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Developing and Validating an Abbreviated Version of the Microscale Audit for Pedestrian Streetscapes (MAPS-Abbreviated)

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Abstract

Purpose—Macroscale built environment factors (e.g., street connectivity) are correlated with physical activity. Less-studied but more modifiable microscale elements (e.g., sidewalks) may also influence physical activity, but shorter audit measures of microscale elements are needed to promote wider use. This study evaluated the relation of an abbreviated 54-item streetscape audit tool with multiple measures of physical activity in four age groups.

Methods—We developed a 54-item version from the original 120-item Microscale Audit of Pedestrian Streetscapes (MAPS). Audits were conducted on 0.25-0.45 mile routes from participant residences toward the nearest nonresidential destination for children (N=758), adolescents

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Competing interests

The authors declare they have no competing interests.

(N=897), younger adults (N=1,655), and older adults (N=367). Active transport and leisure physical activity were measured with surveys, and objective physical activity was measured with accelerometers. Items to retain from original MAPS were selected primarily by correlations with physical activity. Mixed linear regression analyses were conducted for MAPS-Abbreviated summary scores, adjusting for demographics, participant clustering, and macroscale walkability.

Results—MAPS-Abbreviated and original MAPS total scores correlated r=.94 The MAPS-Abbreviated tool was related similarly to physical activity outcomes as the original MAPS. Destinations and land use, streetscape and walking path characteristics, and overall total scores were significantly related to active transport in all age groups. Street crossing characteristics were related to active transport in children and older adults. Aesthetics and social characteristics were related to leisure physical activity in children and younger adults, and cul-de-sacs were related with physical activity in youth. Total scores were related to accelerometer-measured physical activity in children and older adults.

Conclusion—MAPS-Abbreviated is a validated observational measure for use in research. The length and related cost of implementation has been cited as a barrier to use of microscale instruments, so availability of this shorter validated measure could lead to more widespread use of streetscape audits in health research.

Keywords

walkability; built environment; city planning; direct observation; walking; physical activity

1. Introduction

Relationships between several built environment factors and physical activity and walking behavior are well established (Bauman et al., 2012). Measures of neighborhood environment can be classified into two broad categories. Macroscale features include structural characteristics of community design, such as street connectivity, land use mix, and residential density, that do not tend to be easily modifiable (Brennan et al., 2006; Brownson et al., 2009; Frank et al., 2005; Saelens & Handy, 2008). Most research on the associations between the built environment and physical activity has been based on macroscale features. Among adults, the most consistent macroscale features correlated with physical activity are residential density, proximity, and access to recreation facilities, and transportation facilities. In studies of children, consistent macroscale correlations have been found with overall neighborhood design/walkability, traffic speed and volume, land use mix, and proximity and access to recreation facilities. For adolescents, the correlations have been with land use mix and residential density which acts as a proxy for distance to school. There have been some studies of macroscale correlates of physical activity among older adults, with similar patterns of findings (Frank et al., 2010a; Kerr et al., 2012)

Microscale, or smaller details of environments, including sidewalk and crossing quality and aesthetics, are believed to affect people’s confidence, comfort, and safety for walking in neighborhoods (Cain et al., 2014; Sallis et al., 2015), but they have been less well studied. Microscale features can be identified using neighborhood walk audits or other observational measures, and they are more easily modifiable in the short-term than macroscale features.

Numerous observational measures of microscale environments with similar content but different formats have been published and shown good inter-observer reliability, with the number of items ranging up to 188 (Brownson et al., 2009). However, few of the measures have been studied in relation to the physical activity of residents (Boarnet et al. 2011; Hoehner et al. 2005; Pikora et al. 2002; Pikora et al. 2006). Our group developed the original 120-item MAPS (Microscale Audit of Pedestrian Streetscapes) observation tool based on prior instruments, created a systematic scoring system (Millstein et al., 2013), and conducted the most extensive study to date of microscale features and physical activity across four age groups (children, adolescents, adults, and older adults) in three regions of the US (Cain et al., 2014). Analyses adjusted for macro-level GIS-defined neighborhood walkability (Frank et al., 2010b). The prior study found that destinations and land use along a given route, streetscape (e.g., street lights, transit stops), and intersection characteristics were related to walking and biking for transportation across age groups, after adjustment for macroscale GIS-defined neighborhood walkability. Aesthetic variables were positively associated with leisure time physical activity. Importantly, summary scores from MAPS were most strongly associated with physical activity, suggesting the cumulative impact of multiple microscale features may be more important for supporting physical activity than any single feature (Cain et al., 2014).

Shorter audit tools are needed for both research and practice purposes (Brownson et al., 2009, Glanz et al., 2015). Our group recently developed and evaluated a short version of the original MAPS (Cain et al., 2014; Millstein et al., 2013), called MAPS-Mini (Sallis et al., 2015), that has 15 items and a simple scoring system. The brevity of this 15-item tool lends itself well to use by community groups, such as for advocacy purposes. However, there is a need for an audit tool that is more comprehensive than the MAPS-Mini but shorter than the original MAPS for use by the scientific community. The length of the original MAPS, and other similar measures (Brownson et al., 2009, Glanz et. al., 2015), is a barrier to use by researchers. The purpose of the present study was to report the development and validation of the Microscale Audit of Pedestrian Streetscapes-Abbreviated, a 54-item version of the original 120-item MAPS tool.

2. Methods

2.1 Study design

Observed 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, younger adults, and older adults. Neighborhoods in urban and suburban neighborhoods in Seattle/King County, WA, San Diego County, CA, and the Baltimore, MD/Washington, DC region were selected because they varied on macro-environment features and median income (Frank et al., 2010b). Methods of the Senior Neighborhood Quality of Life Study (King et al., 2011), Neighborhood Impact on Kids (Frank et al., 2012, Saelens et al., 2012), and Teen Environment and Neighborhood study (Sallis et al. 2011) 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.

