time (b -1.20; 95% CI -2.22, -0.13 and b -3.20; 95% CI -5.00, -1.41, respectively) (Table 4).

Sex-specific associations between neighbourhood characteristics and sedentary behaviours

Sitting

The negative association between count of *business destinations* and time sitting on weekdays was significant in men (b -12.26; 95% CI -21.00, -3.60) but not women (b -1.65; 95% CI -7.65, 4.36).

Similarly, count of *business destinations* negatively associated with time sitting on weekdays and weekends combined for men (b -73.50; 95% CI -127.64, -19.31) but not women (b -5.74; 95% CI -43.82, 32.34). The *NDVI* was negatively associated with time sitting on a weekday and weekdays and weekends combined for women (b -7.30; 95% CI -11.00, -3.51 and b -45.90; 95% CI -69.30, -22.50, respectively) but not men (b 3.50; 95% CI -2.20, 9.11 and b 6.40; 95% CI -28.60, 41.40, respectively) (Table 5).

Motor vehicle travel

Adjusting for covariates, *walkability* was negatively associated with motor vehicle travel time among men (b -1.43; 95% CI -2.41, -0.44) but not women (b -0.21; 95% CI -0.80, 0.37). Both *3-way intersections* and *population count* were negatively associated with motor vehicle travel time for men (b -3.41; 95% CI -5.42, -1.40 and b -0.44; 95% CI -0.73, -0.15, respectively) but not for women (b 0.14; 95% CI -1.02, 1.31 and b 0.03; 95% CI -0.20, 0.21, respectively) (Table 5).

DISCUSSION

Neighbourhood characteristics were negatively (favorable) and positively (non-favorable) associated with specific sedentary behaviours, mirroring results of previous studies (21, 25), with some associations also being sex-specific. Notably, similar to previous studies (20, 27), these findings suggest the objectively-derived neighbourhood built environment is an important correlate of time spent sitting and time spent travelling in a motor vehicle. Also, similar to previous studies (17, 18, 21-24, 26), we found several sex-specific associations between neighbourhood characteristics and sedentary behaviour.

Congruent with our findings, previous studies have found associations between neighbourhood walkability and sitting behaviour among the general population adults. Koohsari et al. (27) found that a greater '*space syntax walkability'* index (*population density* and *street integration combined)*, estimated within 1600m of home, was associated with less leisure screen time (weekly hours of watching television or using a computer). Likewise, McCormack and Mardinger (20) found that compared with adults who resided in low walkable neighbourhoods, those in high walkable neighbourhoods (reflecting the combination of street connectivity, population density, greenness, pathways, sidewalks, business density, bus stop density, park types, and recreational facilities within 1600m network distance of home) spent less time on leisure-based sedentary behaviour. Conversely, some studies have found *walkability* to be positively associated with sitting time. For instance, Van Dyck et al. (25) found that increases in *walkability* (including *residential density*, *street intersection density*, and *land use mix*) within neighbourhood administrative boundaries were associated with increases in daily sitting time. More recently, Luijkx and Helbich (19) found no associations between neighbourhood walkability (*residential density*, *street connectivity* and *land use mix*) estimated for several neighbourhood network buffers (200m, 400m, and 800m) and total sedentary time. Yet, Owen et al. (21), combining data from multiple countries, reported positive associations between percevied *walkability* (including *residential density*, *pedestrain infrastructure* and *safety*, *no major barriers to walking*, *land use mix diversity*, *street connectivity*, *aesthetics*, and *safety from crime*), and daily minutes of total sitting time. In our study, a one-unit increase in *walkability* (*street intersection density*, *business destination density*, and *population density)* estimated for the 400m Euclidian buffer, was positively associated with, on average, a 13 minute per week increase in sitting. This is alarming given that the creation of walkable neighbourhoods to support physical activity is being recommended, yet our findings along with others (25) suggest some of the health gains from higher physical activity might be offset by the negative health impacts resulting from concurrent increases in sitting time.

