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Built Environment and Physical Activity for Transportation in Adults from Curitiba, Brazil

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ABSTRACT *The goal of this study was to assess the association between features of the built environment and levels of walking and cycling as forms of transportation in the city of Curitiba, Brazil. Data collection was conducted through a telephone survey in 2008. The International Physical Activity Questionnaire was used to identify walking or cycling as forms of transportation. The built environment characteristics were obtained through the Geographic Information System for 1,206 adults. Density indicators were computed, considering a radius of 500 m around each individual's household. For the accessibility measures, the shortest distance to selected built environment features (e.g., bus stop, bike path) was used. The association between characteristics of the environment and the practice of walking or cycling was assessed through logistic regressions. After considering individual characteristics, higher-income areas (OR=0.56, 95 % CI=0.41–0.76), higher density of Bus Rapid Transit stations (OR=1.50, 95 % CI=1.22–1.84), and the proportion of residential (OR=1.25, 95 % CI=1.02–1.53) and commercial (OR=1.47, 95 % CI=1.13–1.91) areas were associated with any walking prevalence (≥10 min/week). Higher access to bike paths (OR=0.80, 95 % CI=0.64–1.00) was inversely associated with walking at recommended levels (≥150 min/week). Higher-income areas (OR=0.26, 95 % CI=0.08–0.81), greater number of traffic lights (OR=0.27, 95 % CI=0.09–0.88), and higher land use mix (OR=0.52, 95 % CI=0.31–0.88) were inversely associated with cycling. The neighborhood built environment may affect active commuting among adults living in urban centers in middle-income countries.*

KEYWORDS *Motor activity, Transportation, Environment and public health, Adult, Brazil*

INTRODUCTION

Walking and cycling are modes of transportation that could potentially replace short to medium distance trips previously made in motor vehicles. These modes of transportation can contribute to achieve the recommended levels of physical activity,

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reduce sedentary behaviors, improve air quality, and reduce greenhouse emissions, thus providing direct and indirect economic benefits.[1–3] Due to their health benefits, low cost, and potential to reach a great portion of the population, walking and cycling have inspired research to better understand correlates of active transportation.[4–7]

Although evidence has shown that personal factors contribute to active transportation,[4] built environment characteristics can also play an important role in this behavior.[8] For example, people who reside in areas with higher population density, land use diversity, higher connectivity of streets and trails, access to places for walking, attractive environments, and higher access to public transit have a greater chance of walking or biking.[9–12]

Despite the relative consistency of those results, how the environment is associated with physical activity varies according to local and cultural characteristics. However, nearly all studies on factors associated with transport physical activity have been conducted in high-income countries.[9,12] Therefore, to better understand the relationship between the built environment and physical activity patterns, specific socioeconomic (SES) and cultural characteristics should be considered.

There is growing research from low-income and middle-income countries in Latin America about the correlates of physical activity for transportation. In Bogota, Colombia, higher street density, connectivity, and access to public transportation have been found to be associated with walking for transportation.[13] In addition, bicycle use was associated with higher density of streets and lower rates of traffic accidents.[13] Among older adults from the same city, higher street connectivity and steep terrain were negatively associated with walking for transportation.[14]

The evidence from Brazil shows that perceived attractiveness, safety, and proximity to destinations are associated with walking as a means of transportation among adults[15] and older adults.[16,17] These studies, however, used self-perceived measures, which have shown a divergent association with transport physical activity when compared with objective measures of the environment.[18] In addition, objective measures of the environment are scarce in Brazil, resulting in limited evidence.[19,20] Thus, the goal of this study was to assess the association between objectively measured features of the built environment and walking and cycling as forms of transportation in the city of Curitiba, Brazil.

METHODS

Sample Population

A geographically diverse and representative sample of adults from Curitiba, Brazil was interviewed by phone in the year 2008. Curitiba is the capital city of Parana state, located in the south of Brazil. With a population of 1,851,215 inhabitants and 435 km^2 of area, Curitiba is the eighth biggest city in the country. Curitiba is classified as a city of high human development (Human Development Index = 0.85) and has also been recognized worldwide by its efforts to promote sustainable growth and mass public transportation.[15,21]

The detailed sampling procedures are documented elsewhere.[19] Briefly, participants were asked for their address to spatially locate their homes. From the total of 2,097 respondents surveyed, 1,206 provided complete address information. Institutional review board approval was obtained prior to data collection from

Pontiff Catholic University of Parana in Curitiba and Washington University in St. Louis. All participants of this study provided verbal consent before the phone interview began.

Outcome Variables: Physical Activity for Transportation

For the assessment of physical activity, the International Physical Activity Questionnaire, Long Form (IPAQ)[22] was used. In Brazil, IPAQ is widely used[19,23,24] and has shown good reliability. For this study, only questions related to walking and bicycling for transportation were used. Time spent walking as a means of transport (in minutes per week) was classified according to two different criteria. Previous studies have shown that the association of built environment characteristics varies according to physical activity levels.[25,26] Hence, the subjects were classified as any walking (≥10 min/week) and walking at recommended levels (≥150 min/week).[27] Cycling for transportation (in minutes per week) was categorized as at least once a week for ten consecutive minutes versus no use due to its low prevalence.

Covariates: Built Environment Variables

Built environment variables were obtained from the Institute of Urban Planning and Research of Curitiba. To calculate the density indicators, a radius of 500 m around each individual's residency was used. Although other studies have analyzed greater buffers sizes (800 m,[28] 1,000 m,[29] and 1,600 m[30]) when the outcome is bicycle use, the environmental characteristics of bigger buffers (1,000 m) have been highly correlated with those observed in smaller buffers (500 m).[31] Furthermore, in denser cities like Curitiba, the increase of buffer size could result in reduced variability of the environmental characteristics at the individual level as well as overlap of urban areas.[30] Thus, a 500-m-radius buffer was used for bicycle use.