2.2 Original MAPS tool and scoring

The development, content, and scoring of the original 120-item MAPS tool has been described elsewhere (Millstein et al., 2013). Briefly, there were four sections of the tool, as follows: overall route, street segments (defined as the area between street crossings), crossings, and cul-de-sacs. Route-level variables captured land uses and destinations, characteristics that were more likely consistent throughout the route (e.g., speed limit, aesthetics and social environment) or infrequent (e.g., transit stops). Segment-level variables were collected on every segment on the route (e.g., sidewalks, buffers between streets and sidewalks, trees, building setbacks from sidewalks). Street crossing variables were measured at every intersection or crossing on the route (e.g., crosswalks, signals). Cul-de-sac variables (e.g., size, amenities) were collected when one or more cul-de-sacs were present within 400 feet of the participant's home. The tiered scoring system summarized items into subscales at multiple levels of aggregation. All sections included positive and negative valence scores based on the expected effect on physical activity. MAPS items and the subscales demonstrated moderate or excellent inter-rater reliability (ICC values ≥.41 and ≥.60, respectively) (Millstein et al., 2013).

2.3 Original MAPS data collection

Data for the original MAPS were collected along a ¼-mile route (n = 2117 routes) starting at a study participant's home (origin) and walking toward the nearest pre-determined destination (i.e., shops or services, a park, or a school) along the street network. Destinations were identified in GIS using tax assessor and ESRI parcel layers, and these were checked using online sources (e.g. Google Maps, basic web searches for location name/address). The shortest routes from the origin to the destination were identified using Network Analyst (ArcGIS version 9.3, ESRI, Redlands, CA, 2009). Data from the same routes were used for evaluating MAPS-Abbreviated and MAPS-Mini.

Data collection training and certification involved a 1-day in-office training, and 2 days of training in the field (see training manual online at http://sallis.ucsd.edu). To be certified to rate independently, data collectors had to complete at least four route assessments with reliability ≥95% agreement with the trainer. More details about training and data collection procedures can be found elsewhere (Cain et al., 2014; Millstein et al., 2013).

2.4 Physical activity measures

2.4.1 Walking and biking for transport—Children (parent-reported) and adolescents (self-reported) indicated how often they usually walked or biked (response range from 0=never to 5=four or more times/week) to 9 common locations, including such places as recreation centers and a friend's house (Grow et al., 2008). Responses were averaged to compute a scale score. Parents of child and adolescent participants completed a survey about their own physical activity. These adults' active transport was assessed using the Global Physical Activity Questionnaire (GPAQ), which has support for reliability and validity (Bull et al., 2009). The active transportation item assessed the number of days walking and biking for transport during a typical week. Older adults completed the Community Healthy Activities Model Program for Seniors (CHAMPS) questionnaire, which has been validated with older populations (Stewart et al., 2001). Participants reported times per week they usually walked or biked to do errands (biking added for older adults in the current study). The sum of the two variables was natural log-transformed, as it was skewed.

2.4.2 Leisure and neighborhood physical activity—Children (parent-reported) and adolescents (self-reported) completed 5 questions about how often they were physically active in settings near home, such as nearby street, sidewalk, or cul-de-sac (0=never to 5= four or more times a week). This scale was adapted from a measure with good test-retest reliability (Grow et al., 2008), and a mean was computed. Parents reported the time per typical day they spent in leisure physical activity on the GPAQ (moderate and vigorous intensity items combined). For older adults, an item from the CHAMPS asking about time per week spent walking for leisure was used.

2.4.3 Accelerometer—Seven-day objective physical activity was measured with the ActiGraph (models 7164/71256 for adolescents/older adults; GT1M/GT3X with Normal filter for children/adolescents; Pensacola, FL). No accelerometer data were collected for younger adults (parents). After their return, Actigraphs were downloaded and screened for completeness using MeterPlus versions 4.0 through 4.3 (www.meterplussoftware.com). Valid wearing time was 10 hours per day, with nonwear defined as 20, 30, or 45 consecutive minutes of zero counts for children, adolescents, and older adults, respectively (Cain et al., 2013). Participants with inadequate wear time were asked to re-wear the device. Data were included in analyses if there was at least one 10-hour wearing day. For adolescents, average daily minutes of MVPA during non-school hours (3 PM–11 PM on weekdays; all hours on weekends) was calculated using Freedson age-specific cut points with a 4-MET moderate intensity threshold (Trost et al., 2002) scaled from a 30-second epoch. For children, average daily minutes of MVPA “in the neighborhood” was calculated using parent-reported locations matched with time-stamped accelerometer data (Kneeshaw-Price et al., 2013) and scored using the Freedson youth age-specific 3-MET moderate-intensity threshold (Trost et al., 2002) scaled from a 30-second epoch. For older adults, 60-second epoch accelerometer data were converted to minutes in MVPA using the Freedson adult cut-point (Freedson et al., 1998), and average daily minutes of MVPA were computed.

2.5 Covariates

Demographic covariates assessed by survey were age, gender, education (highest parent education level for children and adolescents), and race/ethnicity. Education was dichotomized (college degree or higher vs. less), and race/ethnicity was dichotomized into white/Non-Hispanic and Hispanic or non-white. Older adults reported on mobility impairment measured with the validated 11-item lower extremity subscale of the Late-Life Function and Disability Instrument (Sayers et al., 2004). A 4-component walkability index, an indicator of macroscale walkability, was calculated using GIS for all Census block groups in the regions studied. The walkability index was computed as a weighted sum of region-specific z-scores of four macroscale built environment components: 1) net residential density, 2) intersection density, 3) retail floor to land area ratio (RFAR), and 4) mixed use (Frank et al., 2010b). Based on the research designs of the studies providing data, values for the walkability index were deciled for each region independently, and further categorized as lower and higher Block groups that contained a participant’s home were assigned a dichotomous code to reflect region-specific lower (0) or higher (1) macroscale walkability. Participant characteristics for the four study samples and additional design details can be found in Cain et al., 2014.

