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Built Environment and Walking Behavior Among Brazilian Older Adults: A Population-Based Study

Marui Weber Corseuil Giehl, Pedro Curi Hallal, Claudia Weber Corseuil, Ione J. Ceola Schneider, and Eleonora d'Orsi

Background: Understanding the built environment influence on specific domains of walking is important for public health interventions to increase physical activity levels among older adults. **Purpose:** The purpose was to investigate the association between built environment characteristics and walking among older adults. **Methods:** A population-based study was performed in 80 census tracts in Florianópolis, Brazil, including 1,705 older adults (60+ years old). Walking was measured using the International Physical Activity Questionnaire. Built environment characteristics were assessed through a geographic information system. All analyses were conducted through a multilevel logistic regression. **Results:** Individuals living in neighborhoods with a higher population density (odds ratio [OR]: 2.19; 95% confidence interval [CI], 1.40–3.42), with a higher street connectivity (OR: 1.85; 95% CI, 1.16–2.94), a higher sidewalk proportion (OR: 1.77; 95% CI, 1.11–2.83), and paved streets (medium tertile: OR: 1.61, 95% CI, 1.04–2.49; highest tertile: OR: 2.11; 95% CI, 1.36–3.27) were more likely to walk for transportation. Regarding walking for leisure, only 2 predictors were associated, area income (OR: 1.48; 95% CI, 1.04–2.12) and street density (OR: 1.47; 95% CI, 1.02–2.10). **Conclusions:** Improving the neighborhood built environment is an important step for achieving higher levels of walking in the elderly population in a middle-income country.

Keywords: neighborhood, physical activity, elderly

The built environment consists of buildings, spaces, and objects created or modified by humans, such as homes, parks, recreation areas, transportation systems.[1,2] When well designed, these elements can work together to provide opportunities for physical activity and help older adults remain active, independent, and have better social interaction.[3–5]

Physical activity is essential to the process of healthy aging and an important factor in prevention of many chronic noncommunicable diseases and functional and mobility limitations in older adults.[4,6,7] Walking is the opportune mode of physical activity in this population because it is safe, affordable, and easy to incorporate into the daily routine. In addition, it represents a low risk of causing injury among older adults and requires no facilities or special equipment.[8–10]

Walking, either for leisure or transportation, primarily takes place in outdoor settings (eg, parks, neighborhood streets); thus, many researchers have demonstrated positive relationships between specific built environment characteristics and walking among older adults.[11–15] Street connectivity, population density, land-use mix, as well as the proximity of destinations in the neighborhood have been associated with walking for transportation.[16–19] Population density, aesthetics, and proximity to recreation areas and pedestrian facilities may be of higher importance for walking for leisure among older adults.[18–21]

Previous studies investigating the association between objective measures of the built environment and walking in older adults population were conducted in high-income countries,[4,22] and there is a lack of evidence for these associations in middle-income countries, such as Brazil. Furthermore, studies on this topic conducted in Brazil investigated the relationship between the built environment and physical activity among older adults through self-perceived measures, which have shown a divergent association with physical activity when compared to objective measures.[23–27]

Because physical activity is a complex interaction between individuals and the surrounding environment,[28] and there is limited evidence about objective measures of the built environment and its associations with walking in older populations from middle-income countries, the aim of this study was to examine the association between built environment characteristics objectively measured by a geographic information system (GIS) and walking for transportation and for leisure in older adults from Florianópolis, Santa Catarina, Brazil.

Methods

Study Design and Sampling

Data from this study were obtained from the Health Status of the Elderly Population in Florianópolis: Population-Based Study 2009/2010 (EpiFloripa Elderly) study. This is an observational longitudinal population-based study conducted with older adults (60+ years) living in Florianópolis. Data from the first wave of the study were collected between September 2009 and July 2010.