For the accessibility measures, the shortest distance to the selected built environment features (e.g., bus stop, bike path) was used. Both buffer and shortest distance were determined, considering the street network in order to acquire a more precise measure.[32] Furthermore, network buffers show more consistent associations with environmental characteristics when compared with circular (crow-fly) buffers.[33]

Population density was computed as the number of inhabitants per square kilometer based on data from the 2000 national census. As the number of inhabitants was available only at the census tract level, the intersect tool of ArcGIS was used to select census tracts that were wholly or partially contained within the 500-m network buffer. If a census tract was only partly contained within the buffer, inhabitants' unit counts were prorated according to the percentage of the census block area contained within the buffer. Finally, population density was computed as the number of inhabitants divided by the number of kilometers within the 500-m buffer.

Area income was available at the census tract level using data from the 2000 national census. The variable was estimated as the average mean income (in Brazilian Reais) of the census tract sectors contained within a 500-m network buffer area.

Density of public transport was estimated by separately considering the number of “conventional” bus stops and the number of Bus Rapid Transit (BRT) tube station stops within a 500-m network buffer from the participant's home. Accessibility was calculated using the shortest distance from these features to the participant's home, considering street network.

The presence of traffic lights was used as an indicator of traffic safety (e.g., traffic calming device). The number of traffic lights contained within the 500-m network buffer area was computed for each participant household.

To calculate land use mix, we used land use patterns based on 32 types of parcels classified into 5 categories (residential, commercial, industrial, recreational, and empty or other). The proportion of commercial or residential areas and the associated entropy were calculated based on available methodology,[34] considering the 500-m network buffer surrounding each residence.

Considering street patterns, for each individual 500-m network buffer, the following variables were computed: (a) streets density (in meters per square meter); (b) average length of the streets; (c) number of blocks; (d) proportion of dead-end streets; and (e) proportion of street intersections (≥4 segments). The density of bike paths (in meters per square meter) was estimated within a 500-m network buffer, and the accessibility was computed based on the shortest distance to a bike path (in meters).

The terrain slope was calculated using the city's contours, which were converted into an irregular triangular network.[35] Average slope of the triangles within the 500-m buffer was calculated in percentage values,[14] with 0° indicating a 0 % slope (lowest) and 45° indicating a 100 % slope.

All the variables were classified into tertiles, except for the number of bus stops, traffic lights, and bike lane density, which were dichotomized. The variables were categorized due to no linearity on the logit (Table 1).

Sociodemographic and Health Status Variables

Sociodemographic variables assessed in the study were sex, age (18–34, 35–54, and ≥55 years), education (did not complete high school, completed high school, some college), marital status (single, married, and other, which included widowed/separated/divorced), car ownership (yes versus no), and body mass index (BMI) (underweight/normal weight versus overweight/obese) based on self-reported height and weight (Table 2).

Statistical Analysis

Descriptive statistics were calculated. Colinearity among the built environment variables was tested using Pearson's correlation coefficient, considering $r \geq 0.5$ and $p < 0.05$ as criteria for exclusion from the multivariate model. Binary logistic regressions were used to analyze the association between physical activity outcomes (any walking, walking at recommended levels, and bicycling) and built environment variables. The final multivariate models included environmental variables with $p \leq 0.15$ entered together, adjusting by sociodemographic variables (sex, age, BMI, educational, marital status, and car ownership). All analyses were performed in Stata 9.2 using sample weights for gender and age and considering the design effect.

RESULTS

The final sample was composed mostly of women and middle-aged individuals (35–54 years old). The sample was equally distributed with regard to education; a large proportion was married and had at least one car at home. Almost half of the participants in the study were classified as overweight or obese (Table 2). Only a fraction of the analytical sample size was classified as in any walking and cycling for

TABLE 1 Descriptive statistics of built environment variables (Curitiba, Brazil; $n = 1{,}206$)

Variable	Unit	Mean	Median	SD	Min	Max
Population density within a 500-m buffer area	Persons/km^2	7,312.2	6,583.9	4,146.4	51.5	31,910.7
Area income within a 500-m buffer area	Brazilian Reais	1,538.8	1,062.9	1,158.6	276.4	5,501.7
Public transport density						
Bus stop number within a 500-m buffer area	Units	9.8	9.0	5.5	0.0	30.0
BRT tube stations number within a 500-m buffer area	Units	0.6	0.0	1.3	0.0	9.0
Traffic safety number within a 500-m buffer area	Units	1.5	0.0	3.3	0.0	27.0
Land use mix						
Entropy (land use heterogeneity) within a 500-m buffer area	Index	0.53	0.55	0.15	0.00	0.85
Residential area proportion within a 500-m buffer	%	57.5	62.4	20.3	0.0	98.1
Commercial area proportion within a 500-m buffer area	%	15.2	10.5	14.0	0.0	75.2
Street pattern						
Street density within a 500-m buffer area	m/m^2	0.0175	0.0169	0.0043	0.0055	0.0357
Number of blocks within a 500-m buffer area	Units	20.6	20.0	12.1	0.0	75.0
Average length of the streets within a 500-m buffer area	m	116.8	112.0	41.9	45.4	631.0
Dead-end streets proportion within a 500-m buffer area	%	11.0	7.6	11.2	0.0	64.3
Street intersections (≥4 way) proportion within a 500-m buffer area	%	43.2	41.9	23.3	0.0	100.0
Slope within a 500-m area	%	3.0	3.1	0.5	1.0	4.3
Bike path density within a 500-m buffer area	m/m^2	0.0008	0.0000	0.0013	0.0000	0.0084
Public transport accessibility						
Distance to nearest bus stop	m	175.3	146.8	148.4	0.5	2,111.1
Distance to nearest BRT tube station	m	1,850.3	1,024.9	1,977.6	2.1	10,019.7
Bike path accessibility						
Distance to nearest bike path	m	853.4	582.2	1,018.4	0.4	7,266.8

Land use heterogeneity $= -\sum n(pi \times \ln(pi))/\ln(k)$, where p is the proportion of total land use, i is the land use category, and k is the number of land use category (residential, commercial, industrial, recreational, empty, and others)

SD standard deviation, *Min* minimum, *Max* maximum, *BRT* Bus Rapid Transit

transportation (0.05 %) or walking at recommended levels and cycling (0.03 %) (data not shown).

