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Built environment, contextual income, and obesity in older adults: evidence from a population-based study

Ambiente construído, renda contextual e obesidade em idosos: evidências de um estudo de base populacional

Ambiente construido, renta contextual y obesidad en ancianos: evidencias de un estudio de base poblacional

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Abstract

The objective was to verify the association between built environment, contextual income, and obesity in older adults in Florianópolis, Santa Catarina State, Brazil. This was a cross-sectional study in a sample of 1,197 older people (≥ 60 years) evaluated in the EpiFloripa Older Adults Cohort in 2013/2014. The outcomes were overall obesity, abdominal obesity, waist circumference (WC), and body mass index (BMI). Contextual income in the census tract and characteristics of the built environment were analyzed using data from the Florianópolis Institute of Urban Planning (IPUF) and the 2010 Population Census. Logistic and multilevel linear regression models were used. For older women, intermediate mean income was associated with lower odds of abdominal and overall obesity, while higher percentage of paved streets in the census tract was associated with lower odds of abdominal obesity; one percentage point increment in local commerce decreased WC by 0.20cm, and a one percentage point increase in paved streets decreased WC by 0.43cm and BMI by 0.22kg/m². For older men, better street connectivity and intermediate percentage of local commerce were associated with lower odds of overall obesity; the increment in street density decreased WC by 0.34cm and BMI by 10kg/m²; a one-point increment in lighting increased WC by 0.51cm and BMI by 0.11kg/m². The results showed different associations according to sex and target outcome, highlighting the need for further studies to explore additional relevant contextual variables for these outcomes in older adults.

Obesity; Aged; Social Class

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Introduction

Obesity is considered a global epidemic that affects all age brackets and accounts for the death of approximately 2.8 million individuals per year [1]. More specifically in the older adult population, epidemiological studies have identified growing obesity prevalence rates and strong negative health impacts [2,3].

Data from 12 European countries show obesity prevalence ranging from 12% to 41% in older women and 8% to 24% in older men [4]. High prevalence has also been observed in Japan [5], Australia [6], and Latin American countries [7]. In Brazil, according to data from 2013, approximately one out of four women and one out of five men from 65 to 74 years were obese [8].

Obesity is associated with various health problems such as type 2 diabetes, hypertension, cardiovascular diseases, and certain types of cancer [9]. The presence of these conditions together with physiological alterations of aging such as decreased bone mineral density and increased visceral fat [10] contribute to functional incapacities and increased mortality risk in the older population [11].

Various individual demographic and socioeconomic characteristics show positive associations with obesity [12], but the influence of environmental factors on the occurrence of this outcome has been studied less. Some studies have found that residing in neighborhoods with higher mean income is associated with lower odds of obesity, independently of individual characteristics [13,14,15]. Neighborhoods with low socioeconomic status offer fewer facilities for physical activities while including more small markets and fast food restaurants that sell high-energy, unhealthy foods [16], in a sense making the neighborhood itself obesogenic [17].

Meanwhile, neighborhoods with a higher proportion of green areas, large supermarkets, and recreational areas tend to facilitate regular exercise and adequate eating, enhance the feeling of local safety, and foster greater social interaction between neighbors and friends, thus decreasing the odds of becoming obese [18,19]. In urban places, characteristics such as higher proportion of paved streets, good connectivity between streets, and larger supply of commercial establishments tend to reflect an environment with better infrastructure, where residents can move around more easily on foot and acquire healthier habits [20]. All these characteristics suggest even greater relevance for older people, who spend most of their time in domestic and/or community activities and thus use their neighborhood environment more intensely when compared to younger adults [21].

Despite the findings published to date, most studies on this topic have been done in high-income countries [14,15,18,19,20,22,23,24,25]. Few studies in Brazil have addressed neighborhood and obesity, and the samples have only included younger adults [26]. Since the country has sharp socioeconomic disparities and rapid population aging, it is essential to investigate environmental factors that can influence the occurrence of obesity in older Brazilians in order to support strategies for the promotion of healthy behaviors and to increase healthy life expectancy in this age group.

The aim of this study was thus to test the association between built environment, contextual income, and obesity in older adults in Florianópolis, Santa Catarina State, Brazil.

Methods

Study design and location

This was a cross-sectional study nested in a cohort of older residents in the city of Florianópolis, capital of Santa Catarina State (EpiFloripa Older Adults Study). The baseline was performed in 2009/2010, and the data for the current study were collected in 2013/2014. The city's population in 2010 was 421,000, of whom 11.4% were older adults (60 years or older), and of these, 14% were considered very old (80 years or older) [27].

