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Neighbourhood urban form and individual-level correlates of leisure-based screen time in Canadian adults

Gavin R McCormack, Cynthia Mardinger

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Department of Community Health Sciences, Cumming School of Medicine, University of Calgary, Calgary, Alberta, Canada

Correspondence to
Dr Gavin R McCormack; gmccorma@ucalgary.ca

ABSTRACT

Objectives: Despite evidence for an association between the built environment and physical activity, less evidence exists regarding relations between the built environment and sedentary behaviour. This study investigated the extent to which objectively assessed and self-reported neighbourhood walkability, in addition to individual-level characteristics, were associated with leisure-based screen time in adults. We hypothesised that leisure-based screen time would be lower among adults residing in objectively assessed and self-reported 'high walkable' versus 'low walkable' neighbourhoods.

Setting: The study was undertaken in Calgary, Alberta, Canada in 2007/2008.

Participants: A random cross-section of adults who provided complete telephone interview and postal survey data (n=1906) was included. Captured information included leisure-based screen time, moderate-intensity and vigorous-intensity physical activity, perceived neighbourhood walkability, sociodemographic characteristics, self-reported health status, and self-reported height and weight. Based on objectively assessed built characteristics, participant's neighbourhoods were identified as being low, medium or high walkable.

Primary and secondary outcome measures: Using multiple linear regression, hours of leisure-based screen time per day was regressed on self-reported and objectively assessed walkability adjusting for sociodemographic and health-related covariates.

Results: Compared to others, residing in an objectively assessed high walkable neighbourhood, women, having a college education, at least one child at home, a household income ≥\$120 000/year, and a registered motor vehicle at home, reporting very good-to-excellent health and healthy weight, and achieving 60 min/week of vigorous-intensity physical activity were associated ($p<0.05$) with less leisure-based screen time. Marital status, dog ownership, season, self-reported walkability and achieving 210 min of moderate-intensity physical activity were not significantly associated with leisure-based screen time.

Conclusions: Improving neighbourhood walkability could decrease leisure-based television and computer screen time. Programmes aimed at reducing sedentary behaviour may want to consider an individual's sociodemographic characteristics, physical activity level, health status and weight status, in addition to the walkability of their neighbourhood as these factors were found to be important independent correlates of leisure-based screen time.

Strengths and limitations of this study

- A novel aspect of this study was the investigation of both objectively assessed and self-reported built environmental characteristics in relation to leisure-based screen time in adults.
- Participant recruitment involved simple random sampling from the population.
- Statistical models, with leisure-based screen time as an outcome, adjusted for potential confounders including participation in moderate-intensity and vigorous-intensity physical activity and sociodemographic characteristics.
- Despite the known limitations of using self-report measures, this approach allowed us to assess the relationship between the built environment and a specific and popular sedentary behaviour—that is, leisure-based screen time.

BACKGROUND

Evidence regarding the negative health consequences of sedentary lifestyles is accumulating.[1] Sedentary behaviour includes activities that primarily involve sitting and that require undertaking minimal energy expenditure (eg, watching television, using computers, driving motor vehicles).[2] Sedentary behaviour is a modifiable risk factor for type 2 diabetes, cardiovascular disease, overweight and obesity, and early mortality.[3–6] Moreover, the negative health consequences of sedentary behaviour may offset the positive health benefits derived from being sufficiently physically active—that is, the effect of sedentary behaviour on health is present even after controlling for moderate-to-vigorous leisure-time physical activity.[7]

Several popular sedentary activities have been investigated in relation to health, including screen time (eg, television viewing, computer use and video games), reading, sitting in motorised vehicles and occupational sitting.[8] Second to time spent sitting, the majority of time spent sedentary involves screen-based activities (ie, television and computer use), followed by travelling in motor vehicles.[9] Among Canadian adults, at least two-thirds of waking hours are spent sedentary,[10] and approximately 29% watch television at least 15 h/week and approximately 15% use computers for at least 11 h/week.[11] Similar to physical activity, the socioecological model provides a useful framework for understanding the determinants of sedentary behaviour. Intrapersonal, interpersonal, physical environmental and policy-related factors have been elucidated as potentially important determinants of sedentary behaviour.[2] Evidence to date from this rapidly growing research area suggests that gender, age, education, income, employment status, weight status, those living with children at home, attitude towards sedentary behaviour, participation in moderate-to-vigorous intensity physical activity, and the built environment are associated with sedentary behaviour.[12,13] Further, the correlates of sedentary behaviour appear to be context and behaviour specific (eg, home vs workplace) and therefore different types of sedentary behaviour likely have distinct correlates.[2,9,13] For instance, despite having similarly low-energy expenditure (ie, <2 metabolic equivalents[14]) driving motorised vehicles and television viewing have some shared and also different determinants.[13] Understanding the correlates of specific types of sedentary behaviour could result in an increased focus on these specific determinants for interventions.

