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Exploring the Objective and Perceived Environmental Attributes of Older Adults' Neighborhood Walking Routes: A Mixed Methods Analysis

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Abstract

Walking is a central form of physical activity among older adults that is associated with the physical environment at various scales. This mixed-methods study employs a concurrent nested design to explore objective and perceived environmental characteristics of older adults' local walking routes. This was achieved by integrating quantitative Geographic Information System (GIS) data with qualitative data obtained using the Stanford Discovery Tool (DT). Fifty-nine community-dwelling middle-aged and older adults (14 men and 45 women aged 50+) were recruited in a snowball approach through community centers in the city of Haifa (Israel). Four neighborhood environment themes were identified: pedestrian infrastructure, access to destinations, aesthetics, and environmental quality. Both geometrical traits (i.e., distance, slope) and urban features (i.e., land-uses, greenery) of the route may impact the experience of walking. The findings thus highlight the importance of micro-scale environmental elements in shaping environmental perceptions, which may consequently influence the choice of being active.

Keywords

neighborhood; GIS; walking; content analysis

Walking is a form of physical activity (PA) that most people can easily adopt and participate in given its low level of exertion and relatively low cost. These characteristics make walking especially attractive for older adults; indeed, although PA declines with age (Baptista et al., 2012; Garriguet, Janssen, Craig, Clarke, & Tremblay, 2011; US Department of Health and Human Services, 2008), walking is among the most common forms of PA among older adults (Merom, Cosgrove, Venugopal, & Bauman, 2012). In addition to its benefits for physical health (Lee & Buchner, 2008; Manson et al., 2002), walking provides a range of psychological and social benefits, for example, by reducing the risk for anxiety and depression (Pasco et al., 2011), as well as loneliness and social isolation (Reed, Crespo, Harvey, & Andersen, 2011). Finally, from a broader anti-ageist social policy perspective, and as part of "Active Aging" and "Age Friendly Cities" initiatives, walking can contribute to the visibility and social participation of older persons (Beard & Petitot, 2010; Plouffe & Kalache, 2010).

In recent years, a growing body of evidence emphasizes the role of the physical environment in the promotion of walking and other forms of PA (Frank, Engelke, & Schmid, 2003; Saelens, Sallis, & Frank, 2003; Van Cauwenberg et al., 2011). Several environmental elements have been associated with PA and particularly walking in general populations as well as among older adults, such as: street connectivity (Gómez et al., 2010; Li, Fisher, Brownson, & Bosworth, 2005; Rosso, Auchincloss, & Michael, 2011), land-use mix/access to destinations (Koohsari, Sugiyama, Lamb, Villanueva, & Owen, 2014; Lee & Modoun, 2006), access to recreational facilities (Fisher, Li, Michael, Cleveland, 2004; Gómez et al., 2010), aesthetics (Sugiyama, Neuhaus, Cole, Giles-Corti, & Owen, 2012), and overall walkability, as defined by an index based on residential density, street connectivity and land-use mix (Carlson et al., 2012; Van Holle et al., 2014). In addition to these environmental elements, older adults' PA and walking have also been associated with several aspects of the perceived environment, such as: access to recreational (Booth, Owen, Bauman, Clavisi, &

Leslie, 2000; Chad et al., 2005; Li, Kao, & Dinh, 2015) and commercial facilities, personal safety (Giehl, Hallal, Brownson, & d'Orsi, 2016; Gómez et al., 2010; Piro, Noess, & Claussen, 2006), and aesthetics (Cerin et al., 2014; Hoehner, Ramirez, Elliott, Handy, & Brownson, 2005).

The associations between objective and perceived environmental characteristics have been well researched, mostly by using quantitative measures of the perceived environment (obtained through “closed” survey items and scales) (Adams et al., 2009; Carlson et al., 2012; Leslie et al., 2005). However, relatively few studies combined objective environmental measures with qualitative data on the perceived environment (Brown, Werner, Amburgey, & Szalay, 2007; Christensen, Mikkelsen, Nielsen, & Harder, 2011; Holt, Spence, Sehn, & Cutumisu, 2008; Montemurro et al., 2011; Spessot, 2015; Strath, Isaacs, & Greenwald, 2007), and most of those studies relied on the home-neighborhood approach. This approach seeks to associate environmental characteristics of residential areas with residents' perceptions and behaviors (Leslie et al., 2007; Cerin et al., 2014) often by comparing qualitative data on residents' neighborhood perceptions between high- and low-walkable neighborhoods (Holt et al., 2008; Strath et al., 2007). The home-neighborhood approach relies on the assumption that people spend a large portion of their time in their neighborhood, which is likely to be the case among older adults, due to increased leisure time and age-related mobility decline.

While spatial quantitative measures typically used in the field yield rigorous objective data on the built environment, these measures often fall short in describing the resident's subjective experience of the environment. Similarly, paper-and-pencil questionnaires that have been developed to capture individuals' perceptions of their neighborhoods typically require individuals to recall neighborhood experiences away from the neighborhood context. Spatial qualitative methods, on the other hand, provide in-depth subjective information contextualized *in situ*. When compared to general questionnaires or indoor interviews (i.e., individual and/or focus groups), spatial qualitative methods (i.e., PhotoVoice, observations, walk-along interviews, and virtual reality experiments) have been found to better reflect the unique environmental needs of older adults (e.g., access to resting areas) (Moran et al., 2014). However, studies employing spatial qualitative methods often lack objective built environment data, which is essential to link subjective experiences and actual environmental conditions. The current study addresses this gap in the literature by integrating quantitative and qualitative methodologies to investigate older adults' walking routes. To achieve this, the research instrument chosen for this study was the Stanford Healthy Neighborhood Discovery Tool (henceforth the Discovery Tool [DT]), an electronic tablet-based mobile application that allows the documentation of neighborhood features through geo-coded photographs and audio narratives and GPS-tracked walking routes (Buman et al., 2013).