Sampling procedures and data collection

The study's sample consisted of 1,705 older adults of both sexes, 60 years or older, non-institutionalized and residing within the city limits of Florianópolis. The sample size was estimated on the basis of known parameters for sampling calculations, using a two-stage cluster approach, the first consisting of census tracts and the second consisting of the households picked for interviews [27]. Further details on the sampling procedures have been published recently in an article on the study's methodology [28].

In 2013, all participants in the first wave were considered eligible. Addresses were updated by telephone, e-mail, or letter before the data collection. Deaths that occurred from 2009 to 2012 were checked using the state's data from the Brazilian Mortality Information System (SIM). Losses were defined as individuals that were not located after four attempts (including at least one in the evening and one on weekends), hospitalized individuals, and those who had moved away from the city. Subjects that declined to answer the questionnaire by personal choice were considered refusals. When the refusal was voiced by telephone, the interviewer made one final attempt with a direct household visit.

Data were collected using netbooks for application of a standardized questionnaire, previously tested in a pilot study. The interviews were performed face-to-face at the older adults' homes from November 2013 to November 2014. Data consistency was verified weekly, and quality control was done with an abridged questionnaire, via telephone, with 10% of the selected interviewees, using simple random sampling, considering the principle of equiprobability with low risk of selection bias [29]. Kappa test was used to measure inter-observer reliability, after reapplication of eight randomly selected questions. The results indicate moderate to very good agreement, with values ranging from 0.51 to 0.94 ($p < 0.001$).

Outcome variables

The target outcomes for analysis were abdominal obesity and overall obesity, both dichotomized. Abdominal obesity was defined as waist circumference (WC) according to World Health Organization (WHO) guidelines [9], with obesity in older males defined as WC greater than 102cm and in older females as WC greater than 88cm. WHO cutoff points for overall obesity [1] were also adopted, where body mass index (BMI) > 30kg/m^2 is considered obesity in both sexes.

Weight was measured with a calibrated portable scale (Britania, Joinville, Brazil), with a capacity of 150kg and accurate to 100g. Participants were weighed just once, barefoot and wearing light clothing. Height was measured twice with a tape measure stadiometer, accurate to 1mm. Subjects were measured in standing position, barefoot, with their feet together and their heels, buttocks, and head in contact with the stadiometer, head in the Frankfurt plane, arms handing loosely by their sides, and shoulders relaxed [30]. WC was measured with a non-extensible anthropometric tape measure, 160cm long (Sanny, São Bernardo do Campo, Brazil), with resolution to 1mm, with the individual in standing position. The measurement was taken twice, and when there was a difference ≥ 1cm a third measurement was taken. The measurement was taken in the narrowest portion of the trunk below the last rib, identified by the examiner, after the subject had exhaled. For individuals without a visible waist, the reference was the midpoint between the iliac crest and the last rib. The examiner was positioned in front of the subject and kept the area for measurement free of clothing.

Exposure variables

The environmental variables were elaborated previously, using the ArcGIS 9.3 software (ArcMap) (Environmental Systems Research Institute, Redlands, USA; http://www.esri.com/software/arcgis/index.html), with the following data from the Florianópolis Institute of Urban Planning (IPUF): (a) street layout (urban layout); (b) blocks and lots; (c) land use; and (d) buildings [31].

Elaboration of the environmental variables used editing and updating of IPUF data through georeferenced aerial photographs from 2010 and updated images available on Google Earth (https://www.google.com.br/intl/pt-BR/earth/) and Google Street View (https://www.google.com.br/intl/pt/streetview/). Additional socioeconomic and infrastructure information from around the households was used, published by the Brazilian Institute of Geography and Statistics (IBGE), from Brazil's 2010 Population Census [27]. These data were available as tables and maps for each census tract, which represented the current study's unit of analysis. Based on this, the following environmental variables were analyzed:

• Contextual income: mean monthly nominal income of heads of permanent private households (with and without income);
• Population density: number of inhabitants in the census tract divided by the tract's area in square kilometers;
• Percentage of public lighting in the census tract: this information was determined by direct observation by IBGE staffers, recording whether there was at least one public light post on the same or opposite side of the street from the household. This information was used to determine the percentage of public lighting in the census tract, dividing the total number of households with public lighting by the total number of households in the tract, multiplied by 100;
• Percentage of paved streets in the census tract: existence of paving (public byway covered with asphalt, concrete, cobblestones, etc.) on the stretch in front of the household. Calculation: number of households with paving divided by total households, multiplied by 100;
• Percentage of sidewalks in the census tract: existence of a sidewalk or walkway (concrete or paved) in front of the household. Calculation: number of households with sidewalks divided by total households, multiplied by 100;
• Street density: area served by streets inside the tract, in square kilometers, divided by the tract's total area;
• Intersection density (street connectivity): number of intersections formed by four or more street segments, divided by the tract's area in square kilometers, considering both the streets inside the tract and adjacent streets;
• Mixed land use (entropy): calculated as the presence or absence of five types of land use (residential, commercial, recreational green areas, institutional, and others) in the tract, and defined by the following formula [32]:

$$\{- \Sigma^{k}[(pi) * (\ln pi)]\} / (\ln k)$$

where: p = proportion of land use, i = land use category, ln = natural logarithm, k = number of 141 uses. The entropy index varies from 0 to 1, where 0 indicates homogeneity (predominance of only type of land use) and 1 indicates heterogeneity (equal distribution of all land use categories);
• Recreational green areas in the tract: public domain recreational green areas, e.g., playgrounds, gardens, squares, neighborhood parks, city parks, or metropolitan parks. Calculation: presence or absence of recreational green areas inside the tract (whether or not the area was contained totally within the tract);
• Percentage of commerce in the tract: area classified as commercial divided by total land use area in the tract, multiplied by 100;
After the formulation, all the contextual exposure variables were grouped with the other individual variables in a single data bank using the command "merge", with the census tract variable as the identifier.

Individual level adjustment variables

The individual adjustment variables were: sex (male, female), age bracket (60 to 69 years, 70 to 79, and 80 or older), schooling (≤ 4 years of school, 5 to 8, 9 to 11, and ≥ 12) and per capita income (calculated by dividing family income by the number of residents in the household and categorized in quartiles).

Data analysis

Initially, the interviewees' addresses were updated in relation to the baseline, excluding those who had moved to different census tracts from the study's sample. Descriptive analyses of the sample's distribution considered the outcomes' prevalence rates and respective 95% confidence intervals (95%CI) for each of the individual and contextual variables. Associations between environmental variables and outcomes were analyzed with multilevel logistic regression models, using all the contextual variables categorized in distribution tertiles. The choice of this analytical model was based on the observed values from the likelihood ratio test for comparison between models [33].

The first level of analysis consisted of the individuals, with census tracts as the second level. First the null model was tested (with random interception, but without the exploratory variables) for each outcome, and after this stage, separate multilevel models were created for each contextual variable.

Thus, first the crude models were tested for associations between each environmental characteristic and each outcome. Next, the adjusted models were tested for the individual-level variables (sex, age bracket, schooling, and income). No collinearity was observed between the exposure variables (VIF = 2.26), and all the models were stratified by sex, considering the significant results of the interaction analyses for this variable ($p < 0.05$). Post-estimation analyses were also performed for each of the models using two parameters – calculation of the predicted values and the likelihood ratio test. The first showed positive values for the outcomes in the absence of the models' effect variation, and the second confirmed the null hypothesis for the observed coefficients, both indicating that the models adequately fit the data.

Multilevel models can be represented by the following equation, where *Yi* is the outcome coefficient, *B0* the intercept, and *Xi* and *Wj* the individual and contextual exposure variables, respectively. Random effect is represented by the letter *u* and the model's residuals by the letter *e* [34].

$$Yij = B0j + B1 * X1ij + ... + B5j * X5ij + eij$$

where:

$$B0j = \gamma 00 + \gamma 0j * Wj + u0j;$$
$$Bij = \gamma i0 + \gamma i1 * Wj + u1j$$

For each model, the intra-class correlation coefficient (ICC) was calculated to estimate the total percentage variance of each outcome attributed to the differences between the census tracts. The formula for calculating ICC for logistic models is (variance of level 2/(variance of level 2 + (ϖ^2/3))).

All analyses were performed with the Stata software, version 13.0 (StataCorp LP, College Station, USA) and considered the recalculated sampling weights according to the variables in which selective losses to follow-up were identified. Results with $p < 0.05$ were considered statistically significant.

Ethical aspects

The study was approved by the Ethics Research Committee of the Federal University of Santa Catarina (UFSC), under case review 352/2008 at baseline in 2009/2010, and the Certificate of Submission for Ethical Review (CAAE) n. 16731313.0.0000.0121 in the 2013/2014 wave. Participating older adults received orientation on the study's objectives and signed the free and informed consent form. For older adults who were unable to sign the form, a legal guardian was asked to sign.