There is growing public health interest in the association between the neighbourhood urban form and sedentary behaviour. Increasing neighbourhood walkability has the potential to decrease sedentary behaviour among many adults, which in turn could improve population health. However, findings from a recent review suggest that the evidence for an association between built environment characteristics and sedentary behaviour, including screen time, are equivocal with less than one-third of associations found in the expected direction.[15] For instance, Australian women who resided in low walkable (LW) neighbourhoods spent more time viewing television compared with their counterparts residing in high walkable (HW) neighbourhoods.[16] Similarly, Kozo *et al*[9] found more television viewing time associated with lower neighbourhood walkability in US adults. In contrast, Belgian adults residing in LW neighbourhoods had higher accelerometer-measured and self-reported sitting time than those residing in LW neighbourhoods.[17] Studies have also found associations between self-reported environment characteristics and sedentary behaviour. Van Dyck *et al*[18] reported finding significant associations between individual self-reported individual (ie, land use mix, aesthetics and safety) and composite environment characteristics and self-reported sitting. Moreover, Wallmann-Sperlich *et al*[19] found that among several self-reported measures of the built environment (eg, access to transit, recreation areas, destinations, presence of trees and safety) perception of traffic safety only, was associated with sitting time among German women. However, there are few studies of sedentary behaviour that incorporate both self-reported and objectively assessed built environment correlates within the same analysis. For instance, Ding *et al*[20] found that objectively assessed, but not self-reported, walkability characteristics to be associated with longitudinal changes in television viewing time. The mixed findings regarding the associations between self-reported and objectively assessed built environment characteristics and sedentary behaviour suggests that further investigation is warranted.

Scientific understanding of the correlates of sedentary behaviour in adults is rapidly emerging[9] but our understanding of the built environment correlates is rudimentary.[13] Thus, this study investigated the extent to which the objectively assessed and self-reported neighbourhood walkability, controlling for other sociodemographic, behavioural and health-related characteristics, were associated with leisure-based television and computer screen time in adults. Based on previous evidence, we hypothesise that leisure-based screen time will be lower among adults residing in objectively assessed and self-reported 'high walkable' versus 'low walkable' neighbourhoods.

METHODS

Study design and sample recruitment

The study design and recruitment have been fully described elsewhere.[21,22] The study location was Calgary Alberta, Canada. A random sample of adults (≥18 years of age) was recruited during telephone interviews from August to October 2007 (n=2199, response rate=33.6%) and January–April 2008 (n=2223, response rate=36.7%). Telephone interviews captured information about physical activity, psychosocial and sociodemographic characteristics. A subsample of participants (n=1967; 44.5%) also completed and returned a follow-up postal survey. The postal survey captured information about perceived neighbourhood characteristics, health and weight status, physical activity, sedentary behaviour, and additional sociodemographic characteristics. All the participants provided informed consent.

Measures

Leisure-based screen time

Participants were asked, 'On average, how many hours per week do you spend watching television or using a computer outside of your workplace? (eg, videogames, computer games, DVD/movies, internet, email, etc)'. Time spent on television viewing and computer use can be self-reported reliably.[8] We converted screen time hours per week to hours per day to assist in interpretation of results.

Moderate-intensity physical activity

Participants reported time spent in a usual week undertaking transportation and recreational walking, and other moderate-intensity physical activity (MPA) for recreation, health or fitness, inside and outside of their neighbourhood (within a 15 min walk of home).[23 24] Responses were summed and dichotomised to reflect achievement of 30 min of daily MPA recommended for health benefits (ie, <210 vs ≥210 min/week).

Vigorous-intensity physical activity

Participants reported time spent in a usual week undertaking vigorous-intensity physical activity (VPA) for recreation, health, or fitness, inside and outside of their neighbourhood (within a 15 min walk of home).[23 24] Responses were dichotomised to reflect achievement of at least 60 min of VPA per week—a level that has been reported to provide health benefits.[25]

Health-related characteristics

Participants rated their overall level of health on a five-point scale. Responses were collapsed into three categories: poor/fair, good and very good/excellent. This item had acceptable test–retest reliability (Spearman rank correlation=0.86). Participants' body mass index (BMI; weight/height^2) was estimated from their self-reported height and weight which incorporated a correction factor to account for sex-related reporting bias.[26] BMI was dichotomised into healthy weight (<25 kg/m^2) and overweight (≥25 kg/m^2).

