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Neighborhood walkability: Differential associations with self-reported transport walking and leisure-time physical activity in Canadian towns and cities of all sizes

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ABSTRACT

Objective. To estimate associations between walkability and physical activity during transportation and leisure in a national-level population.

Methods. Walkability was measured by Walk Score® (2012–2014) and physical activity by the Canadian Community Health Survey (2007–2012) for urban participants who worked or attended school. Multiple linear regression was done on the total study population, four age subgroups (12–17, 18–29, 30–64, 65+) and three population center subgroups (1000–29,999, 30,000–99,999, 100,000+).

Results. 151,318 respondents were examined. Comparing highest to lowest Walk Score® quintiles, covariate-adjusted energy expenditure on transport walking [95% confidence interval] was 0.17 [0.15, 0.18] kcal/kg/day higher in the total study population, and significantly higher in all age and population center subgroups. Leisure physical activity was lower in the age 18–29 subgroup (−0.28 [−0.43, −0.12]) and population centers 100,000+ subgroup (−0.10 [−0.18, −0.03]), but higher in the population centers 1000–29,999 subgroup (0.30 [0.12, 0.48]). Total physical activity was higher in the following subgroups: age 30–64 (0.19 [0.12, 0.26]), population centers 100,000+ (0.12 [0.04, 0.19]) and population centers 1000–29,999 (0.40 [0.20, 0.59]).

Conclusions. Walkability is associated with transport walking in all age groups and towns and cities of all sizes. Walkability's inverse associations with leisure physical activity among young adults and in large population centers may offset energy expenditure gains, while positive associations with leisure physical activity in small centers may add to energy expenditure.

Introduction

While there is general agreement on the overall health benefits of physical activity, the most effective means of increasing physical activity behaviors are less certain (Ferrier et al., 2011). Recently, research has increasingly focused on how environmental factors such as neighborhood walkability can influence physical activity and chronic disease risk (Sallis et al., 2005; Killingsworth et al., 2003; Van Holle et al., 2012). Walkability is a measure of how well a neighborhood's built form promotes walking (Riley et al., 2013; Grasser et al., 2013). It includes components such as the proximity and diversity of utilitarian destinations (shops, services, workplaces, schools), an interconnected street layout, and the proximity of green spaces and other recreational areas.

If improved walkability is associated with increased walking for transport, a corresponding increase in total physical activity may also be expected. However, findings from recent systematic reviews point to associations between certain aspects of walkability and walking for transport, but findings have been mixed for associations between walkability and other types of physical activity (Grasser et al., 2013; Sugiyama et al., 2012; McCormack and Shiell, 2011; Ding et al., 2011). Therefore, further study is needed to compare walkability's association with transport walking and its relationship with other types of physical activity. Considering this, our primary objective was to examine associations between walkability and three outcomes: transport walking, leisure physical activity, and total physical activity. Our secondary objective was to investigate these associations in subgroups based on age and population center size.

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Methods

This cross-sectional study received ethics approval from the Ethics Review Board at Public Health Ontario.

Study population

The study population came from the Canadian Community Health Survey (CCHS), an ongoing cross-sectional survey administered by Statistics Canada (Canadian Community Health Survey (CCHS) Annual component, 2009; Canadian Community Health Survey (CCHS) Annual component, 2011; Canadian Community Health Survey (CCHS) Annual component, 2013). The CCHS uses a combination of computer-assisted personal interviewing and computer-assisted telephone interviewing to collect self-reported information on the health status and health determinants of Canadians aged 12 and older. It uses a multistage stratified cluster design to sample from approximately 98% of the Canadian population aged 12 and older. The remaining 2% who are excluded from the CCHS comprise people who live on Aboriginal Reserves or Crown Lands, in institutions or certain remote regions, or who are full-time members of the Canadian Forces (Canadian Community Health Survey (CCHS) Annual component, 2009; Canadian Community Health Survey (CCHS) Annual component, 2011; Canadian Community Health Survey (CCHS) Annual component, 2013).

We combined the 2007–2012 cycles of the CCHS and restricted our study to respondents living in urban areas according to Statistics Canada's definition: a continuously built-up area of 1000 people or more with a population density of 400 people/km^2 or higher (Anon, 2009). We excluded rural areas because identifying physical locations of rural postal codes is generally imprecise (Postal Code^{OM} Conversion File (PCCF), Reference Guide, 2013, 2013). We excluded CCHS respondents who reported they did not work or attend school because the questions assessing transportation physical activity asked respondents whether they walked or biked “to and from work or school” (CCHS, 2007–2008: Data Dictionary, 2009; CCHS, 2009–2010: Data Dictionary, 2011; CCHS, 2011–2012: Data Dictionary, 2013). Consequently, the transportation physical activity outcomes in this study were not relevant to respondents who were not working or attending school. We applied the same eligibility criteria across all outcomes in order to make comparisons between different outcomes in the same population. Finally, we excluded respondents with missing data on key variables such as the exposure of interest or primary outcomes.