More than half of the participants walked at least 10 min/week, and approximately one quarter was classified as engaged in recommended levels of walking (≥150 min/week) as a form of transport. The proportion of people who were engaged in any walk was lower among males, older adults, those reporting

TABLE 2 Sociodemographic characteristics by physical activity outcomes (Curitiba, Brazil; $n=1{,}206$)

	Total sample		Any walking for transport (≥10 min/week)		Walking for transport in recommended levels (≥150 min/week)		Cycling for transport (≥10 min/week)	
Variables	*n*	%[a]	%[a]	OR (95 % CI)	%[a]	OR (95 % CI)	%[a]	OR (95 % CI)
Number of participants	1,206	100	50.8		23.1		9.6	
Sex								
Male	464	37.7	45.7	1.00	23.8	1.00	16.0	1.00
Female	742	62.3	54.2	1.40 (1.05–1.89)	22.7	0.94 (0.66–1.34)	5.2	0.29 (0.17–0.50)
Age (years)								
16–34	343	34.0	58.8	1.00	26.2	1.00	13.9	1.00
35–54	490	42.3	47.6	0.64 (0.44–0.92)	22.0	0.79 (0.51–1.25)	9.4	0.64 (0.24–1.77)
55+	373	23.7	45.1	0.58 (0.35–0.95)	20.7	0.73 (0.51–1.07)	4.0	0.26 (0.12–0.54)
Education								
<High school	396	33.8	47.3	1.00	22.7	1.00	8.7	1.00
High school	440	38.1	55.8	1.41 (1.02–1.95)	28.6	1.36 (0.98–1.88)	13.2	1.61 (0.80–3.23)
>High school	368	28.0	47.8	1.02 (0.69–1.51)	15.8	0.64 (0.44–0.93)	5.7	0.64 (0.21–1.98)
Marital status								
Single	288	27.9	58.5	1.00	26.8	1.00	15.2	1.00
Married	689	60.0	48.0	0.66 (0.40–1.07)	22.4	0.79 (0.47–1.32)	8.5	0.51 (0.22–1.19)
Other[b]	229	12.1	47.3	0.64 (0.38–1.07)	18.8	0.63 (0.48–0.84)	3.2	0.18 (0.04–0.79)
Car ownership								
No car	369	28.3	60.8	1.00	30.9	1.00	15.3	1.00
Yes	837	71.7	46.8	0.57 (0.41–0.78)	20.0	0.56 (0.41–0.78)	7.4	0.44 (0.25–0.77)
BMI								
Underweight/normal	651	56.1	56.5	1.00	24.8	1.00	11.7	1.00
Overweight/obesity	538	43.9	43.7	0.59 (0.45–0.78)	21.2	0.81 (0.58–1.16)	7.3	0.59 (0.31–1.11)

OR odds ratio, *95 % CI* 95 % confidence interval

[a]Percent weighted for age and gender distribution sample

[b]Widow, separated, or divorced

having a car in the household, and among those classified as overweight/obese. The prevalence of walking for transport at recommended levels was lower among individuals of higher education, those reporting having a car in the household, and those who were married or widowed/separated/divorced (Table 2).

After considering confounding variables, the number of BRT tube stations (OR= 1.43, 95 % CI=1.13–1.79) and residential (OR=1.25, 95 % CI=1.02–1.53) and commercial (OR=1.47, 95 % CI=1.13–1.91) area proportion were positively associated with any walking for transportation (Table 3). Participants living in areas with higher income showed 44 % lower likelihood to any walk ($p<0.01$) when compared with residents of lower-income areas. In the multivariate model (Table 4), after adjusting for confounding variables, only greater accessibility to a bike path was associated with less walking. People residing up to 367 m from a bike lane had 20 % lower odds of walking at recommended levels (95 % CI=0.64–1.00).

Only one in ten participants used bicycles as a means of transportation and was higher among males, young adults (18–34 years old), lower education levels, living alone, normal weight status, and not owning a car (Table 2). After adjusting for confounders (Table 5), residing in areas of higher income (OR=0.26, 95 % CI= 0.08–0.81), higher number of traffic lights (OR=0.27, 95 % CI=0.09–0.88), mixed land use (OR=0.52, 95 % CI=0.31–0.88), and residential area proportion (OR= 0.53, 95 % CI=0.34–0.83) were associated with bicycling for transportation.

DISCUSSION

Overall, individual characteristics were more consistently associated with active commuting than were environmental variables. A greater number of individual and environmental variables were associated with walking and cycling at least 10 min/week when comparing with walking 150 min/week or more. Walking for at least 10 min/week was associated with sex, age, education, car ownership, BMI, neighborhood income, number of BRT stations, and residential and commercial area proportions. However, higher volume of total walking (≥150 min/week) was associated only with education, marital status, car ownership, and distance to nearest bike path. Finally, cycling for transportation was associated with sex, age, marital status, car ownership, neighborhood income, traffic lights, and land use.

Our results indicate that environmental variables associated with walking vary according to the amount of walking, as observed in other studies.[36,37] Data from this study suggest that variables such as the proportion of commercial and residential areas are associated with any walking for transportation, but not at the recommended levels. A recent study showed that adults living in highly walkable areas of Curitiba (as measured by an index composed by residential density, density of intersections, and land use mix) are more likely to walk as a mean of transport at recommended levels.[38] These data indicate that the combination of different environmental characteristics may be needed to encourage greater levels of physical activity.[39,40] However, the comparison between the studies needs to take into account that some different methods were applied in both studies. In the present paper, the use of individual buffer increases the variability between the environmental variables. On the other hand, the work from Reis et al.[38] considered characteristics in the census tract level that could reduce the variability among the environmental variables. However, the selection of census tract was done to increase the contrast between high and low walkability and, consequently, could favor finding differences on the walking level.