Sociodemographic characteristics

Sociodemographic characteristics included gender, highest education level achieved (high school or less, college or university), gross annual household income (≤$60 000, $60 000–119 000, ≥$120 000/year, or don't know/refused), dog ownership (non-owner vs owner), marital status (married/living together vs other), the number of dependents <18 years old living in the residence (none vs at least one) and number of registered motor vehicles (0, 1, 2 or ≥3 vehicles). The season in which the telephone interview was conducted was recorded.

Self-reported neighbourhood walkability

Characteristics related to neighbourhood walkability including access to services, personal and traffic safety, neighbourhood aesthetics, and pedestrian infrastructure were captured using items (n=25) from the Neighbour hood Environment Walkability Scale (NEWS-A).[27] Item responses were captured on a balanced four-point scale from strongly agree to strongly disagree. Item responses were averaged and then tertiled into low, medium and high walkability categories. Items had adequate internal consistency (Cronbach's α=0.71) and moderate-to-high 2-week test–retest reliability (r=0.50–0.88).[28]

Objectively assessed neighbourhood walkability

Procedures for determining the neighbourhood built environment have been described elsewhere.[21] Briefly, participants' household postal codes were geocoded and a 1.6 km line-based network walkshed estimated. Using Geographical Information Systems (GIS) we assessed the built characteristics associated with physical activity within the walkshed. The derived built environment variables included: walkshed area (km^2), total population/km^2, proportion of neighbourhood green space, path/cycleway (m)/km^2, number of businesses/km^2, number of bus stops/km^2, length of sidewalk (m)/km^2, mix of park types/km^2 and mix of recreational facilities/km^2. The built characteristics were entered into a two-staged cluster analysis which identified three neighbourhood types: low walkable (LW), medium walkable (MW), and high walkable (HW) neighbourhoods.[21] LW neighbourhoods have smaller walkshed area, lower population density, sidewalk availability and recreational destination mix, fewer business destinations and bus stops, and highest proportion of green space compared with the other neighbourhood types. HW neighbourhoods have higher population density, walkshed area, path/cycleway availability and recreational destination mix, and more business destinations and bus stops compared with LW and MW neighbourhoods (table 1).

Statistical analysis

Means (±SDs) were estimated for all correlates. One-way analysis of variance was used for univariate comparisons of screen time (h/day) between self-reported and objectively assessed walkability, and sociodemographic, behavioural and health variables. Zero-order (unadjusted) and partial (adjusted) correlations were undertaken between screen, MPA and VPA time. Fully adjusted multiple linear regression models were used to regress screen time on the sociodemographic (sex, age, income, dependents <18 years at home, marital status, dog ownership, count of registered motor vehicles),

Table 1 Descriptive comparison of the built characteristics between objectively determined low, medium and high walkable neighbourhoods*

	Neighbourhood walkability		
Built characteristics	**Low**	**Medium**	**High**
Walkshed area (km^2)	3rd	2nd	1st
Number of businesses (stores and services)/km^2	3rd	2nd	1st
Number of bus stops/km^2	3rd	2nd	1st
Mix of park types/km^2	1st	3rd	2nd
Mix of recreation destinations/km^2	3rd	1st	2nd
Sidewalk length (m/km^2)	3rd	1st	2nd
Total population/km^2	2nd	3rd	1st
Percent of neighbourhood area as green space	1st	2nd	3rd
Pathway/cycleway length (m/km^2)	2nd	3rd	1st

*Ranks are based on the neighbourhood types average level of built characteristic relative to the two other neighbourhood types. Statistical details associated with these neighbourhood type comparisons are fully described elsewhere.[21]

Table 2 Descriptive statistics for sociodemographic, behavioural and physical environmental characteristics for sample (n=1906)

	Estimate
Gender (%)	
Men	37.8
Women	62.2
Participant age (years)	
<30	8.4
30–44	27.6
45 to 64	42.8
≥65	21.1
Education level achieved (%)	
High school or less	30.1
College	25.4
University	44.4
Annual gross household income (%)	
<$60 000/year	29.8
$60 000–119 999/year	32.2
≥$120 000/year	29.3
Don't know/refused	8.7
Children at home <18 years of age (%)	
No child	66.6
At least one child	33.4
Marital status (%)	
Married/living together	69.3
Single/divorced/separated	30.7
Ethnicity (%)	
Caucasian	90.5
Non-Caucasian	9.5
Dog ownership (%)	
Non-owner	73.4
Owner	26.6
Registered motorised vehicles at home (%)	
No motor vehicle	3.5
One motor vehicles	31.5
Two motor vehicles	46.3
At least three vehicles	18.7
Moderate-intensity physical activity (%), min/week	
<210	37.1
≥210	62.9
Vigorous-intensity physical activity (%), min/week	
<60	46.1
≥60	53.9
Self-rated health (%)	
Poor/fair	15.1
Good	41.0
Very good/excellent	43.9
Body mass index (%)	
Healthy weight	37.4
Overweight	62.6
Leisure-based screen time/day (median/mean±SD)	1.43/1.77±1.52
Season survey completed (%)	
Summer	13.7
Fall	37.8
Winter	24.8
Spring	23.7
Objectively assessed neighbourhood walkability (%)	
Low	56.5
Medium	36.4
High	7.2
Self-reported neighbourhood walkability (%)	
Low	33.4
Medium	35.0
High	31.6