Results

In 2013/2014, 1,197 older adults were interviewed, or 70.2% of the original cohort. There was a selective loss to follow-up among older adults in the sample (from 2009/2010 to 2013/2014) in relation to the variables sex and age bracket. Men died more than women, but the percentage of refusals was higher in women. The 60-69-year age bracket showed the highest percentage of losses, while the 80-and-over bracket had the highest percentage of deaths. Considering health conditions, there was a higher absolute number of losses in older adults with overweight/obesity (9% of the sample), but the highest relative loss was in the group of normal-weight older adults (11% of the sample). As for socioeconomic variables, there was a higher loss of older adults from the second income quartile (1.7% of the sample).

Mean age of the older subjects was 73.9 years (standard deviation 7.2 years), with a higher proportion of women in the sample (65%). The largest share of the sample subjects were 70 to 79 years of age and had up to four years of schooling (42.5%). Median monthly per capita income was BRL 1,326.66 (USD 402 in current values) (interquartile interval = BRL 2,080.00). Prevalence of overall obesity was 17.3% in men and 34.8% in women. For abdominal obesity, women also showed higher prevalence rates than men, with 64.5% versus 36.7%, respectively.

Differences in the prevalence of overall and abdominal obesity were also observed between men and women according to age, schooling, and per capita income. In general, younger women and those with higher income and schooling showed higher percentages of overall and abdominal obesity. Meanwhile, the highest percentages in men were found in those with intermediate age and schooling and high income (Table 1).

Table 1

Individual and contextual characteristics of the sample. EpiFloripa Older Adults Study, 2013/2014, Florianópolis, Santa Catarina State, Brazil.

