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Contribution of streetscape audits to explanation of physical activity in four age groups based on the Microscale Audit of Pedestrian Streetscapes (MAPS)

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ABSTRACT

Ecological models of physical activity emphasize the effects of environmental influences. "Microscale" streetscape features that may affect pedestrian experience have received less research attention than macroscale walkability (e.g., residential density). The Microscale Audit of Pedestrian Streetscapes (MAPS) measures street design, transit stops, sidewalk qualities, street crossing amenities, and features impacting aesthetics. The present study examined associations of microscale attributes with multiple physical activity (PA) measures across four age groups. Areas in the San Diego, Seattle, and the Baltimore metropolitan areas, USA, were selected that varied on macro-level walkability and neighborhood income. Participants ($n = 3677$) represented four age groups (children, adolescents, adults, older adults). MAPS audits were conducted along a 0.25 mile route along the street network from participant residences toward the nearest non-residential destination. MAPS data were collected in 2009–2010. Subscale and overall summary scores were created. Walking/biking for transportation and leisure/neighborhood PA were measured with age-appropriate surveys. Objective PA was measured with accelerometers. Mixed linear regression analyses were adjusted for macro-level walkability. Across all age groups 51.2%, 22.1%, and 15.7% of all MAPS scores were significantly associated with walking/biking for transport, leisure/neighborhood PA, and objectively-measured PA, respectively. Supporting the ecological model principle of behavioral specificity, destinations and land use, streetscape, street segment, and intersection variables were more related to transport walking/biking, while aesthetic variables were related to leisure/neighborhood PA. The overall score was related to objective PA in children and older adults. Present findings provide strong evidence that microscale environment attributes are related to PA across the lifespan. Improving microscale features may be a feasible approach to creating activity-friendly environments.

1. Introduction

Ecological models of health behavior focus attention on the potential broad reach and long-term effects of environmental influences, and such models have been widely applied to physical activity (Sallis et al., 2008). Many built environment characteristics have been related to physical activity (Bauman et al., 2012).

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Table 1
Study characteristics: Neighborhood Impact on Kids (NIK), Teen Environment and Neighborhood (TEAN), and Senior Neighborhood Quality of Life Study (SNQLS).

Study	Participant ages	Study design	Eligible destinations	Regions	Sample size			
					Routes	Segments	Crossings	Cul-de-sacs
NIK	6–11 and parent	Hi/low activity[a] × Hi/low nutrition[b]	Cluster of ≥3 commercial locations, parks, schools	San Diego County, CA Seattle/King County, WA	365 393	1285 1196	675 581	154 153
TEAN	12–16 and parent	Hi/low walkability[c] × Hi/low income[d]	Cluster of ≥3 commercial locations, one park, one school	Seattle/King County, WA Maryland–DC	427 470	1685 1643	962 938	171 105
SNQLS	66+	Hi/low walkability[c] × Hi/low income[d]	Cluster of ≥3 commercial locations, parks, schools	Seattle/King County, WA	462	1152	511	–

[a] GIS-defined block group walkability and park access.
[b] Defined by the presence or absence of grocery stores and fast food restaurants.
[c] Walkability index defined by GIS-derived residential density, intersection density, retail floor area ratio, and mixed use.
[d] Based on 2000 census data for block group median household income.

Environmental variables fall into two broad categories: *macroscale*, consisting of structural features such as street inter-connectivity and land use mix (Brownson et al., 2009); and *microscale*, or details that can affect the experience of being active in a place, such as aesthetics and sidewalk design (Sallis et al., 2011b). Most research has focused on macroscale variables that characterize walkability (Frank et al., 2010) or park access (Brownson et al., 2009), but studying microscale features may also be useful for understanding physical activity (Moudon and Lee, 2003). Microscale characteristics of the pedestrian environment, such as street crossing design and quality of sidewalks, can be modified at lower cost and in a shorter time-frame than reconfiguring the macroscale design.

