Physical Activity and the Built Environment in Residential Neighborhoods of Seoul and Seattle: An Empirical Study Based on Housewives' GPS Walking Data and Travel Diaries

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Abstract

This paper is based on a collaborative pilot-study to ascertain the characteristic walking patterns and neighborhood features in residential areas of Seoul, Korea and Seattle, USA. As for sample sites, four case neighborhoods were selected: two from Seoul and two from in and outside of the Seattle-Shoreline areas. As for participants, thirty Korean housewives in Seoul and thirty Korean-American housewives in the Seattle area were selected respectively, and their socio-demographic characteristics, GPS records, and travel diary data for seven days were collected and analyzed. Considering the typical rainy seasons in the two cities, data collections, including the physical activity assessment by GPS devices, were carried out from May to June and from September to October in Seoul, and from July to October in Seattle during the year 2010.

Noteworthy research findings include the following: Korean participants in Seoul walk about 2.6 km on average per day, while Korean-American participants in Seattle walk about 400m on average per day. In the case sites of Seoul, 75% of grocery shopping activities happen within the neighborhood by walking, while only 17% of those activities on foot happen in the case sites of Seattle. As for the most walking activity, about 70% of total walking amounts are related to utilitarian walking in Seoul sites, while 50% of total walking are related to recreational walking in Seattle sites. Recreational walking and utilitarian walking occur separately in Seattle sites, while the two walking types are often combined in Seoul sites, which also contribute to more walking amounts and farther walking distances in Seoul sites.

This paper empirically confirms the widely held assumptions in part that residents in Seoul, a relatively high-density and high mixed-use city, walk more than those in Seattle, a relatively low-density and low mixed-use city. This paper also recognizes that in the case of both cities, more walking activities occur in the neighborhood built environment, where finely-grained street networks, small lots and blocks, various pedestrian destinations, public transit access, etc are provided in close connection. The amount and frequency of walking activities, as well as the fineness of neighborhood features, however, are remarkably different in the two cities, whose implications deserve in-depth exploration in further studies.

Keywords: physical activity; neighborhood environment; objective measures; GPS walking data; international comparative study

1. Introduction

The lack of physical activity is a common risk factor for obesity, diabetes and cardiovascular diseases, and it becomes a serious health concern these days in most countries. As responses, many researchers in Western countries have tried to find the critical determinants of physical activity in order to provide a sound empirical basis for public health interventions. They have largely focused on the associations between neighborhood environments and the physical activity of residents (Saelens et al., 2003a and 2003b; Rodriguez et al., 2006; Koohsari et al., 2013).

Although the findings of the existing studies are somewhat inconsistent, the physical activity is recognized as being related to certain characteristics of the built environment, such as higher residential densities, more mixed land uses, more convenient public transit access,
and good-quality public open spaces in the neighborhood (Handy, 1996; Cervero et al., 1997; Craig et al., 2002; Frank et al., 2005; Koohsari et al., 2013).

To date, some studies argue that different types of walking, such as utilitarian walking in contrast to recreational walking, are associated with different sets of environmental attributes (Saelens and Handy, 2008). Other studies insist that it is necessary to distinguish specific domains of physical activity and total walking amounts in coming researches (Owen et al., 2004; Lovasi et al., 2008; Handy et al., 2006). Another issue, raised continuously among researchers, is whether objective measures or perceived measures of the built environment and of physical activity are to be used. This results in increased applications of new tools, such as GPS, GIS, etc, as objective measures have merits with new technologies (Seeger et al., 2008).

While existing studies on the association between built environments and physical activity have proliferated in Western countries, relatively few studies have been conducted in Asian countries, let alone comparative studies between the two continents. Cross-cultural comparative studies on physical activity and its environmental correlates are in an early stage. More detailed knowledge about walking patterns in other parts of the globe and their comparative interpretations would be helpful in bringing broader perspectives and more diverse explanations to current scholarship in the field.

In the methodological aspects, the International Physical Activity Questionnaire (IPAQ) was developed in 1997 as a common surveillance tool to comparably measure four domains of physical activity (Craig et al., 2003). Most international comparative studies on physical activity have collected data using IPAQ. Despite the merits of gathering general information across the globe, IPAQ tends to overestimate the physical activity durations and frequencies, as participants often exaggerate their behaviors. Also their perceived measures of built environments might distort the differences of built environments among countries.