TABLE 3 Crude and adjusted logistic regression model showing association between objectively measured features of the built environment and walking for transportation (Curitiba, Brazil; $n=1{,}206$)

	Any walking for transport (≥10 min/week)						
Variables	Prevalence[a]	Crude OR	95 % CI	p value	Adjusted OR[b]	95 % CI	p value
Population density (inhabitants/km^2)							
(0.1–5.1)	47.7	1.00					
(5.2–8.7)	52.8	1.22	(0.86–1.72)	0.21			
(8.8–31.9)	51.4	1.16	(0.74–1.82)	0.47			
Neighborhood income (Brazilian Reais)							
(210.6–767.6)	53.6	1.00			1.00		
(767.7–1,676.7)	50.6	0.89	(0.62–1.26)		0.79	(0.54–1.15)	0.19
(1,676.8–6,622.9)	46.1	0.74	(0.59–0.92)	0.02	0.56	(0.41–0.76)	<0.01
Public transport density							
Bus stop number							
(0.0–7.0)	47.8	1.00					
(7.1–12.0)	48.4	0.82	(0.76–1.43)	0.85			
(12.1–30.0)	53.4	1.25	(0.81–1.71)	0.17			
BRT tube station number							
None	48.7	1.00			1.00		
1	43.7	0.82	(0.43–1.55)	0.49	0.88	(0.48–1.62)	0.64
≥2	57.5	1.43	(1.13–1.79)	0.01	1.50	(1.22–1.84)	<0.01
Traffic safety							
Traffic lights number							
None	51.0	1.00					
1	47.1	0.85	(0.51–1.43)	0.50			
≥2	51.9	1.03	(0.66–1.62)	0.86			
Land use mix							
Entropy							
(0.00–0.49)	49.2	1.00					
(0.5–0.59)	52.2	1.13	(0.85–1.48)	0.34			
(0.6–0.85)	51.2	1.08	(0.80–1.46)	0.56			
Residential area proportion (%)							
(0.0–53.8)	48.3	1.00			1.00		
(53.9–68.7)	50.9	1.11	(0.88–1.40)	0.34	1.25	(1.02–1.53)	0.03
(68.8–98.1)	52.7	1.19	(0.94–1.51)	0.12	1.28	(0.95–1.72)	0.09
Commercial area proportion (%)							
(0.0–5.9)	46.3	1.00			1.00		
(6–17.2)	54.7	1.40	(1.01–1.93)	0.04	1.47	(1.13–1.91)	<0.01
(17.3–75.2)	51.6	1.24	(1.01–1.52)	0.04	1.51	(0.86–2.65)	0.13
Street pattern							
Street density (m/m^2)							
(0.0055–0.0157)	49.4	1.00					
(0.0158–0.0183)	50.3	1.04	(0.77–1.39)	0.78			
(0.0184–0.0357)	52.2	1.12	(0.87–1.44)	0.33			
Block number							
(0.0–15.0)	51.9	1.00					
(15.1–24.0)	48.9	0.86	(0.60–1.31)	0.50			
(24.1–75.0)	51.2	0.97	(0.69–1.38)	0.87			

TABLE 3 (continued)

	Any walking for transport (≥10 min/week)						
Variables	Prevalence[a]	Crude OR	95 % CI	*p* value	Adjusted OR[b]	95 % CI	*p* value
Dead-end streets proportion (%)							
(0.0–3.6)	50.7	1.00					
(3.7–13.3)	52.5	1.07	(0.79–1.46)	0.61			
(13.4–64.3)	49.3	0.94	(0.68–1.34)	0.73			
Street intersection (≥4 or more segments) proportion (%)							
(0.0–30.3)	48.5	1.00					
(30.4–53.3)	53.8	1.23	(0.73–2.10)	0.38			
(53.4–100.0)	50.0	1.06	(0.74–1.52)	0.72			
Average slope (%)							
(1.0–2.9)	54.8	1.41	(0.99–2.01)	0.06	1.20	(0.83–1.72)	0.28
(3–3.2)	49.7	1.15	(0.73–1.80)	0.71	0.98	(0.64–150)	0.92
(3.3–4.3)	46.2	1.00			1.00		
Streets mean length (m)							
(45.4–104.7)	49.9	0.94	(0.72–1.23)	0.61			
(104.8–120.3)	51.2	0.99	(0.69–1.42)	0.95			
(120.4–631.0)	51.5	1.00					
Bike path density (m)							
None	51.3	1.00					
>0	50.1	0.95	(0.82–1.10)	0.48			
Public transport access							
Distance to nearest bus stop (m)							
(0.5–100.4)	52.3	1.08	(0.79–1.49)	0.56			
(100.5–203.6)	48.8	0.92	(0.66–1.29)	0.59			
(203.7–2,111.1)	50.8	1.00					
Distance to nearest BRT tube station (m)							
(2.1–638.0)	54.5	1.05	(0.71–1.56)	0.79	1.18	(0.85–1.63)	0.28
(638.1–1,781.7)	44.7	0.71	(0.50–0.99)	0.05	0.73	(0.51–1.05)	0.08
(1,781.8–10,019.7)	53.3	1.00					
Distance to nearest bike path (m)							
(0.4–367.4)	47.3	0.88	(0.71–1.09)	0.20	0.82	(0.65–1.05)	0.10
(367.5–849.1)	54.4	1.17	(1.00–1.36)	0.05	1.12	(0.86–1.47)	0.33
(849.2–7,266.8)	50.6	1.00			1.00		

BRT Bus Rapid Transit

[a]Percent weighted for age and gender distribution sample

[b]Adjusted for gender, age, BMI, education, marital status, and car ownership

Our results also showed that the availability of public transport was associated with walking for transportation. Studies from cities such as Bogota (Colombia), New Jersey (USA), and Perth (Australia) support the hypothesis that people who use and/or have access to public transport are more likely to walk and be more physically active than those who do not.[25,41,42] As reported elsewhere,[25,26] the use or access to public transport was associated with some walking, but not with the recommended physical activity levels. Additionally, this association was specific to certain types of transport system (e.g., BRT), as reported in other studies.[25,41,43] A potential explanation is that the BRT is faster than the regular bus system. This could motivate the people to expend more time walking until the BRT tube station stop to save more time to reach the destination using the transit system. Also, these

TABLE 4 Crude and adjusted logistic regression model showing association between objectively measured features of the built environment and walking for transportation in recommended levels (Curitiba, Brazil; $n=1{,}206$)