The present study explored objective and perceived environmental characteristics of routes along which older adults walk in their daily routines. Specifically, the study's aims were to: (1) measure objective environmental attributes of routes along which older adults regularly walk; (2) describe older adults' perceptions concerning environmental barriers to and facilitators of walking along routes that they regularly use; and (3) examine the associations

between objective environmental attributes of walking routes with perceived barriers/facilitators to walking.

Methodology

Study Design

This mixed-method study used a concurrent nested design (Terrell, 2012). Data collection was predominantly qualitative, consisting of participants walking route assessments by the DT, with an embedded quantitative data collection method, consisting of the Global Positioning System (GPS) tracking routes. The GPS routes were then coded into a geographic information system (GIS) in order to calculate environmental measures (aim 1) and the DT's outcomes went through qualitative content analysis (aim 2). The third study aim was addressed by converting the content analysis outcomes into quantitative variables and then correlating them with the GIS-based environmental measures.

The current study was part of a broader initiative of JDC Israel Eshel to engage older adults in promoting healthy lifestyles and age-friendly environments at the local level (Moran et al., 2015). This initiative is part of an ongoing international project named “our voice”, coordinated by the Stanford Healthy Aging Research and Technology Solutions Laboratory at Stanford University School of Medicine (King et al., 2016). One of the goals of these initiatives, among others, was to examine the usability of the DT among its potential end-users, namely older adults. Correspondingly, our study mainly targeted older adults, but a few middle-aged adults were also included, as they constitute tomorrow's older adults, who are also potential end-users of the DT and who are likely to differ from today's older adults in their technological needs and capabilities.

Study Area and Participants

The study was conducted in the city of Haifa, the largest city in northern Israel, the third largest city in the country (273,177 inhabitants) and demographically the oldest (19.1% of its population above the age of 65 compared to 10.4% nationally) (Brodsky, Shnoor, & Be'er, 2014). The city of Haifa is located on the Carmel mountain ranges adjacent to Israel's coastline. In order to represent the diverse population of the city, different neighborhoods were selected based on area socio-economic rank¹ (SER) (Israeli Central Bureau of Statistics [ICBS], 2008) ranging from 1–10, where 1 represents the lowest and 10 the highest SER within the city. The four neighborhoods with varying areal SERs were: *Carmel* (SER ranging from 6–8), *Neve Shaanan* (SER ranging from 5–6), *Kiryat Eliezer* (SER ranging from 3–4), and *Halisa* (SER ranging from 1–3). With respect to the analyses, based on their SER values, *Carmel* and *Neve Shaanan* were defined as high-SER, and *Kiryat Eliezer* and *Halisa* were defined as low-SER neighborhoods.

A convenience snowball approach was used to recruit participants through community centers in each neighborhood area. Consistently with that approach, eligible individuals were at least 50 years of age, lived independently in the community, and regularly walked in

¹A composite index calculated per area administrative units that integrates information regarding: demography, labor force, education, and social welfare.

their neighborhood. Participants were recruited by the last author and a local nongovernmental organization (NGO) worker in various ways, including (1) presentation of the study to seniors at senior centers and at health-related group activities (e.g., walking groups, tai-chi and yoga classes), (2) flyers posted and distributed in senior centers, (3) mailing lists, and (4) word of mouth within the senior community. A total of 59 study participants were equally distributed across the study area, with 13–16 participants residing in each of the four neighborhoods. Participants were told they would participate in a three-phase program. In the present study we present findings pertaining to the documentation of neighborhood features. In our additional work (reported elsewhere: Moran et al., 2015), we use focus groups to analyze the findings and community activism to dialogue with the municipality and promote the neighborhood walking based on the findings.

Qualitative Assessment of Walking Routes

Qualitative assessment of walking routes was facilitated by the DT, which has been developed and subsequently refined through collaborations between researchers at the Healthy Aging Research and Technology Solutions laboratory of the Stanford Prevention Research Center, Stanford University School of Medicine, California, and community and research partners in the US and other countries. A detailed description of the tool and how it has previously been used is provided elsewhere (Buman et al., 2012, 2013, 2015; Moran et al., 2015; Seguin et al., 2015).

Each participant conducted one daytime walk that was initiated from his or her home, and lasted approximately 60 min. A trained, local NGO worker accompanied individuals during the walks, which occurred between March and August 2014. Prior to the walk, participants received a brief training (5–10 min) on how to use the DT, and were then asked to choose a route along which they regularly walk (for either leisure or utilitarian purposes). Throughout the walk, they documented environmental elements that they perceived enhanced or hindered walking by using the DT to record photos and audio narratives. After the walk, participants completed a brief survey embedded within the DT concerning demographics and other psychosocial variables. Institutional approval for this study was received from the university's ethics committee, and all subjects provided written informed consent prior to taking part in this study.

Analysis

Data were analyzed using three different approaches. First, GIS analysis was employed to assess the physical environment of the routes along which the participants walked. Second, content analysis of audio-narratives obtained by participants using the DT was conducted to identify perceived environmental barriers and facilitators to walking. Finally, correlation analysis was conducted to identify associations between GIS-based environmental measures with the content analysis outcomes. To explore SES differences, all of the analyses were repeated across the four neighborhoods separately, and by comparing between high- and low-SER neighborhoods.

GIS analysis of the walking routes—GPS tracks of the walking routes were downloaded from the DT and converted into a GIS layer representing the 59 routes along

which the walking audits were conducted. The GIS data was then analyzed (using ESRI ArcGIS 9.3, Redlands, CA) to obtain objective environmental measures of the walking routes that the residents chose.