behavioural (recommended MPA and VPA), health (self-reported health and BMI), self-reported and objectively assessed walkability variables, and season. Linear regression estimates for all categorical variables were reported as marginal means (with 95% CIs). Analysis was undertaken using SPSS V.20.

RESULTS

Sample characteristics

Complete data from n=1906 were included in the analysis. The sample of participants had higher representation from women, Caucasians, and those university educated, without children <18 years, married or living with another, without a dog, with at least two registered vehicles at home, and in good to excellent health (table 2). Approximately half of the participants resided in LW (56.3%) neighbourhoods, followed by MW (36.4%) and HW (7.3%) neighbourhoods. Over half of all participants achieved recommended MPA (63.0%) and VPA (53.7%). On average, adults participated in 1.78±1.52 h/day of screen time, with 39.5% undertaking ≥2 h/day. Zero-order and partial correlations (adjusting for MPA) showed a significant association between screen time and VPA (r=−0.100 and −0.098, p<0.05, respectively). Zero-order and partial correlations between screen time and MPA were not statistically significant (r=−0.019 and −0.004, respectively), however, time spent in MPA and VPA was positively correlated (zero-order r=0.233, p<0.05).

Correlates of participating in leisure-based screen time

After adjusting for all correlates, screen time was significantly higher (p<0.05) among men versus women, no child versus at least one child at home, owning none versus owning two or at least three registered motor vehicles, and owning one versus two registered motor vehicles, those reporting good versus very good/excellent health, those participating in ≥60 versus <60 min/week, and residents of objectively assessed LW versus HW neighbourhoods (table 3). No other correlates were statistically significantly associated with screen time. The inclusion of all correlates in the linear regression model explained 7.6% of the explainable variance in screen time.

Table 3 Adjusted linear regression estimates and 95% CIs for the association between sociodemographic, behavioural and physical environmental characteristics and leisure-based screen time (h/day; n=1906)

	Unadjusted mean±SD (h/day)	Estimated marginal mean (h/day)	95%CI	Statistically significant differences (p<0.05) after covariate adjustment
Gender*				
Men	1.88±1.53	1.86	1.68 to 2.04	
Women	1.71±1.52	1.71	1.55 to 1.86	vs men
Participant age* (years)				
<30	1.60±1.37[a]	1.66	1.39 to 1.92	
30–44	1.58±1.37[b,c]	1.84	1.65 to 2.03	
45–64	1.78±1.48[b,d]	1.81	1.63 to 1.98	
≥65	2.11±1.78[a,c,d]	1.84	1.61 to 2.05	
Education level achieved*				
High school or less	2.00±1.81[a,b]	1.89	1.71 to 2.07	
College	1.75±1.46[a]	1.69	1.50 to 1.88	vs high school or less
University	1.64±1.32[b]	1.77	1.60 to 1.95	
Annual gross household income*				
<$60 000/year	2.11±1.81[a,b,c]	1.95	1.77 to 2.13	
$60 000–119 999/year	1.72±1.35[a]	1.81	1.63 to 2.00	
≥$120 000/year	1.55±1.36[b]	1.75	1.55 to 1.94	vs <$60 000/year
Don't know/refused	1.63±1.38[c]	1.63	1.37 to 1.89	vs <$60 000/year
Children at home <18 years of age*				
No child	1.95±1.62	1.96	1.81 to 2.11	
At least one child	1.45±1.23	1.61	1.41 to 1.80	vs no child
Marital status*				
Married/living together	1.67±1.39	1.76	1.59 to 1.93	
Single/divorced/separated	2.02±1.76	1.81	1.63 to 1.99	
Dog ownership				
Non-owner	1.79±1.54	1.75	1.60 to 1.90	
Owner	1.74±1.48	1.82	1.63 to 2.01	
Registered motorised vehicles at home*				
No motor vehicle	2.50±1.87[a,b,c]	2.19	1.81 to 2.57	
One motor vehicles	2.01±1.79[a,d]	1.79	1.61 to 1.96	vs no/two motor vehicle
Two motor vehicles	1.60±1.30[b]	1.55	1.38 to 1.72	vs no/one motor vehicle
At least three vehicles	1.68±1.38[c,d]	1.61	1.41 to 1.82	vs no motor vehicle
Moderate-intensity physical activity* (min/week)				
<210	1.89±1.61	1.84	1.66 to 2.02	
≥210	1.71±1.46	1.73	1.57 to 1.89	
Vigorous-intensity physical activity* (min/week)				
<60	2.02±1.71	1.92	1.75 to 2.09	
≥60	1.58±1.31	1.65	1.48 to 1.82	vs <60 min/week
Self-rated health*				
Poor/fair	1.96±1.58[a]	1.80	1.58 to 2.02	
Good	1.93±1.67[b]	1.88	1.72 to 2.04	vs very good/excellent health
Very good/excellent	1.58±1.32[a,b]	1.68	1.50 to 1.85	
Body mass index*				
Healthy weight	1.59±1.38	1.70	1.53 to 1.88	
Overweight	1.89±1.59	1.87	1.70 to 2.03	vs healthy weight
Season survey completed				
Summer	1.90±1.50	1.86	1.63 to 2.08	
Fall	1.75±1.52	1.76	1.58 to 1.93	
Winter	1.82±1.58	1.80	1.61 to 1.99	
Spring	1.72±1.47	1.72	1.53 to 1.92	
Objectively assessed neighbourhood walkability				
Low	1.74±1.44	1.88	1.72 to 2.04	
Medium	1.85±1.65	1.86	1.69 to 2.03	
High	1.75±1.44	1.61	1.34 to 1.89	vs low