2.6 Survey reduction

MAPS-Abbreviated was designed to be shorter than the original MAPS in order to be less time consuming and more feasible for use by researchers conducting audits with limited resources, but not as short as MAPS-Mini which was designed for use by community groups. Items included in MAPS-Abbreviated were selected by examining original MAPS item-level partial correlations to determine the association of individual items with physical activity (primarily walking or biking for transportation, but also leisure physical activity and MVPA), while controlling for socio-demographic variables age, gender, race and education. Partial-correlations were computed separately for each age group and three measures of physical activity. Strength of associations with physical activity outcomes as well as the breadth of impact across age groups were all taken into account when selecting items to keep. Generally, items that were significantly correlated with active transport in at least 1 age group were retained. Items that were not related to active transport but related to one of the other physical activity outcomes in more than one age group were considered. Items with low frequency and likely limited policy relevance were dropped (e.g., historical/cultural features), as well as items that required special equipment, such as for measuring slope.

Because “negative” items and scales (e.g., negative land uses such as industrial land uses, parking facilities, sidewalk trip hazards and permanent obstructions) were not strongly related to physical activity, most of these items were dropped. The few negative items that were related to physical activity, were reverse coded so they could be included in the positive subscales. For example, in the route section, “presence of driveways” was the only significant negative item so the coding was changed to make it positive by assigning 1 point for 0–5 driveways and 0 points for more than 5 driveways along the route. A summary of the items retained and dropped in the different versions of MAPS can be found in Table 1.

The Overall Positive Microscale score was created by summing all the positive valence scores (total positive streetscape, positive aesthetics/social attributes, total positive segments, and total positive crossings). Destinations and land use (DLU) are often considered a macroscale feature, referred to as mixed land use, so this subscale (Total Positive DLU) was examined separately from the Overall Positive Microscale score. The Overall Total Score was created by summing Total Positive DLU and Overall Positive Microscale.

2.7 Data analysis

Data were analyzed using SPSS version 21.0 (Chicago, Il.). Relationships of each MAPS-Abbreviated subscale score with physical activity outcomes for each age group, adjusting for all covariates as fixed effects and participant clustering in Census block groups (per recruitment procedures) as a random effect, were assessed by performing mixed linear regressions (SPSS MIXED procedure). Because we were interested in associations between physical activity outcomes and microscale measures of the pedestrian environment *independent* of macroscale walkability, we also ran all models adjusting for GIS-defined walkability (higher versus lower) (Frank et al., 2010b). Due to variations in measurement units and scales across the MAPS variables, *t* statistics from the macroscale adjusted mixed models were deemed most comparable with previous work and present samples and presented in Tables 2 to 4 instead of b estimates and confidence intervals (CIs). *T* statistics (and significance levels) provided a common indicator for comparing *relative* magnitudes of association across MAPS scores. Box-plots showing the range of scores for the summary scales can be found in Figure 1.

3. Results

3.1 Effects of adjusting for walkability

Both walkability-adjusted and unadjusted associations were computed. The inclusion of macroscale walkability in the models did not have a major impact on the number of significant results (23 lost significance; 3 gained; net loss of 20 of 135 significant findings). Therefore, we only present and interpret the findings that were adjusted for GIS-based walkability.

3.2 Walking and biking for transport

Seventy-one significant associations of MAPS-Abbreviated scores (43 subscales; 28 summary scores) and walking/biking for transport were observed across all age groups (61.7% of MAPS scores; Table 2). Destinations and non-residential land use along the route were consistently related to walking/biking for transport in all age groups. There were three significant subscales for children, four for adolescents, five for younger adults, and four for older adults. Positive land uses were important, particularly restaurants-entertainment for all ages; shops for adolescents, younger adults and older adults; and transit stops for adolescents and younger adults.

Positive streetscape characteristics were consistently related to walking/biking for transport in all age groups, with the strongest association among younger adults. Aesthetics and social characteristics were generally unrelated or “inversely” related to walking/biking for transport across age groups. Negative aesthetic/social features were related in an unexpected direction in younger and older adults (i.e. higher scores associated with more active transport). Positive aesthetics/social features were related in an unexpected direction in older adults (i.e. lower scores associated with more active transport). Positive crossing characteristics were related to walking/biking for transport in children (2 subscales) and older adults (2 subscales) in the expected direction.

Segment characteristics were significantly and positively related to active transport in children (3 subscales), adolescents (2 subscales), younger adults (7 subscales), and older adults (3 subscales). The Total Positive DLU, Overall Microscale Positive and Overall Total scores were positively related to walking/biking for transportation in all age groups.

Because aesthetics and social factors have generally been related to leisure physical activity, but not active transport (Bauman et al., 2012), and because of the unexpected negative relationship between aesthetics and active transport in the present study, additional total scores were created that omitted positive aesthetics from the Overall Positive Microscale score (Overall Positive Microscale for Active Transport and Overall Total Score for Active Transport). It was expected these total scores would be more strongly related to active transport outcomes. The Active Transport versions of the overall scores showed slightly higher associations with walking/biking for transport in younger and older adults only.

Figure 2 shows that MAPS-Abbreviated total scores were linearly related to active transport in all four age groups. Further, the effects appeared to be substantial. For example, living in areas with the highest quintile of MAPS-Abbreviated scores was associated with three to five times higher frequency of active transport for younger adults and older adults, respectively, with the lowest MAPS-Abbreviated scores.