Two types of environmental measures were examined: geometrical attributes and streetscape variables. Geometrical attributes included the route length (in meters) and slope (in degrees). The route slopes were calculated within a 2-m buffer along each route by surface analysis of an elevation raster file that was interpolated by inverse distance weight (IDW) from point entity elevation data. The route length was calculated by integrating the route over the elevation raster (by using surface analysis in ArcGIS). The geometrical attributes were chosen due to their potential associations with perceptions of the environment (no hypotheses were specified in advance).

Streetscape attributes consisted of land uses and greenery, assuming that these elements shape the streetscape along the route by distinguishing, for example, between inner-city and residential areas. All streetscape attributes were measured within a 25-m buffer along the route. Three types of streetscape variables were examined: (1) greenery: the percent of land area along the route covered with greenery (i.e., trees, grass, bushes, hedges etc.); (2) discrete land-use measures: the percent of land area along the route covered by distinct land uses, including residential, retail, public institutes and open area; and (3) mixed land-use index: calculated by the entropy formula, which results in a score ranging from 0–1, with 0 representing a single-land use homogenous area, and 1 representing highly mixed land-uses. A detailed description of the formula is provided elsewhere (Leslie et al., 2007). These streetscape variables were chosen based on previous literature suggesting their associations with perceptions of the environment (e.g., Adams et al., 2009; Leslie et al., 2005; White & Gatersleben, 2011).

Content analysis—Audio narratives were downloaded from the DT and coded for qualitative-quantitative data analysis. First, a qualitative content analysis was conducted to identify themes/subthemes, and then descriptive statistics were generated for those themes/subthemes. It is important to clarify the terminology used in this paper. The term “subthemes” refers to the specific environmental elements that were described by participants during data collection. The term “themes” refers to the content analysis outcomes that were created by grouping together similar “subthemes”. The term, “theme summary variables” refers to quantitative variables that were created by adding up similar subthemes for the sake of correlation analyses.

Content analysis was conducted using a hybrid approach; a deductive approach was applied wherein audio narratives were coded according to a predetermined framework of themes/sub-themes identified in the literature (Buman et al., 2013; Moran et al., 2014). Throughout this analysis, new themes were added when needed according to the participants’ narratives. Each theme/sub-theme was coded as either a barrier or facilitator depending on the context in which it was described. Correspondingly, the analysis yielded two sets of themes/subthemes, one of which included environmental barriers and the other that included facilitators of walking.

The content analysis was carried out in two stages. First, two researchers (the fourth and fifth authors) independently read and coded the transcripts to link them with the aforementioned predetermined list of themes and subthemes (Buman et al., 2013; Moran et al., 2014). Then, the first author met with the researchers to compare their lists of themes, and any discrepancies were resolved by reviewing and discussing the data. The same process was repeated in each neighborhood.

After the content analysis was accomplished, descriptive statistics were calculated for all of the themes/subthemes. The content analysis outcomes were converted into a quantitative data by first counting the occurrences of subthemes and then creating theme summary variables by adding up the counts of similar subthemes. The following four descriptive measures were calculated for all subthemes and theme summary variables: frequency, mean, standard deviation, and range. The theme summary variables were later used for correlation analysis.

Correlation analysis of GIS and qualitative data—To address the third aim of the study, GIS data of the route characteristics were combined with the content analysis outcomes. Pearson correlation analysis was performed to assess associations between objective GIS-based environmental measures of the routes with perceived environmental barriers/facilitators (as represented by their frequencies). Prior to the correlation analysis, all continuous variables (GIS-based environmental variables and theme summary variables) were transformed into natural logarithms where necessary to meet the assumptions of homogeneity of variance and normality. All of the statistical analyses were performed with SPSS 21.0 (IBM, Armonk, NY).

Results

Table 1 presents the sociodemographic characteristics of the participants and provides several differences between the four neighborhoods. Most of the participants were women (76%), and older than 65 years (80%, with 20% [$n = 12$] aged 50–64 years). Ethnicity and level of education varied across the four neighborhoods. While all of the participants from Halisa neighborhood were Arab ($n = 16$), in the remaining three neighborhoods most of the participants (80–100%) were Jewish. Half of the participants had some college or academic education, 20% had high school education, and 30% had less than high school education. Level of education varied significantly across the four neighborhoods, and a positive association was observed between neighborhood SER and participants' level of education ($\chi^2 = 20.69$, $p < .001$), supporting that participants from lower SER neighborhoods were less educated than those from higher SER neighborhoods.

Objectively Measured Environmental Attributes of the Walking Routes

Table 2 presents GIS-based environmental variables of the walking routes across the study area, including the geometrical and streetscape attributes. On average, participants walked 822 m per single route; the shortest walking route was 153 m and the longest was 2.38 km. Corresponding to the hilly nature of the study area, the average slope was relatively steep, consisting of 6.47 degrees. On average, the most common land-use along the routes was residential (69%), followed by green open space (16%), retail (8%), and public institutes

(7%). On average, 19% of the routes surroundings were covered with greenery. The average value of the entropy index of mixed land uses was 0.19, representing relatively homogenous land uses along the routes. The values of the entropy index range from 0.00–0.69, reflecting the different levels of land-use mix along the routes, from homogenous land uses (most residential) to highly mixed land-uses.

As shown in Table 2, the environmental attributes of walking routes varied across the four neighborhoods, with some differences observed between affluent and disadvantaged neighborhoods. Overall, compared to low SER neighborhoods, walking routes in high SER neighborhoods were longer ($M = 1,110$ vs. $M = 561$, $t[58] = -5.57$, $p < .0001$), and included more greenery ($M = 0.27$ vs. $M = 0.12$, $t[58] = -7.47$, $p < .0001$) and less commercial destinations en route ($M = 0.12$ vs. $M = 0.04$, $t[58] = 1.82$, $p = .074$).