Variables	n (%)	Abdominal obesity [% (95%CI)]		Overall obesity [% (95%CI)]	
		Male	Female	Male	Female
Individuals					
Sex					
Male	419 (35.0)	36.8 (32.1; 41.5)	-	17.3 (13.6; 21.0)	-
Female	778 (65.0)	-	64.5 (61.0; 67.9)	-	34.8 (31.4; 38.2)
Age (years)					
60-69	412 (34.4)	32.7 (25.2; 40.1)	63.6 (57.7; 69.6)	19.6 (13.3; 25.9)	38.4 (32.3; 44.4)
70-79	509 (42.5)	41.3 (33.9; 48.7)	69.1 (64.1; 74.1)	18.9 (13.0; 24.9)	38.2 (33.0; 43.4)
≥ 80	276 (23.1)	32.5 (22.3; 42.7)	56.8 (49.3; 64.3)	9.75 (3.3; 16.2)	22.6 (16.1; 29.0)
Schooling (years)					
0-4	523 (43.8)	26.6 (22.3; 36.9)	66.3 (61.3; 71.2)	16.1 (10.1; 22.0)	36.4 (31.3; 41.4)
5-8	199 (16.2)	46.8 (34.2; 59.3)	62.6 (54.3; 70.9)	25.8 (14.8; 36.9)	30.0 (22.1; 37.9)
9-11	180 (15.0)	28.1 (16.3; 39.9)	68.0 (59.6; 76.5)	8.7 (1.3; 16.2)	37.8 (29.0; 46.6)
≥ 12	292 (24.4)	42.3 (34.0; 50.7)	59.4 (51.5; 67.4)	18.4 (11.8; 24.9)	33.1 (25.4; 40.8)
Per capita income					
First quartile	-	31.2 (20.7; 41.6)	63.0 (56.4; 69.7)	11.9 (4.5; 19.2)	36.7 (29.9; 43.4)
Second quartile	-	31.5 (22.6; 40.3)	59.5 (52.0; 66.7)	19.8 (12.2; 27.4)	29.2 (22.3; 36.1)
Third quartile	-	44.4 (34.0; 54.8)	69.6 (63.0; 76.2)	22.5 (13.7; 31.2)	33.7 (26.9; 40.4)
Fourth quartile	-	38.0 (29.3; 46.7)	67.7 (60.4; 75.0)	14.9 (8.5; 21.3)	39.7 (32.0; 47.5)
Environment					
Mean income, head of households (BRL)					
818.00-2,052.00	551 (32.3)	30.4 (22.3; 38.5)	70.8 (64.9; 76.6)	16.3 (9.7; 22.8)	41.9 (35.5; 48.2)
2,052.00-3,607.87	666 (39.1)	35.5 (30.9; 46.0)	61.1 (55.6; 66.7)	17.5 (11.6; 23.4)	30.1 (24.8; 35.4)
> 3,607.87	488 (28.6)	39.3 (30.6; 48.0)	62.3 (55.9; 68.7)	18.2 (11.3; 25.1)	33.5 (27.2; 39.8)
Population density (inhabitants/km²)					
356.37-3,028.07	603 (35.4)	39.5 (32.2; 46.9)	68.3 (62.6; 74.0)	17.0 (11.4; 22.7)	32.3 (26.7; 38.0)
3,028.07-9,319.06	608 (35.6)	31.5 (23.4; 39.6)	61.1 (55.3; 67.0)	16.8 (10.2; 23.4)	34.6 (28.8; 40.3)
≥ 9,319.06	494 (29.0)	36.7 (27.6; 45.8)	64.1 (57.7; 70.4)	18.3 (11.0; 25.7)	38.0 (31.6; 44.6)
Public lighting (%)					
66.90-98.70	522 (36.6)	32.0 (23.8; 40.2)	65.1 (59.1; 71.2)	14.5 (8.27; 20.8)	37.5 (31.4; 43.7)
98.70-100.00	515 (30.2)	39.8 (30.9; 48.7)	59.4 (53.0; 65.9)	16.9 (10.1; 23.8)	31.8 (25.6; 38.0)
100.00	668 (39.2)	37.0 (29.5; 44.4)	67.8 (62.4; 73.2)	19.7 (13.6; 25.9)	34.8 (29.3; 40.4)
Paved street (%)					
62.40-94.43	624 (36.6)	37.4 (29.7; 45.1)	66.2 (60.5; 71.8)	17.0 (11.0; 23.0)	34.9 (29.2; 40.7)
94.43-99.80	531 (31.1)	33.6 (25.0; 42.2)	62.8 (56.6; 69.0)	14.3 (7.9; 20.6)	35.9 (29.7; 41.1)
> 99.80	550 (32.3)	37.3 (29.0; 45.5)	64.2 (58.2; 70.2)	20.4 (13.5; 27.3)	33.6 (27.6; 39.5)
Sidewalks (%)					
Up to 59.00	618 (36.2)	34.9 (27.2; 42.5)	66.4 (60.7; 72.1)	15.3 (9.5; 21.1)	32.8 (27.1; 38.5)
59.00-97.57	589 (34.6)	36.7 (29.9; 44.4)	67.2 (61.4; 72.9)	18.9 (12.6; 25.7)	36.2 (30.3; 42.2)
> 97.57	498 (29.2)	37.7 (28.4; 47.0)	59.3 (52.9; 65.7)	17.9 (10.6; 25.3)	35.5 (29.3; 41.7)
Street densidade (km²)					
3.17-13.97	581 (34.1)	36.0 (28.2; 43.9)	64.9 (59.0; 70.7)	18.7 (12.3; 25.2)	32.2 (26.4; 37.9)
13.97-25.55	653 (38.3)	40.1 (32.2; 48.1)	65.5 (60.0; 71.0)	17.1 (11.0; 23.2)	26.5 (30.9; 42.2)
> 25.55	471 (27.6)	31.6 (23.0; 40.2)	62.6 (56.0; 69.2)	15.8 (9.0; 22.5)	35.8 (29.2; 42.4)

(continues)

Table 1 (continued)

Variables	n (%)	Abdominal obesity [% (95%CI)]		Overall obesity [% (95%CI)]	
		Male	Female	Male	Female
Environment					
Street conectivity					
Up to 3.64	607 (35.6)	39.2 (31.0; 47.5)	65.9 (60.2; 71.6)	23.7 (16.3; 31.0)	35.3 (29.6; 41.1)
3.64-30.94	633 (37.1)	36.2 (29.0; 43.5)	63.0 (57.3; 68.6)	14.6 (9.3; 20.0)	34.3 (28.7; 39.9)
> 30.94	465 (27.3)	32.3 (23.2; 41.5)	64.7 (58.1; 71.3)	13.7 (7.0; 20.4)	34.8 (28.2; 41.4)
Mixed land use (entropy)					
0.01-0.49	503 (29.5)	38.2 (29.0; 47.3)	67.1 (60.9; 73.3)	21.3 (13.5; 29.1)	37.4 (31.0; 43.9)
0.49-0.59	582 (34.1)	29.7 (21.7; 37.6)	59.3 (53.5; 65.1)	13.3 (7.4; 19.2)	33.6 (28.0; 39.1)
> 0.59	620 (36.4)	40.0 (32.6; 47.4)	67.8 (62.1; 73.6)	17.8 (12.0; 23.7)	33.9 (27.9; 39.8)
Recreationl green areas					
0.0000-0.0001	881 (51.7)	36.6 (29.6; 43.6)	64.4 (59.6; 69.2)	18.3 (12.6; 24.0)	36.8 (32.0; 41.6)
0.0001-0.4500	291 (17.0)	35.2 (24.0; 46.4)	61.4 (52.9; 69.9)	16.9 (8.1; 25.7)	32.5 (24.3; 40.7)
> 0.4500	533 (31.3)	36.4 (28.7; 44.0)	66.2 (60.2; 72.3)	16.3 (10.4; 22.2)	32.7 (26.7; 38.8)

95CI: 95% confidence interval.

