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Variations in active transport behavior among different neighborhoods and across adult life stages

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ABSTRACT

Objective: Built environment characteristics are closely related to transport behavior, but observed variations could be due to residents own choice of neighborhood called residential self-selection. The aim of this study was to investigate differences in neighborhood walkability and residential self-selection across life stages in relation to active transport behavior.
Methods: The IPEN walkability index, which consists of four built environment characteristics, was used to define 16 high and low walkable neighborhoods in Aarhus, Denmark (250.000 inhabitants). Transport behavior was assessed using the IPAQ questionnaire. Life stages were categorized in three groups according to age and parental status. A factor analysis was conducted to investigate patterns of self-selection. Multivariable logistic regression analyses were carried out to evaluate the association between walkability and transport behavior i.e. walking, cycling and motorized transport adjusted for residential self-selection and life stages.
Results: A total of 642 adults aged 20–65 years completed the questionnaire. The highest rated self-selection preference across all groups was a safe and secure neighborhood followed by getting around easily on foot and by bicycle. Three self-selection factors were detected, and varied across the life stages. In the multivariable models high neighborhood walkability was associated with less motorized transport (OR 0.33 95% CI 0.18–0.58), more walking (OR 1.65 95% CI 1.03–2.65) and cycling (OR 1.50 95% CI 1.01–2.23). Self-selection and life stage were also associated with transport behavior, and attenuated the association with walkability.
Conclusion: This study supports the hypothesis that some variation in transport behavior can be explained by life stages and self-selection, but the association between living in a more walkable neighborhood and active transport is still significant after adjusting for these factors. Life stage significantly moderated the association between neighborhood walkability and cycling for transport, and household income significantly moderated the association between neighborhood walkability and walking for transport. Getting around easily by bicycle and on foot was the highest rated self-selection factor second only to perceived neighborhood safety.

1. Introduction

There are several benefits of increasing non-motorized transport modes. Walking and cycling for transport i.e. active transport can enhance public health and additionally decrease CO_2 emissions, ease traffic congestion and contribute to more liveable cities (Gehl, 2010; Hallal et al., 2012; Hamer and Chida, 2008; Saunders et al., 2013; Woodcock et al., 2009). The decision to walk or cycle for transport is rooted in a complex interplay of factors at the individual, social, environmental and political level (Burbidge and Goulias, 2009). The built environment is one of the most important factors, and growing evidence supports the association between certain urban form characteristics and active transport (Ewing and Cervero, 2010; Pucher et al., 2010). Previous research has shown consistent positive associations between active transport and residential density, land-use-mix and street connectivity, among others (Ewing and Cervero,

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2010; Saelens and Handy, 2008). These characteristics have furthermore been evaluated as a composite, the so-called walkability index, developed in the Neighborhood Quality of Life Study (NQLS) (Frank et al., 2010; Sallis et al., 2009). The index has later been replicated in various settings in the International Physical Activity and the Environment Network (IPEN) (Kerr et al., 2013), and has shown a consistently positive relationship with walking for transport and cycling for transport (Frank et al., 2006; Owen et al., 2010; Sallis et al., 2009; Van Dyck et al., 2012). By and large, the objective walkability index differentiates the denser, more developed city centers from the more sprawled, less developed suburbs. It does not capture the fine scale microenvironment qualities such as greenery, sidewalks, streetscapes, cycle lanes and safe crossings (Moudon and Lee, 2003).

Even though built environment and urban form characteristics are important for transport behavior within a city, uncertainty exists regarding whether observed differences across urban forms could be due to underlying preferences for transport activity and residential choices (Eid et al., 2008). The self-selection bias has frequently been mentioned as one of the most fundamental biases in establishing causation between the built environment and urban form (Cao et al., 2009; Ding and Gebel, 2012; Handy et al., 2006). It generally results from two sources: attitudes and socio-demographic traits (Cao et al., 2009). The self-selection mechanism can be observed when people with a positive attitude for an active lifestyle choose to live in neighborhood with those opportunities e.g. close proximity to recreational venues or vice versa. Besides this intentional self-selection bias, socio-demographic factors can also influence the choice of neighborhood. The segregation of a population in more alike groups defined by ethnic, economic and social characteristics is widely accepted (Riggs, 2014). Additionally, the life stage itself can have great impact on the transport behavior and therefore also on the relation to the built environment (Villanueva et al., 2013). Within the health and place based research there has been a focus on four main groups: children; adolescents; adults and older adults (Papas et al., 2007). Adults are often categorized as one common group, even though a variety of fundamental life events occur from early, across middle to late adulthood, e.g. from education to paid employment; from single to married: from non-parent to parent (Scheiner and Holz-Rau, 2013). These events can often trigger changes in neighborhood preference and residential relocation (Boone-Heinonen et al., 2010; Scheiner and Holz-Rau, 2013).