The small literature on microscale features assessed by direct observation in relation to physical activity is encouraging. Pikora et al. (2002, 2006) showed that well-maintained walking surfaces, destinations, and public transit were correlated with walking for transport or recreation. Boarnet et al. (2011) found sidewalk infrastructure, crossing and street characteristics, traffic calming, parking structure type, and building design mix were associated with physical activity, while aesthetics, negative land uses, and lighting were not. Hoehner et al. (2005) found active transportation was positively related to public transit and bike lanes, but negatively associated with aesthetics. However, there are not enough studies of microscale features to support conclusions about consistent correlates of physical activity (Bauman et al., 2012). The literature is further limited by inconsistent definitions and scoring, few studies of youth and older adults, and failure to control for macroscale attributes.

The present study contributes to the literature by examining associations of microscale environmental attributes, using a reliable instrument and systematic scoring system (Millstein et al., 2013), with multiple physical activity measures, in four age groups.

2. Methods

2.1. Design of three studies that provided data

Objective microscale environmental data were collected as part of three studies examining the relation of neighborhood design to physical activity, nutrition behaviors, and weight status in children, adolescents, adults, and older adults. These studies were conducted in urban and suburban neighborhoods in Seattle/King County, WA, San Diego, CA, and the Baltimore, MD–Washington, DC region. Neighborhoods were selected to vary on macro-environment features and median income (Frank et al., 2010). Methods of the Senior Neighborhood Quality of Life Study (SNQLS) (King et al., 2011), Neighborhood Impact on Kids (NIK) (Frank et al., 2012; Saelens et al., 2012), and Teen Environment and Neighborhood study (TEAN) (Sallis et al., 2011a) have been reported. These studies were approved for research with human subjects by the Institutional Review Boards at San Diego State University, Seattle Children's Hospital, and Stanford University. Table 1 summarizes study characteristics and sample sizes for the MAPS evaluation.

2.2. Microscale Audit of Pedestrian Streetscapes (MAPS)

2.2.1. Development and sections of tool

The MAPS direct observation instrument was adapted from previous tools (Millstein et al., 2013), primarily the Analytic Audit Tool (Brownson et al., 2004), as modified by the Healthy Aging Network (Kealey et al., 2005). MAPS has four sections: route, crossings, street segments and cul-de-sacs (available for download at http://sallis.ucsd.edu/measure_maps.html). Route-level items evaluated characteristics for a 0.25 mile route from the participant's home towards pre-selected non-residential destinations. Items included land use and destinations, street amenities, and aesthetic and social characteristics. Segment-level (street segments between intersections) items assessed sidewalks, slope, buffers between street and sidewalk, bicycle facilities, building aesthetics, trees, setbacks of buildings from the sidewalk or street, and building height. Street crossing items assessed crosswalk markings, width of crossings, curbs, crossing signals, and pedestrian protection. Cul-de-sac items included size and condition of surface area, slope, and amenities within cul-de-sacs (e.g., basketball hoops).

2.2.2. Subscale, valence, overall, and grand scores

The tiered scoring system summarized items into subscales at multiple levels of aggregation. Figs. 1 and 2 illustrate the hierarchy of scores from lowest to highest level of aggregation. The numbers of segments and crossings varied by route, so segment and crossing scores represent means for each route. All sections had positive and negative valence scores based on the expected effect on physical activity (e.g. crosswalk amenities were positive and crossing impediments were negative). Negative valence scores (higher scores indicated more negative attributes) were subtracted from positive valence scores (higher scores indicated more positive attributes) to create "overall" section scores. For example, if segment positive score is 10 and segment negative score is 6, then the segment overall score would be 4. Overall positive and negative valence scores were produced from the section valence scores, and a grand score was calculated by subtracting the overall negative valence score from the overall positive valence score. The cul-de-sac section had a single positive valence score that was not included in the overall scores because the expected direction of its relation to physical activity was unclear.

2.3. MAPS data collection

MAPS data were collected in 2009–2010. MAPS observations were conducted along a 1/4 mile route starting at a study