Continued

Table 3 Continued

	Unadjusted mean±SD (h/day)	Estimated marginal mean (h/day)	95%CI	Statistically significant differences (p<0.05) after covariate adjustment
Self-reported neighbourhood walkability				
Low	1.84±1.67	1.80	1.63 to 1.98	
Medium	1.73±1.43	1.74	1.56 to 1.92	
High	1.77±1.46	1.81	1.62 to 1.99	
Variance explained (R^2)		*7.6%*		

*Statistically significant univariate test (analysis of variance (ANOVA) or t test; p<0.05). For unadjusted results with significant ANOVA, categories within variables with same superscript are significantly different (p<0.05) based on Tukey's Least Significance Tests. Estimated marginal means for categorical correlates are adjusted for all covariates.

DISCUSSION

Our study findings contribute to the mixed evidence regarding the influence of the built environment on sedentary behaviour.[15] In support of prior evidence,[9 16] we found that objectively assessed, but not self-reported, neighbourhood walkability was independently associated with leisure-based screen time. We also found that gender, education, household income, having a child at home, having a registered motor vehicle, VPA, self-reported health and self-reported weight status were significant correlates, supporting previous studies showing the importance of sociodemographic and health-related factors in relation to sedentary behaviour.[13] The finding between access to registered motor vehicles and screen time in particular is novel. Marital status, dog ownership, season, self-reported walkability or MPA were not associated with leisure-based screen time.

Similar to others,[9 16 20] we found that adults residing in objectively assessed LW neighbourhoods participated in more leisure-based screen time than those in HW neighbourhoods. Higher sedentary time has been found among men and women residing in regional centres versus the city centre, which to some extent might reflect the difference in urban form and physical activity opportunities in these two environments.[29] Others have found relationships between objectively assessed walkability and television viewing time after considering effect modification by other characteristics such as working status[20] and gender.[16] Similar to our findings, Ding *et al*[20] found no significant association between perceived walkability characteristics in models that included objectively assessed walkability, as well as other sociodemographic characteristics. Together, these findings might suggest that the walkability of the neighbourhood in which adults live is more important than their perception of walkability for determining leisure-based television and computer use. This finding is not surprising given that there is often discordance between objective and self-report measures of the same built environment characteristics,[30] as well as differences in their associations with physical activity.[22]

Residing in a HW neighbourhood was associated with less leisure-based screen time than residing in a LW neighbourhood. Our finding is encouraging given the importance of the neighbourhood environment for supporting physical activity.[31 32] Notably, the operational definition of neighbourhood walkability in our study differed from previous studies investigating correlates of screen time. We estimated neighbourhood walkability using cluster analysis which incorporated nine built environment characteristics.[21] Furthermore, our walkability variable reflected a range of characteristics hypothesised to support transportation and recreational physical activity. Objectively assessed walkability in other studies incorporate three or four built environment characteristics (eg, land use mix, residential density, street connectivity and retail floor area) that are commonly associated with transportation walking.[9 16 20] The fact that slightly different approaches for estimating neighbourhood walkability are associated with screen time is encouraging yet some individual built characteristics may be more strongly associated screen time than others.[15] Urban planners and health practitioners need more evidence about which objectively assessed and self-reported neighbourhood environmental characteristics individually or in combination best explain differences in leisure-based screen time as well as other sedentary behaviours.[15]