Florianópolis, located in the south of Brazil and the capital of state of Santa Catarina, has 675.4 km^2 of land area and a population density of 623.7 inhabitants per km^2, and 96.0% of the population lives in urban areas. In 2010, the average per-capita income was R$1,798.12,[29] and the human development index (HDI) was 0.847, placing the city in the third position among all Brazilian cities. The HDI, basically, is a composite index that measures the average achievements in 3 basic dimensions of human development:

Weber Corseuil Giehl (mwcorseuil@gmail.com), Schneider, and d'Orsi are with the Dept of Public Health, Universidade Federal de Santa Catarina, Florianópolis, Santa Catarina, Brazil. Hallal is with the Dept of Epidemiology, Universidade Federal de Pelotas, Pelotas, Brazil. Weber Corseuil is with the Dept of Energy Engineering, Universidade Federal de Santa Catarina, Florianópolis, Santa Catarina, Brazil.

life expectancy at birth, education, and income per capita).[30] Life expectancy at birth was 77.4 years.[29] The estimated population of Florianópolis in 2009 was 408,163 inhabitants, 44,460 of them belonging to the age group over 60 years (18,844 males and 25,616 females), representing 10.9% of the total population.[30]

The sample selection had a multistage clustered design. The urban census tracts of the city (420 census tracts), used as proxies for neighborhoods, were stratified by deciles of household income (average monthly income of the head of the family; from R$314.76 to R$5,057.77, 1 USD = R$1.70 in 2009) into 80 randomly selected tracts, for a total of 8 tracts in each decile. Selected census tracts were composed of 22,953 eligible households; from these, 5,120 were systematically selected for this study. In each census tract, around 60 households were systematically selected. All older adult residents in the selected households were invited to participate in the study. A total of 1,911 eligible individuals were identified in selected households. Further details on the study methodology are described in previous studies.[26,27] The sample size was established to estimate the prevalence of the main study outcomes. In this study, size was adequate to detect odds ratios (ORs) greater than or equal to 1.15 with a power of 0.90 and a significance level of 95%.[31]

Older adults with severe cognitive problems had the questionnaire answered by guardians/caregivers. Institutionalized individuals were excluded from the study. In addition, those with impaired mobility (defined in this study as the inability to get out of bed or walk) were excluded from the analysis of the current study. Losses were considered when it was not possible to carry out the interviews after 4 attempts (including at night and on weekends).

Procedures

The home visits included the administration by trained interviewers of a structured questionnaire in the form of face-to-face interviews using a personal digital assistant. The pretest was conducted with 30 elderly individuals and the pilot study with almost 100 older adults living in 2 census tracts not included in the sample. Data quality control was performed weekly in 10% of randomly sampled individuals. For this group, a short version of the questionnaire (16 questions) was applied by telephone. Written informed consent was obtained from all participants before survey application. This study was approved by the Ethics Committee on Research with Human Beings of the Federal University of Santa Catarina (protocol number 352/2008).

Study Variables

Walking for Transportation and for Leisure. Walking for transportation and for leisure was assessed through the leisure and transportation sections of the long version of the International Physical Activity Questionnaire (IPAQ).[32] The IPAQ has moderate validity criterion compared to objective measures[33] and adequate reproducibility in older adult populations from Florianópolis.[34,35] The older adults reported how often they walked for at least 10 continuous minutes per day in a typical week for walk for transportation and for leisure. Hence, the subjects were classified as any walking (≥10 minutes/week) or no walking (<10 minutes/week).

Built Environment Data. ArcGIS 9.3 ESRI software (ArcMap; ArcInfo Version 9.3, Environmental Systems Research Institute, Redlands, CA) was used for data acquisition, development, editing, and subsequent spatial analysis. This study used the existing geographical databases provided by the Institute of Urban Planning of Florianópolis (IPUF), which includes a complete and current street network database (urban roads) as well as many other data layers (eg, blocks, land use, public open spaces) from which the built environment characteristics relevant to this study were derived. To assess the built environment variables, it was necessary to edit and update the IPUF database using georeferenced aerial photographs from 2010 and images available on Google Earth and Street View.

Four built environment variables were assessed based on the available methodology[36]: land-use mix, street density, street connectivity (density of 4-way intersections), and public open spaces. For the street connectivity variable, both streets that were within the limits of the census tracts and their adjacent streets were considered. For the public open spaces variable, the presence or absence of these areas within the census tracts was considered (regardless of whether this area was entirely within the census tract or not).

