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Short Communication

Validity of Walk Score® as a measure of neighborhood walkability in Japan

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ABSTRACT

Objective measures of environmental attributes have been used to understand how neighborhood environments relate to physical activity. However, this method relies on detailed spatial data, which are often not easily available. Walk Score® is a free, publicly available web-based tool that shows how walkable a given location is based on objectively-derived proximity to several types of local destinations and street connectivity. To date, several studies have tested the concurrent validity of Walk Score as a measure of neighborhood walkability in the USA and Canada. However, it is unknown whether Walk Score is a valid measure in other regions. The current study examined how Walk Score is correlated with objectively-derived attributes of neighborhood walkability, for residential addresses in Japan.

Walk Scores were obtained for 1072 residential addresses in urban and rural areas in Japan. Five environmental attributes (residential density, intersection density, number of local destinations, sidewalk availability, and access to public transportation) were calculated using geographic information systems for each address. Pearson's correlation coefficients between Walk Score and these environmental attributes were calculated (conducted in May 2017).

Significant positive correlations were observed between Walk Score and environmental attributes relevant to walking. Walk Score was most closely associated with intersection density ($r = 0.82$) and with the number of local destinations ($r = 0.77$).

Walk Score appears to be a valid measure of neighborhood walkability in Japan. Walk Score will allow urban designers and public health practitioners to identify walkability of local areas without relying on detailed geographic data.

1. Introduction

Ecological models of physical activity have highlighted the importance of the built environment in shaping people's behavior such as walking (Sallis and Owen, 2015). Measuring environmental attributes is an important step in understanding the role of the built environment in physical activity (Brownson et al., 2009). Objective measures of environmental features computed using geographic information systems (GIS) are frequently used for this purpose (Sallis, 2009). However, this method requires detailed geographic data, which are often not easily available. For example, the Walkability Index (Frank et al., 2010), which has been shown to be associated with walking (Carlson et al., 2015; Owen et al., 2007), typically consists of four components: intersection density, net residential density, land use mix, and net retail area ratio. But, except for intersection density, they require cadastre-level data, including property boundary and land use of each land parcel for all private and public land (Frank et al., 2010). These geographical data are difficult to source not just in low-income countries but also in high-income ones (Kerr et al., 2013; Salvo et al., 2014). This is a major limitation that deters the application of such objective indices in urban design and public health practice. In addition, data management and analysis using GIS software require trained personnel and special computational equipment, which is an additional limitation (Brownson et al., 2009). These issues highlight the need for easily-available tools

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that characterize environmental attributes relevant to physical activity.

Walk Score® is a free, publicly available web-based tool that calculates a score in relation to access to local destinations for a given location. Using a decay function, Walk Score first assigns a raw score to each location based on their network distance to destinations such as grocery shops, restaurants, bookstores, banks, schools, fitness centers, and parks within 1.6 km from that location (Front Seat Management, 2017). These raw scores are then normalized from 0 to 100 with adjustment of two street network measures (intersection density and block length) around each location (Nykiforuk et al., 2016). Higher scores represent areas with more local destinations nearby, where walking is an easy option for shopping and errands. Source maps obtained from Google, Education.com, Open Street Map, and other open-source data are used to calculate Walk Score (Front Seat Management, 2017; Nykiforuk et al., 2016). Several studies have found positive associations of Walk Score with walking for transport (Cole et al., 2015) and with recreational physical activity in small towns (Thielman et al., 2015), and negative associations of Walk Score with body mass index (Hirsch et al., 2014). For example, a study in Australia found participants who lived in areas of the top Walk Score category (highly walkable) were twice more likely to walk 30 min or more for transportation per day, compared with those who lived in areas of the bottom category (very car dependent) (Cole et al., 2015). Another study in the USA found moving to a location with a higher Walk Score to be associated with a reduction in body mass index (Hirsch et al., 2014). Nevertheless, there are several studies reporting null (Chiu et al., 2015) or negative (Hajna et al., 2015; Tuckel and Milczarski, 2015) associations between Walk Score with leisure physical activity, recreational walking, and daily steps.

Walk Score is a commercial product, and its detailed algorithm to calculate a score is not open to public. In addition, it is unknown whether different countries use comparable methods in constructing the base map (i.e., the way destinations are sourced, categorized and geocoded), from which Walk Score is derived. Thus, in order to make sure that Walk Score provides a reasonable measure of walkability outside the countries where Walk Score has been validated (USA, Australia, Canada), its concurrent validity, i.e., correlation with other environmental attributes known to be associated with walking, needs to be examined.