We found several individual built environment characteristics associated with sitting. A 10 count increase in 3-way intersections (i.e., connectivity) within 400m of home, was associated with about a 4 minute per day average increase in weekday sitting and a 24 minute per week average increase in total sitting. Neighbourhoods that have more 3-way intersections (versus 4-way intersections) are typically considered to have lower connectivity and thus less walkable (53, 54) however, we also found a weak positive correlation between the count of 3 and 4 way intersections in neighbourhoods. Previous research shows that perceived *residential density* is positively associated with daily minutes of total sitting time (21). Similarly, we found a positive association between population count within 400m of home and sitting time. Higher residential densities can be associated with perceptions of unsafe traffic conditions and perceive risk of crime (57), which may be a deterrent for neighbourhood physical activity, thus potentially resulting in more sitting time. Previous evidence of associations between street connectivity and sedentary behaviour are mixed (28). We found having more business destinations within 400m of home was associated with a decrease in sitting time. Proximity to and mix of local destinations might support more physical activity (58), thus resulting in less time sitting. Our measure of greenness was not specific, reflecting the presence of parks, gardens, tree canopies and natural areas. Nevertheless, higher neighbourhood greenness was associated with less time sitting. Some studies have found increases in the density of parks (59) and perceived aesthetics (60) associated with less time spent sedentary. Neighbourhood green spaces could encourage more outdoor physical activity (61). While some built characteristics associated with neighbourhood walkability might reduce sitting time, other characteristics may paradoxically encourage more sitting. These mixed findings suggest that the neighbourhood built environment can influence sitting via pathways independent of physical activity.

More time spent in driving is associated with poorer health, including increased risk of obesity (6). Higher walkability is associated with less time spent driving (27, 62). In the Canadian context, higher population density, intersection density, and density of destinations have also been associated with less driving time (27). Our findings were similar in that we found higher walkability, count of 3-way and 4-ways intersections associated with less time travelling in a motor vehicle. Living in an environment where walking is more convenient than driving might explain why those residing in walkable neighbourhoods spend less time in motor vehicles. Our findings suggest that modifying the neighbourhood to improve connectivity or walkability could reduce time spent travelling in motor vehicles, however the impact of these modifications on other sedentary behaviours (i.e., sitting) should also be considered.

In support of previous studies (17, 18, 21-24, 26), we found sex-specific associations between neighbourhood characteristics and sedentary behaviours. In contrast to our findings, positive associations between *street connectivity* with weekday sitting time and total sitting time among men have been found (22). *Higher walkability* (*dwelling density, street connectivity, land use mix,* and *net retail area*) is also found to be associated with less television viewing time among women only (24). However, we found *walkability* was negatively associated with motor vehicle travel time among men only. In contrast to previous studies (59), we found *more neighbourhood* *greenness* to be associated with less sitting time among women. Socio-demographic factors like education and income as well as social factors like social cohesion and community participation might impact sedentary behaviours differently among men and women (17, 23, 26). Assuming sedentary behaviour is related to physical activity, the different effects of the neighbourhood built environment on sedentary behaviour for men and women is not surprising given that sex related differences have been found for associations between the built environment and physical activity (63). Future studies should test for sex and gender interactions when estimating associations between the built environment and sedentary behaviour.