With these backgrounds mentioned above, this paper draws characteristic walking patterns and neighborhood environmental features in representative residential areas of Seoul and Seattle, and interprets the meanings of their associations. This paper is based on the research findings of a collaborative pilot-study, conducted by the teams of the Seoul National University in Seoul and the University of Washington in Seattle.

As for sample sites, two case neighborhoods in Seoul and two in and outside of the Seattle-Shoreline areas were selected. As for participants, thirty Korean housewives for the Seoul cases and thirty Korean-American housewives for the Seattle cases were selected respectively, minimizing their differences in terms of cultural background. Participants' socio-demographic data, GPS records, and travel diary data for seven days were collected and analyzed. Considering the typical rainy seasons and extreme weathers, which hinder outdoor walking activities, assessing physical activity by GPS was carried out from May to June and from September to October in Seoul, and from July to October in Seattle, both in 2010.

While it is largely assumed that residents in Seoul might walk more than those in Seattle, this paper reveals empirical walking patterns and neighborhood features, and provides their implications, by comparing the two cases. The findings and interpretations of this paper would contribute to inspire future international comparative studies and to enable more in-depth explanations about the relationships between built environments and physical activity.

2. Material and Methods

2.1 Research Design

The existing studies of international comparisons have applied similar methodologies, which investigate the relationships between self-reported physical activity and perceived neighborhood environment, using survey questionnaires, such as IPAQ. For this paper, however, the built environment was objectively measured using GIS and confirmed by experts' audit, while the physical activity was objectively assessed using GPS, and checked with a travel diary.

These research methods were adopted from the Travel Assessment and Community (TRAC) project at the University of Washington, in which the GPS device and other tools had been already pre-tested for use. The same devices were purchased and pre-tested in the Korean context, while the questionnaires, travel diary and subject instructions were translated for Korean participants. Comparable GIS data on the built environment were also identified. GPS data were processed and displayed on the ArcGIS program.

As for participant groups, thirty Korean and thirty Korean-American housewives, aged between their 20s and 50s were recruited from two case neighborhoods respectively in Seoul and Seattle. With the socio-demographic variables controlled, participants' physical activities for seven days were collected and detailed characteristics of the built environment in each case neighborhood were drawn in relation to the activity patterns. Qualitative methods were applied. Walking destinations and route characteristics were examined in particular, as identifying mechanisms of activity-supportive neighborhood environments.

Concurrent with wearing GPS, approved by the Institutional Review Boards at both Universities, participants collected GPS records for seven days and completed a seven-day travel diary.

2.2 Selecting Participants and Case Sites

For comparison purposes, Korean and Korean-American housewives were selected as participants for each case neighborhood respectively in Seoul and Seattle. Korean-American participants were those first generation Korean immigrants in Seattle, who had been born in Korea and then later immigrated to Seattle. They are likely to share similar cultural backgrounds with Korean participants in Seoul, but are exposed more to auto-oriented
built environments. Selecting the two groups was intended to examine how exposures to different built environments might affect physical activity patterns differently.

The participants of this study are full-time housewives. The intention in selecting this focus group is because they spend more time in their neighborhoods than other population groups. Also, given the tasks of participating in this research, such as carrying two devices (GPS and accelerometer) and writing a seven-day travel diary, etc., this focus group would be able to fulfill the tasks. Furthermore, other conditions for being selected as participants include 'Have lived within one of the designated study neighborhoods for at least 3 months' 'Able to walk outside their home', and 'Not have a full-time job' etc. This research went through proper reviews by the Institutional Review Board at each university.

In order to draw the maximum interpretation of the built environment characteristics, two representative neighborhoods of contrasting residential sites were selected in Seoul. Urban form features and housing types were considered based on two criteria: 1) Gradually and incrementally evolved traditional single-family (Dan-dok) and multi-family (Da-se-dae) housing type areas versus planned high-rise apartment complexes (Go-cheung Apt); and 2) Grid street pattern versus curved/branch pattern. According to these criteria, two residential neighborhoods were selected in Seoul: Gahoe-dong and Sanggye7-dong.

A set of two contrasting residential sites was also selected in the Seattle Metropolitan area, which would match relatively well with Seoul's pair in terms of street patterns and housing density. These are 1) old urban residential neighborhoods of grid street patterns versus new suburban residential neighborhoods of cul-de-sac street patterns 2) relatively higher housing density versus relatively lower housing density in the Seattle context. Two residential neighborhoods were selected accordingly. These are the Seattle/Shoreline area and the Outside Seattle/Shoreline area. Configurations of the selected case sites with seven built environment elements are summarized in Table 1 and are explained in the following Section 3.

