

Development and Validation of an Urban Walkability Index for Toronto, Canada

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SUMMARY

There is evidence that urban environments that discourage walking and other physical activities have contributed to the current epidemic of overweight and obesity. Various indices have been created to describe area 'walkability' combining aspects of the built environment that promote or inhibit walking. Due to issues of data quality and availability in Toronto, we were unable to exactly replicate some of the most commonly used indices. Therefore, the purpose of this work was to create a walkability index for Toronto, Canada, informed by work that has already been published in this field and subsequently to validate and test its performance at different levels of census geography. Variables that have been shown to be associated with active transportation or that have been included in existing, validated walkability indices were identified from the literature. Based on data quality and availability in our setting, a final list of candidate variables was identified that could be generated for Toronto using geographic methods. Factor analysis was then used to identify the variables that would comprise our final index. The resulting walkability index was composed of population density, dwelling density, availability of retail stores and services within a 10-minute walking distance, and street connectivity. The index was validated against measures related to physical activity, transportation choice and body weight from three independent surveys. Index values had positive associations with walking, cycling and public transit use and inverse associations with car ownership and driving trips (all p-values ≤ 0.001). The most walkable quintile of Toronto census tracts had 36% lower obesity rates than the least walkable quintile. The index for Toronto, Canada was consistently associated with activity levels, transportation choices, and obesity.

INTRODUCTION

According to the World Health Organization, 1.5 billion adults were overweight in 2008, and approximately 500 million of these adults were obese (World Health Organization [WHO], 2011). While changes in portion sizes and energy intake have played an important role in the rise in obesity, decreases in physical activity have also been a major contributor to this epidemic. Environmental factors that may lead to excess food consumption and physical inactivity are complex. However, an increasing body of evidence has identified a relationship between the built environment and physical activity (Saelens, Sallis, & Frank, 2002; Davison & Lawson, 2006), and measures of body weight (Raine et al., 2008; Papas et al., 2006). Given concern over increasing levels of overweight and obesity, identifying and modifying related built environment characteristics may be an important policy step for chronic disease prevention.

Several indices have been developed to measure ‘walkability,’ combining aspects of the built environment that promote or inhibit walking (Owen et al., 2007; Ewing, Schmid, Killingsworth, Zlot, & Raudenbush, 2003; Frank, Schmid, Sallis, Chapman, & Saelens, 2005; Frank et al., 2006; Krizek, 2003; Cervero and Duncan, 2003; Frank et al., 2009). These indices commonly include measures such as residential dwelling density (Frank, Schmid, Sallis, Chapman, & Saelens, 2005; Berke, Koepsell, Moudon Hoskins & Larson, 2007; Lee and Moudon, 2006; Li, Fisher, Brownson, Bosworth, 2005; Moudon et al., 2006; Frank et al., 2009) intersection density (a measure of street connectivity) (Owen et al., 2007; Frank, Schmid, Sallis, Chapman, & Saelens, 2005; Li, Fisher, Brownson, Bosworth, 2005), density or proximity to walkable destinations (Berke, Koepsell, Moudon Hoskins & Larson, 2007; Lee and Moudon, 2006; Moudon and Lee, 2006; Rundle et al., 2007) and land use mix (Owen et al., 2007; Frank, Schmid, Sallis, Chapman, & Saelens, 2005; Rundle et al., 2007; Frank et al., 2009; Frank, Saelens, Powell, Chapman, 2007; Frank et al., 2006) and have shown positive associations with the frequency or duration of physical activity and negative associations with body weight in various settings. It is common for researchers to tailor the development of an index based on the availability and quality of built environment data for their study area. Common indices such as those employed by Frank et al. (Frank et al., 2009; Frank, Saelens, Powell, Chapman, 2007; Frank et al., 2006) rely on lot-level property tax assessment data for several key variables, such as land use mix. Such data was not available for this work in Toronto, in part due to high procurement costs and due to data quality issues. At the time of this research no pre-existing walkability index had been examined in our study area.