Perceived Barriers to and Facilitators of the Walking Routes

Content analysis—Content analyses yielded four themes and several subthemes that were described as related to walking: (1) pedestrian infrastructure (i.e., sidewalk condition, blocked sidewalks, and street stairs condition), (2) access to facilities (i.e., shops, food-related destinations, healthcare services, and community centers), (3) aesthetics (i.e., building appearance and streetscape, greenery and urban waterscape), and (4) environmental quality (i.e., air quality, noise, litter and messy streets). The four themes and corresponding subthemes are presented in Table 3 and Figure 1, and are described below.

It is noteworthy that all themes/subthemes were commonly reported across all four neighborhoods participating in the study, and no major differences were observed between low and high SER neighborhoods. An exception to this is the subtheme of “high quality of sidewalks” that is described below.

Pedestrian Infrastructure

Participants most frequently described two issues related to pedestrian infrastructure: sidewalk condition and lack of pedestrian space on sidewalks. The features of sidewalk conditions described by participants included: narrow sidewalks, uneven surfaces, cracks and holes, and high curbs. Although most of the participants described poor sidewalk conditions as a barrier, a few participants described high quality of sidewalks as a facilitator by making walking easy and pleasant. High quality of sidewalks was more commonly described in the more affluent neighborhoods (reported by 50% compared to 10% of the participants in high and low SER neighborhoods, respectively). In more hilly areas, street stairs conditions were described mainly as a barrier for walking due to: broken stairs, holes and cracks, and lack of railings and street lighting nearby. Another subtheme, which emerged mainly as a barrier for walking, was lack of pedestrian space on sidewalks due to: parked cars, garbage cans, garbage on sidewalks, and overgrown hedges.

The participants described several ways through which pedestrian infrastructure impacted walking. First, the participants described a strong fear of falling and getting injured, especially for those who were physically disabled and/or use walking assistive devices (see Table 3, 1a and 1c barriers). In addition, the lack of pedestrian space on sidewalks compelled

participants to walk on the road, thereby increasing their risk of getting injured by traffic, as illustrated in Table 3, 1b (barrier). In this context, poor road infrastructure (e.g., cracks, wholes, and uneven road surface) was also described as a barrier, reflecting older adults' fear of falling when walking on the road (due to lack of pedestrian space on sidewalk).

Access to Facilities

Participants described access to various facilities as part of their neighborhood walking routes. These facilities were divided into subthemes based on the opportunities for activities they provided, as follows: commercial facilities (i.e., food-related, shops, and banks), outdoor and indoor leisure facilities (i.e., parks, trails and community centers, healthcare centers, respectively), public transportation (i.e., bus stops), and rest areas (i.e., benches) (see Table 3, 2a–2f).

Greater access to these facilities was described as enhancing walking for both utilitarian and leisure purposes. Specifically, participants mentioned the benefits of easy access to commercial facilities, indoor leisure facilities, healthcare services, and public transportation for daily utilitarian walking (see Table 3, 2a, 2c, 2d, and 2e). They also mentioned the benefits of ease of access to outdoor leisure facilities and resting areas that enhance leisure walking (see Table 3, 2b and 2f). Less access to facilities was described as a barrier to walking, particularly long distances between bus stops, lack of outdoor leisure facilities, and missing or poorly maintained benches (see Table 3, 2b, 2e, and 2f).

Aesthetics

Participants described the aesthetics of their living environment by focusing on three elements: building appearance, streetscape, greenery and urban waterscape (see Table 3, 3a–3d). Beautiful architecture, well-kept building facades, and highly maintained streets and sidewalks were described as enhancing walking by creating visual stimuli and providing nice things to look at while walking. On the other hand, neglected lots, unappealing building facades, and poorly maintained streets and urban landmarks (e.g., statues, water fountains) were described as inhibiting walking by making it unpleasant and boring, as well as decreasing the sense of security in public spaces.

Environmental Quality

Participants mentioned environmental quality mainly as a barrier, while focusing on two issues: traffic-related pollution (i.e., noise, air pollution, traffic jams), and litter and messy streets along the walking routes, specifically on sidewalks and in designated garbage areas. Several traffic-related pollutants (noise, air pollution, and crowded streets) were described as inhibiting walking. Litter and messy streets were mentioned as inhibiting walking in two ways, first, by creating environmental/health nuisances, such as bad smells and attracting insects, and also by blocking pedestrian space on sidewalks.

Descriptive statistics of themes/subthemes—Table 4 provides descriptive statistics of the themes and subthemes (frequency, M, SD, range), while distinguishing between barriers and facilitators. As aforementioned, the four main themes are represented by the theme summary variables, which consist of the sum of the corresponding subthemes. To

illustrate the results presented in Table 4, “litter and messy streets” were described, on average, 1.42 times per participant as a barrier and 0.17 times per participant as a facilitator. Also, sidewalk condition was described at least once during the walking assessments by 68% of the participants ($n = 40$) as a barrier and by 29% ($n = 17$) as a facilitator.

Certain themes were reported mainly as barriers, while others were reported as facilitators. Specifically, pedestrian infrastructure and environmental quality were described by most of the participants as barriers (86% and 75%, respectively), while fewer participants described these themes as facilitators (29% and 32%, respectively). Access to facilities and aesthetics were described by most of the participants as facilitators (66% and 70%, respectively), while fewer participants described these themes as barriers (34% and 37%, respectively). In most cases, these trends were repeated in the corresponding subthemes, except for two cases. Access to public transportation, a subtheme of access to facilities, was reported as a barrier as frequent as it was reported as a facilitator (19% and 17%, respectively), unlike the other subthemes of access to facilities that were mainly reported as facilitators. In addition, building appearance and streetscape, a subtheme of aesthetics, was reported more frequently as a barrier than as a facilitator (24% vs. 3%), unlike the other subthemes of aesthetics that were mainly reported as facilitators.