Strengths and limitations of this study

This study has several strengths. Sitting time and time spend travelling by motor vehicle were analyzed separately as both are prevalent sedentary behaviours and are negatively associated with health (5, 64). The large sample size and inclusion of objective measures of the built environment was also a strength of the study. The study, however, has limitations. The cross-sectional analysis does not allow causality to be inferred. Residential relocation studies and natural or quasi experiments are needed to infer causality between the built environment and sedentary behaviour (39, 65). Despite including covariates based on prior research (20, 25, 29), the use of existing survey data meant some covariates related to sedentary behaviour (i.e., sitting and driving) might have been excluded. For example, except for a few studies (37), the influence of residential self-selection and preferences on the relations between the built environment and sedentary behaviour have not been considered. Despite being reliable and able to capture domain and context specific behaviour, self-reported measures may underestimate sedentary time relative to objective measures (e.g., accelerometers)(66). There is no agreed upon operational definition for buffer shape or size for estimating neighbourhood characteristics in relation to sedentary behaviour (28, 35, 36) however, our 400m Euclidian buffer neighbourhood definition may not fully capture built characteristics accessible to households and may underestimate the influence of the built environment. Similar to previous physical activity (67), travel behaviour (35) and sedentary behaviour studies (19), future research should continue to investigate the sensitivity of estimated associations between built environment characteristics and different context specific types of sedentary behaviour to different residential neighbourhood definitions (28, 29). The study included survey and built environment data that were collected in 2008, however, some built environment characteristics and the nature of sedentary behaviour could have changed since 2008 (e.g., greater of use of mobile technologies). Despite this limitation, there is some evidence to suggest that neighbourhood built characteristics are temporally stable within the Canadian context (68) and more recent data continue to demonstrate links between the built environment and sedentary behaviour (28, 29). Our study focused on built characteristics within the residential neighbourhood, yet people undertake behaviour in different contexts (or activity spaces) outside their local neighbourhoods (69, 70). Some of the sedentary behaviour reported by our participants was likely undertaken in a range of activity spaces and the built characteristics of these activity spaces may encourage or discourage sedentary behaviour.

Conclusions

Our study found that neighbourhood built characteristics are associated with sedentary behaviour in the Alberta (Canada) context and some of neighbourhood environment-sedentary activity associations are sex, type, and environment specific (28, 29, 71). Our findings highlight the importance of the favorable impact of some neighbourhood characteristics on different sedentary activities among men and women. Urban planners need to consider how neighbourhood design impacts health, including sedentary behaviours. In addition, health promotion interventions (65, 72, 73) may need to be adapted and target neighbourhoods with less supportive infrastructure to encourage residents to reduce their sedentary behaviours. Our findings suggest that neighbourhoods with more 3-way intersections, higher population counts, and higher overall walkability may need to be targeted for specific interventions designed to reduce sitting time while neighbourhoods with lower connectivity and low walkability may require specific interventions that can reduce time spent sitting in motor vehicles. More research is needed to disentangle the complex relationships between different neighbourhood built characteristics and specific types of sedentary behaviour.

Acknowledgements

Alberta’s Tomorrow Project is only possible due to the commitment of its research participants, its staff, and its funders: Alberta Health, Alberta Cancer Foundation, Canadian Partnership Against Cancer and Health Canada, and substantial in-kind funding from Alberta Health Services. Environmental exposure data was obtained through linkage with Canadian Urban Environment Health Research. The views expressed herein represent the views of the authors and not of the ATP or any of its funders.

Conflict of interest statement

All authors declare that they have no conflict of interest.

Table 1: Pearson correlations between built environment characteristics estimated for the 400m Euclidean buffer

	3-way intersections count	4-way intersections count	Business destinations count	Population count	Normalized difference vegetation index
3-way intersections count					
4-way intersections count	0.195*				
Business destinations count	-0.113*	0.408*			
Population count	0.332*	0.276*	0.078*		
Normalized difference vegetation index	-0.193*	-0.252*	-0.397*	-0.357*	
Walkability index	0.388*	0.767*	0.676*	0.635*	-0.492*

*p <.001 (2-tailed).
N=14,785

Table 2: Socio-demographic and health-related characteristics of the participants

	Socio-demographic and health-related characteristics			
	Pooled sample (n=14,785) %	**Men** (n=5,659) %	**Women** (n=9,126) %	**p-value**[#]
Age (years)				
35 to <45	14.8	13.8	15.4	
45 to <55	37.5	36.4	38.2	<.001[*]
55 to <65	30.2	32.1	29.0	
≥65	17.5	17.7	17.4	
Sex				
Men	38.3	-	-	-
Women	61.7			
Self-reported general health status				
Poor or fair	7.6	8.0	7.4	
Good	34.2	37.3	32.3	<.001[*]
Very good	41.1	39.2	42.2	
Excellent	17.1	15.5	18.1	
Current marital status				
Married or not married, but living with someone	77.1	83.4	73.3	
Separated or divorced	12.4	8.8	14.6	
Widowed	4.6	1.7	6.4	<.001[*]
Single, never married	5.9	6.1	5.7	