In addition, 5 measures were developed using 2010 Census data[37]: (1) area income (average income within each census tract in Brazilian currency), (2) population density, (3) percentage of street lighting, (4) percentage of paved streets, and (5) percentage of sidewalks.

All data were spatially integrated within a GIS, using ArcMap software to characterize the built environment of the sampled census tracts, which represented the unit of analysis in this study. Study variables were categorized based upon on the tertiles distribution of the data, excepted for the public open spaces, which were dichotomized. A detailed description of each built environment variable is found in Table 1.

Individual Variables

Individual variables included were gender (male/female), age group (60–69 years, 70–79 years, and 80 years or older) and education (≤4 years, 5–8 years, 9–11 years, and ≥12 years of schooling).

Data Analysis

Descriptive statistics were calculated for individual and built environment variables. Multilevel logistic regression with random intercepts was run to analyze the association between walking for transportation and for leisure and the built environment variables. Initially, the effects of level 2 (census tract) on the 2 outcomes variables were determined by calculating the intraclass correlation coefficient (ICC), which is defined as the ratio between the variability between census tracts divided by the sum of variability between census tracts and within census tracts. In multilevel logistic regression, it is assumed that the variance of the first level is constant and equal to $\pi^2/3 = 3.29$.[38] The empty model was tested (with random intercept and without covariates) to estimate the proportion of the total variance of walking for transportation and for leisure can be attributed to the differences between the census tracts (level 2).

Second, mixed-effects multilevel models were created. The unadjusted associations of the built environment variables with walking for transportation and for leisure were estimated in separate models. Following, the adjusted models were performed, in which the association of outcomes with each built environmental variables was tested, controlling for the individual variables (gender, age, and education). This strategy was adopted due to the high degree of correlation between some built environmental variables (population density, paved street, sidewalk, street density, and street connectivity). All analyses were performed in 2014 using Stata 12.0 software. Confidence intervals (CIs) of 95% were adopted.

Table 1 Definition of the Built Environment Variables in Florianópolis, Brazil

Variable	Data source	Description
Area income (Brazilian currency)	IBGE 2010 Census (tabular data and maps of the census tracts)	Average income of the census tract, as measured in the Brazilian Census
Population density/km^2	IBGE 2010 Census (tabular data and maps of the census tracts)	Number of persons in housing units / total area in squared kilometers
Percentage of streetlights	IBGE 2010 Census (tabular data and maps of the census tracts)	Number of households that have at least 1 streetlight / total of households × 100
Percentage of paved streets	IBGE 2010 Census (tabular data and maps of the census tracts)	Number of households that have a paved street along the entire length / total of households × 100
Percentage of sidewalks	IBGE 2010 Census (tabular data and maps of the census tracts)	Number of households that have a sidewalk along the entire length of at least 1 side / total of households × 100
Street density/km^2	IPUF (road data with centerlines)	Average length of road in kilometers with interstates removed / total area of the census tract in square kilometer
Street connectivity	IPUF (road data with centerlines)	Number of 4-way intersections within the census tract / total area of census tract in squared kilometers
Land-use mix (entropy index)	IPUF (land use data [parcels] and zoning data)	Determined according to the distribution of 5 land use categories (residential, commercial, institutional, recreational and other)[a]
Public open spaces	IPUF (land use data [parcels] and zoning data)	Presence or absence of playgrounds, parks, and open green areas within the census tracts

[a] The entropy index was calculated based the following formula: $\{-\Sigma k\ [(pi) \times (\ln pi)]\} \div (\ln k)$, where p = proportion of total land uses, i = land use category, ln = natural logarithm, k = number or land uses (range 0–1). A value of 0 indicates homogeneity, wherein all land uses are of 1 single type; a value of 1 means heterogeneity, wherein area is evenly distributed among all land-use categories.

Abbreviations: IBGE, Brazilian Institute of Geography and Statistics; IPUF, Institute of Urban Planning of Florianópolis.

Results

The outcomes and demographic characteristics of the study are shown in Table 2. Of the 1,911 eligible individuals, 1,705 answered the questionnaire (response rate: 89.2%). However, 38 individuals were excluded from the analysis due to impaired mobility, defined in this study as the inability to get out of bed or walk.