3. Built Environment Characteristics

From the previous studies of auditing neighborhood walkability, seven built environmental elements were drawn to describe the physical characteristics of the case sites (Park et al., 2008, 2011). For population and household density, representing the number of persons per the areas of km$^2$, census data and administrative boundaries were used for Seoul sites, while block level data from the US Census Bureau were used for Seattle sites. Average lot size (m$^2$) and block size (m$^2$) were calculated with residential use parcels and blocks. Street connectivity was defined and measured as density of intersections. As significant facilities of walking destinations which attract more walking than others, large parks greater than 30,000 m$^2$ (4.9 acres) and commercial districts were selected and their presences within a certain radius (1~1.5 km) from home locations as well as the center of the sites were identified with GIS data.

Walking destinations and route characteristics, among others, are largely regarded as critical attributes of neighborhood walkability (Park et al., 2008, 2011). Considering the built environment elements, walking destinations are closely related to land use mix, access to large parks and access to neighborhood commercial districts. Population and household densities are closely associated with the intensity of commercial land use.

Route characteristics, on the other hand, are closely related to average lot sizes and block sizes as well as intersection densities of the sites, representing street connectivity. The physical characteristics of the selected case sites through seven built environmental elements could be summarized as follows.

Average population and household density measures of Seoul neighborhoods are more than twice those in Seattle sites. The lowest density is shown in the Outside Seattle/Shoreline area, whose order was followed by the Gahoe site, Seattle/Shoreline area, and then Sanggye site. Also, there are significant differences between the two sites of one city, which, in fact, deserve more attention than the comparisons of the differences between the two cities. For example, average lot size and block size are two to three times bigger between the two Seattle sites, as one is 549 m$^2$ and the other is 1,380 m$^2$. In Seoul, on the other hand, the intersection density, representing the street connectivity is much lower in the Gahoe site with 218/km$^2$ than in the Sanggye site with 399/km$^2$. All case sites are located within a 1.5km radius boundary from the large parks, but the accessibility to commercial districts is lower in the Seattle case, which reflects the greater separation of land uses (Table 1).

<table>
<thead>
<tr>
<th>Built environmental variables</th>
<th>Seoul, Korea</th>
<th>Seattle WA, United States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population Density (Number of persons)</td>
<td>13,217</td>
<td>36,739</td>
</tr>
<tr>
<td>Household Density (Number of households/km$^2$)</td>
<td>5,462</td>
<td>14,845</td>
</tr>
<tr>
<td>Lot Size (m$^2$)</td>
<td>235</td>
<td>1,680</td>
</tr>
<tr>
<td>Block Size (m$^2$)</td>
<td>4,509</td>
<td>5,816</td>
</tr>
<tr>
<td>Street Connectivity (Number of intersections)</td>
<td>218</td>
<td>399</td>
</tr>
<tr>
<td>Access to Large Park (Percentage of yes)</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Access to Commercial District (Percentage of yes)</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Park et al., 2011, 61p
Table 2. Percentages of Building/Parcel Main Use by Site and by Country (Park et al., 2011, p. 62)

<table>
<thead>
<tr>
<th>Building (Korea)/Parcel (USA)</th>
<th>Seoul, Korea</th>
<th>Average</th>
<th>Seattle/WA, United States</th>
<th>Outside S/S</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gahoe</td>
<td>Sanggye</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residential</td>
<td>58.5</td>
<td>60.1</td>
<td>59.3</td>
<td>56.6</td>
<td>56.7</td>
</tr>
<tr>
<td>Institutional/Religious/Public</td>
<td>4.2</td>
<td>8.1</td>
<td>6.15</td>
<td>18.8</td>
<td>6.7</td>
</tr>
<tr>
<td>Commercial</td>
<td>23</td>
<td>25.6</td>
<td>24.3</td>
<td>8.0</td>
<td>6.1</td>
</tr>
<tr>
<td>Recreational</td>
<td>2</td>
<td>0.2</td>
<td>1.1</td>
<td>2.3</td>
<td>9.0</td>
</tr>
<tr>
<td>Office</td>
<td>5.8</td>
<td>3.6</td>
<td>4.7</td>
<td>2.9</td>
<td>7.1</td>
</tr>
<tr>
<td>Others</td>
<td>6.4</td>
<td>2.5</td>
<td>4.45</td>
<td>11.4</td>
<td>12.7</td>
</tr>
</tbody>
</table>

*Difference in data availability in two countries led to building/parcel main use analysis: land use data available for buildings in Seoul, and for parcel level data in Seattle WA.

