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Built environment characteristics and perceived active park use among older adults: Results from a multilevel study in Bogotá

Diana C. Parra [a,*], Luis F. Gomez [b,c], Nancy L. Fleischer [d], Jose David Pinzon [e,f]

[a] George Warren Brown School of Social Work, Washington University in St. Louis. Prevention Research Center in St. Louis. St. Louis MO, 8150 Whitburn Dr 2W Clayton, MO 63105, USA
[b] Health Division, Fundacion FES Social, Bogota, Colombia
[c] Social Medicine Department, School of Medicine, Universidad Javeriana, Bogota, Colombia
[d] University of Michigan School of Public Health, Department of Epidemiology, Center for Social Epidemiology and Population Health, Ann Arbor, MI, USA
[e] Corporacion de Universidades del Centro de Bogotá, Bogotá, Colombia
[f] Urban Design Department, Fundacion Universidad de Bogotá Jorge Tadeo Lozano, Bogotá, Colombia

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ABSTRACT

Objective: Examine the associations between selected built environment (BE) attributes and perceived active park use among older adults in Bogota.

Methods: A cross-sectional multilevel study was conducted. Participants included 1966 older adults in 50 neighborhoods. Socio-demographic covariates and BE attributes were measured. Multilevel logistic regression models were used for the analyses.

Results: Residents from areas with higher park density and high land-use mix were more likely to report active park use while those from areas with high connectivity were less likely.

Conclusions: This study suggests that objective attributes of the residential BE are associated with perceived active park use. However, our study also points to the importance of surrounding environment, with the result of an inverse relationship between connectivity and physical activity, which highlights the potentially necessary interventions in the realm of traffic and pedestrian safety.

1. Introduction

With an ever-aging global population, researchers and policy makers are questioning if older adults are living healthier, and not just longer lives (Schwartz and Walter, 1997). Several studies suggest that older adults who are physically active are more likely to preserve functional capacity and independence, thereby reducing chronic illness and disability, and attaining greater levels of health-related quality of life (Nelson et al., 2007; Peel et al., 2007).

Promoting physical activity during leisure time among older adults has particular relevance because of the numerous benefits to mental health and perceived health status (Wendel-Vos et al., 2004). Physical activity during leisure time can also contribute to increased social interactions and social support, as well as a greater sense of community cohesion (Bedimo-Rung et al., 2005; Lindstrom et al., 2001). Despite these recognized benefits, a large proportion of the world population is inactive. In Colombia, 42.6% of the population does not meet recommended levels of physical activity for health, and only 5.9% are regularly active during their leisure time (InstitutoColombianodeBienestarFamiliar, 2005).

Recently, there has been an increased research interest in identifying the potential effects of the built environment on active living, primarily guided by socio-ecological models (Frank et al., 2003; Owen et al., 2004; Saelens et al., 2003; Sallis et al., 2006). Specifically, the importance of public parks in promoting active recreation and social interaction for the older adult population has been highlighted (Kaczynski et al., 2008; Saelens et al., 2003). Some studies have found that adults who live in areas with a large availability of spaces for recreation and park density are more likely to engage in physical activity (Baker et al., 2008; Bedimo-Rung et al., 2005; Diez Roux et al., 2007). A study conducted by Takano et al. (2002) found that urban areas with walkable green spaces had an influence on longevity, after controlling for individual risk factors. Takano et al. (2002) highlight that it is not only the accessibility of spaces that matters for the promotion of physical activity, but also the quality and maintenance of these spaces (Takano et al., 2002).

In addition to the evidence documenting the relationship between lower levels of physical activity in areas with less green space, it is also hypothesized that because people need to walk through surrounding areas in order to access parks, some natural and built environment attributes, such as street connectivity, the different types of land-use and the slope of the terrain, could be relevant determinants of parks use (Bedimo-Rung et al., 2005). However, most of the studies in this area have been conducted in

* Corresponding Author. Tel.: +1 314 362 9650; fax: +1 314 362 9665.
E-mail address: dianacpp79@yahoo.com (D.C. Parra).

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developed countries (Diez Roux et al., 2007; Humpel et al., 2004; Huston et al., 2003; Owen et al., 2004). In a region like Latin America, one of the most urbanized areas in the world that is also experiencing rapid aging, the study of urban form and its relationship with health-promoting behaviors, such as park use, has a special relevance and warrants exploration (Palloni et al., 2006). In consequence, this study aims to explore this relationship in Bogota, a highly urbanized city of almost 8 million inhabitants and a population density of approximately 3912 inhabitants per square kilometer. Bogota has experienced important transformations in its urban environment, including an increase in green space (parks) from 2.5 to 4.12 m per inhabitant (Parra et al., 2007). However, this indicator is still well below the recommended international standard of 10 m^2 per inhabitant (Gebre-Egziabher, 2004).