	Walking for transport in recommended levels (≥150 min/week)						
Variables	Prevalence[a]	Crude OR	95 % CI	p value	Adjusted OR[b]	95 % CI	p value
Population density (inhabitants/km^2)							
(0.1–5.1)	22.2	1.00					
(5.2–8.7)	24.3	1.13	(0.72–1.76)	0.56			
(8.8–31.9)	22.8	1.04	(0.72–1.49)	0.81			
Neighborhood income (Brazilian Reais)							
(210.6–767.6)	24.8	1.00			1.00		
(767.7–1,676.7)	23.1	0.91	(0.61–1.37)	0.62	0.96	(0.61–1.54)	0.86
(1,676.8–6,622.9)	20.2	0.77	(0.66–0.90)	0.01	0.82	(0.60–1.13)	0.19
Public transport density							
Bus stop number							
(0.0–7.0)	24.2	1.00					
(7.1–12.0)	21.4	0.85	(0.50–1.46)	0.51			
(12.1–30.0)	23.4	0.96	(0.65–1.40)	0.79			
BRT tube station number							
None	23.0	1.00					
1	21.9	0.94	(0.46–1.94)	0.86			
≥2	24.5	1.09	(0.74–1.61)	0.62			
Traffic safety							
Traffic lights number							
None	24.4	1.00					
1	18.3	0.69	(0.34–1.44)	0.28			
≥2	20.6	0.80	(0.54–1.21)	0.25			
Land use mix							
Entropy							
(0.00–0.49)	22.4	1.00					
(0.5–0.59)	25.4	1.18	(0.79–1.77)	0.37			
(0.6–0.85)	21.7	0.96	(0.63–1.46)	0.82			
Residential area proportion (%)							
(0.0–53.8)	19.7	1.00					
(53.9–68.7)	25.2	0.77	(0.43–1.36)	0.32			
(68.8–98.1)	24.3	1.05	(0.65–1.67)	0.83			
Commercial area proportion (%)							
(0.0–5.9)	23.0	1.00					
(6–17.2)	24.6	1.09	(0.70–1.72)	0.66			
(17.3–75.2)	21.3	0.91	(0.71–1.16)	0.40			
Street pattern							
Street density (m/m^2)							
(0.0055–0.0157)	22.9	1.00					
(0.0158–0.0183)	22.0	0.95	(0.60–1.50)	0.81			
(0.0184–0.0357)	24.2	1.08	(0.68–1.72)	0.71			
Block number							
(0.0–15.0)	26.4	1.00					
(15.1–24.0)	19.2	0.66	(0.37–1.20)	0.15			
(24.1–75.0)	22.9	0.83	(0.53–1.30)	0.37			
Dead-end streets proportion (%)							
(0.0–3.6)	23.1	1.00					

TABLE 4 (continued)

	Walking for transport in recommended levels (≥150 min/week)						
Variables	Prevalence[a]	Crude OR	95 % CI	*p* value	Adjusted OR[b]	95 % CI	*p* value
(3.7–13.3)	22.6	0.97	(0.64–1.49)	0.89			
(13.4–64.3)	23.6	0.94	(0.62–1.44)	0.76			
Street intersection (≥4 or more segments) proportion (%)							
(0.0–30.3)	22.2	1.00					
(30.4–53.3)	24.9	1.16	(0.77–1.76)	0.43			
(53.4–100.0)	22.2	1.00	(0.61–1.64)	1.00			
Average slope (%)							
(1.0–2.9)	24.9	1.37	(0.72–2.62)	0.30			
(3–3.2)	24.0	1.31	(0.65–2.64)	0.41			
(3.3–4.3)	19.5	1.00					
Streets mean length (m)							
(45.4–104.7)	22.9	1.04	(0.69–1.56)	0.84			
(104.8–120.3)	24.3	1.13	(0.65–1.95)	0.64			
(120.4–631.0)	22.2	1.00					
Bike path density (m)							
None	23.4	1.00					
>0	22.8	0.96	(0.78–1.19)	0.69			
Public transport access							
Distance to nearest bus stop (m)							
(0.5–100.4)	25.4	1.20	(0.87–1.67)	0.23			
(100.5–203.6)	22.3	1.02	(0.73–1.41)	0.91			
(203.7–2,111.1)	22.0	1.00					
Distance to nearest BRT tube station (m)							
(2.1–638.0)	22.3	0.83	(0.62–1.12)	0.19	1.00	(0.64–1.57)	1.00
(638.1–1,781.7)	21.1	0.78	(0.55–1.10)	0.14	0.86	(0.57–1.28)	0.40
(1,781.8–10,019.7)	25.6	1.00			1.00		
Distance to nearest bike path (m)							
(0.4–367.4)	21.9	0.81	(0.65–1.03)	0.07	0.80	(0.64–1.00)	0.05
(367.5–849.1)	21.9	0.81	(0.64–1.03)	0.08	0.86	(0.67–1.11)	0.21
(849.2–7,266.8)	25.7	1.00			1.00		

BRT Bus Rapid Transit

[a]Percent weighted for age and gender distribution sample

[b]Adjusted for gender, age, BMI, education, marital status, and car ownership

types of transportation are more disperse and available as compared to the regular bus system. On average, in Curitiba, the nearest bus stop is located <200 m from a destination, which would require only 3 min of brisk walking. On the contrary, BRT stations are located at 1,850 m on average, hence helping explain the associations we found. The finding of BRT is very relevant given that more than 100 cities worldwide have implemented this system that was first implemented in Curitiba.[44]

Regarding built environment features, a higher density of bike paths was negatively associated with walking for transportation at the recommended levels. In Curitiba, such structure connects city parks and is used for leisure purposes rather than daily commuting. Therefore, participants residing near bike paths are likely to live closer to parks, which are typically large areas that may hinder accessibility to nearby destinations. Supporting this assumption, a study by Mass et al.[45] identified that local residents living in neighborhoods with more green areas walk and bike less

TABLE 5 Crude and adjusted logistic regression model showing association between objectively measured features of the built environment and cycling for transportation (Curitiba, Brazil; $n=1{,}206$)