Our primary goal was to create and validate a walkability index for Toronto, Canada, drawing on variables identified in the literature to be related to walkability or that were included in other validated walkability indices. As a secondary goal we examined the performance of the index at three different levels of census geography to determine the role unit selection may play in the resulting index scores.

METHODS

Setting

The City of Toronto is Canada's largest municipality with a 2006 population of 2.48 million people, a land area of 630.1 square kilometres, and an average population density of nearly 4000 people per square kilometer.

Selection of candidate variables

We conducted a thorough literature review and generated a list of candidate variables from the existing literature that had been shown to be relevant to perceived walkability, transportation choices, walking, physical activity levels, or body weight. We further restricted candidate variables to those for which suitable data sources were readily available in our setting. Suitability was determined based on availability of data, cost and data quality. The resulting candidate variables, along with their data sources, are shown in Table 1.

Creation of Candidate Variables

To create the candidate variables we constructed a walking network using network analysis tools in ArcGIS 9.3. All non-walkable roadways (e.g., express highways) were removed, while footpaths and walkable roadways were retained. Spatial data sources used in calculation of the candidate variables ranged in date from 2004 to 2008.

A geometric centre point (centroid) was created as a representative "sample point" for each of the census tracts in our study area. Geographic buffers around tract centroids, and other network analysis procedures, were used to create the candidate variables. Initial comparisons between measures calculated using 360 metre, 720 metre, and 1080 metre buffers (equivalent to 5, 10, and 15 minute walking times based on a walking speed of 1.2m/s (Gutteridge, 2002)) indicated excellent agreement between the 720 and 1080 metre buffers (spearman correlation 0.9), and good agreement between the 360 and 720 metre (spearman correlation 0.8) and 360 and 1080 metre (spearman correlation 0.7) buffers. We thus chose a buffer size of 720 metres based on previous use of this value for defining 'walkable' destinations in related literature (Kirtland et al., 2003).

Census tracts were selected as the main unit of analysis because data from some of the surveys used for validation were not available at smaller geographic levels, nor at the individual-level. All census tracts with a suppressed or 0 population, and/or whose 720 metre centroid buffer did not overlap with any residential areas were excluded from analysis. The remaining 524 census tracts (out of 531) ranged in population from 20 to 22724 (median 4638) people. These units are roughly similar in size and composition to census tracts in the U.S.

Density variables

Spatially averaged density variables were calculated using 720 metre *Euclidean* (straight-line) buffers to capture neighbouring tracts, as the areal boundaries of some census tracts were too small to accurately represent density in a neighbourhood context on their own. Density variables for a given census tract were calculated as the average density across all tracts intersecting a 720 metre *Euclidean* buffer of the tract centroid.

Availability variables

Availability variables were calculated as the count of locations of a given resource type within a 720 metre network buffer of the tract centroid, based on walkable streets and paths.

Access variables

Access variables were calculated as the shortest travel time along the walking network from the tract centroid to the nearest location of a given resource (e.g., park).

Detailed descriptions of how each candidate variable was created are provided in Table 1.

Table 1. Candidate variables for an urban walkability index.

Variable	Data Source	Description of Derived Variable	Previous Use
<i>Density Variables</i>			
1. *Population per km ²	2006 Census	Sum of numerator (population or dwelling) values in all tracts whose polygon area intersected the 720 metre Euclidean buffer of a given tract centroid, divided by the summed area of all intersecting tracts.	Ewing et al., 2003; Glazier et al., 2007; Rundle et al., 2007
2. *Dwellings per km ²	2006 Census		Berke et al., 2007; Frank et al., 2005; Lee and Moudon, 2006; Li et al., 2005; Moudon et al., 2006; Owen et al., 2007; Rundle et al. 2007
<i>Resource Availability Variables - Measured as number of locations within a 10 minute walking distance for:</i>			
3. *All retail and services, consisting of:	Dunn & Bradstreet, Inc.‡	Network analysis was used to generate variables describing “availability” of selected resources. "Availability" was measured as the count of locations of a given resource type within the 720 metre network buffer of each tract centroid.	Berke et al., 2007; Moudon et al., 2007;
a) Grocery stores and fruit and vegetable stands	Dunn & Bradstreet, Inc.‡		Berke et al., 2007; Lee and Moudon, 2006; Morland et al. 2006; Moudon et al., 2006
b) Convenience and variety stores	Dunn & Bradstreet, Inc.‡		Morland et al., 2006
c) Bank branches†	Dunn & Bradstreet, Inc.‡		Lee and Moudon, 2006; Weyman et al., 2008