Research to date states that self-selection attenuates, but not eliminates, the relationship between the built environment and physical activity (Cao et al., 2009; Handy et al., 2006; McCormack and Shiell, 2011). In a Belgian study it was found that walkability characteristics were strongly associated with neighborhood selection, independent of age group, education and gender. Surprisingly, people living in objectively measured low-walkable areas stated walkability characteristics as an important factor for their residential choice (Van Dyck et al., 2011b). Living in less dense neighborhoods (suburbs) in a European context is therefore not per se synonymous with living in an environment hostile to active transport. Conditions for walking and cycling can still be good given lower traffic loads and high quality walking and bicycle infrastructure. The same study also found a negative relationship between residential density and neighborhood satisfaction, which could rely on poorer esthetics, more pollution, lower overall safety and more crime in the most dense high walkable neighborhoods (Van Dyck et al., 2011a). Frank et al. (2007) found differences between neighborhood preferences and actual residential neighborhoods, and stated that living in a high walkable neighborhood was not related to walking if people had no preference for living in a walkable neighborhood.

Regarding self-selection from a life stage perspective, Villanueva et al. (2013) investigated the correlation between walking and walkability for three groups of adults (18–65 years) and one group of older adults (+65 years) living in different walkable neighborhoods, and found no life stage related difference between the groups. Thus, adults living in high walkable neighborhoods were more likely to walk independent of life stage. This study did however not report differences in self-selection across the four groups.

Research on transport behavior from a life stage perspective, referred to as a mobility biography approach, is fragmentary at best (Scheiner and Holz-Rau, 2013), and research into life stage groups including built environment and self-selection is almost absent. It has been recommended to take a more detailed life stage perspective into account when examining the association between built environment and physical activity (Papas et al., 2007), and within transportation research it is seen as a promising emerging approach (Scheiner, 2007).

The aim of this study was to investigate differences in walkability and residential self-selection across life stages, and in continuation hereof how this was related to active transport behavior. It involves analyses of the associations between neighborhood characteristics and preferences at different adult life stages, and how these associations are related to active transport behavior.

2. Material and methods

This study followed the International Physical Activity and the Environment Network (IPEN) study design (Kerr et al., 2013) and contributes data as one of the 12 countries participating in the cross national IPEN analyses. It is a cross sectional study which was designed to maximize the variation within the sample by selecting participants based on objectively measured walkability and household income of the neighborhoods.

2.1. Walkability index and neighborhood selection

In Denmark the smallest administrative unit, called statistical districts, was used to delineate neighborhoods, and the study site, the city of Aarhus, consisted of 87 districts. For every district a walkability index score was calculated as a function of four variables: (a) net residential density (ratio of residential units to the land area devoted to residential use), (b) land use mix (diversity of the following land use types: residential; retail; commercial; entertainment and civic institutions), (c) intersection density (ratio of intersections, at least 3-way, to area of district), and (d) the retail floor-area-ratio (ratio of retail building footprint to the area of the land devoted to retail). The walkability index is described in more detail elsewhere (Frank et al., 2010). In short, the walkability index (Wi) for the districts was calculated using a summed score of normalized values (z-scores) of the four variables, with intersection density counting double:

$$\text{Wi} = 2 \times z_{\text{intersection density}} + z_{\text{net residential density}} + z_{\text{retail floor area ratio}} + z_{\text{land use mix}}$$

Additionally, the median household income of the districts was derived from municipality records. Based on the median split of walkability and household income, four types of districts were categorized: high walkability-high income, high walkability-low income, low walkability-high income and low walkability-low income. Four districts from each quadrant were selected aiming at maximizing the variation of the walkability index and household income while ensuring geographic separation of districts (Fig. 1). The districts have an average size of 3 km^2, but vary in size as they were intended to have a more or less equal number of inhabitants. A photo codebook illustrating the built environment of the different districts is available as electronic supplementary material.

2.2. Study sample

From each of the 16 selected districts 115 persons between 20 and 65 years were randomly sampled, which gave a total sample of 1840 persons. The aim was to assess 150 respondents in every quadrant with an equal distribution between districts, age groups and gender, which corresponded with the IPEN protocol and gave reasonable