	Cycling for transport (≥10 min/week)						
Variables	Prevalence[a]	Crude OR	95 % CI	p value	Adjusted OR[b]	95 % CI	p value
Population density (inhabitants/km^2)							
(0.1–5.1)	8.5	1.00			1.00		
(5.2–8.7)	9.1	1.07	(0.56–2.03)	0.81	1.10	(0.59–2.09)	0.73
(8.8–31.9)	11.2	1.36	(0.95–1.95)	0.09	1.21	(0.65–2.22)	0.50
Neighborhood income (Brazilian Reais)							
(210.6–767.6)	14.9	1.00			1.00		
(767.7–1,676.7)	7.1	0.43	(0.17–1.13)	0.08	0.53	(0.21–1.37)	0.16
(1,676.8–6,622.9)	4.4	0.27	(0.13–0.54)	0.00	0.26	(0.08–0.81)	0.03
Traffic safety							
Traffic lights number							
None	11.1	1.00			1.00		
1	9.9	0.87	(0.19–0.41)	0.84	1.12	(0.30–4.12)	0.85
≥2	3.4	0.28	(0.10–0.76)	0.02	0.27	(0.09–0.84)	0.03
Land use mix							
Entropy							
(0.00–0.49)	11.3	1.00			1.00		
(0.5–0.59)	10.9	0.95	(0.44–2.04)	0.89	1.32	(0.62–2.83)	0.42
(0.6–0.85)	6.2	0.52	(0.27–1.01)	0.05	0.52	(0.31–0.88)	0.02
Residential area proportion (%)							
(0.0–53.8)	10.9	1.00			1.00		
(53.9–68.7)	7.1	0.62	(0.44–0.86)	0.01	0.53	(0.34–0.83)	0.01
(68.8–98.1)	10.7	0.98	(0.48–1.98)	0.94	0.61	(0.33–1.14)	0.11
Commercial area proportion (%)							
(0.0–5.9)	11.7	1.00					
(6–17.2)	8.4	0.69	(0.39–1.24)	0.19			
(17.3–75.2)	8.4	0.70	(0.26–1.85)	0.42			
Street pattern							
Street density (m/m^2)							
(0.0055–0.0157)	6.2	1.00			1.00		
(0.0158–0.0183)	8.8	1.47	(0.69–3.16)	0.28	1.75	(0.53–5.76)	0.31
(0.0184–0.0357)	12.9	2.26	(1.24–4.13)	0.01	1.44	(0.57–3.64)	0.39
Block number							
(0.0–15.0)	9.0						
(15.1–24.0)	9.6	1.07	(0.47–2.42)	0.86			
(24.1–75.0)	10.4	1.17	(0.79–1.73)	0.39			
Dead-end streets proportion (%)							
(0.0–3.6)	8.9	0.71	(0.24–2.06)	0.48	1.00	(0.23–4.36)	1.00
(3.7–13.3)	7.3	0.57	(0.32–1.00)	0.05	0.68	(0.32–1.44)	0.27
(13.4–64.3)	12.2	1.00			1.00		
Street intersection (≥4 or more segments) proportion (%)							
(0.0–30.3)	11.3						
(30.4–53.3)	9.4	0.82	(0.45–1.52)	0.48			
(53.4–100.0)	7.9	0.67	(0.36–1.26)	0.18			
Average slope (%)							
(1.0–2.9)	9.6	1.16	(0.56–2.41)	0.66			
(3–3.2)	10.7	1.30	(0.58–2.93)	0.47			
(3.3–4.3)	8.4						

TABLE 5 (continued)

	Cycling for transport (≥10 min/week)						
Variables	Prevalence[a]	Crude OR	95 % CI	*p* value	Adjusted OR[b]	95 % CI	*p* value
Streets mean length (m)							
(45.4–104.7)	11.3	1.90	(1.17–3.06)	0.02	1.04	(0.52–2.10)	0.90
(104.8–120.3)	10.6	1.75	(0.72–4.26)	0.18	2.07	(0.59–7.28)	0.22
(120.4–631.0)	6.3	1.00			1.00		
Bike path density (m)							
None	11.0	1.00			1.00		
≥0	8.0	0.71	(0.46–1.08)	0.10	0.60	(0.34–1.03)	0.06
Distance to nearest bike path (m)							
(0.4–367.4)	8.1	0.77	(0.50–1.18)	0.20			
(367.5–849.1)	10.4	1.01	(0.50–2.06)	0.98			
(849.2–7,266.8)	10.3	1.00					

[a]Percent weighted for age and gender distribution sample
[b]Adjusted for gender, age, BMI, education, marital status, and car ownership

frequently due to the great dispersion of destinations when compared with commercial areas. A study from Bogota, Colombia also found that residents who lived nearby urban parks were less likely to participate in the recreational program that occurs on Sundays and holidays called the Ciclovia program.[13]

This study showed that bicycling for transportation is associated with a greater number of built environment characteristics. In Curitiba, areas with higher number of traffic lights, land use mix, and residential areas and lower density of bike paths were generally found in high-income areas and in the city's downtown, where people own cars and are less likely to use bicycles. Areas with these characteristics also have higher levels of motorized vehicle traffic, also associated with less bicycle use.[46,47] These factors could be associated with more traffic accidents within high SES neighborhoods which in turn have been associated with less biking.[13] These findings, despite being opposite from those in the literature, may be reflections of existing social and cultural differences between countries. As mentioned, bike lanes in Curitiba connect parks and are more often used for leisure. As such, cyclists rely on the use of streets where they share the same space with cars, motorcycles, and buses, creating unsafe environments and adding tension to the constant conflict between active commuters and drivers. Brazil is known to have one of the most hostile traffic environments of the world.[48] Between 2000 and 2008, road traffic mortality per 100,000 population was between 18 (northeast region) and 30 (center west region) per year,[49] higher than countries such as Japan (5 out of 100,000), USA (13 out of 100,000), and Canada (9 out of 100,000).[50] In 2006, 22 % of traffic-related accidents in Brazil involved cyclists.[51] The proportion of deaths involving cyclists in Brazil is about 5 %, also higher compared to the USA (2 %) and Canada (3 %).[50]

However, the present study did not consider some important environmental variables that often are not available in Geographic Information System (GIS) databases (e.g., availability and quality of sidewalks, garbage accumulation) or cannot be evaluated through objective measures (e.g., safety perception) and that might be important to better understand some cultural factors related to our results. For example, studies in Brazil have found that perceived safety[52] and esthetics[53] were negatively related with walking for transportation. Similar results were also observed in low-income countries.[54,55] In this sense, future studies in culturally and economically diverse regions should consider a more comprehensive framework including objective and perceived measures of the built environment, since the evidence emerging from high-income countries might not reflect the contextual characteristics from other regions.