To date, there are a few studies examining the concurrent validity of Walk Score (Carr et al., 2010, 2011; Duncan et al., 2013; Duncan et al., 2011; Nykiforuk et al., 2016). For example, a Canadian study found high to very high correlation between Walk Score and an index of walkability consisting of street connectivity and access to destinations (Nykiforuk et al., 2016). Another study conducted in four metropolitan areas in the USA found positive correlations between Walk Score and measures of walkability such as street connectivity and density of retail destinations (Duncan et al., 2011). However, it is unknown how Walk Score is correlated with other environmental attributes known to be related to walking in regions or countries outside of North America. Concurrent validity needs to be checked locally because the source and process of constructing the base map is unknown.

To check whether Walk Score can be used as a measure of walkability in Japan, the current study examined the correlation between Walk Score and attributes of neighborhood environments relevant to walking for residential addresses chosen from an urban and a rural area in Japan.

2. Methods

2.1. Address data

Residential address data were collected as a part of the Healthy Built Environment in Japan (HEBEJ) project. The HEBEJ project, conducted at the Faculty of Sport Sciences, Waseda University, aims to identify the environmental determinants of health behaviors and outcomes in Japan. Residential addresses of two localities, Nerima Ward (urban area) and Kanuma City (rural area), were identified in 2011 (for the purpose of recruiting study participants). Guided by the method of the International Physical Activity and the Environment Network (IPEN) studies (Kerr et al., 2013), the study selected participants from high walkable (Nerima Ward) and low walkable (Kanuma City) areas. Having a larger variability in environmental attributes helps to assess correlations accurately as the study areas cover almost the full range of Walk Score. Nerima Ward is part of the Tokyo Metropolitan area with 716,000 residents and an area of 48 km^2, and Kanuma is located about 120 km north of Tokyo with 102,000 residents and an area of 491 km^2. A total of 1500 residents aged 40 to 69 years were randomly selected from the registry of residential addresses (balanced in gender and age group) from each city, and a postal questionnaire was sent to them. Of these, 1076 participants (569 from Nerima, 507 from Kanuma) responded to the questionnaire, and agreed to attend the HEBEJ study. Residential addresses of these participants were geocoded, and used in this study. This process received prior ethics approval from the Institutional Ethics Committee of Waseda University (2010-238).

2.2. Measures

2.2.1. Walk Score

Each residential address was manually entered into the Walk Score website (www.walkscore.com) by two independent project members in 2016. The discrepancy between two members was checked and rectified by the first author. Walk Scores were examined as continuous values.

2.2.2. Built environment attributes

Five environmental attributes were calculated within an 800 m circular buffer of each residential address using GIS. They included (1) population density (the number of residents per km^2); (2) intersection density (the number of three-way or more intersections per km^2); (3) access to destinations: in line with a previous study (Carr et al., 2011), the number of destinations for the following eight types: food outlets, grocery stores, parks, schools, libraries, fitness facilities, drug stores, and retail per km^2); (4) sidewalk availability (the length of roads with sidewalks per km^2); (5) access to public transportation (the number of train stations and bus stops per km^2). The chosen 8 destination types were similar with those used in a previous study (Carr et al., 2011). GIS data (population points, street centerlines, destinations, sidewalks, and public transportation stations) were sourced from the Environmental Systems Research Institute (ESRI) Japan data 2011. These attributes were selected on the basis of previous evidence showing their associations with walking (Saelens and Handy, 2008; Sugiyama et al., 2012). We included non-destination measures such as residential density and sidewalk availability in order to assess the concurrent validity in a comprehensive manner. Since environmental attributes related to walking are often clustered (e.g., higher population density is needed to support retail destinations), it can be argued that Walk Score, an overall measure of walkability, would perform better if it is associated with multiple environmental attributes related to walking.

2.2.3. Analysis

Descriptive statistics of environmental attributes and Walk Score were reported. Pearson's correlation coefficient and multivariate linear regression were used to investigate the associations between Walk Score and attributes of neighborhood environments, using SPSS 20.0 (SPSS, Inc., Chicago, IL).

3. Results

After excluding addresses where Walk Score was not available ($n = 4$), data from 1072 addresses were analyzed. Table 1 shows the environmental characteristics of the study areas. The mean Walk Score

Table 1
Characteristics of the study areas and correlation coefficients between Walk Score and environmental attributes (conducted in May 2017).