Table 2 shows the results of multilevel logistic regression with abdominal obesity as the outcome. The values with the adjusted model showed that older women residing in places with intermediate mean income and higher percentage of paved streets showed lower odds of abdominal obesity. For older men, no significant association was observed. Table 3 shows the multilevel logistic regression with overall obesity as the outcome. In the adjusted model, intermediate mean income was associated with lower odds of obesity among women, while better street connectivity and intermediate percentage of local commerce were associated with lower odds of overall obesity in men.

Calculation of estimated ICC for the null models of the two outcomes (overall and abdominal obesity) ranged from 0% to 5.18% in both sexes. The adjusted models, after inclusion of the individual variables, did not substantially modify the observed ICC values in the null models, independently of the target outcome and sex.

Discussion

According to the study's main results, for older women, census tracts with intermediate mean income were associated with lower odds of abdominal and overall obesity, and higher percentage of paved streets was associated with lower odds of abdominal obesity. For older men, better street connectivity and intermediate percentage of commerce were associated with lower odds of overall obesity.

Corroborating the current study's results, other researchers have shown that neighborhoods with worse social and economic conditions (lower income and higher unemployment) are associated with higher odds of overall obesity in older women in England and in older adults of both sexes in the United States [19,23]. The mean income of the census tract generally represents its level of wealth and is related to the local infrastructure and supply of opportunities. Neighborhoods with better infrastructure tend to encourage healthier lifestyles, since they offer spaces for leisure and physical activity, which helps maintain adequate weight [18]. In addition, poorer neighborhoods generally present lower availability and/or accessibility of healthy foods such as fruits, vegetables, and greens, while offering a wider variety of high-calorie foods that contribute substantially to weight gain [14,35].

The significant association between intermediate mean income in the census tract and lower odds of obesity in older women may be due to the fact that the sample only included individuals from inside the city limits, where socioeconomic inequalities between census tracts may be smaller. At any rate, it is necessary to analyze other socioeconomic variables, such as employment and unemployment levels and inequality in income distribution (e.g., Gini coefficient) between the tracts, which have also been

Table 2

Multilevel logistic regression analysis of contextual variables and abdominal obesity, according to sex. EpiFloripa Older Adults Study 2013/2014, Florianópolis, Santa Catarina State, Brazil.