Most participants were female (61.4%), between 60 and 69 years old (50.9%; mean age = 70.4 ± 8 years), and had 4 years or less of schooling (43.8%). Participants were distributed in 80 census tracts, with a range of 10 to 56 persons per tract and an average of 22 respondents per tract.

Regarding walking for transportation, 61.4% (95% CI, 59.1–63.8) of individuals reported walking for 10 minutes or more per week. The average time of walking for transportation was 113.1 ± 181.9 minutes/week. As for walking for leisure, 34.5% (95% CI, 32.2–36.8) of individuals reported walking for at least 10 minutes/week; the mean time for walking for leisure was 76.5 ± 144.6 minutes/week.

The average income of the census tracts was R$3,199.83. The average 4-way intersections density was 36.8 intersections points per km^2. Almost all tracts had street lighting and paved streets (Table 3).

Associations Between Built Environment and Walking for Transportation

The ICC of walking for transportation was 0.112, showing that 11.2% of the variation in walking for transportation was attributed to the between-census-tracts differences. Older adults living in areas with higher population density (OR: 2.19; 95% CI, 1.40–3.42) and with higher street connectivity (OR: 1.85; 95% CI, 1.16–2.94) were more likely to walk (≥10 minutes/week) for transportation. Similarly, positive associations were found between higher percentage of sidewalks (OR: 1.77; 95% CI, 1.11–2.83) and paved streets (intermediate tertile: OR: 1.61, 95% CI, 1.04–2.49; high tertile: OR: 2.11; 95% CI, 1.36–3.27) and walking for transportation, where older adults living in areas with these characteristics were more likely to walk in this domain (Table 4).

Associations Between Built Environment and Walking for Leisure

Regarding walking for leisure, 7.5% of the variation in this activity can be attributed to the between-census-tracts differences (ICC = 0.075). In the adjusted models, average household income and street density were associated with walking for leisure. In areas classified in the middle tertile of income and street density, individuals had odds of 58% (95% CI, 5%–116%) and 47% (95% CI, 2%–100%) higher for walking for leisure (≥10 minutes/week). No other built environment variables were significantly associated with this outcome (Table 5).

Table 2 Descriptive Statistics of Outcomes and Individual Variables in Florianópolis, Brazil

Variable	n	% (95% CI)
Outcomes		
Walking for transportation		
0 min/week	643	38.53 (36.26–40.93)
≥10 min/week	1,014	61.43 (59.06–63.74)
Walking for leisure		
0 min/week	1,091	65.45 (63.12–67.70)
≥10 min/week	576	34.55 (32.30–36.87)
Individual variables		
Gender		
Male	602	36.11 (33.83–38.45)
Female	1,065	63.89 (61.54–66.16)
Age		
60–69 years	849	50.93 (48.53–53.32)
70–79 years	595	35.69 (33.43; 38.02)
≥80 years	223	13.38 (11.82–15.00)
Education (years of schooling)		
≤4 years	727	43.82 (41.45–46.22)
5–8 years	315	18.99 (17.17–20.95)
9–11 years	231	13.91 (12.34–15.68)
≥12 years	386	23.27 (21.29–25.36)

Abbreviation: CI, confidence interval.

Table 3 Descriptive Statistics of Built Environment Variables Among Census Tract in Florianópolis, Brazil

Contextual variables	Mean	SD
Area income (Brazilian currency)	R$3,199.83	R$1,976.97
Population density (hab/km^2)	9.482	13.593
Percentage of streetlights (%)	97.91	4.54
Percentage of sidewalks (%)	68.21	32.29
Percentage of paved streets (%)	92.67	11.26
Street density (km^2)	19.99	12.87
Street connectivity (4-way intersections/km^2)	36.81	66.67
Land use mix (entropy index)	0.52	0.16
Public open spaces (%)	1.23	2.63

Discussion

The results from this study showed positive associations between walking and built environment characteristics, and associations were specific to the walking domain. Generally, higher population density, greater street connectivity, and higher sidewalk and paved streets percentages were associated with walking for transportation. On the other hand, only higher income and street density were associated with walking for leisure in older adults living in Florianópolis.