The objective of this paper is to assess the relationship between perceived active park use and objective measures of the neighborhood built environment, such as park density, connectivity index, land-use mix index and the slope of the terrain in Bogota.

2. Methods

2.1. Study design

The present study used data from the Built Environment and Older Adults Project of Bogotá (BEOAP), a multilevel cross-sectional study conducted in 2007 in Bogotá (Gomez et al., 2007). The aim of the study was to examine the role of the built environment on walking patterns and health-related quality of life among Bogotá citizens 60 years and older. The study used a two-stage random sampling framework, described below.

A neighborhood was defined as a small geographic area of same socio-economic status (SES), similar urban environment characteristics and delimited by natural geographic boundaries. GIS and aerial-photography restitution were used to identify the neighborhoods. A total of 1734 neighborhoods were classified in low, middle-low and middle-high SES according to the classification used by the city administration (Alcaldia Mayor de Bogota, 2005). In the first sampling stage, 58 neighborhoods were selected using a systematic selection technique with oversampling of middle-high SES in order to increase the variability of urban forms. Eight neighborhoods were not included in the final sample due to small cell sample size. A mean of 39 (SD 31.3) older adult residents was surveyed in each neighborhood. Only participants 60 years and older with at least one year of residence in the address were interviewed. The final response rate was 67.8% (1966 older adults residing in 50 neighborhoods).

2.2. Outcome variable

Perceived active park use was based on a single item from the instrument designed by Fuzhong et al. (2005), using a Likert response scale of five categories. The questions were translated into Spanish and back translated to English to compare accuracy and consistency. The question was translated into Spanish and back translated to English to compare accuracy and consistency; and was also culturally adapted through cognitive interviews (Forsyth and Lessler, 1991; Jobe and Mingay, 1990). The question was: *How often do you visit the parks from the area where you reside to go for a walk, exercise or perform any other physical activity*? Response options were: never, rarely, sometimes, frequently and very frequently. For analytic purposes, responses were dichotomized as perceived active park use (frequently and very frequently) versus no active park use (never, rarely and sometimes). This cut-point was defined based on convergent validity tests, which compared these two categories with the selected IPAQ items of this study, showing that this cut-point made the best discrimination between regularly and not regularly active respondents (La Importancia de Los Ambientes Urbanos en Patrones de Actividad Fisica y Calidad de Vida en Adultos Mayores en la Ciudad de Bogota, 2009).

2.3. Built environment variables

Data from 2004 (connectivity, land-use mix and slope) and 2006 (park density) were provided by the Cadastral Department and the Sports and Recreation Institute of Bogotá, respectively Variables, such as park density, connectivity index, land-use mix and slope of the terrain, were selected based on prior evidence from built environment studies in Bogota (Cervero et al., 2009). The built environment variables were measured in a crow-fly buffer of 500 m around the centroid of each neighborhood. GIS indicators (built environment attributes and SES of the neighborhoods) were assigned to individuals based on their neighborhood of residence. ArcGIS software was used to process the geographic information (ESRI, 2006). Table 1 describes the operational definition of the built environment variables, their cut points, classification and their distribution in the sample.

2.4. Individual covariates

Individual covariates included gender, age, education level (elementary education or less and more than elementary education) and having a limitation to engage in physical activity. This last individual covariate was determined through a question from the SF8, an instrument used to measure quality of life in the

Table 1
Built environment measures obtained by GIS in the selected neighborhoods.

Variable	Definition/formula	Mean or %	Median	SD
Land-use mix index[a]	$1((\sum i(pi)(\ln pi))/\ln k)$ (Cervero and Kockelman, 1997) where p=proportion of total land uses, i=category of land use, ln=natural logarithm and k=number of land-use categories	0.64	0.64	0.09
Park density[b]	Park area/land area (500 m) × 100	6.61	6.14	5.49
Connectivity[c]	Number of streets (links) divided by the number intersections (nodes)	1.77	1.77	0.11
Slope[d]	Vertical distance in meters × 100/horizontal distance in meters	3.05	1	4.08

[a] This index ranges from 0 (when there is one single land use) to 1 (when there is maximum heterogeneous land use).
[b] Small parks, also known as "pocket parks" were not included as part of this indicator because they are less than 1000 m^2 and were not originally designed for the practice and promotion of physical activity.
[c] This index ranges from 1 to 2, with 1 indicating the lowest connectivity and 2 indicating the highest connectivity.
[d] This calculation was obtained by averaging the degrees of slope in a triangulated irregular network (TIN) previously created in the terrain levels. Based on the urban criteria for building pedestrian ramps two categories were created: less than 5% of slope and 5% or more of slope (for example, a 5% slope means that the elevation of the terrain raises 5 m for every 100 m).