Fig. 1. Main Building Use of Gahoe and Sanggye in Seoul, Korea (Park et al., 2011, pp.63-64)

Fig. 2. Parcel Main Use of Seattle/Shoreline and outside Seattle/shoreline, USA (Park et al., 2011, pp.66-67)
The percentages of each land use and building’s main use categories also vary for each case site and for residential buffer areas. While the percentage of residential and office land uses is similar (about 60% and 5% respectively) in both the Seoul and Seattle cases, the share of commercial land use in Seoul sites was more than three times higher than that of Seattle sites. Commercial uses include neighborhood commercial areas, cafés and restaurants etc. As commercial uses provide attractive walking destinations, the case sites in Seoul possess more potential for walking activities within the neighborhood boundary than the Seattle case sites do (Table 2).

In particular, it is noticeable that neighborhood commercial areas are well integrated into residential uses in the Gahoe site. And, it is also a merit that Seoul’s city center commercial district is located near the south side of the Gahoe neighborhood boundary. Within the apartment complexes in the Sanggye site, commercial areas are located along the main street of the complexes. And, regional commercial districts with large department stores are located near the north side of the Sanggye neighborhood boundary. Fig. 1. shows these conditions in the Gahoe and the Sanggye sites.

In contrast, selected neighborhood sites in the Seattle case have relatively few commercial areas in general as seen in Fig. 2. Although a portion of the commercial district, featured in the Seattle/Shoreline map occupies a large area, the majority of this area consists of parking lots with automobile spaces.

Institution/religious/public uses and recreational uses, on the other hand, occupy a greater percentage of land in the Seattle case, compared to those in the Seoul case. The Sanggye site shows the highest percentage of commercial land uses, while the area outside Seattle/Shoreline shows the largest portion of recreational uses, as seen in Fig. 1., Fig. 2., and Table 2.

4. Physical Activity Characteristics

Among meaningful research findings, a most noticeable one concerns the total amounts of walking trips. There are remarkable differences in frequency and total distance of walking trips between the case sites of Seoul and Seattle. Korean participants in the Seoul case walk about 2.6 kilometers per day on average in and around their neighborhoods, which is equivalent to about 39 minutes of outdoor walking per day. Korean-American participants in the Seattle case, on the other hand, walk less than about 400 meters per day on average in and around their neighborhoods, which is approximately 6 minutes of outdoor walking per day. Accordingly, average walking distance per tour is also greater for Korean participants in the Seoul case (1,342 meters) than for the Korean-American participants in the Seattle case (940 meters), as seen in Table 3.

<table>
<thead>
<tr>
<th>Table 3. Amount of Walking Trips</th>
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<tbody>
<tr>
<td><strong>Item</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Frequency of total trips per week</td>
</tr>
<tr>
<td>Numbers of walking trips per week</td>
</tr>
<tr>
<td>Average walking distance per trip (m)</td>
</tr>
<tr>
<td>Average walking distance per day (m)</td>
</tr>
</tbody>
</table>

**Average walking distance per day or per trip includes walking trips and also includes those using public transit or non-motorized transportation modes, such as bicycles.

<table>
<thead>
<tr>
<th>Table 4. Walking Frequency by Purpose and Walking Distance (SS = Seattle Shoreline)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Korean</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Frequency (per week)</strong></td>
</tr>
<tr>
<td>Utilitarian walking</td>
</tr>
<tr>
<td>Multipurpose walking (utilitarian + recreational walking)</td>
</tr>
<tr>
<td>Recreational walking</td>
</tr>
<tr>
<td>Total (week)</td>
</tr>
<tr>
<td><strong>Distance (per week)</strong></td>
</tr>
<tr>
<td>Utilitarian walking</td>
</tr>
<tr>
<td>Multipurpose walking</td>
</tr>
<tr>
<td>Recreational walking</td>
</tr>
<tr>
<td>Total (week)</td>
</tr>
</tbody>
</table>
While Seoul participants make walking trips farther than the 800m boundary limit, about 12.77 times per week, Seattle participants make such trips, about 1.93 times per week. The difference in walking frequency responds to the difference in average walking distance between the cases of Seoul and Seattle (Table 5.).