A little less than half of our participants undertook 2 h of screen time per day—similar levels have been reported in Canada and elsewhere.[20 29 33] In support of evidence elsewhere,[16 33 34] we found that adults of healthy weight reported less screen time than their overweight counterparts. Speculatively, the home environment might have contributed to the association between weight status and leisure-based screen time in our study. Overweight adults have been found to own a higher count of televisions and to be more likely to have a television in the bedroom compared with healthy weight adults.[34] The count of televisions and computers in the home[33 34] and television size[33] might be positively associated with screen-based activity in adults. Despite including measures of the physical environment (urban form and season) we did not include measures of the home-based environment (ie, where the majority of leisure-based screen time occurs), which has been found to be important with regard to television viewing.[35] Home-based interventions that modify the physical environment could discourage television viewing.[36] The estimated association between weight status and screen time might also be confounded by unhealthy diet, which is associated with compromised weight status and sedentary behaviour.[37] Related to this was our finding that participants reporting better health also reported lower screen time than those who reported worse health. Self-reported poor health among those watching more television has been found elsewhere.[38] While there appears to be an association, we are unable to infer the causal pathway between self-reported health and screen time based on our cross-sectional data. Longitudinal and quasi-experimental studies that examine changes in sedentary behaviour, physical activity, and diet in response to modifications to the neighbourhood and home physical environments are needed to provide stronger temporal evidence.

Noteworthy, was that the number of registered motor vehicles at home was negatively associated with screen time. A recent study found an increase in the likelihood of watching television ≥2 h/day among older Japanese women who reported being non-drivers.[39] Not having a registered motor vehicle (or being a non-driver) could decrease an individual's ability to access physical activity opportunities outside the home and therefore result in more time spent in the home where television viewing is a convenient activity option. Despite adjusting for income and education, it is possible that the association between registered motor vehicles at home and screen time could to some extent reflect other dimensions of socioeconomic status.[40] Others have found associations between socioeconomic status and leisure-based sedentary behaviour.[9 16 17] Higher education, in particular, is consistently associated with less television viewing time and computer use.[9 16 17 20 29 33 38] We found that adults with high school or less education had significantly higher screen time than those with a college education. The negative relationship between household income and screen time found in our study, while not always statistically significant, showed a consistent pattern. Other studies also report higher television viewing in those with lower incomes.[16] This finding might reflect the financial barrier to participating in recreational activities outside of the home among low-income households, thus television and computer use are alternative and less-expensive leisure pursuits. Interventions for decreasing sedentary behaviour should target adults across the education and income spectra.

In general, weak correlations between physical activity and screen time have been found.[41] An Australian study found similar estimates of television viewing time between those who achieved sufficient (ie, ≥150 min/week) versus insufficient moderate-to-vigorous intensity physical activity.[29] Conversely, others have found lower television viewing time among women participating in high (≥2 h/week) versus low levels of leisure-time physical activity.[16] We did not find a significant difference in screen time between those achieving and not achieving recommended MPA (ie, ≥210 min/week); however, participants achieving recommended VPA (ie, ≥60 min/week) reported less screen time than those not achieving this level. This finding is similar to those found among Australian adults whereby participating in ≥90 min/week of VPA was associated with a lower likelihood of watching television ≥10 h/week.[42] Encouraging adults to participate in more VPA might lead to reductions in screen time as well as provide additional health benefits. Our finding that achieving recommended MPA was not associated with screen time suggest that separate public health strategies might be needed for decreasing sedentary behaviour in addition to increasing MPA among adults.

Several limitations should be considered when interpreting these findings. Self-reported screen time, physical activity and other variables are subject to measurement error and recall bias. While less useful for identifying specific sedentary activities compared with self-reports, motion monitors may more accurately estimate total sedentary time. Our study captured leisure-based screen time only, yet other sedentary behaviours are associated with the built environment.[15] Simple random sampling from the Calgary population resulted in a lower proportion of participants from HW neighbourhoods. While we were still able to detect a significant difference in screen time between LW and HW neighbourhoods, the small sample size in the HW neighbourhoods restricted our analysis to testing main effects only. It is possible that neighbourhood walkability has differential effects on screen time for different sociodemographic groups.[16 20] The sample characteristics (adults from one Canadian city), the low-response and follow-up participation rates, and the elapsed time since data collection may limit the generalisability of our findings. Compared with participants who completed the telephone interview, those who also completed the postal survey included a higher proportion women, those with no child dependents, and those with postsecondary education.[43]

Despite these limitations, the direction of associations found between the correlates and screen time in our study appeared to correspond with the associations found in other populations.[13] However, <8% of the explainable variance in screen time was accounted for by the fully adjusted model, suggesting that other factors not examined in this study could be important for determining leisure-based screen time.[12 13] While the magnitude of the differences in screen time by neighbourhood walkability found in this study and elsewhere[9 16 20] appear small, the reduction of screen time accumulated overtime and across many people could have a significant population health impact. Our study is just one of only a few studies to show a potential association between the built environment and leisure-based screen time.[15] More studies are required to identify other environmental and non-environmental correlates of screen time.