This study is one of the first in Brazil and Latin America to investigate the relationship between objective measures of the built environment and active commuting. To this date, the studies in Brazil have only analyzed perceived environments,[15–17] and studies using objective measures of the built environment have focused on leisure time physical activity[20] or have not included environmental measures at the individual level.[38] The study included a sample population of the city that was geographically well distributed and with good variability in built environments. The conclusions of this study, however, should take into consideration some limitations. First, it was not possible to determine a causal relationship between the associated factors. The measure used to assess the practice of physical activity has limitations inherent to self-reported data such as comprehension and recall bias. This problem can be further complicated with measures of sporadic activities, such as physical activity. In addition, IPAQ only captures bouts of at least 10 min, which is usually more than the usual commuting to and from public transport. This might have undermined our ability to detect associations between walking and the availability and accessibility of bus stops. Even though objective measures of the built environment were used, data were based on GIS, which were not originally gathered for physical activity research purposes.

CONCLUSION

This study shows that features of the built environment were associated with walking or bicycling for transportation among Curitiba residents. Several observed relationships (e.g., number of BRT stations and walking) show face validity and are leads for future studies. In countries of low and middle income, the built environment may affect active commuting despite the individual characteristics of commuters. Findings from this and other recent studies reflect the contextual factors that might be needed to be included in further research such as access to public transportation,[13] number of plazas and public facilities,[20] and crime-related and traffic-related safety.[52,54]

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REFERENCES

1. Hamer M, Chida Y. Active commuting and cardiovascular risk: a meta-analytic review. *Prev Med*. 2008; 46(1): 9–13.

2. Boone-Heinonen J, Evenson KR, Taber DR, Gordon-Larsen P. Walking for prevention of cardiovascular disease in men and women: a systematic review of observational studies. *Obes Rev*. 2009; 10(2): 204–217.
3. Giles-Corti B, Foster S, Shilton T, Falconer R. The co-benefits for health of investing in active transportation. *NSW Public Health Bull*. 2010; 21(5–6): 122–127.
4. Ogilvie D, Egan M, Hamilton V, Petticrew M. Promoting walking and cycling as an alternative to using cars: systematic review. *BMJ*. 2004; 329(7469): 763.
5. Lee C, Moudon AV. Physical activity and environment research in the health field: implications for urban and transportation planning practice and research. *J Plan Lit*. 2004; 19(2): 147–181.
6. Saelens BE, Sallis JF, Frank LD. Environmental correlates of walking and cycling: findings from the transportation, urban design, and planning literatures. *Ann Behav Med*. 2003; 25(2): 80–91.
7. Dannenberg AL, Jackson RJ, Frumkin H, et al. The impact of community design and land-use choices on public health: a scientific research agenda. *Am J Public Health*. 2003; 93(9): 1500–1508.
8. Owen N, Humpel N, Leslie E, Bauman A, Sallis JF. Understanding environmental influences on walking: review and research agenda. *Am J Prev Med*. 2004; 27(1): 67–76.
9. Wendel-Vos W, Droomers M, Kremers S, Brug J, van Lenthe F. Potential environmental determinants of physical activity in adults: a systematic review. *Obes Rev*. 2007; 8(5): 425–440.
10. Saelens BE, Handy SL. Built environment correlates of walking: a review. *Med Sci Sports Exerc*. 2008; 40(7S): S550–S566.
11. McCormack GR, Shiell A. In search of causality: a systematic review of the relationship between the built environment and physical activity among adults. *Int J Behav Nutr Phys Act*. 2011; 8(1): 125.
12. Bauman AE, Reis RS, Sallis JF, Wells JC, Loos RJ, Martin BW. Correlates of physical activity: why are some people physically active and others not? *Lancet*. 2012; 380(9838): 258–271.
13. Cervero R, Sarmiento OL, Jacoby E, Gomez LF, Neiman A. Influences of built environments on walking and cycling: lessons from Bogotá. *Int J Sust Transp*. 2009; 3(4): 37–41.
14. Gomez LF, Parra DC, Buchner D, et al. Built environment attributes and walking patterns among the elderly population in Bogota. *Am J Prev Med*. 2010; 38(6): 592–599.
15. Parra DC, Hoehner CM, Hallal PC, et al. Perceived environmental correlates of physical activity for leisure and transportation in Curitiba, Brazil. *Prev Med*. 2011;53:234–8.
16. Salvador EP, Reis RS, Florindo AA. A prática de caminhada como forma de deslocamento e sua associação com a percepção do ambiente em idosos. *Rev bras Ativ Fís Saúde*. 2009; 14(3): 195–205.
17. Salvador EP, Reis RS, Florindo AA. Practice of walking and its association with perceived environment among elderly Brazilians living in a region of low socioeconomic level. *Int J Behav Nutr Phys Act*. 2010; 7: 67.
18. Hoehner CM, Brennan Ramirez LK, Elliott MB, Handy SL, Brownson RC. Perceived and objective environmental measures and physical activity among urban adults. *Am J Prev Med*. 2005; 28(2 Suppl 2): 105–116.
19. Reis RS, Hallal PC, Parra DC, et al. Promoting physical activity through community-wide policies and planning: findings from Curitiba, Brazil. *J Phys Act Health*. 2010; 7(Suppl 2): S137–S145.
20. Hino AA, Reis RS, Sarmiento OL, Parra DC, Brownson RC. The built environment and recreational physical activity among adults in Curitiba. *Braz Prev Med*. 2011; 52(6): 419–422.
21. Reis RS, Hino AA, Parra DC, Hallal PC, Brownson RC. Bicycling and walking for transportation in three Brazilian cities. *Am J Prev Med*. 2013; 44(2): e9–e17.
22. Craig CL, Marshall AL, Sjostrom M, et al. International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc*. 2003; 35(8): 1381–1395.