Another remarkable finding is related to the types and purposes of walking. Recent studies done in North America have differentiated utilitarian walking and recreational walking, and have revealed that there existed different correlates of walking between the two walking types (Lee and Moudon, 2006).

This study also confirms that utilitarian walking and recreational walking are likely to take place in different settings of neighborhoods, in which the degree of land-use mixes plays a critical role. In Seattle sites, for example, mixed land uses are much less common, compared to those in Seoul sites. While there exist great differences between the cases of Seoul and Seattle, this study also recognizes that utilitarian and recreational walking trips within Seoul sites themselves do not show great differences from one another.

With this and other conditions, 70% of the total walking amounts by the Korean participants in Seoul sites are for utilitarian purposes, while 50% of them are for recreational purposes for Korean-American participants in Seattle sites.

5. Discussions

In Seattle sites, recreational walking and utilitarian walking each occur on distinctively different routes and time zones, while those two walking types are often observed in the same routes as combined activities in the case of Seoul. This implies that land use mix is critical to facilitate walking type behaviors. In the case of Seattle, shopping malls, department stores, supermarkets, as well as neighborhood commercial shops, which are accompanied by huge shared parking lots, are designed to be separated from residential areas and public parks. In the case of Seoul, on the other hand, neighborhood commercial shops and small open spaces such as playgrounds within easy walking distance are well integrated into the residential neighborhoods (Table 4.).

In order to better understand walking behaviors and surrounding built environments, it is necessary to look carefully at how many different stopping points are dropped by participants during each trip and how diverse the types of those stopping points are.

Korean participants in Seoul sites were observed to drop by at least two stopping points on average during one walking trip from home to home, which culminated in about a total of 10.5 different types of stop visits per week. This means that there are many accessible and various destinations by walking due to the greater land use mixes in residential areas in Seoul sites, compared to those in Seattle (Table 5.).

Compared to this phenomenon in Seoul sites, Korean-American participants in Seattle sites were observed to rarely drop by anywhere during their walking trips, which contain less than one stopping point. The types of shop destinations were also very limited in Seattle sites. This indicates that utilitarian walking is more prevalent in Seoul sites, while recreational walking is a major source of walking trips in Seattle sites (Fig.1., 2.; Table 4., 5.).

Between the two sites of the Seattle case, however, a larger number and more diverse type of destinations were identified in the Seattle/Shoreline (SS) site than outside the Seattle/Shoreline (Outside SS) site. As expected, this reflects the differences in land use mixes, population and housing densities, and accessibility of destinations within Seattle sites. For example, one participant, who resided in the relatively old and urban SS site, walked to a fitness center in the neighborhood, and after working out, on the way home, she dropped by an organic grocery store and then by a dry cleaner's, located near her home. This type of walking was not identified in the relatively new and suburban Outside SS site. Walking patterns there were rather simple. If a participant walked to one place, she returned home without stopping by any other places. Multiple tasks during one trip were largely done by car.

In the daily lives of both Korean and Korean-American participants, most significant walking activities were commonly related to grocery shopping and to walking children to schools and nurseries (Table 6.). Both participant groups visited several different places for grocery shopping to meet their diverse needs for goods. However, their travel modes used for grocery shopping differed from one another. In Seoul sites, for example, about 75% of grocery shopping happened in and around the neighborhood by walking, which was closely related to the built environment characteristics, such as higher density, more mixed uses, smaller block and lot sizes, denser street connectivity, and more public transit.
In Seattle sites, on the other hand, only 17% of grocery shopping happened in and around the neighborhood by walking. When Korean-American participants went shopping, they drove to discount stores outside the neighborhood, and stopped by restaurants or a friend’s house on their way back home. They even drove to grocery stores within their neighborhoods. When Korean-Americans happened to walk to neighborhood supermarkets, they tended to do shopping only there and did not combine any other walking activities during one trip.