These findings are consistent with previous studies reporting an increased probability of walking for transportation in areas with higher population density and greater street connectivity.[15,16,18,19] Higher population density can generate greater investment in infrastructure and availability of services in the neighborhood,[19] resulting in a favorable environment for walking.[39] Street connectivity was another important characteristic to promoting walking among older adults,[11,16,19] as more connected streets can minimize distances for pedestrians and provide multiple routes or alternative paths to various destinations, making it more convenient for people to walk through the neighborhood.[40,41] A higher percentage of sidewalks and paved streets was positively correlated with walking for transportation. More available sidewalks and streets in good conditions would encourage older adults to walk more, which is consistent with previous findings.[22,42]

These characteristics are related to the neighborhood infrastructure, and it is recognized that places with good attributes of the built environment can encourage physical activity and walking among older adults.[3–5] Borst et al[17] discussed that in streets with the presence of sidewalks, older adults were more likely to walk. Similarly, the presence of sidewalks was an important factor in encouraging older adults to walk in studies using perceived measures.[26,43]

Due to the difference in the measurement of sidewalks between this study and those previously cited, direct comparisons are not possible. In this study, the measurements of sidewalks were obtained from census data. In addition, the data obtained did not allow us to evaluate the quality of sidewalks. Despite these limitations, these are important features of the built environment, especially for urban environment planning, as sidewalks are modifiable characteristics of the built environment, and simple and relatively low-cost strategies, such as maintenance and small repairs on the surface of sidewalks, can influence behaviors related to physical activity.[28,44]

In the current study, walking for leisure was only associated with the income of the census tract and street density. The association between the income of the census tract and walking for leisure was independent of individual characteristics such as education, suggesting people with lower socioeconomic status who reside in areas with higher income can benefit from better built environment infrastructure compared with low-income areas.[45]

Previous studies[13,16,46] also reported few associations between built environment characteristics and walking for leisure, especially in older adults; it is noteworthy that these studies were conducted in high-income countries. A possible explanation for the limited associations of walking for leisure is that this activity may often occur outside the neighborhood environment where older individual live; thus, the attributes of the environment surroundings would be irrelevant. In addition, other built environment characteristics that were not included in this study—such as the presence and proximity

Table 4 Association of Walking for Transportation With Built Environment Variables Among Older Adults From Florianópolis, Brazil (Multilevel Logistic Regression)