Variable	Data Source	Description of Derived Variable	Previous Use
<i>Resource Availability Variables – Continued</i>			
d) Restaurants and cafés (including fast food establishments)	Dunn & Bradstreet, Inc. [‡]		Lee and Moudon, 2006; Moudon et al., 2007; Moudon et al., 2006
e) Other miscellaneous retail and services (e.g. dry cleaner, hair salon, post office, library)	Dunn & Bradstreet, Inc. [‡]		Tilt et al., 2007
4. Public recreation centres	City of Toronto, 2004		Li et al., 2005; McCormack et al., 2006;
<i>Other Availability Variables</i>			
5. Proportion of all food stores that are grocery stores (within 10 minute network buffer)	Dunn & Bradstreet, Inc. [‡]	Grocery stores as a % of total food store (grocery + convenience) counts within a 720 metre network buffer of the tract centroid.	California Center for Public Health Advocacy et al., 2008
6. *Number of street intersections (within 10 minute network buffer)	DMTI Spatial Inc., 2006	Count of 3-way or greater intersections within a 720 metre network buffer of the tract centroid.	Carver et al., 2008; Frank et al., 2005; Li et al., 2008; Owen et al., 2007
<i>Other Availability Variables – Continued</i>			

Variable	Data Source	Description of Derived Variable	Previous Use
7. Heterogeneity of land use (within 10 minute network buffer)	Land Information Toronto, 2004; DMTI Spatial Inc., 2006	Land Use entropy, calculated within a 720 metre buffer of the tract centroid. Values range from complete homogeneity of land use (value = 0) to the most heterogeneous mix of land uses possible (value = 1).	Frank et al., 2005; Larsen et al., 2009; Owen et al., 2007; Rundle et al., 2007
<i>Resource Access Variables - Measured as walking time in seconds to the nearest:</i>			
8. Park or school	Land Information Toronto, 2004; Ministry of Education, 2007	Network analysis was used to generate variables describing "access" to selected resources. "Access" was measured as the shortest travel time by	Larsen et al., 2009; Li et al., 2005; McCormack et al., 2006;
9. Walking time to the nearest bus, streetcar or subway stop location	Toronto Transit Commission, 2008	walking from the centroid of a given tract to the nearest location of a given resource.	Glazier et al., 2007

* Included in the final walkability index

† Includes commercial, federal, state and international bank branches, and credit union branches

‡ Selected SIC codes data for 15 urban centres in Ontario (Dunn & Bradstreet, Inc. 2008)

Examination at other levels of census geography

In order to investigate whether measuring and defining local environment characteristics at an even finer level of geography changes the association between a walkability index and validation outcomes (described below), we repeated the generation of candidate variables and subsequent analyses for two smaller Statistics Canada census units, the dissemination area (DA) (n = 3,561 units for which data was available, out of a total of 3,577), and the dissemination block (DB) (n = 10,535, out of a total of 11,805) (Oppenshaw, 1984). This sensitivity analysis was also meant to help determine the suitability of these methods for application to settings or study designs where smaller units of analysis are preferred. Unit population and area ranges were 5 to 7,333 (median 537) and 0.0236 km² to 5.636 km² (median 0.0978 km²), respectively for DAs, and 5 to 7,333 (median 126) and 0.000487 km² to 4.3631 km² (median 0.0236 km²), respectively for DBs.

