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Short Report

Association between residential self-selection and non-residential built environment exposures

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ABSTRACT

Studies employing 'activity space' measures of the built environment do not always account for how individuals self-select into different residential and non-residential environments when testing associations with physical activity. To date, no study has examined whether preferences for walkable residential neighborhoods predict exposure to other walkable neighborhoods in non-residential activity spaces. Using a sample of 9783 university students from Toronto, Canada, we assessed how self-reported preferences for a walkable neighborhood predicted their exposure to other walkable, non-residential environments, and further whether these preferences confounded observed walkability-physical activity associations. We found that residential walkability preferences and non-residential walkability were significant associated ($\beta = 0.42$, 95% CI: (0.37, 0.47)), and further that these preferences confounded associations between non-residential walkability exposure and time spent walking (reduction in association = 10.5%). These results suggest that self-selection factors affect studies of non-residential built environment exposures.

1. Introduction

Many studies have explored potential links between the properties of neighborhood environments and human behavior. In particular, residents living in highly walkable communities may be more likely to engage in walking for transportation and have higher levels of overall physical activity (Frank et al., 2007; Howell et al., 2017; Creatore et al., 2016; Sallis et al., 2016). However, studies linking characteristics of the residential built environment to walking behaviours often suffer from residential self-selection bias (McCormack and Shiell, 2011). Residential self-selection suggests that individuals who are predisposed to walk seek to live in walkable neighborhoods, and that this may, in part, explain the association between walkability and physical activity (Handy et al., 2006; Mokhtarian and Cao, 2008). Prior work has identified that associations between characteristics of individuals' home neighborhoods and their physical activity levels may be confounded by self-selection and activity preferences, even after adjustment for other individual socio-demographic characteristics (Cao et al., 2006; Handy et al., 2006, 2005).

Recently, studies have begun to employ more holistic measures of the built environment that incorporate information from residential, workplace, and other locations (Patterson and Farber, 2015; Perchoux et al., 2015; Troped et al., 2010; van Heeswijck et al., 2015; Zenk et al., 2011). Sometimes described as 'activity space' measures, these tools assess exposures at locations that individuals visit across space and over time, as opposed to restricting to specific types of environments (e.g. home neighborhood exposures, workplace exposures, etc) (Perchoux et al., 2013). Various geospatial approaches have been used to define activity spaces, including convex polygons, path-based exposures, and simple averages of exposures across geographic units visited (Chaix et al., 2012; Howell et al., 2017; van Heeswijck et al., 2015; Zenk et al., 2011). These activity space tools are believed to more accurately characterize individuals' neighborhood exposures and may partially address the uncertain geographic context problem (Kwan, 2012). By enhancing exposure measurement, stronger observed relationships between the built environment and physical activity may emerge. Supporting this idea, a recent study found that walkability defined according to activity spaces was more strongly associated with

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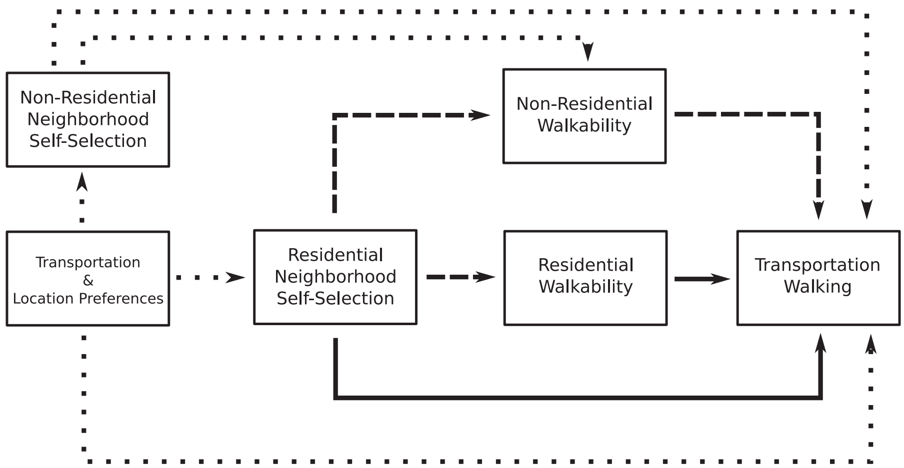

Fig. 1. Relationship between residential self-selection, walkability exposures, and transportation physical activity. Previous research has identified associations between residential self-selection and residential neighborhood walkability exposure, along with transportation physical activity. We aim to examine whether residential self-selection may also influence non-residential walkability exposures, and hence serve as a confounder. The dotted lines indicate relationships between constructs unmeasured in this study, dashed lines indicate relationships estimated in this study, and solid lines indicate a relationship previously investigated in this sample.

transportation physical activity than when based on residential exposures alone (Howell et al., 2017).

