Journal of Transport & Health xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Journal of Transport & Health

journal homepage: www.elsevier.com/locate/jth

Neighborhood walkability and objectively measured active transportation among 10–13 year olds

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ARTICLE INFO

Keywords:
walking
bicycling
environment design
child

ABSTRACT

Current active transportation literature within children is based almost exclusively on questionnaire measures of the trip to school. This literature suggests that the walkability of the built environment can influence active transportation to school. The purpose of this study was to use objective measures to examine the relationship between neighborhood walkability and children's active transportation to school and other destinations. This was a cross-sectional study of 367 children and early adolescents (aged 10–13 years) from Kingston, Ontario, Canada. Participants wore a Garmin Forerunner 220 GPS watch during waking hours for seven consecutive days. Personal Activity Measurement Location System (PALMS) software used the GPS data to identify trips, and for each trip the time spent in that trip and the trip modality (active or passive). GIS measures of connectivity, proximity to destinations, and pedestrian infrastructure and safety were used to create a walkability index. Participants living in the neighborhoods with the highest walkability quartile spent an average of 16.2 min/day (95% CI: 11.8, 22.4) in active transportation while those in the lowest walkability quartile spent an average of 7.1 min/day (95% CI: 5.0, 10.4) in active transportation. Consistent patterns between walkability and active transportation were observed in age, sex, and season of study subgroups. An increase in active transportation minutes was seen across walkability quartiles for all of the most common active travel destinations (i.e., home, school, other people's homes). In conclusion, in this study of 10–13 year olds, those living in the most walkable neighborhoods accumulated more than twice as much active transportation than those living in the least walkable neighborhoods.

1. Introduction

Active transportation is one way that children can incorporate moderate-to-vigorous physical activity into their daily lives (Faulkner et al., 2009). Children who walk and bicycle to school have higher overall physical activity (Larouche et al., 2014; van Sluijs et al., 2009), better cardiorespiratory fitness (Larouche et al., 2014), and healthier waistlines (Pizarro et al., 2013). In Canada, 25% of school-aged children and adolescents report using active transportation as their main mode of transportation to school (Barnes et al., 2016). This number varies worldwide from 79% in the Netherlands (Burghard et al., 2016) to 13% in the United States (Katzmarzyk et al., 2016).

Research on active transportation to school suggests that this behavior can be influenced by the built environment, which consists of the man made surroundings that provide the setting for human activity (Larouche et al., 2014; D'Haese et al., 2015; Wong et al., 2011). Built environment factors associated with increased active transportation to school include measures of walkability such as

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https://doi.org/10.1016/j.jth.2017.12.006
Received 27 September 2017; Received in revised form 5 December 2017; Accepted 6 December 2017
2214-1405/

how well the streets connect to each other (Dill, 2004; Giles-Corti et al., 2011), having a variety of destinations within walking distance (Sallis and Glanz, 2006), and the presence of safety features such as traffic calming measures (e.g., speed humps, 4-way-stop intersections) and pedestrian infrastructure (e.g., crosswalks, sidewalks) (Wong et al., 2011). These walkability features can be examined individually or summed to create a walkability index (Giles-Corti et al., 2011; Frank et al., 2010; D'Haese et al., 2014; Carlson et al., 2015).

Although some research on non-school destinations exists (Carlson et al., 2015; Oliver et al., 2016), the pediatric active transportation literature is based almost exclusively on questionnaire measures of the trip to school (Dill, 2004). The lack of insight into determinants of travel behaviors outside of the trip to school is a recognized gap in the active transportation literature (Barnes et al., 2016; D'Haese et al., 2015). Furthermore, the self- or parental-reported nature of the school travel mode data are likely subject to measurement bias, a widely recognized issue in the physical activity field (Adamo et al., 2009), resulting in under or over reporting of the observed associations between the built environment and active transportation. We are only aware of two walkability studies of children that used objective measures of active travel (Carlson et al., 2015; Helbich et al., 2016).

The objective of this study was to examine the relationship between neighborhood walkability and objectively measured total active transportation and active transportation to common travel destinations among 10–13 year olds.