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BEOAP study: "*During the past 4 weeks, how much did physical health problems limit your usual physical activities (such as walking or climbing stairs)*?" Response choices were dichotomized for analytic purposes as "could not perform physical activities" and "quite a lot" versus "somewhat", "very little" and "not at all" (QualityMetrics, 2008).

2.5. Statistical analyses

Lowess smoothing curves were generated for the park density, connectivity and land-use mix variables in order to identify inflexion points of these variables in relation to the binary outcome variable. This statistical tool guided the decision to define tertiles for the statistical models. The tertile classifications of the variables are included in Table 3.

Multilevel logistic regression models were carried out using STATA 10 software using the command xtmelogit (Stata, 2005). Random-intercept models were used to account for the differences between neighborhoods. Three sets of multilevel models were carried out. The first model is unadjusted. The second model adjusted for individual covariates and slope of the terrain. The third model included all the GIS variables and the individual covariates. Prevalence odds ratios with 95% confidence intervals were reported before and after adjustment for individual characteristics, and finally p trend values were calculated.

A set of four maps was created using ArcGIS 9.3 to illustrate the results obtained with the multilevel logistic regression models regarding the relationship between selected built environment attributes (connectivity and land-use mix) and active park use. The geographic data provided by the Cadastral Department of Bogota and the Sports and Recreation Institute and the active park use information were entered into the GIS as overlaying Arc View shapefiles.

3. Results

Table 2 displays selected characteristics of the participants included in the analysis. Most of the participants were female (62.5%) and reported an education level of elementary school or less (66.2%). The mean age was 70.7 years, and participants resided in their neighborhoods for an average of 24.5 years. Only 23% (n=452) of the sample was classified as active park users. 38% of the neighborhoods (19) belonged to low SES, 52% (26) to middle-low and 10% (5) to high SES.

Multilevel logistic regression analyses of the relationship between perception of active park use and built environment attributes are presented in Table 3. Results are reported both before and after adjusting for individual covariates. Prior to adjusting for individual covariates (Model 1), older adults residing in areas with 5% slope of the terrain or greater were more likely to report active park use as compared to those older adults residing in areas with less that 5% slope. After adjusting for individual covariates, the strength of the association was somewhat attenuated, although it remained statistically significant. Once the model was adjusted by individual and GIS variables (Model 3), the negative direction of the association was maintained, although attenuated even more (OR=0.53, CI=0.30–0.93).

Higher park density was positively associated with perceived active park use even after controlling for individual and environmental covariates (Model 3). Older adults residing in areas with the second (OR=2.78, CI=1.72–4.48) and third tertile (OR=2.98, CI=1.80–4.93) of park density have almost three times the odds of reporting active park use as compared to those living in areas with the lowest density (p trend <0.001).

Regarding the connectivity index, unadjusted models were not statistically significant; however, once the model was adjusted for individual covariates (Model 2), the third tertile for connectivity index was statistically significant (OR=0.51, CI=0.28–0.94). Once the model was adjusted by individual and environmental variables the association was maintained (OR=0.56, CI=0.30–0.93). The map in Fig. 1 depicts a neighborhood with the highest tertile for connectivity and also classified as having no active park use. In contrast, Fig. 2 depicts a map of a neighborhood located in an area with the lowest tertile of connectivity and also classified as having an active park use.

Before adjusting for individual covariates, the highest tertile of land-use mix was associated with perceived active park use (Model 1). This relationship was no longer statistically significant when the model was adjusted for individual covariates (Model 2). Once the model was adjusted by individual and environmental variables those older adults residing in neighborhoods with the highest land-use mix index were more likely to report active park use as compared to those living in areas with a low index (OR=1.71, CI=1.12–2.59). Fig. 3 includes a map with a neighborhood located in an area with the highest land-use mix

Table 2
Descriptive individual sample characteristics (n=1966), Bogotá, Colombia, 2007.