Number of children currently in the household				
0	72.9	71.4	73.8	
1	12.0	12.1	11.9	
2	11.1	11.9	10.7	<.01*
≥3	4.0	4.6	3.6	
Highest education level				
Some or entire high school	22.9	20.5	24.3	
Some or entire technical college training	38.3	38.0	38.5	
Some or entire university degree	26.0	25.9	26.1	<.001*
Some or entire university post-graduate degree	12.8	15.6	11.1	
Current employment status				
Working full-time	53.6	68.5	44.3	
Working part-time	14.5	7.4	18.9	
Home maker	6.4	0.1	10.3	<.001*
Retired	20.7	20.0	21.2	
Other or not employed or student	4.8	4.0	5.3	

Annual household income				
$0 to 49,999	18.9	13.9	22.0	
$50,000 to 99,999	31.7	32.1	31.4	
$100,000 to 149,999	22.9	26.0	21.0	
$150,000 to 199,999	9.4	11.6	8.1	<.001*
$200,000 to 249,999	4.0	4.7	3.6	
$≥250,000	5.3	6.2	4.7	
Refused to answer	7.8	5.5	9.2	
Season of receipt of the survey				
Winter	19.5	18.9	19.9	
Spring	4.5	4.4	4.6	>.05
Summer	25.2	26.3	24.5	
Fall	50.8	50.4	51.0	

Abbreviation: SD=standard deviation
test statistic estimated by using chi-square tests (categorical variables) for difference between men and women
*p<.05

Table 3: Neighbourhood characteristics and sedentary behaviours of the participants

Neighbourhood characteristics				
	Pooled sample (n=14,785) mean (SD)	**Men** (n=5,659) mean (SD)	**Women** (n=9,126) mean (SD)	**p-value**[#]
3-way intersections (raw counts)	18.6 (11.0)	18.5 (10.8)	18.7 (11.0)	>.05
4-way intersections (raw counts)	6.6 (6.3)	6.6 (6.4)	6.6 (6.2)	>.05
Business destinations (raw counts)	4.5 (5.7)	4.3 (5.6)	4.6 (5.8)	<.01[*]
Population count (raw counts)	1088 (656)	1093 (658)	1085 (656)	>.05
Normalized difference vegetation index (raw values)	0.4 (0.1)	0.4 (0.1)	0.4 (0.1)	>.05
Walkability[a]	-0.3 (2.1)	-0.3 (2.1)	-0.2 (2.1)	>.05

Sedentary behaviours				
	Pooled sample (n=14,785) mean (SD)	**Men** (n=5,659) mean (SD)	**Women** (n=9,126) mean (SD)	**p-value**[#]
Time spent sitting on weekdays (minutes/day)	337.0 (181.5)	348.3 (188.5)	330.0 (176.6)	<.001[*]

Time spent sitting on weekend days (minutes/day)	291.7 (160.1)	305.5 (167.3)	283.1 (155.0)	<.001*
Time spent sitting on weekdays and weekends (minutes/week)	2268.1 (1125.0)	2352.2 (1170.0)	2216.0 (1093.0)	<.001*
Time spent travelling in a motor vehicle (minutes/day)	69.3 (68.2)	82.8 (83.3)	61.0 (55.1)	<.001*

Abbreviation: SD=standard deviation
[a]Walkability estimated by adding z scores
Neighbourhood defined as a 400m Euclidean buffer around each participant's household
#Test statistic estimated by using t-tests (continuous variables)
*p<.05

Table 4: Generalized linear models showing the associations between neighbourhood characteristics and sedentary behaviours (pooled analysis)