23. Gomes GA, Reis RS, Parra DC, et al. Walking for leisure among adults from three Brazilian cities and its association with perceived environment attributes and personal factors. *Int J Behav Nutr Phys Act*. 2011; 8: 111.
24. Hallal PC, Gomez LF, Parra DC, et al. Lessons learned after 10 years of IPAQ use in Brazil and Colombia. *J Phys Act Health*. 2010; 7(Suppl 2): S259–S264.
25. Wener RE, Evans GW. A morning stroll levels of physical activity in car and mass transit commuting. *Environ Behav*. 2007; 39(1): 62–74.
26. Lachapelle U, Frank LD. Transit and health: mode of transport, employer-sponsored public transit pass programs, and physical activity. *J Public Health Pol*. 2009; 30(Suppl 1): S73–S94.
27. World Health Organization. *Global recommendations on physical activity for health*. Geneva: World Health Organization; 2010.
28. Dalton AM, Jones AP, Panter JR, Ogilvie D. Neighbourhood, route and workplace-related environmental characteristics predict adults' mode of travel to work. *PLoS One*. 2013; 8(6): e67575.
29. Sallis JF, Conway TL, Dillon LI, et al. Environmental and demographic correlates of bicycling. *Prev Med*. 2013. doi:10.1016/j.ypmed.2013.06.014
30. Beenackers MA, Foster S, Kamphuis CB, et al. Taking up cycling after residential relocation: built environment factors. *Am J Prev Med*. 2012; 42(6): 610–615.
31. Winters M, Brauer M, Setton EM, Teschke K. Built environment influences on healthy transportation choices: bicycling versus driving. *J Urban Health*. 2010; 87(6): 969–993.
32. Thornton LE, Pearce JR, Kavanagh AM. Using Geographic Information Systems (GIS) to assess the role of the built environment in influencing obesity: a glossary. *Int J Behav Nutr Phys Act*. 2011; 8: 71.
33. Oliver LN, Schuurman N, Hall AW. Comparing circular and network buffers to examine the influence of land use on walking for leisure and errands. *Int J Health Geogr*. 2007; 6: 41.
34. Leslie E, Coffee N, Frank L, Owen N, Bauman A, Hugo G. Walkability of local communities: using geographic information systems to objectively assess relevant environmental attributes. *Health Place*. 2007; 13(1): 111–122.
35. ESRI. Surface creation and analysis. http://resources.esri.com/help/9.3/arcgisdesktop/com/gp_toolref/geoprocessing/surface_creation_and_analysis.htm (2010). Accessed 1 April 2010.
36. Christian HE, Bull FC, Middleton NJ, et al. How important is the land use mix measure in understanding walking behaviour? Results from the RESIDE study. *Int J Behav Nutr Phys Act*. 2011; 8: 55.
37. Owen N, Cerin E, Leslie E, et al. Neighborhood walkability and the walking behavior of Australian adults. *Am J Prev Med*. 2007; 33(5): 387–395.
38. Reis RS, Hino AAF, Rech CR, Kerr J, Hallal PC. Walkability and physical activity: findings from Curitiba, Brazil. *Am J Prev Med*. 2013; 45(3): 269–275.
39. Van Dyck D, Cerin E, Conway TL, et al. Perceived neighborhood environmental attributes associated with adults' leisure-time physical activity: findings from Belgium, Australia and the USA. *Health Place*. 2013; 19: 59–68.
40. Sallis JF, Bowles HR, Bauman A, et al. Neighborhood environments and physical activity among adults in 11 countries. *Am J Prev Med*. 2009; 36(6): 484–490.
41. Gomez LF, Sarmiento OL, Parra DC, et al. Characteristics of the built environment associated with leisure-time physical activity among adults in Bogota, Colombia: a multilevel study. *J Phys Act Health*. 2010; 7(Suppl 2): S196–S203.
42. Villanueva K, Giles-Corti B, McCormack G. Achieving 10,000 steps: a comparison of public transport users and drivers in a university setting. *Prev Med*. 2008; 47(3): 338–341.
43. MacDonald JM, Stokes RJ, Cohen DA, Kofner A, Ridgeway GK. The effect of light rail transit on body mass index and physical activity. *Am J Prev Med*. 2010; 39(2): 105–112.
44. Hidalgo D, Gutiérrez L. BRT and BHLS around the world: explosive growth, large positive impacts and many issues outstanding. *Res Transp Econ*. 2013; 39(1): 8–13.
45. Maas J, Verheij RA, Spreeuwenberg P, Groenewegen PP. Physical activity as a possible mechanism behind the relationship between green space and health: a multilevel analysis. *BMC Public Health*. 2008; 8: 206.

46. Garrard J, Rose G, Lo SK. Promoting transportation cycling for women: the role of bicycle infrastructure. *Prev Med*. 2008; 46(1): 55–59.
47. Fraser SD, Lock K. Cycling for transport and public health: a systematic review of the effect of the environment on cycling. *Eur J Public Health*. 2011; 21(6): 738–743.
48. Bacchieri G, Barros AJ. Traffic accidents in Brazil from 1998 to 2010: many changes and few effects. *Rev Saude Publica*. 2011; 45(5): 949–963.
49. Chandran A, Kahn G, Sousa T, Pechansky F, Bishai DM, Hyder AA. Impact of road traffic deaths on expected years of life lost and reduction in life expectancy in Brazil. *Demography*. 2013;50:229–36.
50. World Health Organization. *Global status report on road safety: time for action*. Geneva: World Health Organization; 2009.
51. Mascarenhas MDM, Silva MMA, Malta DC, et al. Atendimentos de emergência por acidentes na Rede de Vigilância de Violências e Acidentes—Brasil, 2006. *Ciênc Saúde Colet*. 2009; 14(5): 1657–1668.
52. Rech CR, Reis RS, Hino AA, et al. Neighborhood safety and physical inactivity in adults from Curitiba, Brazil. *Int J Behav Nutr Phys Act*. 2012; 9(1): 72.
53. Hallal PC, Reis RS, Parra DC, Hoehner CM. Association between perceived environmental attributes and physical activity among adults in Recife, Brazil. *J Phys Act Health*. 2010; 7(Suppl 2):S213–22.
54. Oyeyemi AL, Adegoke BO, Sallis JF, Oyeyemi AY, De Bourdeaudhuij I. Perceived crime and traffic safety is related to physical activity among adults in Nigeria. *BMC Public Health*. 2012; 12: 294.
55. Oyeyemi AL, Adegoke BO, Oyeyemi AY, Sallis JF. Perceived environmental correlates of physical activity and walking in African young adults. *Am J Health Promot*. 2011; 25(5): e10–e19.