Walkability measure

Previous studies have validated the Walk Score® metric as a measure of walkability (Carr et al., 2011; Carr et al., 2010). This metric has been enhanced to measure distances along the street network instead of using geodesic distances; this enhanced version is the Street Smart Walk Score® metric (Frank et al., 2013). As such, we used the Street Smart Walk Score® (hereafter referred to simply as Walk Score®) metric to assess walkability. Unique Walk Score® values (ranging from 0–100) were calculated for latitude and longitude coordinates, with a higher value indicating a more walkable location (Anon, 2012). Walk Score® measured the distance along the street network to nearby amenities, such as grocery stores, schools, and parks, with closer and more numerous amenities resulting in higher scores. Scores were then penalized according to street connectivity, with lower intersection density and longer block lengths resulting in lower scores (Anon, 2012). Additional information is available on the Walk Score® website: www.walkscore.com.

We obtained a Walk Score® value for each unique CCHS respondent postal code. First we identified a latitude/longitude coordinate for each postal code using the Postal Code Conversion File Plus (PCCF+) supplied by Statistics Canada (Postal Code Conversion File (PCCF), 2013, 2013). We sent the latitude/longitude coordinates to the Walk Score® developers, who provided Walk Score® values for each coordinate, which we then merged to the CCHS data by postal code. Walk Score® values were calculated in 2012 for all CCHS data available at that time, and in 2014 for data from the 2012 CCHS that became available after the initial Walk Score® calculation in 2012.

Outcome measures

The primary study outcomes comprised daily energy expenditure on three types of physical activity: transport walking, defined as walking to work or school; leisure-time physical activity, defined as all physical activities for recreation or exercise (e.g., soccer, tennis, aerobics, walking for exercise); and total physical activity, defined as the sum of transport walking, transport biking, and all leisure physical activities. Daily energy expenditure was calculated for each activity by multiplying the self-reported frequency and time spent doing the activity by the metabolic equivalents (METS) value assigned to the activity (CCHS, 2007–2008: Data Dictionary, 2009; CCHS, 2009–2010: Data Dictionary, 2011; CCHS, 2011–2012: Data Dictionary, 2013). As an example, the METS value assigned to playing basketball by the CCHS was 6 kcal/kg/h. A respondent who reported playing basketball 20 times in the past three months (or 91.25 days) for an average duration of one hour on each occasion would have the following energy expenditure from playing basketball: $(20 * 1\text{ h} * 6\text{ kcal/kg/h}) / 91.25\text{ days} = 1.3\text{ kcal/kg/day}$. The energy expenditure on each leisure-time physical activity was summed to obtain overall leisure-time physical activity. Energy expenditure on total physical activity was the sum of energy expenditure on all leisure-time physical activities, plus transport walking and transport cycling.

Statistical analyses

We merged Walk Score® values to CCHS data and conducted all analyses using SAS version 9.3 (Anon, 2000–2004). We assigned CCHS respondents to Walk Score® quintiles. We then calculated descriptive statistics on the total study population and the population within each Walk Score® quintile. As the CCHS used multistage stratified cluster sampling, we used the provided survey weights to ensure that all estimates were representative of the target population (Canadian Community Health Survey (CCHS) Annual component, 2009; Canadian Community Health Survey (CCHS) Annual component, 2011; Canadian Community Health Survey (CCHS) Annual component, 2013). We calculated all reported regression models using PROC SURVEYREG and used bootstrapping methods to calculate confidence intervals (Carpenter and Bithell, 2000).

First we estimated unadjusted associations between Walk Score® quintiles and the three primary outcomes using survey-weighted linear regressions. We then built multivariable linear regression models of associations between Walk Score® quintiles and each physical activity outcome, adjusting for socio-demographic variables shown to be associated with both neighborhood and physical activity (Butler et al., 2007; Adamo et al., 2012; Seliske et al., 2012; Ross et al., 2004). We adjusted for the following socio-demographic characteristics (Table 1): age category, sex, ethnicity, immigrant status, number of children under 12 in the household, household education, and household income quintile. We calculated differences in energy expenditure between the lowest Walk Score® quintile (Q1) and other quintiles with 95% confidence intervals (CI) for each outcome. We did this for all respondents, as well as four age subgroups (12–17, 18–29, 30–64, 65+) and three population center size subgroups (1000–29,999, 30,000–99,999, 100,000+). For the leisure-time physical activity outcome, we built an additional regression model with the addition of transport walking as an explanatory variable. This was a post-hoc analysis to investigate whether associations between Walk Score® quintile and leisure-time physical activity were independent of transport walking.

The regression method we used did not account for clustering, which was a concern given that Walk Score® values were assigned to postal codes and a single postal code can include multiple respondents. As there was very little repetition within clusters (there was only one respondent in 75% of the included postal codes), we anticipated clustering would have a minimal effect on variance estimates. We explored this further with sensitivity analyses using generalized linear models with generalized estimating equations (GEE), which account for clustering but do not allow for bootstrapping (we used normalized survey weights as an alternative to bootstrapping). Estimates were identical or very close to those obtained from the linear regression models. We report estimates from the linear regression models that accommodate bootstrapping because these provide more accurate variance estimates given the complex survey design and minimal amount of clustering.

Results

Study population

The average response rate for the 2007–2012 CCHS was 72.2% (76.0% for 2007–08, 72.3% for 2009–10, 68.4% for 2011–12), yielding a total of 361,126 respondents. 98,496 (27.3%) of these respondents were excluded from our study because they lived in rural areas and an additional 84,472 (32.2%) were excluded because they did not work or attend school. 26,840 (15.1%) of eligible respondents were removed from our analysis because they were missing data on outcomes, Walk