Creation of a Walkability Index

The walkability index was constructed from the candidate variables using factor analysis (Kim, 1978), which is a method designed to develop composite measures of latent constructs. Given the large number of variables that have been identified in the literature to be associated with perceived ‘walkability’, we used factor analysis as a guide to identify components of the built environment that were both statistically associated with each other and, in combination, had face validity as a measure of ‘walkability’. Once the components were identified, we used principal components analysis to construct the first principal, a walkability index. The principal components procedure produced standardized scores with a mean of zero and variance of one. Index quintiles were generated by ordering tracts according to increasing walkability and allocating an equal number to each quintile. Factor analysis and principal components analysis have been used previously to create indices comprising built environment (Ewing, Schmid, Killingsworth, Zlot, Raudenbush, 2003; Krizek, 2003; Cervero and Duncan, 2003 and sociodemographic characteristics (Morenoff et al., 2007; Messer et al., 2006).

Index Validation

To investigate whether the walkability index was associated with actual levels of walking and physical activity, and ultimately with body weight, we validated the census tract-level index against self-reported survey data from the 2006 Census of Canada (Statistics Canada, 2008), the 2006 Transportation Tomorrow Survey (TTS) (Data Management Group, 2006), and the Canadian Community Health Survey (CCHS). All validation variables were generated at the census tract level to avoid attributing area-level walkability index characteristics to individuals. For the walkability indices generated at DA and DB geographic levels we were only able to validate against 2006 Census of Canada variables due to low numbers of respondents for the TTS and CCHS surveys within these smaller areal units.

Using the census data, we calculated the percent of the employed population aged 15 years and over within each tract that walked, took public transit, cycled or drove to work. From the TTS we extracted the average number of cars per household and average daily number of trips per person

by walking, bicycling, driving, and public transit. From the CCHS we used the proportion of people who are active (based on average daily energy expended during leisure time activities); the proportion of the population who have a body mass index (BMI) ≥ 25 (overweight) or ≥ 30 (obese); and the average BMI of respondents. BMI is a ratio of weight-to-height and can be calculated according to the equation: $BMI = \text{weight}(\text{kg}) / \text{height}(\text{m})^2$.

Spearman correlation coefficients were used to evaluate the census tract-level associations between walking/activity variables and the index factor scores. The validation variables were then averaged by walkability index quintile. For the individual-level CCHS survey data, census tract-level estimates were derived using random intercept models in order to account for geographic clustering and help adjust for small-area effects on the variance. Tests for trend were performed using regression analysis to determine whether differences across quintiles were significant, and p-values were reported (see Table 3). Rate ratios of the highest (most walkable) to lowest (least walkable) quintile were also generated. All analyses were conducted using SAS, version 9.1. Approval was granted by the Research Ethics Board of the Sunnybrook Health Sciences Centre.

RESULTS

The final composite index determined from the Factor Analysis was composed of four variables: two measures of density, walkable retail and service outlets, and street connectivity (see Table 2). Factor loadings for variables reflecting access to recreation centres and public transit, as well as land-use mix were low (< 0.50) and thus these variables were not retained in the index. Due to its common use in other walkability indices, we examined the correlation between land-use mix and physical activity in our setting to see if its exclusion from the index was simply an artifact of the factor analysis procedure. We found that in Toronto, the Spearman correlation coefficient of land-use mix and percent walking to work was 0.20 ($p < 0.0001$) indicating a weak association.

Correlations between the walkability index and its component measures ranged from 0.70 to 0.94 (all $p \leq 0.001$). Almost identical factor loadings and correlations were found when we examined the same candidate variables using the same methodology for smaller standard census units, the DA and DB. Eigenvalues (2.8) and standardized chronbach's alpha (0.85) were identical for all three levels examined.

Figure 1 shows walkability index values for census tracts in the City of Toronto. The highest index values were found in the south-central "downtown" portion of the city, roughly corresponding with the area built prior to World War II. The lowest index values were found in the outer, more suburban, areas of the city which were more recently built. Table 3 shows the mean values and standard deviations for self-reported activity measures by walkability index quintile at the census tract level.