Variables	Frequency	Mean or %	Median	Min.	Max.	SD
Gender						
Male	737	37.5				
Female	1229	62.5				
Age (yr)	1966	70.7	70	60	98	7.7
Age groups						
60–74	1366	69.5				
75–98	600	30.5				
Years of residence in the neighborhood	1966	24.5	25	1	90	16.1
Education levels						
Elementary school or less	1302	66.2				
More than elementary school	664	33.8				
Active park use						
Never	1160	59.0				
Rarely	354	18.0				
Sometimes	265	13.5				
Frequently	147	7.5				
Very frequently	40	2.0				

Table 3
Multilevel logistic regression analysis for active park use among 1966 older adults (environmental attributes measured in a buffer of 500 m from the centroid of the neighborhood), Bogotá, Colombia, 2007.

GIS variables	Model 1			Model 2[a]			Model 3[b]		
	Unadjusted POR	CI 95%	*p trend*	Adjusted POR	CI 95%	*p trend*	Adjusted POR	CI 95%[c]	*p trend*
Slope									
Less than 5%	1			1			1		
5% and above	0.25	0.13–0.51		0.37	0.19–0.71		0.53	0.30–0.93	
Public park density									
0.01–4.14%	1		< 0.001	1		< 0.001	1		< 0.001
4.53–7.98%	4.40	2.41–8.05		2.99	1.80–4.98		2.78	1.72–4.48	
8.11–35.21%	3.88	2.06–7.32		3.05	1.80–5.17		2.98	1.80–4.93	
Connectivity index									
1.46–1.74	1		0.955	1		0.030	1		0.007
1.75–1.80	1.37	0.67–2.78		0.77	0.43–1.36		0.79	0.54–1.16	
1.81–1.99	1.00	0.48–2.09		0.51	0.28–0.94		0.56	0.37–0.87	
Land-use mix									
0.36–0.61	1		0.018	1		0.129	1		0.014
0.62–0.66	1.07	0.55–2.18		1.17	0.67–2.05		1.23	0.83–1.82	
0.68–0.81	2.32	1.19–4.53		1.58	0.88–2.84		1.71	1.12–2.59	

[a] POR adjusted by age gender, education level and slope of the terrain.
[b] POR adjusted by all the variables included in the model.

Fig. 1. Neighborhood with high connectivity index (1.81–19.99) and low proportion of perceived active park use (less than 9%).

and also classified as having active park use. Fig. 4 presents a map of a neighborhood located in the lowest tertile for land-use mix and classified as having no active park use.

4. Discussion

This study suggests that objective attributes of the residential built environment, namely slope of the terrain, park density, connectivity and land-use mix are associated with perceived active park use among older adults in Bogota. This study brings new insights to the understanding of the links between built environment and physical activity in the context of Latin America.

The positive association between public park density and perceived active park use is in agreement with existing evidence from high-income countries that show an increase in physical activity with higher park density (Cohen et al., 2007; Diez Roux et al., 2007; Huston et al., 2003; Kaczynski et al., 2008; Takano et al., 2002). Several potential explanations have been provided by various researchers regarding these findings, including, that increased availability and accessibility to parks increases the likelihood that a person will visit a park and potentially engage in physical activities. Despite this evidence, the finding that park density increases park visitation among some populations does not guarantee that all populations will visit a park if it is provided (Wiggs et al., 2008). Moreover, the mere presence of a park also

Fig. 2. Neighborhood with low connectivity index (1.46–1.74) and high proportion of perceived active park use (9% and above).