Self-selection may also influence individuals' choices regarding non-residential environments. If true, analyses that fail to account for self-selection could cause confounding in associations using activity space variables, similar to the case of residential exposures. While several previous studies have examined the relationship between activity space environments and physical activity (Hirsch et al., 2016; Perchoux et al., 2015; van Heeswijck et al., 2015), most did not address self-selection bias, and some have suggested that self-selection biases may be stronger for non-residential exposures than residential ones (Chaix et al., 2012; Zenk et al., 2011). To date no study has examined this possibility. Building from our recent work exploring associations between activity space walkability and transportation physical activity, we sought to investigate how self-selection relates to non-residential walkability (Howell et al., 2017). Our first objective in this study was to assess the association between neighborhood self-selection and individuals' non-residential walkability exposures (Fig. 1). We then aimed to examine possible confounding in the association between individuals' exposure to walkable non-residential environments and their transportation walking by self-selection factors.

2. Materials and methods

2.1. Data source

The StudentMoveTO (SMTO) survey was a cross-sectional study designed to investigate student travel behaviours and preferences. Further information on this study is available elsewhere (Howell et al., 2017; StudentMoveTO, 2018). In brief, students enrolled at university campuses in Toronto, Ontario between September and December 2015 were contacted by email and invited to participate in the survey, with the potential to win one of 20 $50 gift certificates to the campus bookstore. 15,266 individuals responded for an overall response rate of 8.3%. In previous analyses, weighting individuals to account for non-response did not cause an appreciable change in the distribution of key covariates including age, car ownership, transit pass ownership, living situation, or main mode of commuting to campus (Howell et al., 2017). For this analysis, we included students who reported having one or more trips during the previous 24 h period ($n = 11{,}068$). We excluded individuals who resided or exclusively traveled outside of the study area ($n = 691$) and those with missing covariates ($n = 554$). The final sample size was 9783. Reasons individuals reported for not taking a trip are listed in Supplementary Table 1. The survey included a one-day travel diary where students reported all trips taken during the previous 24 h, including the reason for travel, mode of transportation, and the origin and destination of each trip. In addition to SMTO data, individuals were also linked to their neighborhood median total after-tax household income ($CAD) from the 2016 Canadian Census (reflecting income over 2015). All individuals provided informed consent to participate in SMTO, and this study was approved by the University of Toronto Research Ethics Board.

2.2. Measures

Self-selection was assessed by examining responses to two questions regarding individuals' reasons for choosing their residential neighborhood. Several response options were available. The distribution of reasons for selecting a given neighborhood are reported in Supplementary Table 2. Individuals indicating that their first or second reason for moving into the neighborhood were any of "ability to walk or bike to campus" or "walkability of neighborhood" were considered to have self-selected into a walkable neighborhood.

Walkability was measured using a previously described and validated index (Glazier et al., 2012; 2014). The index was constructed for geographic units representing neighborhoods (Canadian Census defined dissemination areas), generating a continuous variable from four components: i) dwelling density (number of dwellings/km^2), ii) population density (population/km^2), iii) density of street intersections (number of intersections/km^2), and iv) number of destinations (number of retail and services/km^2). Each of these components was standardized and summed to construct the final score (Supplementary materials). Individuals' (i) walkability exposures were assessed as the average walkability of all non-residential trip locations (j) visited:

$$Walkability_i = \frac{\sum Walkability_{i,j}}{n_{trips(i)}}$$

We additionally created a version of the variable weighted by the amount of time each individual (i) reported spending at each non-residential location (j) within the 24 h trip diary:

$$Walkability_{TWi} = \sum \left(Walkability_{i,j} x \frac{time\ at\ location_{i,j}}{total\ time\ at\ all\ non{-}res\ locations_i} \right)$$

Walking activity was measured by aggregating individuals' self-reported time spent walking in minutes using their trip diaries. Additionally, we used individuals' reported origin-destination pairs to estimate the amount of walking time that occurred during transit trips based on public transit schedules from transit agencies in the region, a walking network dataset sourced from OpenStreetMap, the time of day and day of the week the trip occurred, and assuming that individuals took the fastest path between the two points. Trip routing was determined using OpenTripPlanner Project (2018). Walking that may have occurred in the course of cycling, car, plane, paratransit, multi-modal, or other trips was not able to be included (37.1% of trips).