3.3 Leisure and neighborhood physical activity

There were 26 significant associations (18 subscales; 8 summary scores) with leisure/neighborhood physical activity across all age groups (24.31% of MAPS scores; Table 3). Associations with destinations and land use and positive streetscape were generally negative or unrelated in all age groups. Aesthetics and social characteristics were related to neighborhood physical activity in children and leisure physical activity in younger adults in the expected direction. The total aesthetics/social score was the strongest correlate in both groups. The cul-de-sac score was positively related to neighborhood physical activity for children and adolescents. A few other significant findings in the expected direction were found for higher curb and sidewalk quality, but only in children, and optimal building height setback ratio and building height-road width ratio, but only in older adults. The Overall Positive Microscale score was positively related to more leisure physical activity only in older adults.

3.4 Objectively measured moderate-to-vigorous physical activity (MVPA)

There were 14 associations (8 subscales; 6 summary scores) with accelerometer-measured MVPA (17.5% of MAPS scores; Table 4). Shops, private recreation, and total destinations were positively related to children's neighborhood MVPA, and more residential mix was related to more MVPA among older adults. Several positive MVPA associations with crossing and segment characteristics were found in children (2 subscales), adolescents (1 subscale) and older adults (2 subscales). The Overall Positive Microscale and Overall Total were positively related to MVPA in both children and older adults.

4. Discussion

The main finding of the present study was that the MAPS-Abbreviated streetscape audit measure was similarly related to physical activity outcomes as the original MAPS (Table 6), which has twice as many items. It was surprising that reducing the MAPS from 120 items to 54 items did not diminish the construct validity, and the two versions were correlated at r=0.94, $p<0.00$. Thus, MAPS-Abbreviated is a more feasible validated observational measure for use in research. The length and related costs of microscale audits has been cited as a barrier to their use in research (Brownson et al., 2009; Glanz et al., 2015), so availability of a shorter validated measure could lead to more widespread use of streetscape audits in health research. Limited use of standardized observational measures in studies has probably contributed to the inconsistent findings of associations with physical activity in the literature (Bauman et al., 2012). Because microscale environment features related to sidewalks, street crossings, and aesthetics are subject to improvement in shorter time frames, more frequent use of validated audit measures could provide better data to guide faster environment and policy changes to create more activity-friendly environments.

As with the original MAPS, the strongest evidence of associations of MAPS-Abbreviated was with walking and bicycling for transport (Table 5). The overall microscale score for positive subscales was significant for all age groups. The total positive scores were significant for all age groups for the destinations and land use, streetscape, and street segment content areas. The total positive scores were significant for two age groups in the aesthetics and for three age groups in the crossings content areas. We speculate the negative association between aesthetics and active transport in both younger and older adults could be explained by suburban-type neighborhoods with pleasant aesthetics having fewer attractive destinations to walk to, while perhaps busy urban streets with numerous destinations are more likely to have graffiti and other incivilities. The complex associations of aesthetics and incivilities with urban form and socioeconomic status are not well understood (Sallis et al., 2011, Thornton et al., 2016), so more studies are needed.

The subscale, total positive, and overall scores allow for examination of the pattern of associations with active transportation. In all age groups, the overall total score (or overall total score for active transport that deleted aesthetic items) had the highest *t*-values in their column, higher than for any specific subscale. This pattern provides further evidence that the cumulative pattern of microscale features had stronger associations with active transport than any specific feature or subset of features (Cain et al., 2014). The finding that the overall microscale score appeared to have a higher *t*-value than destinations and land use (5.3 vs 3.2 in children) indicates the importance of assessing microscale variables separate from destinations and land use (which can be considered a macroscale feature). The strength of association of the overall microscale score with active transport suggests the potential impact of interventions that improve microscale features.

Figure 2 shows the MAPS-Abbreviated total score was linearly and strongly related to active transport in all age groups. The linear pattern implies that each incremental improvement in streetscape quality can be expected to facilitate more walking (and bicycling) for transport, with no obvious upper limit in the present study. The potential for sidewalks and street crossing improvements to increase active transport up to five-fold is highly relevant in the United States, which has one of the lowest rates of walking and bicycling for transport in a recent international comparison (Kerr et al., 2016).

The main finding for the leisure/neighborhood physical activity outcome was the significance of both positive and negative aesthetics and social characteristics, at least for children and adults, although there were fewer significant associations than for transport-based activity. The relation of aesthetics with leisure-time physical activity is relatively consistent in the literature for both youth and adults (Bauman et al., 2012). Another interesting finding was that characteristics of cul-de-sacs were positively related to leisure or neighborhood physical activity of children and adolescents. Combined with a few previous findings (Carver et al., 2008; Handy et al., 2008), the present results support an interpretation that young people often use cul-de-sacs as low-traffic recreation areas. In general, positive aspects of neighborhood environments were related to reported leisure physical activity, mainly for adolescents and children.

As found with the original MAPS, there were few significant associations of MAPS-Abbreviated subscales with accelerometer-measured MVPA in any age group. However, the overall positive microscale and overall total score were significant for children and older adults. As seen previously, the association of cumulative streetscape elements with physical activity was important, even though few associations were found with the components. Thus, associations between environments and physical activity are expected to be specific to setting (e.g., neighborhood) and domain of physical activity (e.g., transport or leisure). Ecological models of physical activity (Sallis et al., 2006) and prior findings (Ding et al., 2011) are consistent with this specificity of effect. The relations between children's MVPA measured during time spent in the neighborhood and the microscale environment support the specificity of environmental influences.

MAPS-Abbreviated was designed to retain advantages of the longer original MAPS, including content-based subscales and total scores. MAPS-Abbreviated was empirically derived by deleting items with less evidence of association with physical activity, less policy relevance, and rarely observed items. Thus, MAPS-Abbreviated is shorter and simpler to assess than the original instrument, while retaining strong evidence of construct validity. The box-plots in Figure 1 show the Abbreviated scale produces substantial variation in scores, suggesting the measure is sensitive enough to provide good statistical power to detect associations.