Environmental attributes	Mean (SD)	r
Population density[a]	9521 (8115)	0.72***
Intersection density[b]	354 (230)	0.81***
Local destinations[c]	61.9 (52.2)	0.77***
Food outlets	5.8 (8.3)	0.54***
Grocery stores	8.4 (7.7)	0.73***
Parks	3.1 (3.7)	0.49***
Schools	5.2 (4.0)	0.71***
Libraries	0.3 (0.5)	0.42***
Fitness facilities	1.5 (2.1)	0.48***
Drug stores	8.9 (8.0)	0.74***
Retail	28.6 (24.7)	0.74***
Sidewalk availability[d]	12,170 (7664)	0.76***
Access to public transportation[e]	12.6 (7.1)	0.76***

*** $p < 0.001$.
[a] The number of residents per km^2.
[b] The number of intersections per square km^2.
[c] The number of destinations per km^2.
[d] The length of roads with sidewalks in m per km^2.
[e] The number of train stations and bus stops per km^2.

was 62.2 (SD = 27.5), ranging from 0 to 97. Table 1 also shows the correlation coefficients between Walk Score and the environmental attributes. Significant positive correlations were observed between Walk Score and all five environmental attributes assessed. There were also significant positive correlations between Walk Score and each type of destinations. The r-squared value from the multivariate linear regression indicates that about 80% of variation in the Walk Score can be explained by five environmental attributes.

4. Discussion

This was the first study to examine the validity of Walk Score as a measure of neighborhood walkability in two communities in Japan. Using over 1000 residential addresses from urban and rural areas in Japan, our study indicated Walk Score to be significantly correlated with multiple environmental attributes known to be associated with walking. These findings are consistent with previous studies conducted in the USA and Canada, which showed high correlations between Walk Score and objective environmental attributes (Carr et al., 2011; Duncan et al., 2011; Nykiforuk et al., 2016). For example, a study in the USA found Walk Score to be highly correlated with availability of local destinations (Carr et al., 2011): correlation coefficients were above 0.70 both in this American study and in the present study.

Since Walk Score is a destination-based index, it was expected to have a significant correlation with the number of destinations. Walk Score was also found to be significantly correlated with the other non-destination measures (population density, intersection density, sidewalk availability, and access to public transport). Another study in the USA also found Walk Score to be positively associated with population density (Carr et al., 2010). It is plausible that areas with more local destinations have higher population density, higher street connectivity, longer sidewalks, and better access to public transport stops. Studies have shown correlations between these environmental factors (Frank et al., 2005). For example, it has been shown that areas with well-connected streets tend to have many local shops (Koohsari et al., 2017). This study suggests that Walk Score captures not only access to local destinations but also the characteristics of routes to them, both of which are key to facilitate walking (Sugiyama et al., 2012).

This study had some limitations. There was a temporal mismatch between objective environmental measures (based on the 2011 geographic data) and Walk Score (extracted in 2016). The objective environmental measures were calculated within an 800 m circular buffer area around each address; while Walk Score was calculated within 1.6 km network distance from each address. The difference in the buffer sizes used and in the way buffers were drawn may not be critical as Walk Score was calculated using a distance decay function: destinations within 800 m are given much higher weights compared to those beyond 800 m (Nykiforuk et al., 2016). In addition, the fact that the study found significant correlations under these circumstances suggest that Walk Score is associated at least with environmental attributes measured within an 800 m buffer area, in which the majority of walking trips occur (Daniels and Mulley, 2013; Millward et al., 2013). Regardless of these issues, this study found evidence supporting the validity of Walk Score in measuring walkability of local areas in Japan.

5. Conclusions

Walk Score is a readily-available tool that allows urban designers, government officials, and public health practitioners to identify walkability of local areas without relying on detailed geographic data or GIS expertise. Since Walk Score is an overall indicator, it does not provide information about what specific aspects of the environment may have to be modified to promote physical activity. Nonetheless, it assists practitioners to locate areas that hinder residents from being active and would inform future interventions. This study found that Walk Score is a valid measure of walkability in Japan, but a further country-specific validity check is necessary to expand its application to other countries, where obtaining detailed geographic data is a challenge.

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Conflict of interest

The authors declare there is no conflict of interest. None of the authors has any financial interest in walkscore.com.

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