The findings demonstrate that increasing levels of walkability were statistically significantly associated in a dose-response pattern with lower levels of car ownership, driving trips, and driving to work and higher levels of walking/bicycling and use of public transit both overall and for transportation to work. Lower walkability was consistently associated with higher BMI and rates of obesity ($p \leq 0.01$). Although lower walkability was also associated with lower levels of physical activity and higher rates of overweight, the association was not statistically significant, likely reflecting a lack of power due to small sample sizes in the CCHS survey data. The inverse correlation with BMI remained statistically significant even after controlling for age, sex and socio-economic status (SES) ($p < 0.01$). Correlations derived from the same analyses performed at the DA and DB level were very similar to those at the census tract level (results shown in appendix).

Table 2. Factor loadings and correlations for the walkability index.

Variable	Census Tract Level		Dissemination Area Level		Dissemination Block Level	
	Factor Loading	Correlation with Factor	Factor Loading	Correlation with Factor	Factor Loading	Correlation with Factor
Population density *	90	0.904 †	90	0.903 †	91	0.908 †
Dwelling density *	94	0.941 †	93	0.935 †	94	0.936 †
Availability of all retail and services ‡	77	0.770 †	77	0.772 †	77	0.771 †
Street connectivity §	70	0.704 †	70	0.701 †	71	0.706 †

* Density per square kilometre of all census tracts intersecting 720 metre Euclidean buffer of a given tract centroid.

† $p < 0.0001$

‡ Count of all retail locations within 720 metre network buffer of tract centroid.

§ Count of all 3-segment or greater intersections within 720 metre network buffer of tract centroid.

Figure 1. Walkability index quintiles, by census tract, in the City of Toronto, Ontario, Canada