There is flexibility of scoring, and it is possible to create new subscales, such as for sidewalks, building characteristics, and food-related land uses. In our experience it is common for users of MAPS to desire to customize it to some extent. The approach we recommend is to retain the integrity of a published version (original, Abbreviated, or Mini) so scores can be compared across studies. However, we encourage additional items to explore attributes specific to their region or study aims. Newly-developed items should be pre-tested for inter-observer reliability. An alternate summary score can be reported and analyzed, in addition to the standard score. As with the MAPS-Mini (Sallis et al., 2015), we encourage the use of percent scores computed by calculating the observed score as a percent of the possible maximum score. The possible maximum score is created by summing the maximum scores for each item in a scale (including new items for modified versions). Even if somewhat different MAPS versions are used, percent scores should enhance comparability. In addition, percent scores have a more intuitive interpretation than absolute scores. For example, percent scores (e.g., 60% of maximum) have a more intuitive interpretation than absolute scores (e.g., 45 points).

Limitations of MAPS-Abbreviated included the loss of items that may be of interest to some users. Those items or new items could be added for a customized version, if items are scored on the same 0–2 scale as present items, are pre-tested for clarity, and shown to be reliably coded by observers. For example, the amount of slope among paths in a neighborhood can influence the amount of walking undertaken by older populations, but slope items were deleted from MAPS-Abbreviated. Modifications to MAPS-Abbreviated should be clearly described in reports. Obtaining quality data with MAPS-Abbreviated still requires substantial observer training and certification, ongoing monitoring of inter-observer agreement, and management of complex data. Construct validity for MAPS-Abbreviated was assessed with the same data set used with the original MAPS, so cross-validation with new samples is recommended. In addition to studying multiple outcomes among four age groups of participants recruited from three regions of USA, an important strength of the study was adjusting all analyses for macroscale walkability and demographics in order to reveal independent associations between physical activity and microscale features.

The various versions of MAPS are suited to different purposes. MAPS-Abbreviated has almost the same explanatory power as the original MAPS, but the lower investigator burden of the former should enable more studies of microscale characteristics. Investigators working with city planning and transportation officials may want the additional items available in the original MAPS obtain a more detailed assessment of neighborhoods being considered for environmental improvements. MAPS-Mini should be easier to learn for community residents, and it can be applied in large studies or to assess many neighborhoods. Table 6 summarizes associations with active transport (for the adult age group as an example), and number of items for each scale score and summary score for all three MAPS versions can be found in Table 1. This comparison can aid potential users in identifying the most appropriate MAPS version for their purpose. Additional guidance for selecting physical activity environment measures for research and practice is available (Carlson et al., 2017).

Several streetscape audits have been published by diverse groups of investigators, and they have similar content (Brownson et al., 2009). The main distinguishing features of MAPS instruments are the systematic scoring methods and extensive evidence of construct validity with multiple physical activity measures in four age groups. All MAPS versions, data collection forms, illustrated manuals, and scoring syntax can be found online. (http://sallis.ucsd.edu/measure_maps.html)

In summary, the MAPS-Abbreviated audit tool offers an efficient means for systematically capturing important features of local environments associated with physical activity. As such it adds to the growing armamentarium of valid research tools that can continue to advance understanding of the role of built environments in physical activity and other outcomes, hopefully leading to evidence-based recommendations for healthy urban design (Sallis et al., 2016).

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HIGHLIGHTS

1. MAPS-Abbreviated is a validated observational measure for use in research.
2. This shorter measure could lead to more widespread use of streetscape audits.
3. Microscale attributes were consistently associated with active transportation.

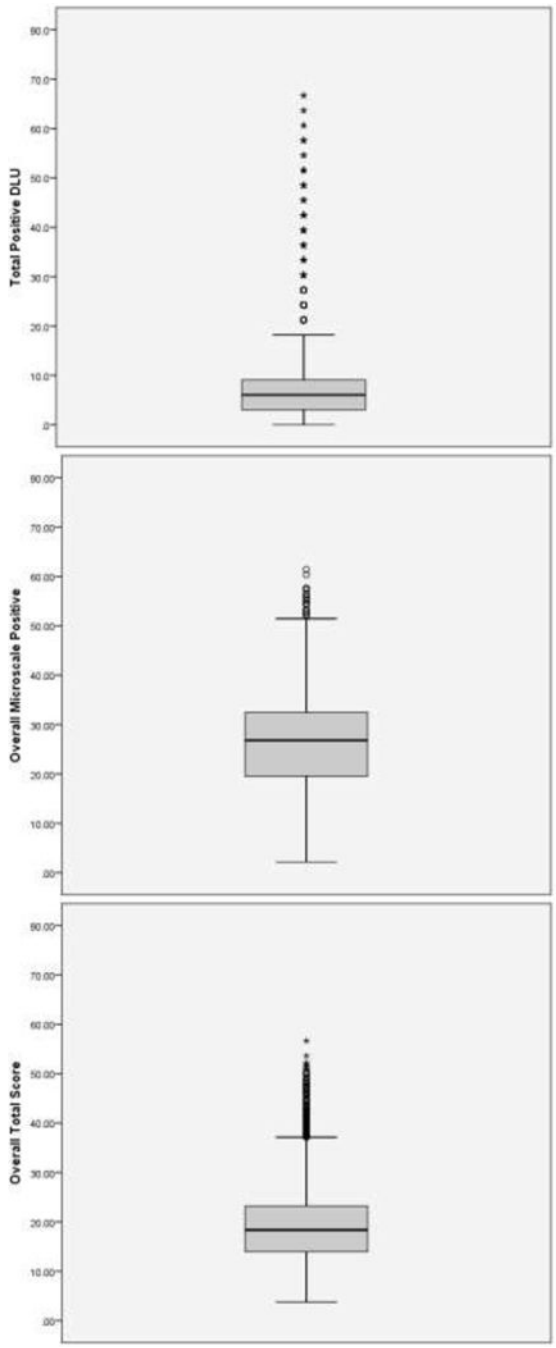

Figure 1.
Box-plots showing the distribution of the MAPS-Abbreviated summary scores as a percentage of the total possible points.