	Walking for transportation ≥10 min/week % (95% CI)	Crude OR (95% CI)	Adjusted[a] OR (95% CI)
Area income (census tract; Brazilian currency)			
Low (R$818.00–R$2,051.99)	56.62 (52.47–60.78)	1.00	1.00
Medium (R$2,052.00–R$3,606.99)	57.96 (54.20–61.72)	1.02 (0.67–1.55)	1.01 (0.65–1.58)
High (≥R$3,607.00)	66.80 (62.61–71.00)	**1.59 (1.03–2.47)**	1.59 (0.98–2.59)
Population density (km^2)			
Low (356.37–3,028.06)	52.40 (48.41–56.40)	1.00	1.00
Medium (3,028.07–9,319.05)	59.87 (55.96–63.78)	1.34 (0.91–2.00)	1.36 (0.90–2.07)
High (≥9,319.06)	69.64 (65.57–73.70)	**2.14 (1.42–3.24)**	**2.19 (1.40–3.42)**
Street density (km^2)			
Low (3.17–13.96)	57.66 (53.63–61.69)	1.00	1.00
Medium (13.97–25.54)	57.12 (53.31–60.93)	1.04 (0.69–1.59)	1.01 (0.64–1.58)
High (≥25.55)	67.09 (62.83–71.35)	**1.58 (1.02–2.45)**	1.55 (0.96–2.49)
Street connectivity (km^2)			
Low (0.00–3.63)	55.52 (51.55–59.48)	1.00	1.00
Medium (3.64–30.93)	58.93 (55.08–62.77)	1.22 (0.81–1.84)	1.23 (0.79–1.91)
High (≥30.94)	67.53 (63.25–71.80)	**1.80 (1.17–2.678)**	**1.85 (1.16–2.94)**
Percentage of streetlights			
Low (66.90–98.68)	55.56 (51.27–59.83)	1.00	1.00
Medium (98.69–99.98)	59.81 (55.56–64.05)	1.22 (0.77–1.93)	1.15 (0.70–1.89)
High (100)	63.77 (60.12–67.43)	1.46 (0.97–2.23)	1.38 (0.87–2.17)
Percentage of sidewalks			
Low (0.00–58.99)	54.21 (50.27–58.15)	1.00	1.00
Medium (59.00–97.56)	59.93 (55.96–63.90)	1.26 (0.83–1.90)	1.17 (0.75–1.82)
High (≥97.57)	67.47 (63.34–71.60)	**1.76 (1.16–2.70)**	**1.77 (1.11–2.83)**
Percentage of paved streets			
Low (62.40–94.42)	51.12 (47.19–55.05)	1.00	1.00
Medium (94.43–99.79)	62.15 (58.01–62.29)	**1.55 (1.04–2.32)**	**1.61 (1.04–2.49)**
High (≥99.80)	68.18 (64.27–72.09)	**2.11 (1.42–3.16)**	**2.11 (1.36–3.27)**
Land-use mix (entropy index)			
Low (0.01–0.48)	56.86 (51.51–62.20)	1.00	1.00
Medium (0.49–0.58)	61.17 (57.20–65.14)	1.26 (0.81–1.96)	1.29 (0.80–2.06)
High (≥0.59)	61.61 (57.77–65.45)	1.22 (0.78–1.90)	1.23 (0.77–1.97)
Presence of public open spaces			
No	64.25 (61.07–67.42)	1.00	1.00
Yes	55.58 (52.22–58.98)	**0.68 (0.48–0.97)**	0.66 (0.46–1.00)

[a] Adjusted models control for sex, age, and education.

Note. Boldface indicates significance.

Abbreviations: OR, odds ratio; CI, confidence interval.

Table 5 Association of Walking for Leisure With Built Environment Variables Among Older Adults From Florianópolis, Brazil (Multilevel Logistic Regression)

	Walking for transportation ≥10 min/week % (95% CI)	Crude OR (95% CI)	Adjusted[a] OR (95% CI)
Area income (census tract; Brazilian currency)			
Low (R$818.00–R$2,051.99)$$	27.22 (23.50–30.95)	1.00	1.00
Medium (R$2,052.00–R$3,606.99)$$	38.29 (34.59–41.99)	**1.68 (1.17–2.42)**	**1.48 (1.04–2.12)**
High (≥R$3,607.00)$	35.25 (30.99–39.50)	**1.47 (1.01–2.15)**	1.11 (0.75–1.65)
Population density (km^2)			
Low (356.37–3,028.06)	34.66 (30.85–38.47)	1.00	1.00
Medium (3,028.07–9,319.05)	33.55 (29.79–37.31)	1.01 (0.69–1.48)	0.96 (0.67–1.39)
High (≥9,319.06)	33.20 (29.03–37.36)	0.96 (0.65–1.41)	0.85 (0.58–1.25)
Street density (km^2)			
Low (3.17–13.96)	28.74 (25.05–32.43)	1.00	1.00
Medium (13.97–25.54)	37.06 (33.34–40.77)	**1.60 (1.11–2.30)**	**1.47 (1.02–2.10)**
High (≥25.55)	35.67 (31.32–40.01)	**1.50 (1.03–2.20)**	1.27 (0.87–1.86)
Street connectivity (km^2)			
Low (0.00–3.63)	32.45 (28.71–36.19)	1.00	1.00
Medium (3.64–30.93)	33.97 (30.26–37.66)	1.12 (0.76–1.63)	1.03 (0.72–1.50)
High (≥30.94)	35.48 (31.12–39.85)	1.22 (0.83–1.81)	1.06 (0.72–1.55)
Percentage of streetlights			
Low (66.90–98.68)	30.46 (26.50–34.42)	1.00	1.00
Medium (98.69–99.98)	38.25 (34.04–42.46)	**1.57 (1.05–2.36)**	1.42 (0.96–2.10)
High (100)	33.08 (29.51–36.66)	1.21 (0.84–1.77)	1.02 (0.71–1.47)
Percentage of sidewalks			
Low (0.00–58.99)	31.55 (27.87–35.22)	1.00	1.00
Medium (59.00–97.56)	34.13 (30.28–37.96)	1.17 (0.80–1.70)	0.98 (0.68–1.42)
High (≥97.57)	36.35 (32.11–40.58)	1.32 (0.89–1.95)	1.17 (0.79–1.71)
Percentage of paved streets			
Low (62.40–94.42)	31.41 (27.75–35.06)	1.00	1.00
Medium (94.43–99.79)	34.84 (30.77–38.90)	1.28 (0.87–1.89)	1.24 (0.85–1.81)
High (≥99.80)	35.64 (31.62–39.65)	1.24 (0.84–1.82)	102 (0.70–1.49)
Land-use mix (entropy index)			
Low (0.01–0.48)	30.82 (26.77–34.86)	1.00	1.00
Medium (0.49–0.58)	33.85 (29.99–37.70)	1.20 (0.81–1.77)	1.19 (0.81–1.73)
High (≥0.59)	36.29 (32.49–40.08)	1.32 (0.89–1.95)	1.25 (0.86–1.83)
Presence of public open spaces			
No	33.14 (30.02–36.26)	1.00	1.00
Yes	34.59 (31.33–37.84)	1.09 (0.79–1.49)	1.09 (0.80–1.48)