	Time spent sitting on weekdays (minutes/day) (n=14,785) b (95% CI)[a]	Time spent sitting on weekends (minutes/day) (n=14,785) b (95% CI)[a]	Time spent sitting on weekdays and weekends (minutes/week) (n=14,785) b (95% CI)[a]	Time spent travelling in a motor vehicle (minutes/day) (n=14,785) b (95% CI)[a]
Neighbourhood characteristics[b]				
3-way intersections[c]	4.11 (1.50, 6.71)*	1.58 (-0.74, 3.90)	23.70 (7.50, 39.92)*	-1.20 (-2.22, -0.13)*
4-way intersections[c]	0.10 (-4.45, 4.63)	-0.97 (-5.02, 3.10)	-1.50 (-29.81, 26.85)	-3.20 (-5.00, -1.41)*
Business destinations[c]	-5.54 (-10.53, -0.55)*	-1.45 (-5.98, 3.10)	-30.60 (-62.00, 0.80)	0.43 (-1.40, 2.26)
Population count[c]	1.86 (1.40, 2.31)*	1.08 (0.65, 1.50)*	11.43 (8.60, 14.31)*	-0.15 (-0.32, 0.01)
Normalized difference vegetation index[c]	-3.20 (-6.35, -0.002)*	-5.10 (-7.90, -2.22)*	-26.00 (-45.75, -6.24)*	0.41 (-0.90, 1.71)
Walkability	2.10 (0.72, 3.50)*	1.24 (-0.02, 2.50)	13.00 (4.25, 21.66)*	-0.68 (-1.21, -0.15)*

Abbreviations: b=beta coefficient and CI=confidence interval
[a]Adjusted for age, sex, self-reported general health, current marital status, number of children in household, highest education level, current employment status, annual household income, and season of the receipt of survey
[b]Neighbourhood characteristics were examined in separate regression models
[c]Raw values were rescaled prior to regression analysis (street intersections and business destinations divided by 10, population count divided by 100, and normalized difference vegetation index divided by the interquartile range)
Neighbourhood defined as a 400m Euclidean buffer around each participant's household
*p<.05

Table 5: Sex-specific analysis for the associations between neighbourhood characteristics and sedentary behaviours

Neighbourhood characteristics[b]	Sedentary behaviours	Estimate for men (n=5,659) b (95% CI)[a]	Estimate for women (n=9,126) b (95% CI)[a]
Business destinations[c]	Time spent sitting on weekdays	-12.26 (-21.00, -3.60)*	-1.65 (-7.65, 4.36)
Normalized difference vegetation index[c]	Time spent sitting on weekdays	3.50 (-2.20, 9.11)	-7.30 (-11.00, -3.51)*
Business destinations[c]	Time spent sitting on weekdays and weekends	-73.50 (-127.64, -19.31)*	-5.74 (-43.82, 32.34)
Normalized difference vegetation index[c]	Time spent sitting on weekdays and weekends	6.40 (-28.60, 41.40)	-45.90 (-69.30, -22.50)*
3-way intersections[c]	Time spent travelling in a motor vehicle	-3.41 (-5.42, -1.40)*	0.14 (-1.02, 1.31)
Population count[c]	Time spent travelling in a motor vehicle	-0.44 (-0.73, -0.15)*	0.03 (-0.20, 0.21)
Walkability	Time spent travelling in a motor vehicle	-1.43 (-2.41, -0.44)*	-0.21 (-0.80, 0.37)

Abbreviations: b=beta coefficient and CI=confidence interval

[a]Adjusted for age, sex, self-reported general health, current marital status, number of children in household, highest education level, current employment status, annual household income, and season of the receipt of survey

[b]Neighbourhood characteristics were examined in separate regression models

[c]Raw values were rescaled prior to regression analysis (street intersections and business destinations divided by 10, population count divided by 100, and normalized difference vegetation index divided by the interquartile range)

Neighbourhood defined as a 400m Euclidean buffer around each participant’s household
*$p<.05$

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