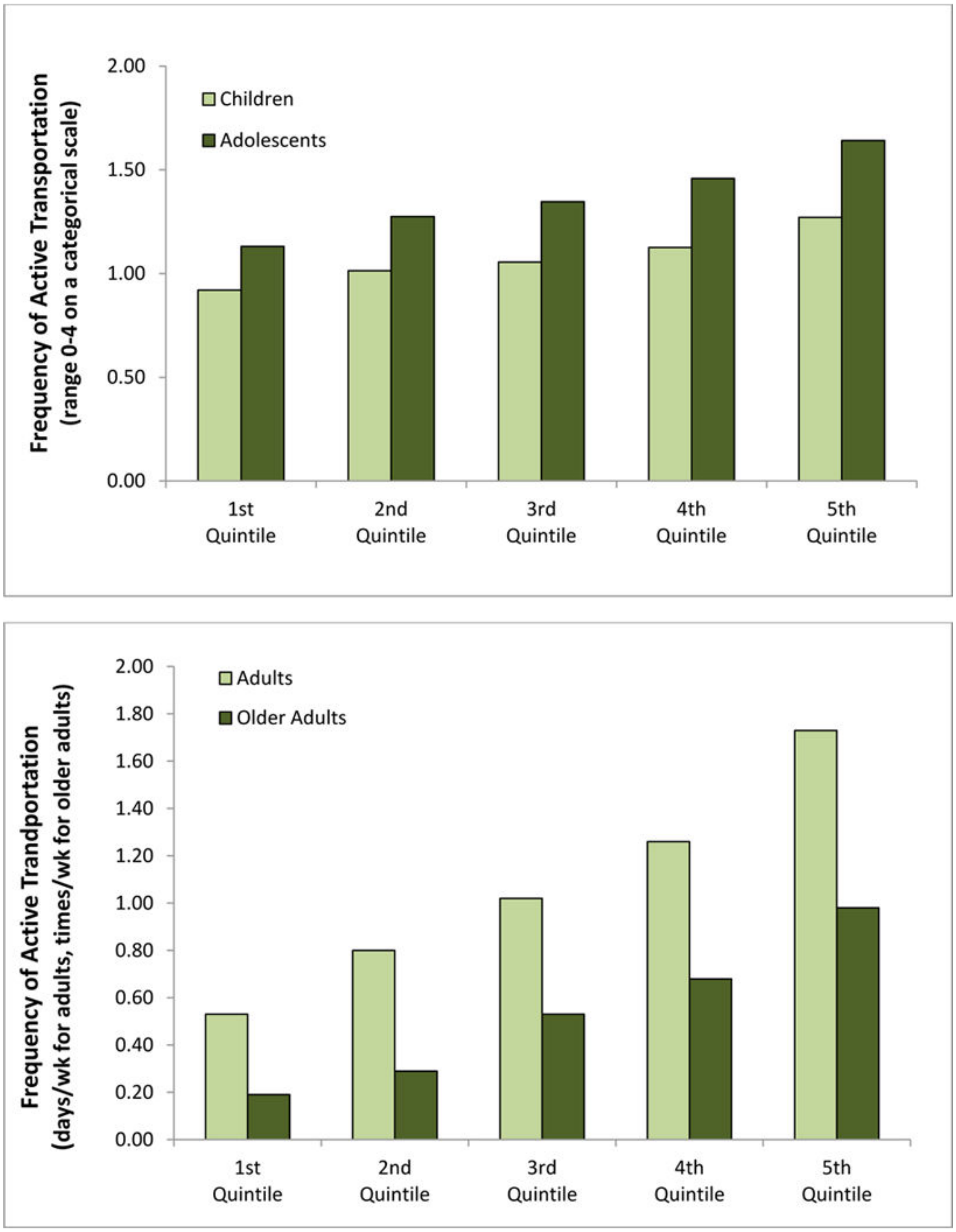

Figure 2.

Association of active transport with MAPS-Abbreviated Overall Total score (percentage of total possible) ranked in quintiles from the poorest (lowest quintile) to the best (highest quintile) activity supportive microscale attributes of the built environment in the 4 age groups.

Table 1

Number of items for MAPS Original compared to MAPS-Abbreviated and MAPS-Mini for each subscale

	MAPS Original	MAPS-Abbreviated	MAPS-Mini	Items deleted for MAPS-Abbreviated (examples)	Items retained for MAPS-Mini
Destinations & Land Use (DLU)					
Positive DLU	32	17	2	Big box stores, pharmacy, library	Public parks, commercial destinations
Negative DLU	5	0	0	Parking, casinos, warehouse	
Streetscape Characteristics					
Positive streetscape	8	6	4	Posted speed limit, crosswalk signs	Transit stops, benches, streetlights, bike path
Negative streetscape	2	0	0	Roll over curbs, drainage ditches	
Aesthetics & Social Characteristics					
Positive aesthetics/social	6	5	2	Historical/cultural features	Well-maintained buildings, graffiti
Negative aesthetics/social	4	1	0	Physical disorders, extent social disorder	
Crossings/Intersections					
Positive crossing	9	6	3	Yield signs, number crossing legs, stop lines	Walk signal, curb ramp, crosswalk
Negative crossing	4	0	0	Crossing width, gutters, poor visibility	
Street Segments					
Positive segment	24	16	4	Building colors, windows, buffer width	Sidewalks, trip hazards, buffer, tree/awning coverage
Negative segment	9	0	0	Slope, obstructions, one-way streets	
Cul-De-Sacs	17	3	0	Diameter, slope, percentage paved	
Total Items	**120**	**54**	**15**		

Table 2

Mixed regression results of relations between MAPS-Abbreviated scores and walking and biking for transport