[a] Adjusted models control for sex, age, and education.

Note. Boldface indicates significance.

Abbreviations: OR, odds ratio; CI, confidence interval.

of recreational areas, walking paths, parks, and other green areas—may be more important to promoting walking for leisure among older adults from Florianópolis. Future studies should include these variables to better understand those relationships.

This study is 1 of the first carried out in Brazil that investigated the association between walking in different domains and objective measures of the built environment, showing a positive relationship between these factors in the older adult population. These results are important for several reasons: Older adults represent the fastest growing age group, especially in middle-income countries such as Brazil[47] and tend to show lower levels of physical activity compared with younger individuals[48,49]; additionally, this target population is more sensitive to built environment barriers or facilities because of functional and mobility decline and the reduction of its social networks.[3]

Given those current trends, strategies to improve certain built environment characteristics, such as street connectivity and density, sidewalks, and population density, should be incorporated into the urban planning of Florianópolis, and other cities in Brazil with similar characteristics, so that the cities can provide to older residents environments that are more supportive in promoting and encouraging healthy behaviors such as walking.[28,50]

Some limitations should be considered when interpreting the results of this study. First, the use of a cross-sectional design limits the identification of a causal link between the built environment variables and walking but indicates the magnitude of associations and can bring new approaches for the development of the study area. The use of self-reported measures can overestimate the prevalence of the outcomes. However, a validated instrument was used, and interviewers were trained to avoid possible report errors.[33] Although built environment objective measures were used, such data were not originally collected for research purposes related to physical activity. The area of analysis in this study was the census tract, understood as a neighborhood representation, but cannot fully represent the environment to which individuals are exposed and might not match a person's perceived neighborhood area.

Strengths of this study included a representative sample, composed of older adults of a state capital in southern Brazil, and the high response rate of the study. The application of the instrument in the form of face-to-face interviews at home contributed to a better quality of data collected. The inclusion of built environment variables based on measurements obtained by GIS in studies with an older adult population is a pioneering concept in Brazilian public health research and still little explored in different contexts of middle-income countries, especially in Latin America.

Conclusions

Specific built environment characteristics were independently associated with walking, mainly for transportation, among older adults from Florianópolis. These findings have important implications for public health and urban policies aimed at promoting healthy behaviors in the older population, showing that higher population density, high street connectivity, and better infrastructure such as sidewalks and street paving can increase the likelihood of walking for transportation. Therefore, environmental-based interventions are needed and might have a stronger influence on walking in large groups or entire communities.[51] Environmental attributes associated with walking for leisure need to be further explored to better understand this behavior. So, this study highlights the need for more research on the built environmental determinants of leisure-time walking.

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