Variables	Female		Male	
	Crude OR (95%CI)	Adjusted * OR (95%CI)	Crude OR (95%CI)	Adjusted * OR (95%CI)
Mean income in the census tract (BRL)				
Low (818.00 < 2,052.00)	1.00	1.00	1.00	1.00
Medium (2,052.00-3,607.00)	0.65 (0.44; 0.96)	0.62 (0.41; 0.94)	1.36 (0.83; 2.24)	1.31 (0.77; 2.22)
High (≥ 3,607.00)	0.63 (0.42; 0.95)	0.63 (0.40; 1.00)	1.02 (0.59; 1.74)	0.85 (0.45; 1.52)
Population density (inhabitants/km2)				
Low (356.37 < 3,028.07)	1.00	1.00	1.00	1.00
Medium (3,028.07 < 9,319.06)	0.86 (0.58; 1.26)	0.82 (0.55; 1.22)	0.70 (0.42; 1.16)	0.62 (0.37; 1.05)
High (≥ 9,319.06)	0.82 (0.55; 1.22)	0.85 (0.56; 1.29)	0.95 (0.56; 1.58)	0.86 (0.50; 1.48)
Paved street (%)				
Low (62.40 < 94.43)	1.00	1.00	1.00	1.00
Medium (94.43 < 99.80)	0.96 (0.64; 1.42)	0.69 (0.47; 1.03)	0.79 (0.47; 1.35)	1.03 (0.58; 1.82)
High (≥ 99.80)	0.87 (0.59; 1.28)	0.66 (0.44; 0.99) *	1.00 (0.61; 1.65)	1.17 (0.67; 2.04)
Public lighting (%)				
Low (66.90 < 98.69)	1.00	1.00	1.00	1.00
Medium (98.69 < 99.99)	0.85 (0.57; 1.28)	0.96 (0.63; 1.46)	1.27 (0.73; 2.22)	1.28 (0.72; 2.28)
High (100.00)	1.06 (0.72; 1.55)	1.09 (0.73; 1.63)	1.18 (0.70; 1.97)	1.10 (0.65; 1.88)
Sidewalks (%)				
Low (0.00 < 59.00)	1.00	1.00	1.00	1.00
Medium (59.00 < 97.57)	1.10 (0.74; 1.62)	1.11 (0.74; 1.67)	1.00 (0.61; 1.64)	0.95 (0.57; 1.59)
High (≥ 97.57)	0.81 (0.55; 1.20)	0.87 (0.57; 1.34)	1.08 (0.63; 1.85)	1.02 (0.57; 1.82)
Street conectivity (km2)				
Low (0.00 < 3.64)	1.00	1.00	1.00	1.00
Medium (3.64 < 30.94)	0.85 (0.58; 1.24)	0.87 (0.60; 1.29)	0.86 (0.53; 1.40)	0.74 (0.44; 1.23)
High (≥ 30.94)	0.96 (0.63; 1.44)	1.06 (0.68; 1.65)	0.74 (0.42; 1.29)	0.60 (0.33; 1.09)
Commerce in the tract (%)				
Low (0.00 < 4.62)	1.00	1.00	1.00	1.00
Medium (4.62 < 12.98)	1.16 (0.78; 1.71)	1.21 (0.81; 1.81)	0.68 (0.40; 1.16)	0.71 (0.41; 1.22)
High (≥ 12.98)	0.83 (0.56; 1.23)	0.84 (0.56; 1.26)	0.80 (0.48; 1.34)	0.72 (0.42; 1.24)
Presence of recreational green areas				
Não	1.00	1.00	1.00	1.00
Sim	1.08 (0.75; 1.55)	1.02 (0.70; 1.50)	1.10 (0.69; 1.76)	1.14 (0.71; 1.84)
Mixed land use (entropy)				
Low (0.01 < 0.49)	1.00	1.00	1.00	1.00
Medium (0.49 < 0.59)	0.81 (0.55; 1.20)	0.81 (0.54; 1.21)	0.69 (0.40; 1.21)	0.66 (0.37; 1.17)
High (≥ 0.59)	1.10 (0.73; 1.66)	1.12 (0.74; 1.72)	1.02 (0.61; 1.71)	1.03 (0.61; 1.74)
Street density (km2)				
Low (3.17 < 13.97)	1.00	1.00	1.00	1.00
Medium (13.97 < 25.55)	1.12 (0.77; 1.65)	1.21 (0.82; 1.80)	1.07 (0.65; 1.76)	0.96 (0.57; 1.60)
High (≥ 25.55)	0.95 (0.63; 1.42)	1.00 (0.65; 1.55)	0.82 (0.48; 1.39)	0.65 (0.36; 1.15)

95%CI: 95% confidence interval; OR: odds ratio.

* Models stratified by sex and adjusted by age bracket, schooling, and per capita income.

Table 3

Multilevel logistic regression analysis of contextual variables and overall obesity, according to sex. EpiFloripa Older Adults Study 2013/2014, Florianópolis, Santa Catarina State, Brazil.