Correlations Analysis

Pearson correlation analyses were conducted to detect associations between environmental attributes of the routes objectively measured by the researchers (Table 2) with the frequency of themes reported during the walks by participants (Table 4). The routes' geometry was found to be related to perceived facilitators, with facilitators being more frequently described by participants who walked along longer and steeper routes. Specifically, participants who walked longer distances described more facilitators related to pedestrian infrastructure ($r = .30$, $p = .02$), access to destinations ($r = .35$, $p = .007$), and aesthetics ($r = .28$, $p = .03$). Participants who walked along steeper routes described more facilitators related to pedestrian infrastructure ($r = .25$, $p = .06$) and environmental quality ($r = .28$, $p = .03$), and less barriers related to aesthetics ($r = -.22$, $p = .10$). The greenery en route was also related to perceived facilitators, as participants who walked along greener streetscapes described more facilitators related to aesthetics ($r = .29$, $p = .03$). The extent of mixed-land uses along the route was associated with both barriers and facilitators. Participants who walked along more mixed-use streets described more facilitators related to access to destinations ($r = .31$, $p = .02$), but less facilitators related to pedestrian infrastructure ($r = -.24$, $p = .07$). Specifically, participants who walked along routes with more retail land uses described more barriers related to aesthetics ($r = .29$, $p = .03$).

After stratifying the sample into low and high SER neighborhoods ($n = 31$ and $n = 28$, respectively), most of the aforementioned correlations disappeared. However, this may be due to the small sample sizes and/or limited variability of the GIS measures within the two subsamples. An exception was observed in the positive correlations between reported greater access to facilities (as a facilitator) with the land-use mix en route (i.e., the entropy index), which were stronger in low vs. high SER neighborhoods ($r = .48$, $p = .007$, $n = 31$ vs. $r = .28$, $p = .15$, $n = 28$).

Discussion

This study assessed objective and perceived environmental attributes of older adults' walking routes through an innovative mixed-method design. Although previous studies used spatial qualitative methods similar to the one used in our study, such as go-along interviews and PhotoVoice (Mahmood et al., 2012; Mitra, Siva, & Kehler, 2015; Van Cauwenberg et al., 2012), only a few studies combined such methods with quantitative environmental data, and these usually focused on larger neighborhood scales (Chaudhury, Mahmood, Michael, Campo, & Hay, 2012; Oliver et al., 2011). To the best of our knowledge, our study is the first to integrate qualitative and quantitative data at the route scale. Therefore, the current study adds to the existing literature by exploring microscale environmental features of routes along which people regularly walk and documenting perceptions of the routes surrounding while walking. This innovative methodology, integrating quantitative GIS route data gathered by researchers with qualitative audio-narratives obtained en route by participants, yielded rich contextual information concerning older adults' environmental needs for walking.

According to the findings, four neighborhood environment themes were identified during the walking assessments: pedestrian infrastructure, access to destinations, aesthetics, and environmental quality. These themes were found to be associated with both geometrical traits (i.e., route length and slope) and urban features (i.e., land uses and greenery en route).

The study results add to the understanding of the environment-perception nexus by revealing several correlations between objectively measured environmental features and perceptions of the environment at the route scale. In general, participants who walked longer and steeper routes tended to describe more facilitators of all kinds (pedestrian infrastructure, access to facilities, aesthetics). A possible explanation for these findings could be that those who walk along more challenging routes (longer and steeper), also walk more frequently in general, and thus may perceive their environment as more inviting for walking. This explanation is supported by previous studies suggesting that, at least in some populations, walking and other forms of PA are positively associated with hilly areas (e.g., Brownson et al., 2000; Chad et al., 2005) and larger activity space area (e.g., Rantakokko, Iwarsson, Portegijs, Viljanen, & Rantanen, 2015; Rantanen et al., 2012; Tsai et al., 2015). For example, a recent Finish study examined older adults' life-space mobility, defined as the spatial area one moves through in daily life (home, yard, neighborhood, town, and beyond) and the frequency of travel through different areas (Rantanen et al., 2012). According to their findings, older adults' life-space mobility was positively related to objectively measured PA (Tsai et al., 2015), and negatively associated with perceived environmental barriers to outdoors mobility (Rantakokko et al., 2015).

In addition to the routes' geometrical traits, mixed-use streets were found to be associated with perceived facilitators, but also with perceived barriers for walking. The high perceived access to facilities in mixed-use streets is commensurate with previous studies (Adams et al., 2009; Leslie et al., 2005), and validates the use of DT by indicating that participants who walked along commercial streets reported higher access to facilities. The negative perceptions of pedestrian infrastructure and aesthetics in mixed-use streets may be explained by complementary findings of this study (obtained through focus group discussions and

reported elsewhere: Moran et al., 2015), according to which participants described commercial streets as untidy due to litter discarded in the street by business owners, particularly on sidewalks near shop facades. Positive perceptions of aesthetics were found to be associated with greater amounts of greenery en route. These associations add to an extensive body of literature concerning the potential impact of greenery on perceptions of the environment (e.g., Van den Berg, Koole, & van der Wulp, 2003; White & Gatersleben, 2011), walking (e.g., Larsen, Buliung, & Faulkner, 2016; Larsen, Gilliland, & Hess, 2012; Sugiyama, Thompson, & Alves, 2009), and health outcomes (e.g., Sugiyama et al., 2009; Takano, Nakamura, & Watanabe, 2002; Ulrich et al., 1991).