Utilization patterns of parks and public transportation stations, among others, were also remarkably distinctive, which revealed the differences in walking activities between Korean participants in Seoul sites and Korean-American participants in Seattle sites. Both participant groups preferred large attractive parks to small neighborhood parks. However, in Seoul sites, 98% of participants use the parks within the neighborhood walking boundaries, while only 26% of Korean-American participants do so in Seattle sites. Most Korean-American participants drove a few miles to parks with more amenities and attractiveness, and then walked there. This indicates that the presence of neighborhood parks with amenities is critical in Seoul sites, where driving is less convenient and a limited number and types of recreational resources are provided.

The level of providing public transit services also brought different walking patterns between Seoul and Seattle sites. In Seoul sites, for example, participants used the public transportation stations within the neighborhood boundary about 3 times on average per week. As expected, participants in Seattle sites rarely use public transit stations, because they are not conveniently provided. For Seattle participants, driving a car is a more convenient and efficient mode of travel than is riding public transit. In contrast, public transportation systems in Seoul provide a sufficient level of services throughout the city.

In average residential areas of Seoul, there is a subway station within 1km and a bus stop within 300 meters. Transfers and waiting times are relatively easy and shorter than those in Seattle sites. This resulted in public transit stops ranking high as frequently visited walking destinations in Seoul sites. This means that a high level of public transit service provision encourages more walking in neighborhoods.

6. Conclusion

Existing studies, mostly conducted by North American scholars, suggested physical activities are related to the built environment characteristics, such as finely-grained street networks, human-scaled lots, and diverse pedestrian destinations, etc. This paper recognizes that these characteristics of neighborhood features operate similarly for residents’ walking activities in the Seoul and Seattle contexts. However, this paper supplements that the amount and frequency of neighborhood walking activities, as well as the fineness of neighborhood features are remarkably different between Seoul and Seattle sites. Differences in walking patterns are closely associated with the differences in the built environment characteristics of Seoul and Seattle sites.

Among others, neighborhood commercial areas, small open spaces, and large parks, as well as public transit stations are relatively more accessible on foot in Seoul sites than they are in Seattle sites. With these, this paper confirms that Korean participants in Seoul walk more than do Korean-American participants in Seattle in and around their residential neighborhoods.
This paper also explains that due to differences in the built environment characteristics, the major walking type of Korean participants in Seoul sites is utilitarian, while that of Korean-American participants in Seattle sites is recreational.

This paper could be regarded as an early stage of international comparative studies, in order to explore more in-depth relationships between the neighborhood built environment and physical activity. As the studies of cross-cultural comparisons on the association of physical activity and the built environment have been relatively rare so far, this paper contributes to bringing broader and more diverse perspectives to current researches on walkable neighborhoods locally and globally.

By using a GPS device, this paper also tests a new research method of more objective data collecting tools than previous studies did. This paper confirms that this method is very useful and could supplement the existing researches on walking patterns and built environment in Korea, which largely relied on self reported survey data.

This study focused on walking patterns of housewives in their 20s through 50s and the sample size is relatively small. Although the actual GPS data, analyzed were those of 210 days and of about 720 routes respectively in the Seoul and Seattle cases rather than those of 30 participants, it has certain limits in generalizing the overall walking behaviors of larger populations. It also has limits in inferring a direct causality between the built environment and physical activity, as this paper was largely based on qualitative methods. Also, it may be a small issue, but there exists a need to overcome a certain inaccuracy of location information from the GPS between high-rise buildings in Seoul. These are to be modified further in future studies.

In spite of these and other limits, this paper could become a meaningful foundation for future researches in the fields of public health, urban planning, physical education, leisure studies and other related disciplines.

Acknowledgement

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Note

As a pilot study, this research collected data from 30 participants in each case, which might seem a low number of subjects for statistical analyses. Although the number of participants is 30 in each case, the data attributes are based on those participants' walking patterns of 24 hours for seven days, collected by a GPS device and travel logs. As this research focuses on walking destinations and walking routes, for example, the actual data analyzed were 210 days' or 720 routes' rather than 30 subjects'. This kind of approach is common in similar pilot studies utilizing GPS tools. For example, Wiehe et al. (2008) analyzed adolescents' 100 day travel patterns with the GPS data of 15 participants, while Troped (2007) analyzed a total of 29 bouts of moving activities with 10 adults. More than 10 participants seem acceptable in recent pilot studies of activity sensing, based on GPS, because this device provides richer data sets of space-time attributes, empirically reflecting the locations, routes, and activity characteristics. Besides, this research was not based on vigorous statistical analyses, proving causality. It relied largely on qualitative methods of site observations and interpretations, describing patterns.

References