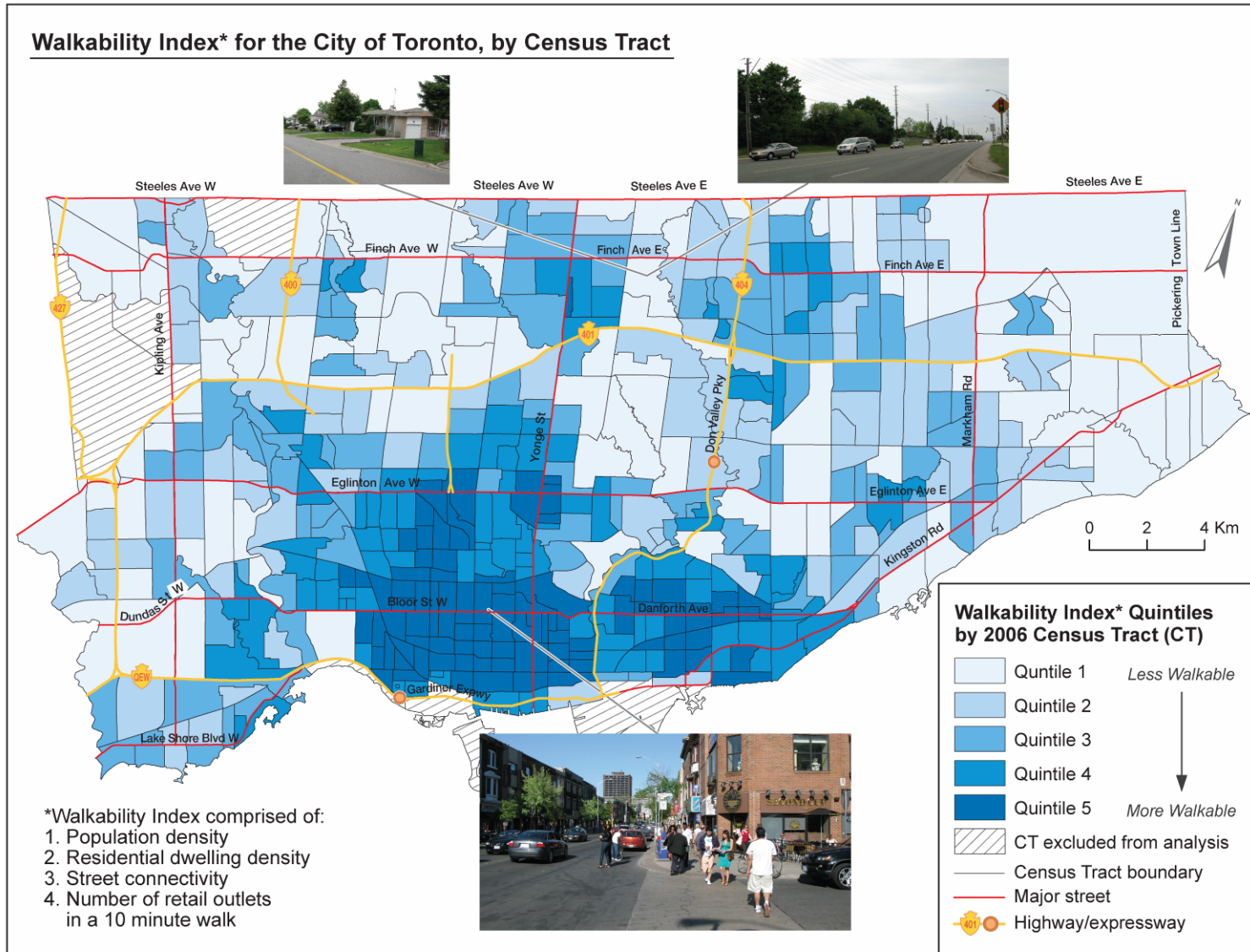


Table 3. Mean values (SD) of activity measures by walkability index quintile with tests for trend and correlations

Variable	Walkability Index Quintile					Q5/Q1 Ratio	Test for Trend (p- value)*	Spearman Correlation Coefficient with Index (p-value)
	1 (lowest)	2	3	4	5 (highest)			
Number of census tracts (n = 515)	102	103	105	102	103			
2006 Transportation Tomorrow Survey								
Cars per household	1.36 (0.30)	1.24 (0.25)	1.16 (0.26)	1.05 (0.28)	0.79 (0.25)	0.58	0.006	-0.58 (<0.0001)
Cars per person	0.48 (0.11)	0.47 (0.09)	0.45 (0.10)	0.43 (0.10)	0.35 (0.10)	0.72	0.025	-0.40 (<0.0001)
Average number of daily driving trips/person/day	0.76 (0.08)	0.74 (0.08)	0.71 (0.10)	0.64 (0.12)	0.49 (0.13)	0.64	0.029	-0.64 (<0.0001)
Average number of daily walking or biking trips/person/day	0.05 (0.03)	0.06 (0.04)	0.06 (0.03)	0.08 (0.04)	0.17 (0.10)	3.24	0.162	0.54 (<0.0001)
Average number of daily public transit trips/person/day	0.18 (0.07)	0.19 (0.06)	0.22 (0.08)	0.27 (0.10)	0.32 (0.08)	1.81	0.005	0.56 (<0.0001)

**2006 Canada Census (based on
employed population aged 15+)**

								0.55
Population who walk to work (%)	3.25 (2.57)	3.84 (3.54)	3.84 (2.23)	6.42 (5.87)	16.04 (13.91)	4.94	0.179	(<0.0001)
								0.54
Population who bike to work (%)	0.57 (0.75)	0.64 (0.81)	0.75 (1.18)	1.89 (1.99)	4.83 (3.71)	8.52	0.116	(<0.0001)
Population who walk or bike to work (%)	3.82 (2.84)	4.48 (3.99)	4.60 (3.10)	8.31 (6.72)	20.87 (14.49)	5.46	0.154	(<0.0001)
								0.61
Population who take public transit to work (%)	28.32 (7.82)	29.91 (7.54)	32.99 (8.73)	37.35 (10.91)	41.39 (8.96)	1.46	0.002	(<0.0001)
								0.47
Population who drive to work (%)	67.18 (8.96)	64.86 (8.96)	61.64 (9.54)	53.53 (12.72)	36.76 (11.27)	0.55	0.025	(<0.0001)
								-0.68