The findings of our study suggest that neighbourhood urban form is associated with leisure-based screen time, independent of other correlates including sociodemographic, health, neighbourhood perceptions and physical activity-related characteristics. This finding is important, as most research to date support the potential role of neighbourhood urban form in supporting and discouraging physical activity. Creating walkable neighbourhoods could increase physical activity but have the additional benefit of also decreasing leisure-based screen time among adults. Other potentially important correlates of screen time in adults include gender, education, household income, having a child at home, having a registered motor vehicle VPA, self-reported health, and weight status. Mutlilevel interventions that encourage physical activity as well as discourage leisure-based screen time might be necessary for improving population health.[2 41]

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REFERENCES

1. Tremblay MS, Colley RC, Saunders TJ, *et al*. Physiological and health implications of a sedentary lifestyle. *Appl Physiol Nutr Metab* 2010;35:725–40.
2. Owen N, Sugiyama T, Eakin EE, *et al*. Adults' sedentary behavior determinants and interventions. *Am J Prev Med* 2011;41:189–96.
3. Katzmarzyk PT, Church TS, Craig CL, *et al*. Sitting time and mortality from all causes, cardiovascular disease, and cancer. *Med Sci Sports Exerc* 2009;41:998–1005.
4. Wijndaele K, Duvigneaud N, Matton L, *et al*. Sedentary behaviour, physical activity and a continuous metabolic syndrome risk score in adults. *Eur J Clin Nutr* 2009;63:421–9.
5. McCormack GR, Virk JS. Driving towards obesity: a systematized literature review on the association between motor vehicle travel time and distance and weight status in adults. *Prev Med* 2014;66:49–55.
6. Grøntved A, Hu FB. Television viewing and risk of type 2 diabetes, cardiovascular disease, and all-cause mortality: a meta-analysis. *JAMA* 2011;305:2448–55.
7. Healy GN, Dunstan DW, Salmon J, *et al*. Television time and continuous metabolic risk in physically active adults. *Med Sci Sports Exerc* 2008;40:639–45.
8. Clark BK, Sugiyama T, Healy GN, *et al*. Validity and reliability of measures of television viewing time and other non-occupational sedentary behaviour of adults: a review. *Obes Rev* 2009;10:7–16.
9. Kozo J, Sallis JF, Conway TL, *et al*. Sedentary behaviors of adults in relation to neighbourhood walkability and income. *Health Psychol* 2012;31:704–13.
10. Colley R, Garriguet D, Janssen I, *et al*. Physical activity of Canadian adults: accelerometer results from the 2007 to 2009 CHMS. *Health Rep* 2011;22:1–8.
11. Shields M, Tremblay M. Screen time among Canadian adults: a profile. *Health Rep* 2008;19:31–43.
12. Uijtdewilligen L, Twisk JW, Singh AS, *et al*. Biological, socio-demographic, work and lifestyle determinants of sitting in young adult women: a prospective cohort study. *Int J Behav Nutr Phys Act* 2014;11:7.
13. Rhodes RE, Mark RS, Temmel CP. Adult sedentary behavior: a systematic review. *Am J Prev Med* 2012;42:e3–28.
14. Ainsworth BE, Haskell WL, Whitt MC, *et al*. Compendium of physical activities: an update of activity codes and MET intensities. *Med Sci Sports Exerc* 2000;32Suppl):S498–504.
15. Koohsari MJ, Sugiyama T, Sahlqvist S, *et al*. Neighbourhood environmental attributes and adults' sedentary behaviors: review and research agenda. *Prev Med* 2015;77:141–9.
16. Sugiyama T, Salmon J, Dunstan DW, *et al*. Neighbourhood walkability and TV viewing time among Australian adults. *Am J Prev Med* 2007;33:444–9.
17. Van Dyck D, Cardon G, Deforche B, *et al*. Neighbourhood walkability and sedentary time in Belgian adults. *Am J Prev Med* 2010;39:25–32.
18. Van Dyck D, Cerin E, Conway TL, *et al*. Associations between perceived neighbourhood environmental attributes and adults' sedentary behavior: findings from the U.S.A., Australia and Belgium. *Soc Sci Med* 2012;74:1375–84.
19. Wallmann-Sperlich B, Bucksch J, Hansen S, *et al*. Sitting time in Germany: an analysis of socio-demographic and environmental correlates. *BMC Public Health* 2013;13:196.
20. Ding D, Sugiyama T, Winkler E, *et al*. Correlates of change in adults' television viewing time: a four-year follow-up study. *Med Sci Sports Exerc* 2012;44:1287–92.
21. McCormack GR, Friedenreich C, Sandalack BA, *et al*. The relationship between cluster-analysis derived walkability and local recreational and transportation walking among Canadian adults. *Health Place* 2012;18:1079–87.
22. Jack E, McCormack GR. The associations between objectively-determined and self-reported urban form characteristics and neighbourhood-based walking in adults. *Int J Behav Nutr Phys Act* 2014;11:71.
23. McCormack GR, Shiell A, Doyle-Baker PK, *et al*. Testing the reliability of neighbourhood-specific measures of physical activity among Canadian adults. *J Phys Act Health* 2009; 6:367–73.
24. Giles-Corti B, Timperio A, Cutt H, *et al*. Development of a reliable measure of walking within and outside the local neighbourhood: RESIDE's neighbourhood physical activity questionnaire. *Prev Med* 2006;42:455–9.
25. Hallal PC, Andersen LB, Bull FC, *et al*. Global physical activity levels: surveillance progress, pitfalls, and prospects. *Lancet* 2012;380:247–57.
26. Orpana HM, Berthelot JM, Kaplan MS, *et al*. BMI and mortality: results from a national longitudinal study of Canadian adults. *Obesity (Silver Spring)* 2010;18:214–18.
27. Cerin E, Saelens BE, Sallis JF, *et al*. Neighbourhood environment walkability scale: validity and development of a short form. *Med Sci Sports Exerc* 2006;38:1682–91.
28. McCormack GR, Friedenreich CM, Giles-Corti B, *et al*. Do motivation-related cognitions explain the relationship between perceptions of urban form and neighbourhood walking? *J Phys Act Health* 2013;10:961–73.
29. Clark BK, Sugiyama T, Healy GN, *et al*. Socio-demographic correlates of prolonged television viewing time in Australian men and women: the AusDiab study. *J Phys Act Health* 2010;7:595–601.
30. Ball K, Jeffery RW, Crawford DA, *et al*. Mismatch between perceived and objective measures of physical activity environments. *Prev Med* 2008;47:294–8.
31. McCormack G, Shiell A. In search of causality: a systematic review of the relationship between the built environment and physical activity among adults. *Int J Behav Nutr Phys Act* 2011;8:125.
32. Bauman AE, Reis RS, Sallis JF, *et al*. Correlates of physical activity: why are some people physically active and others not? *Lancet* 2012;380:258–71.
33. Van Dyck D, Cardon G, Deforche B, *et al*. Socio-demographic, psychosocial and home-environmental attributes associated with adults' domestic screen time. *BMC Public Health* 2011;11:668.