This study is the first to use the DT in Israel, a geographical area less studied in the built environment and PA field, particularly among older adults. Overall, the environmental themes identified in our study correspond to previous studies on the built environment and older adults PA (e.g., Moran et al., 2014; Strath et al., 2007; Sugiyama et al., 2012; Van Cauwenberg et al., 2011, 2012; Yen, Michael & Perdue, 2009). Specifically, several themes that were identified in our study also have been described in DT studies in the United States (Buman et al., 2013; Seguin et al., 2015) and Mexico (Goldman Rosas et al., 2014), such as the importance of sidewalk features, aesthetics, and access to facilities. On the other hand, our study also identified a few environmental attributes that were not commonly reported in previous studies, such as poor road infrastructure, street stairs condition, and overgrown hedges. Interestingly, poor road infrastructure (i.e., wholes, cracks) was described as increasing the risk of falling while walking on the road due to the lack of pedestrian space on sidewalks.

Older adults may develop unique environmental needs due to age-related changes, such as decreased functional capacity and impaired sight or hearing.

This is indeed reflected in some of the themes identified in our study. For example, high curb-cuts and uneven sidewalk surfaces, which were described as barriers in this study, may reflect older adults' limited mobility and fear of falling (as illustrated in quotes presented in Table 3, 1a). Similarly, benches, which were described as both barriers (i.e., missing or poorly maintained benches) and facilitators, may reflect older adults' need of rest during walks (as illustrated in quotes presented in Table 3, 2f).

The neighborhoods in this study included both Jewish and Arab residents and a wide range of SERs. These neighborhoods were chosen to ensure socioeconomic and sociocultural diversity in order to provide a comprehensive and comparative view of the topic being studied. And indeed, several differences emerged between high and low SER neighborhoods, particularly in terms of the routes' objective environmental attributes. For example, participants from more affluent neighborhoods walked longer distances compared to those from disadvantaged neighborhoods. These findings may reflect inequalities in PA, if one assumes that the longer walking distances are associated with higher levels of PA (Tsai et al., 2015). However, the current study did not include data on PA levels, and thus this assumption is yet to be tested. In addition, participants from more affluent neighborhoods walked along streets with more greenery and less commercial destinations (i.e., more suburban streetscapes). These findings reflect the built-environmental conditions across the

study area, and thus may reflect inequalities in walking opportunities when the target group is older adults. While concepts of “walkability” traditionally have grown out of active transport opportunities for working-age adults (Frank et al., 2006; Grasser, Van Dyck, Titze, & Stronegger, 2013; Van Holle et al., 2012), in at least some populations of older adults, more walking has been reported in “less walkable”, more suburban neighborhoods (Merom et al., 2015; Sallis, King, Sirard, & Albright, 2007). Building upon previous studies, it is likely that the greater amount of greenery and other aesthetics in more affluent neighborhoods may enhance leisure PA (Moore, Roux, Evenson, McGinn, & Brines, 2008; Rigolon & Flohr, 2014), while the greater amount of commercial destinations in disadvantaged neighborhoods may enhance travel walking (active transport) in those areas (Goodman, 2013; Turrell, Haynes, Wilson, & Giles-Corti, 2013). Indeed, the purpose of this study’s DT walks differed across the study area, with leisure walking and travel walking being more commonly reported in affluent and disadvantaged neighborhoods, respectively (findings reported elsewhere: Moran et al., 2015).

No differences were observed between high and low SER neighborhoods in terms of the environmental barriers/facilitators to walking reported through the DT. This might indicate that when it comes to walking outdoors, older adults from diverse socioeconomic and sociocultural backgrounds share common concerns. On the other hand, these findings might be attributed to the relatively limited sample size in this study, and thus future research on larger samples is needed in order to address this issue.

Interestingly, perceived access to facilities was significantly related to objectively measured land-use mix en route only in low SER neighborhoods. These results might imply that the link between perceived and objective environmental features is partially attributed to neighborhood-level SER, and/or is enhanced in low SER neighborhoods; however, future research on larger samples is needed in order to produce generalizable results and conclusions concerning this issue.

Several limitations of the current study should be noted. The generalizability of the results is limited due to the small sample size and convenience sampling approach. The sample included Jewish residents from high and low SER neighborhoods, and Arab residents from a low-SER neighborhood. Therefore, the comparability between Arab and Jewish residents in this study is limited, and future research on a larger and more diverse sample may help in isolating findings related to SER from those related to ethnic background. Finally, the DT data were collected during daytime, and thus the participants’ environmental needs for walking after dark might be underrepresented (for example, increased concern related to personal safety).

In conclusion, this study adds depth to the understanding of the objective and subjective dimensions of walking routes among midlife and older adults in a less studied geographic area, and thereby may help in identifying micro-scale environmental elements that encourage daily walking among older adults. The results support the initial utility and cultural transferability of the DT in enabling residents to capture neighborhood features important to walking. According to the results, both geometrical traits (i.e., route length and slope) and urban features (i.e., land uses and greenery en route) may impact the experience

of walking, and thus may also impact the choice of being physically active. Future research may benefit from further exploring these person-environment interactions, and examining their association with overall PA levels and related health and wellbeing outcomes. Finally, from a social policy perspective, this study supports existing calls for developing healthy and age-friendly cities through the investment in urban greenery and aesthetics.