**Canadian Community Health
Survey[‡]**

Proportion of people who are active [§]	22.68 (14.63)	22.21 (17.94)	23.71 (16.54)	27.43 (19.18)	27.48 (19.91)	1.21	0.034	0.09 (0.032)
BMI	24.81 (0.79)	24.75 (0.80)	24.92 (1.12)	24.61 (0.90)	24.56 (0.68)	0.99	0.148	-0.14 (0.001)
% Overweight (BMI ≥ 25) (%)	41.54 (19.20)	41.79 (19.57)	43.79 (21.12)	38.73 (21.53)	38.55 (17.56)	0.93	0.225	-0.09 (0.037)
% Obese (BMI ≥ 30) (%)	12.47 (12.60)	11.01 (11.55)	12.39 (11.98)	10.06 (14.58)	8.02 (9.38)	0.64	0.063	-0.13 (0.004)

* Test for significance of slope using linear and logistic regression

[†] p-value ≤ 0.001

[‡] Due to the sparse nature of the data, four consecutive cycles (from 2003 to 2008) of the CCHS were combined for a total sample size of 9,757. Combined weights provided by Statistics Canada were used for descriptive analyses.

[§] Active defined as those who were labeled 'active' in the derived variable PACnDPAI based on their total average daily energy expended during leisure time activities in the past three months (PACnDEE)

^{||} p-value ≤ 0.01

DISCUSSION

In this study, built environment characteristics that have previously shown an association with physical activity levels, transportation choices, perceived walkability, and body weight were identified, combined using factor analysis, and evaluated against measures of physical activity derived from three different population-based sources. The resulting index exhibited a dose response relationship with all of the activity-related measures examined whereby residents of areas that were more walkable reported higher levels of active transportation and physical activity. The index was also inversely associated with levels of overweight and obesity, even after adjusting for known confounders such as age, sex, income and education. Through creation and validation of the walkability index at three geographic levels, we also examined the consistency of results across different sizes of geographic units (Oppenshaw, 1984). The validation demonstrated robust associations with walking behaviors at all levels of geography evaluated, indicating that this methodology can be tailored to suit different types of study designs and units of analysis, from census tracts (area, or neighbourhood level) to dissemination blocks (near-individual level).

All of the measures that were retained in our final factor are commonly found in other walkability indices as well. In particular, dwelling density and street connectivity are features of many indices utilized in other study areas. It is notable, however, that one of the most commonly examined measures in the literature – land-use mix – was included as a candidate variable in our work, but was not retained in the final factor solution due to a low factor loading. On further examination we found that it had only weak statistically significant relationships with measures of activity in our setting. Toronto may differ from other settings in that high land use mix is found in both densely populated areas with a high residential, commercial and retail mix and in sparsely populated industrial and suburban residential areas. Alternately, our use of generalized land use data, as opposed to the more commonly used lot-level property tax assessment data, for calculating land-use mix in our setting may also have limited the performance of this measure. Lot-level property tax assessment data is available for Toronto, but the purchase cost was prohibitive to use in this study. A measure that was included in our final factor – availability of all retail and services – may act as a strong proxy for land use mix in settings where available data is not well-suited to calculation of the latter.

This work has several limitations. Our methodology relied on factor analysis to combine built environment characteristics into a composite index capturing “walkability.” Factor analysis is designed to develop composite measures of latent constructs and it is possible that characteristics of the built environment which are individually associated with activity-related outcomes may not be included in a composite index (Frank et al., 2010). However, this approach avoids the problem of multicollinearity that would result from analyzing multiple built environment metrics simultaneously in a regression equation. As such we followed the recommendation of Land *et al.* (Land, McCall & Cohen, 1990) in favour of factor analysis in this situation. Our list of candidate

variables did not include less commonly-examined factors, such as crime (perceived or objectively measured), lighting, and other aesthetic factors that may influence walkability. Suitable data for measuring these variables was not available for our study area at the geographic level used in our analysis. We were also unable to incorporate walking, cycling, or multi-use trails outside those already listed in our road network files because they were not available in our data sources.