	Children[a]	Adolescents[a]	Adults[a]	Older Adults[a]
Destinations & Land Use (DLU)				
Residential Mix	1.482	**1.989** *	**4.358** ***	**2.392** *
Shops	1.574	**1.972** *	**3.230** **	**4.169** ***
Restaurant-Entertainment	**3.093** **	**2.090** *	**3.720** ***	**4.960** ***
Institutional-Service	**2.754** **	1.102	**3.495** ***	**3.670** ***
Public Recreation	0.527	1.058	0.779	−1.564
Private Recreation	**2.106** *	−0.134	−0.355	0.888
Transit Stops	1.832	**2.463** *	**3.826** ***	0.983
Total Positive DLU	**3.195** **	**2.396** *	**4.323** ***	**4.796** ***
Streetscape Characteristics				
Positive Streetscape	**2.819** **	**2.540** *	**5.031** ***	**2.190** *
Aesthetics & Social Characteristics				
Positive Aesthetics/Social	0.852	0.278	−1.294	**−2.314** *
Negative Aesthetics/Social	−0.853	1.437	**2.809** **	**2.312** *
Total Aesthetics/Social	1.015	−0.779	**−2.579** *	**−2.748** **
Crossings/Intersections				
Crosswalk Amenities	**2.111** *	0.524	1.195	**2.373** *
Curb Quality	**3.042** **	−0.296	1.911	**2.403** *
Intersection Control	−1.577	0.861	0.971	1.648
Total Positive Crossings	**2.698** **	0.239	**2.081** *	**2.868** **
Street Segments				
Building Height-Setback	**3.080** **	**2.056** *	**3.347** **	**3.108** **
Building Height-Road Width	0.828	0.032	**2.499** *	1.631
Ratio Buffer	**3.285** **	**2.140** *	**4.729** ***	**2.271** *
Bike Infrastructure	0.355	0.974	**2.706** **	−0.517
Trees	1.819	0.834	**2.080** *	0.731
Sidewalk	**4.756** ***	1.379	**3.254** **	**2.165** *
Road Width[b]	0.063	1.555	**2.231** *	0.744
Total Positive Segments	**4.893** ***	**1.981** *	**4.749** ***	**2.779** **
Cul-De-Sacs				
Total cul-de-sac[c]	−0.289	0.365	0.26	N/A
Total Positive and Overall Scores				
Total Positive DLU	**3.195** **	**2.396** *	**4.323** ***	**4.796** ***
Overall Microscale Positive[d]	**5.224** ***	**2.227** *	**5.724** **	**3.434** **

	Children[a]	Adolescents[a]	Adults[a]	Older Adults[a]
Overall Total Score[e]	**5.286**[***]	**2.711**[**]	**6.094**[***]	**4.718**[***]
Overall Microscale Positive for Active Transport[f]	**5.308**[***]	**2.267**[*]	**5.397**[***]	**3.044**[**]
Overall Total Score for Active Transport[g]	**5.466**[***]	**2.755**[**]	**5.932**[***]	**4.467**[***]

Values presented in table are t-test results. Significant results are **bolded**.

[a] analyses adjusted for age, gender, education, race, GIS-defined walkability (high/low), physical functioning (older adults) and clustering of participants within block groups

[b] not included in total segment

[c] not included in grand valence and overall scores

[d] positive streetscape + positive aesthetics/social + total positive crossings + total positive street segments

[e] Total Positive DLU+ Overall Microscale Positive

[f] total streetscape characteristics + total crossings/intersections + total street segments (no aesthetics)

[g] Total Positive DLU + Overall Microscale Positive for Active Transport

[*] $p \leq 0.05$

[**] $p \leq 0.01$

[***] $p \leq 0.001$

Table 3

Mixed regression results for relations between MAPS-Abbreviated scores and leisure and neighborhood physical activity

	Children[a]	Adolescents[a]	Adults[a]	Older Adults[a]
Destinations & Land Use (DLU)				
Residential Mix	**−3.257** **	−1.631	−1.121	1.171
Shops	**−2.710** **	−0.890	−0.928	0.301
Restaurant-Entertainment	−1.886	−0.973	0.191	0.686
Institutional-Service	**−2.582** *	−1.180	−1.052	0.366
Public Recreation	1.778	0.108	0.234	−0.288
Private Recreation	0.010	−0.583	−1.028	−1.05
Transit Stops	**−2.137** *	−0.142	−0.122	0.325
Total Positive DLU	**−3.307** **	−1.513	−1.108	0.397
Streetscape Characteristics				
Positive Streetscape	−1.144	**−2.056** *	0.464	1.815
Aesthetics & Social Characteristics				
Positive Aesthetics/Social	**2.915** **	−1.875	**2.617** **	0.588
Negative Aesthetics/Social	**−3.477** **	0.743	**−5.839** ***	0.631
Total Aesthetics/Social	**3.844** ***	−1.56	**5.389** ***	−0.139
Crossings/Intersections				
Crosswalk Amenities	0.476	**−2.065** *	0.818	1.103
Curb Quality	**2.212** *	−1.698	−1.160	1.193
Intersection Control	**−2.498** *	**−2.398** *	0.362	0.178
Total Positive Crossings	1.230	**−2.629** **	−0.382	1.235
Street Segments				
Building Height-Setback	0.899	−1.404	−0.040	**2.933** **
Building Height-Road Width	−0.427	0.079	1.097	**2.724** **
Ratio Buffer	−0.068	0.296	−1.517	−0.218
Bike Infrastructure	−1.553	−1.344	0.608	0.798
Trees	1.526	0.055	0.156	0.582
Sidewalk	**2.088** *	−0.963	−0.986	1.195
Road Width[b]	−1.804	0.108	0.061	1.762
Total Positive Segments	1.687	−0.852	−0.605	**2.168** *
Cul-De-Sacs				
Total cul-de-sac[c]	**5.888** ***	**2.596** *	−0.231	N/A
Total Positive and Overall Scores				
Total Positive DLU	**−3.307** **	−1.513	−1.108	0.397

	Children[a]	Adolescents[a]	Adults[a]	Older Adults[a]
Overall Microscale Positive[d]	1.602	**−2.444** *	0.080	**2.526** *
Overall Tota Score[e]	−0.503	**−2.429** *	−0.499	1.814

Values presented in table are t-test results. Significant results are **bolded**.