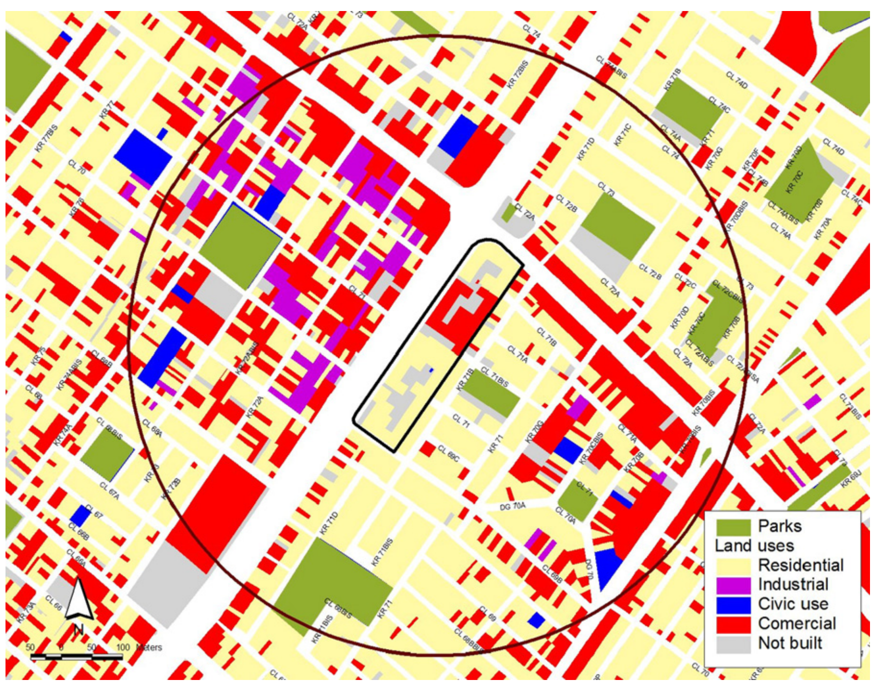

Fig. 3. Neighborhood with high land-use mix index (0.68–0.81) and high proportion of perceived active park use (9% and above).

does not reassure that a person will engage in physical activity. Community-based programs that provide physical activity classes can potentially increase population levels of physical activity when parks are available. In several countries from Latin America, including Brazil and Colombia, there are a series of community-based programs organized by local administrations that provide physical activity classes and nutrition counseling free of cost (Hoehner et al., 2008; Simoes et al., 2009). These programs may increase the community appropriation of public spaces, improving its maintenance and security conditions (Cali, Colombia: Toward a City Development Strategy, 2002; Rau, 2004). In addition, other types of environmental interventions like the creation of, or enhanced access to places for physical activity including building walking paths that connect parks, have been recommended to increase physical activity at the community level (Kahn et al., 2002).

Besides examining the relationship between park density and perceived park use, this study evaluated the association between perceived active park use and certain features of the built environment that were thought to influence accessibility to public parks, particularly among older adults. We found that

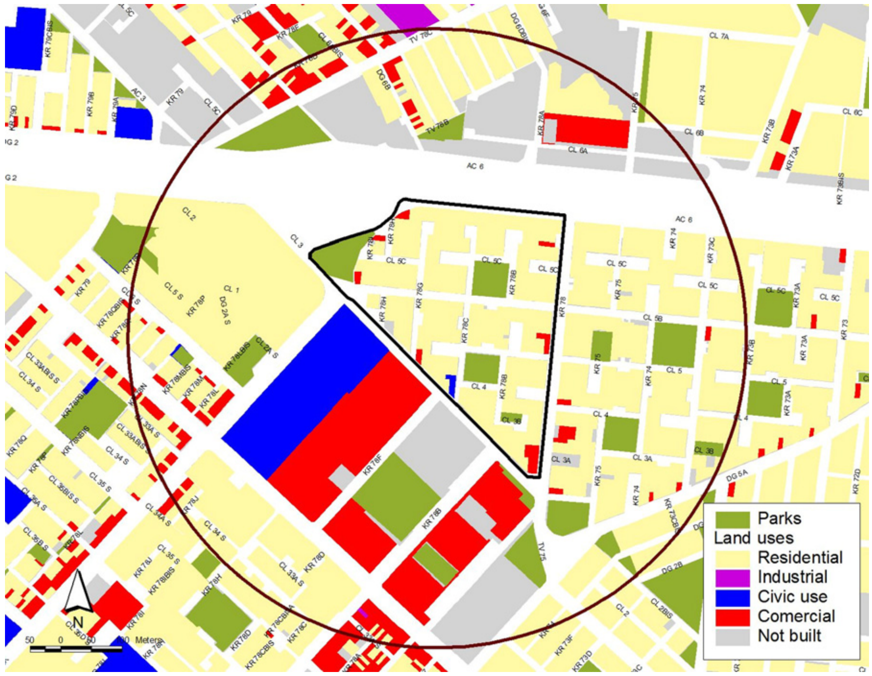

Fig. 4. Neighborhood with low land-use mix index (0.36–0.61) and low proportion of perceived active park use (less than 9%).

in areas with high slope of the terrain ($\geq$5%) older adults had a reduced likelihood of reporting an active park use. Considering that we adjusted the results for several individual covariates, including having a limitation to walk; this finding has important implications regarding the areas where older adults reside and the decision of the areas in which new parks will be located in the city.