CONCLUSIONS

Walkability indices are powerful tools to study the impact of the built environment on physical activity, obesity and obesity-related diseases. Utilizing an index creation approach (factor analysis) less commonly found in the literature we created and validated a walkability index for Toronto, Canada. Our initial validation of the index shows consistent relationships with transportation modal choice and with measures of physical activity, overweight and obesity at the census tract level. These relationships were consistent at three levels of census geography suggesting that the index is robust. The measures in the resulting index were quite similar to those found in many existing indices. While the specific combination and weighting of this index may be unique to Toronto, the methodology should be generally applicable in other settings. Nonetheless, further work is needed to understand performance of this index for application of its methodology in other urban settings.

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APPENDIX

Table A1. Mean values (SD) of activity measures by walkability index quintile with tests for trend and correlations, dissemination area-level (DA-level) validation

Variable	Walkability Index Quintile					Q5/Q1 Ratio	Test for Trend (p-value)*	Spearman Correlation Coefficient with AFI (p-value)
	1 (lowest)	2	3	4	5 (highest)			
Number of DAs (n = 3,524)	712	712	713	712	712			
2006 Canada Census (based on employed population aged 15+)								
Population who walk to work (%)	3.03 (3.83)	3.36 (4.42)	3.89 (4.34)	5.93 (6.24)	15.00 (14.44)	4.95	0.130	0.42 (<0.0001)
Population who bike to work (%)	0.50 (1.47)	0.60 (1.76)	1.04 (2.48)	2.22 (3.45)	5.02 (5.67)	10.04	0.060	0.42 (<0.0001)
Population who walk or bike to work (%)	3.53 (4.29)	3.96 (4.85)	4.93 (5.54)	8.15 (7.61)	20.02 (15.61)	5.67	0.102	0.49 (<0.0001)
Population who take public transit to work (%)	25.97 (10.88)	27.70 (12.28)	30.41 (12.83)	37.20 (12.84)	41.13 (12.72)	1.58	0.005	0.41 (<0.0001)
Population who drive to work (%)	69.33 (11.98)	67.07 (13.43)	63.40 (14.41)	53.48 (14.58)	37.32 (15.00)	0.54	0.020	-0.61 (<0.0001)

* Test for significance of slope using linear and logistic regression

† p-value ≤ 0.001

Table A2. Mean values (SD) of activity measures by walkability index quintile with tests for trend and correlations, dissemination block-level (DB-level) validation

Variable	Walkability Index Quintile					Q5/Q1 Ratio	Test for Trend (p-value)*	Spearman Correlation Coefficient with AFI (p-value)
	1 (lowest)	2	3	4	5 (highest)			
Number of DBs (n = 10,535)	712	712	713	712	712			
2006 Canada Census (based on employed population aged 15+)								
Population who walk to work (%)	2.85 (3.74)	3.48 (4.37)	3.73 (4.19)	5.69 (5.48)	15.28 (14.44)	5.36	0.143	0.39 (<0.0001)
Population who bike to work (%)	0.57 (1.89)	0.61 (1.86)	0.97 (2.29)	2.19 (3.39)	5.03 (5.69)	8.82	0.072	0.37 (<0.0001)
Population who walk or bike to work (%)	3.42 (4.39)	4.09 (4.84)	4.71 (5.19)	7.88 (6.95)	20.31 (15.59)	5.94	0.115	0.45 (<0.0001)
Population who take public transit to work (%)	25.47 (10.92)	27.41 (11.91)	30.60 (12.62)	37.09 (12.51)	41.59 (12.85)	1.63	0.003	0.41 (<0.0001)
Population who drive to work (%)	69.89 (12.00)	67.22 (13.00)	63.59 (14.12)	53.80 (13.70)	36.56 (14.69)	0.52	0.020	-0.59 (<0.0001)
* Test for significance of slope using linear and logistic regression								
† p-value ≤ 0.001								