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1. Pedestrian infrastructure (barriers)			
1.a. Holes and cracks in the sidewalk	1.b. cars parking on sidewalks	1.c. overgrown hedge	1.d. broken street stairs

2. Access to facilities (facilitators)			
2.a. food-related destinations	2.b. shopping facilities	2.c. benches

3. Aesthetics (barriers and facilitators)			
3.a. poor condition of statue (barrier)	3.b. beautiful architecture (facilitator)	3.c. Neglected building (barrier)	3.d. Poor condition of water fountain (barrier)

4. Environmental quality (barriers)			
4.a. Litter	4.b. overloaded garbage cans	4.c. heavy traffic

Figure 1.
Selected photos taken by participants with the DT.

Table 1

Sociodemographic Characteristics of the Sample

		High SER Neighborhoods			Low SER Neighborhood		
		Total Sample (n= 59)	Carmel (n=13)	Nave-Shanan (n = 15)	Kiryat Eliezer (n = 15)	Halisa (n = 16)	
Gender	Men	14 (24%)	2 (15%)	2 (13%)	6 (40%)	4 (25%)	
	Women	45 (76%)	11 (85%)	13 (87%)	9 (60%)	12 (75%)	
Age	50-64	12 (20%)	2 (15%)	3 (20%)	2 (13%)	5 (31%)	
	65-74	26 (44%)	5 (39%)	8 (53%)	7 (47%)	6 (38%)	
	75+	21 (36%)	6 (46%)	4 (27%)	6 (40%)	5 (31%)	
Ethnicity	Jewish	38 (65%)	13 (85%)	15 (100%)	12 (80%)	–	
	Arab	19 (32%)	–	–	3 (20%)	16 (100%)	
	Not reported	2 (3%)	2 (15%)	–	–	–	
Education	Less than high school	17 (29%)	–	2 (14%)	3 (20%)	12 (76 %)	
	High school	12 (21%)	3 (23%)	1 (7%)	5 (33%)	3 (18%)	
	College or academic	30 (50%)	10 (77%)	12 (79%)	7 (47%)	1 (6%)	

Abbreviation: SER = socioeconomic rank.

Table 2

Descriptive Statistics of GIS-Based Environmental Variables of the Walking Routes

	High SER Neighborhoods						Low SER Neighborhoods						High-Low SER Comparisons			
	Total Sample (n = 59)			Carmel (n = 13)			Nave-Shanan (n = 15)			Kiryat Eliezer (n = 15)				Halisa (n = 16)		
	Mean (SD)	Range		Mean (SD)	Range		Mean (SD)	Range		Mean (SD)	Range			Mean (SD)	Range	
Route geometry	Length (m)	821.61 (466.49)	152.52–2,377.72	1,053.36 (346.62)	552.52–1,750.05	1,159.96 (548.45)	523.99–2,377.72	575.72 (211.56)	198.83–880.76	546.62 (347.37)	152.52–1,508.26	–5.40 (58)	.0001			
	Slope (degrees)	6.47 (5.90)	0.00–26.48	10.08 (5.15)	4.66–23.93	5.88 (6.68)	0.00–26.48	1.37 (0.59)	0.49–2.29	8.87 (5.27)	0.00–21.36	–1.78 (58)	.08			
Streetscape attributes	Greenery (%)	0.19 (0.11)	0.03–0.51	0.28 (0.09)	0.17–0.51	0.27 (0.07)	0.16–0.38	0.17 (0.09)	0.03–0.31	0.07 (0.03)	0.03–0.11	–7.64 (58)	.0001			
	Retail (%)	0.08 (0.17)	0.00–0.97	0.06 (0.07)	0.00–0.18	0.02 (0.04)	0.00–0.14	0.12 (0.18)	0.00–0.48	0.12 (0.28)	0.00–0.97	1.82 (58)	.07			
	Residential (%)	0.69 (0.30)	0.00–1.00	0.80 (0.13)	0.49–0.93	0.83 (0.12)	0.60–0.97	0.41 (0.26)	0.05–0.87	0.72 (0.37)	0.00–1.00	–0.05 (58)	.10			
	Public institute (%)	0.07 (0.10)	0.00–0.58	0.07 (0.08)	0.00–0.24	0.07 (0.06)	0.00–0.26	0.12 (0.16)	0.00–0.58	0.03 (0.05)	0.00–0.18	0.082 (58)	.94			
	Mixed land-uses	0.19 (0.30)	0.00–0.69	0.38 (0.25)	0.00–0.76	0.26 (0.19)	0.00–0.74	0.47 (0.21)	0.00–0.87	0.19 (0.19)	0.00–0.64	0.043 (58)	.97			

Abbreviation: SER = socioeconomic rank.