Evidence derived from high-income countries shows that residents from areas with high connectivity are more likely to be physically active, including having increased levels of walking for leisure and transportation (Wendel-Vos et al., 2008, 2007). In our study we found that older adults residing in areas with high-connectivity index, which can be interpreted as high number of street intersections, were less likely to report active park use. This finding should be interpreted within the context of Bogota, a city with a high prevalence of traffic accidents and high mortality of older adults involved in pedestrian traffic accidents (“SecretariadeTransitoyTransporte”, 2006). It is possible that areas with high-connectivity index are proportionately related to a larger number of intersections with higher rates of traffic accidents that involve pedestrians. This could potentially create a sense of fear among older adults or their families and ultimately prevent them from visiting nearby parks. These hypotheses require further exploration since to our knowledge this is the first study documenting built environment correlates of perceived active park use in a large urbanized city from Latin America.

The positive association between land-use mix and park use found in this study is similar to the available evidence from the United States and some countries in Europe (Ogilvie et al., 2008; Owen et al., 2004) in regard to utilitarian physical activity. We found that the highest tertile of land-use mix “entropy” (indicating maximum heterogeneity of land use) was associated with an increased likelihood of reporting active park use. Several studies have documented the relationship between perceptions of the environment and an increased propensity to walk for leisure (Ogilvie et al., 2007). In this sense, living in an area with more than two types of land use, such as residential and commercial, could motivate people to leave their houses and go for a walk, and potentially to a nearby park. This could be particularly relevant for the older adult population who may base their decision of visiting a park or not on the availability of other attractions or establishments surrounding the parks, for example a small convenience store or a coffee shop. Mixed land use alone, however, is unlikely to motivate physical activity. The overall safety and aesthetics of an area are also likely to have an impact.

This is the first known published study from a developing country that focuses exclusively on the older adult population to establish the association between urban attributes and perceived park use. One of the primary strengths of this study, when compared to similar studies in the field, is the use of a more homogeneous geographic unit of analysis (neighborhoods). Previous studies have used census tracks or neighborhoods as defined by the city administration; these artificial divisions may lack homogeneity within the same geographic unit. For instance, in a study conducted in Bogota during 2005, which used neighborhoods (according to the administrative division of the city) as the primary unit of analysis, it was common to find two or more socio-economic strata within the same neighborhood, as well as different types of urban forms (Cervero et al., 2009). Thus, the current analysis uses the previously defined neighborhoods identified by the BEOPA study as a way to maintain homogeneity within neighborhoods. The use of objective information obtained through GIS as compared to perceived and self-reported information increases the reliability of the results since it is not subject to respondent bias, reducing the risk of endogeneity, however, it must be acknowledged that people’s perceptions of their neighborhoods contributes to how they use and recognize their environment (Boehmer et al., 2006).

Some limitations of this study are the use of self-reported data to measure park use, since this type of data is subject to recall bias or social desirability issues. Additionally, it is impossible to establish any causal relationships between features of the built environment and park use due to the cross-sectional nature of this survey. The use of an objective definition and measure of the neighborhoods and their related attributes does not necessarily

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correspond with the perceived concept of neighborhoods of the residents. However, we believe that the use of smaller geographic areas of analysis will aid in reducing this limitation mainly due to the selection of a homogeneous area. Other limitation is that the geographic information used is from 2004 and 2006, while the survey data is from 2007. However, the city has not experienced drastic changes during this time frame with regards to the built environment attributes used in this study, namely, slope of the terrain, park density, connectivity and land-use mix.

The links between neighborhood environment and individual health have been extensively recognized and public health professionals are creating more collaborative research, policy and practice actions within the fields of urban design and transportation in order to create healthier communities. However, while the links between those fields grow stronger, there is still some disconnection between the parks and recreation services and the public health sector. Because parks have a large potential for the promotion of physical activity among all segments of the population, and particularly among vulnerable populations, such as older adults and those of low SES, communities would benefit from city officials and the public health community working together. These efforts should focus on increasing the accessibility, availability and quality of park resources based on the available evidence. However, our study also points to the importance of surrounding environment, with the result of an inverse relationship between connectivity and physical activity, which highlights the potentially necessary interventions in the realm of traffic and pedestrian safety to improve physical activity. This study is an important step in that direction as it provides new and specific evidence on park use by older adults within the specific context of a large, urbanized city from Latin America, where built environments have high levels of connectivity, density and land-use mix.

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