2. Material and methods

2.1. Study participants

The study sample consisted of a cross-sectional sample of 10–13 year olds from Kingston, Ontario, Canada. Children were excluded if they were not ambulatory or English or French speaking. A sample of 230 boys and 228 girls were recruited from the approximately 5000 children aged 10–13 who live in Kingston. The 21 participants who lived on agricultural properties or on highways or county roads in rural areas were excluded for the analyses for this study because these areas do not reflect the built environment this study intended to capture. Participants' data were collected between January 2015 and December 2016. Because physical activity levels vary by season, enrollment was balanced across the four seasons. Participants were recruited within each of the city's 12 electoral districts in proportion to the population of 10–14 year olds in each electrical district. The economic, social and physical attributes are similar within each electoral district but vary considerably across districts. To recruit participants, we used a comprehensive program with overlapping strategies including word of mouth, social medial advertisements, distribution of study postcards (at schools, day camps, youth organizations), and posting of study materials (at libraries, community centers, stores). Participants and a parent/guardian provided written informed consent prior to participation and children were compensated $40 for completing the study. The study was approved by the General Research Ethics Board at Queen's University.

2.2. Walkability

City of Kingston and DMTI Spatial Inc. (Richmond Hill, Ontario, Canada) geospatial databases were used in ArcGIS software version 10.4 (ESRI, Redlands, California, USA) to obtain all GIS measures in the home neighborhoods of all participants, with the exception of the Walk Score® (Walk Score, Seattle, Washington, USA), which was determined using the publicly accessible Walk Score® application (https://www.walkscore.com/). ArcGIS was used to create a 1 km road network buffer around each participant's home address to define their home neighborhood. This buffer size and type has been identified as the best fit when measuring youth travel environments in Canada (Seliske et al., 2013, 2012). One kilometer corresponds to a ~ 10–15 min walk or ~5 min bicycle ride (Seliske et al., 2012). As described below, within each participant's home neighborhood buffer several measures of connectivity, proximity to destinations, and pedestrian infrastructure and safety were determined. These measures were chosen based on previous findings showing an association with children's active transportation (D'Haese et al., 2015; Wong et al., 2011). First, connectivity, proximity to destinations, and pedestrian infrastructure and safety indexes were calculated. They were determined by creating a percentile rank of the individual measures discussed in the following paragraphs. The percentile ranks were then averaged and ranked to create the individual indexes. Finally, an overall walkability index was created by averaging the connectivity, proximity, and pedestrian safety and infrastructure indexes. Our decision to create the walkability index using an overall average wherein the connectivity, proximity, and pedestrian safety and infrastructure indexes were weighted equally was based on preliminary analyses which demonstrated that these indexes had similar effects on active transportation levels.

The measures of connectivity included: length of roads (Panter et al., 2010), intersection density (i.e., number of intersections per km^2 of land area) (Carlson et al., 2015; Dill, 2004; Mecredy et al., 2011), average block length (i.e., length of roads/number of true intersections) (Dill, 2004; Mecredy et al., 2011) and connected node ratio (i.e., ratio of intersections to all nodes including cul-de-sacs) (Mecredy et al., 2011; Gropp et al., 2012).

The measures of proximity to destinations included the Walk Score® (Carr et al., 2011), distance to school (Wong et al., 2011), and population density per square km of land area (Braza et al., 2004). These measures were chosen as they reflect both proximity to and a variety of destinations within the neighborhood. The Walk Score® has been shown to be a reliable and valid measure of estimating access to walkable amenities and it is strongly correlated with residential density ($r = 0.76$, $p < 0.001$) (Carr et al., 2011). The Walk Score® is, in part, determined by proximity to the closest school; however, in our sample the closest school was often not the school the participants attended. Therefore, we also measured the road network distance to their school. Proximity to destinations is a strong predictor of a children's active transportation to school and other destinations (Wong et al., 2011; Duncan et al., 2016).

The measures of pedestrian safety and infrastructure included the total length of sidewalks and paths (Kerr et al., 2006), estimated