Table 3

Themes, Subthemes, and Illustrating Quotes

Themes	Subthemes	Selected Quotes Coded As:
1. Pedestrian infrastructure	(a) Sidewalk condition	Barrier: “A person like me, who walks with crutches, can fall because of the sidewalk’s poor condition and uneven surface” (man, 65–74; see Figure 1[1a]) Facilitator: “This sidewalk is made of interlocking stones, which makes it pleasant to walk on...” (woman, 50–64)
	(b) Blocked sidewalks	Barrier: “Cars parked on sidewalks block the way for pedestrians, who have no other choice than to walk on the road” (woman, 65–74; see Figure 1[1b]) Barrier: “this overgrown hedge spreads into the sidewalk and blocks the way for pedestrians, especially older adults” (man, 65–74; see Figure 1[1c])
	(c) Street stairs condition	Barrier: “these street stairs are broken and need to be fixed. Many older adults climb up and down these stairs, but nobody cares about these broken stairs...” (woman, 75–84; see Figure 1[1d])
2. Access to facilities	(a) Commercial facilities	Facilitator: “There is a shopping center here, a grocery store and a fruit and vegetables market... the elderly who live here don’t need to go too far, they have everything they need nearby... this is very good...” (woman, 50–64; see Figure 1[2a,2b])
	(b) Outdoor leisure facilities	Barrier: “Once there was a park here, where children and neighbors used to gather to chat and play, but now it is a neglected lot where people park their cars, they should turn it back into a park so that people will have a place to meet, and children will have a place to play...” (woman, 65–74) Facilitator: “We passed through a playground that is very tidy and well-kept, including play facilities, benches, and even public restrooms... it’s a good place for everybody—children, parents and even the elderly...” (woman, 65–74)
	(c) Indoor leisure facilities	Facilitator: “The senior center is about 10 minutes’ walk from my home. We have activities there about 2–3 times a week, and it’s very convenient” (man, 65–74)
	(d) Healthcare services	Facilitator: “On my way back home, we pass by the healthcare center-located 2–3 minutes’ walk from my home, which is very convenient for me...” (man, 75–84)
	(e) Public transportation	Barrier: “The distance between bus-stops is too long, and it is very hard for the elderly to walk all the way...” (woman, 50–64) Facilitator: “There is a high frequency of buses passing here for that serves all of the population” (woman, 65–74)
	(f) Rest areas	Barrier: “This is the only bench along the way from my home and all the way uphill, they should have put at least one more bench along the way...” (man, 75–84) Facilitator: “One of the good things that we have here along the street is many resting areas... there are multiple benches that people can sit on and rest if they get tired” (woman, 75–84; see Figure 1[2c])
3. Aesthetics	(a) Building appearance	Barrier: “The entrance to this block is very neglected and dirty, it’s unpleasant to pass by” (woman, 85–94; see Figure 1[3c]) Facilitator: “Our neighborhood is very well kept, people take good care of their private gardens” (woman, 75–84; see Figure 1[3b])
	(b) Streetscape	Barrier: “This statue is broken, they haven’t fixed it nor did they repaint it for over 20 years, I think...” (woman, 50–64; see Figure 1[3a]) Facilitator: “This display window is so beautiful and it’s so pleasant to pass by it and look inside...” (woman, 75–84)
	(c) Greenery	Barrier: “Our neighborhood lacks green areas, where you can simply sit and rest...” (woman, 65–74) Facilitator: “Here you have a viewpoint to the valley, which is so beautiful with all shades of green...” (woman, 75–84)
	(e) Urban waterscape	Barrier: “This water fountain is empty of water and that’s too bad, it gives a lot of relaxation and serenity to see water...” (woman, 65–74; see Figure 1[3d]) Facilitator: “There’s a nice little trail here the takes you down all the way to the river” (woman, 65–74)

Themes	Subthemes	Selected Quotes Coded As:
4. Environmental quality	(a) Traffic-related pollution	Barrier: “ <i>This street is very central and it serves many people who come to this area, and so there’s always heavy traffic, a lot of noise and dirt, and it’s unpleasant to walk here...</i> ” (woman, 65–74; see Figure 1[4a,c])
	(b) Litter	Barrier: “ <i>Garbage cans are overloaded, and left open, it’s very unpleasant to pass by...</i> ” (woman, 65–74; see Figure 1[4b])

Table 4

Descriptive Statistics of Themes/Subthemes

Themes and Subthemes	Reported as Barriers			Reported as Facilitators		
	Frequency (%)	Mean (SD)	Range	Frequency (%)	Mean (SD)	Range
Pedestrian infrastructure ^a	51 (86%)	2.97 (2.93)	0–12	17 (29%)	0.59 (1.25)	0–6
Sidewalk condition	40 (68%)	1.90 (2.24)	0–10	17 (29%)	0.54 (1.15)	0–6
Blocked sidewalks	24 (41%)	0.68 (1.07)	0–5	2 (3%)	0.03 (0.18)	0–1
Street stairs condition	12 (20%)	0.39 (0.93)	0–5	1 (2%)	0.02 (0.13)	0–1
Access to facilities ^a	26 (44%)	0.98 (1.69)	0–7	39 (66%)	2.59 (3.19)	0–12
Commercial facilities (food-related, shops, banks)	6 (10%)	0.13 (0.43)	0–2	22 (37%)	1.03 (1.70)	0–6
Outdoor leisure facilities (parks, trails)	3 (5%)	0.07 (0.31)	0–2	11 (19%)	0.37 (0.85)	0–3
Indoor leisure facilities (community centers)	3 (5%)	0.05 (0.22)	0–1	9 (15%)	0.22 (0.56)	0–2
Healthcare services	3 (5%)	0.05 (0.22)	0–1	13 (22%)	0.24 (0.47)	0–2
Public transportation (bus stops)	11 (19%)	0.41 (1.05)	0–5	10 (17%)	0.25 (0.63)	0–3
Rest areas (benches)	10 (17%)	0.27 (0.72)	0–4	21 (36%)	0.47 (0.73)	0–3
Aesthetics ^a	22 (37%)	0.66 (1.03)	0–4	41 (70%)	2.22 (2.69)	0–11
Building appearance and streetscape	14 (24%)	0.34 (0.71)	0–3	2 (3%)	0.03 (0.18)	0–1
Greenery	9 (15%)	0.17 (0.42)	0–2	26 (44%)	0.73 (1.14)	0–6
Urban waterscape (rivers, water fountains)	7 (12%)	0.15 (0.45)	0–2	32 (54%)	1.46 (2.16)	0–10
Environmental quality ^a	44 (75%)	1.91 (2.08)	0–9	19 (32%)	0.66 (1.67)	0–11
Traffic-related pollution	19 (32%)	0.49 (0.88)	0–4	13 (22%)	0.49 (1.39)	0–9
Litter and messy streets	39 (66%)	1.42 (1.64)	0–8	9 (15%)	0.17 (0.42)	0–2

^aTheme summary variables represent the themes and were calculated by summing up the corresponding subthemes.