34. Gorin AA, Phelan S, Raynor H, *et al*. Home food and exercise environments of normal-weight and overweight adults. *Am J Health Behav* 2011;35:618–26.
35. Kaushal N, Rhodes RE. The home physical environment and its relationship with physical activity and sedentary behavior: a systematic review. *Prev Med* 2014;67:221–37.
36. French SA, Gerlach AF, Mitchell NR, *et al*. Household obesity prevention: take action—a group-randomized trial. *Obesity (Silver Spring)* 2011;19:2082–8.
37. Hobbs M, Pearson N, Foster PJ, *et al*. Sedentary behaviour and diet across the lifespan: an updated systematic review. *Br J Sports Med* 2015;49:1179–88.
38. King AC, Goldberg JH, Salmon J, *et al*. Identifying subgroups of US adults at risk for prolonged television viewing to inform program development. *Am J Prev Med* 2010;38:17–26.
39. Kikuchi H, Inoue S, Sugiyama T, *et al*. Correlates of prolonged television viewing time in older Japanese men and women. *BMC Public Health* 2013;13:213.
40. Singh GK. Area deprivation and widening inequalities in US mortality, 1969–1998. *Am J Public Health* 2003;93:1137–43.
41. Owen N, Healy G, Matthews C, *et al*. Too much sitting: the population health science of sedentary behavior. *Exerc Sport Sci Rev* 2010;38:105–13.
42. McCormack G, Giles-Corti B. Does participation in recommended levels of vigorous-intensity physical activity decrease participation in moderate-intensity physical activity? *J Phys Act Health* 2004;1:45–55.
43. McCormack GR, Friedenreich C, Shiell A, *et al*. Sex and age-specific seasonal variations in physical activity among adults. *J Epidemiol Community Health* 2010;64:1010–16.