[a]analyses adjusted for age, gender, education, race, GIS-defined walkability (high/low), physical functioning (older adults) and clustering of participants within block groups

[b]not included in total segment

[c]not included in grand valence and overall scores

[d]positive streetscape + positive aesthetics/social + total positive crossings + total positive street segments

[e]Total Positive DLU+ Overall Microscale Positive

* $p \leq 0.05$

** $p \leq 0.01$

*** $p \leq 0.001$

Table 4

Mixed regression results for relations between MAPS-Abbreviated scores and objective MVPA

	Children[a]	Adolescents[a]	Older Adults[a]
Destinations & Land Use (DLU)			
Residential Mix	0.098	−1.042	**2.209** *
Shops	**2.280** *	0.522	0.364
Restaurant-Entertainment	1.546	0.993	0.718
Institutional-Service	1.451	−0.635	−0.108
Public Recreation	1.284	1.590	−0.599
Private Recreation	**3.201** **	−0.399	−0.921
Transit Stops	0.801	0.600	0.469
Total Positive DLU	**2.028** *	0.383	0.562
Streetscape Characteristics			
Positive Streetscape	1.015	−0.053	1.660
Aesthetics & Social Characteristics			
Positive Aesthetics/Social	0.822	−0.807	−0.281
Negative Aesthetics/Social	−1.810	−0.611	−0.264
Total Aesthetics/Social	1.590	−0.058	0.039
Crossings/Intersections			
Crosswalk Amenities	−1.001	0.029	0.845
Curb Quality	**2.599** *	1.102	1.887
Intersection Control	−1.469	1.045	0.881
Total Positive Crossings	1.142	0.993	1.648
Street Segments			
Building Height-Setback	0.471	−1.332	**2.650** **
Building Height-Road Width	−0.838	0.383	**3.139** **
Ratio Buffer	1.091	1.000	0.547
Bike Infrastructure	−0.824	1.262	0.180
Trees	1.44	0.543	1.236
Sidewalk	**2.054** *	1.388	1.755
Road Width[b]	0.131	**2.365** *	0.513
Total Positive Segments	1.791	1.191	**2.657** **
Cul-De-Sacs			
Total cul-de-sac[c]	−1.058	1.890	N/A
Total Positive and Overall Scores			
Total Positive DLU	**2.028** *	0.383	0.562
Overall Microscale Positive[d]	**1.928** *	0.919	**2.678** **
Overall Total Score[e]	**2.412** *	0.819	**2.017** *

Values presented in table are t-test results. Significant results are **bolded**.

[a] analyses adjusted for age, gender, education, race, GIS-defined walkability (high/low), physical functioning (older adults) and clustering of participants within block groups

[b] not included in total segment

[c] not included in grand valence and overall scores

[d] positive streetscape + positive aesthetics/social + total positive crossings + total positive street segments

[e] Total Positive DLU+ Overall Microscale Positive

[*] $p \leq 0.05$

[**] $p \leq 0.01$

[***] $p \leq 0.001$

Table 5

Summary of significant associations of physical activity outcomes with MAPS-Abbreviated Total and Overall scores

	Positive Streetscape Characteristics	**Total Aesthetics & Social Characteristics**	**Positive Crossings/ Intersections**	**Positive Street Segments**	**Cul-de-sacs**	**Overall Positive Destinations & Land Use**	**Overall Positive Microscale**	**Overall Total Score**
Walking/biking for transport	Children** Adolescents* Adults*** Older adults*	*Adults** *Older adults***	Children* Adults* Older adults**	Children*** Adolescents* Adults*** Older adults**		Children** Adolescents* Adults*** Older adults***	Children*** Adolescents* Adults*** Older adults**	Children*** Adolescents** Adults*** Older adults***
Leisure/neighborhood physical Activity	*Adolescents**	Children*** Adults***	*Adolescents***	Older adults*	Children*** Adolescents*	*Children***		*Adolescents**
Objective physical activity (MVPA)[a]				Older adults**		Children*	Children* Older Adults**	Children* Older adults*

Italicized text indicates results in unexpected direction

[a]MVPA measured in children, adolescents and older adults only (not adults)

[*] $p \leq 0.05$

[**] $p \leq 0.01$

[***] $p \leq 0.001$

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Table 6

Mixed regression results of relations between MAPS scores and walking and biking for transport in adults for each version of MAPS

	MAPS-Original	MAPS-Abbreviated	MAPS-Mini
Positive DLU	4.38***	4.32***	0.78
Negative DLU	1.50	—	—
Positive streetscape	3.76***	5.03***	3.77***
Negative streetscape	−2.76**	—	—
Positive aesthetics/social	−0.68	−1.29	−2.36*
Negative aesthetics/social	3.33**	2.81**	—
Positive crossing	0.72	2.08*	2.39*
Negative crossing	−1.21	—	—
Positive segment	5.08***	4.75***	4.72***
Negative segment	−3.48**	—	—
Cul-de-sac	0.26	0.26	—
Total positive	5.10***	—	—
Total negative	−2.15*	—	—
Total score	4.91***	6.09***	5.59***

Values presented in table are t-test results.

[a]analyses adjusted for age, gender, education, race, GIS-defined walkability (high/low), physical functioning (older adults) and clustering of participants within block groups

* $p \leq 0.05$

** $p \leq 0.01$

*** $p \leq 0.001$