Variables	Female		Male	
	Crude OR (95%CI)	Adjusted * OR (95%CI)	Crude OR (95%CI)	Adjusted * OR (95%CI)
Mean income in the census tract (BRL)				
Low (818.00 < 2,052.00)	1.00	1.00	1.00	1.00
Medium (2,052.00-3,607.00)	0.52 (0.34; 0.81)	0.52 (0.33; 0.82)	1.30 (0.71; 2.79)	1.43 (0.75; 2.74)
High (≥ 3,607.00)	0.69 (0.45; 1.08)	0.70 (0.43; 1.15)	0.85 (0.42; 1.71)	1.08 (0.49; 2.36)
Population density (inhabitants/km^2)				
Low (356.37 < 3,028.07)	1.00	1.00	1.00	1.00
Medium (3,028.07 < 9,319.06)	1.25 (0.80; 1.94)	1.23 (0.78; 1.95)	1.04 (0.56; 1.94)	0.89 (0.47; 1.71)
High (≥ 9,319.06)	1.40 (0.88; 2.21)	1.46 (0.91; 2.36)	1.04 (0.54; 2.00)	1.11 (0.57; 2.17)
Paved street (%)				
Low (62.40 < 94.43)	1.00	1.00	1.00	1.00
Medium (94.43 < 99.80)	1.14 (0.72; 1.80)	1.18 (0.73; 1.89)	0.79 (0.40; 1.54)	0.81 (0.41; 1.63)
High (≥ 99.80)	1.00 (0.64; 1.57)	1.05 (0.66; 1.70)	1.06 (0.57; 1.95)	1.18 (0.61; 2.26)
Public lighting (%)				
Low (66.90 < 98.69)	1.00	1.00	1.00	1.00
Medium (98.69 < 99.99)	0.82 (0.51; 1.32)	0.86 (0.52; 1.41)	0.97 (0.48; 1.93)	1.07 (0.52; 2.21)
High (100.00)	0.95 (0.61; 1.48)	0.97 (0.61; 1.54)	1.09 (0.58; 2.05)	1.17 (0.60; 2.26)
Sidewalks (%)				
Low (0.00 < 59.00)	1.00	1.00	1.00	1.00
Medium (59.00 < 97.57)	1.20 (0.77; 1.87)	1.27 (0.80; 2.02)	1.13 (0.61; 2.08)	1.28 (0.67; 2.43)
High (≥ 97.57)	1.31 (0.83; 2.06)	1.48 (0.91; 2.41)	0.98 (0.50; 1.95)	1.24 (0.59; 2.57)
Street conectivity (km^2)				
Low (0.00 < 3.64)	1.00	1.00	1.00	1.00
Medium (3.64 < 30.94)	0.82 (0.53; 1.27)	0.86 (0.55; 1.35)	0.55 (0.30; 0.99)	0.54 (0.29; 1.00)
High (≥ 30.94)	1.03 (0.64; 1.64)	1.13 (0.69; 1.87)	0.45 (0.21; 0.91)	0.43 (0.20; 0.94)
Commerce in the tract (%)				
Low (0.00 < 4.62)	1.00	1.00	1.00	1.00
Medium (4.62 < 12.98)	0.77 (0.50; 1.20)	0.80 (0.51; 1.25)	0.45 (0.22; 0.89)	0.46 (0.23; 0.95)
High (≥ 12.98)	0.70 (0.45; 1.11)	0.69 (0.43; 1.11)	0.77 (0.42; 1.42)	0.95 (0.50; 1.79)
Presence of recreational green areas				
Não	1.00	1.00	1.00	1.00
Sim	0.85 (0.51; 1.44)	0.83(0.49; 1.41)	0.92 (0.43; 1.96)	0.90 (0.41; 1.98)
Mixed land use (entropy)				
Low (0.01 < 0.49)	1.00	1.00	1.00	1.00
Medium (0.49 < 0.59)	0.89 (0.56; 1.41)	0.90 (0.56; 1.44)	0.49 (0.25; 0.97)	0.52 (0.26; 1.05)
High (≥ 0.59)	0.92 (0.58; 1.47)	0.90 (0.55; 1.45)	0.61 (0.33; 1.14)	0.69 (0.33; 1.29)
Street density (km^2)				
Low (3.17 < 13.97)	1.00	1.00	1.00	1.00
Medium (13.97 < 25.55)	1.28 (0.83; 1.98)	1.33 (0.85; 2.09)	0.73 (0.39; 1.35)	0.68 (0.36; 1.29)
High (≥ 25.55)	1.31 (0.82; 2.10)	1.45 (0.88; 2.40)	0.74 (0.38; 1.43)	0.79 (0.39; 1.60)

95%CI: 95% confidence interval; OR: odds ratio.

* Models stratified by sex and adjusted by age bracket, schooling, and per capita income.

associated with worse health behaviors in the Brazilian population [36,37] and could help shed light on the observed association.

The observed associations between higher percentages of street paving and connectivity and lower odds of obesity also corroborate previous studies [15,18,20]. Unpaved streets with few sidewalks, with various route options, and low connectivity stimulate the use of transportation and tend to make older adults more sedentary and thus suffer higher odds of becoming obese [38]. Meanwhile, the higher percentage of local commerce reflects greater access to common destinations such as restaurants, supermarkets, shops, and services, which promotes commuting on foot and other active behaviors [13,18]. The absence or low proportion of paved streets in neighborhoods can also contribute to a lower supply of services focused on the prevention of obesity, such as workout gyms and recreational clubs [39].

The built environment is further capable of directly impacting the formation and maintenance of social ties between residents, since neighborhoods with relatively more public spaces and adequate paving provide greater opportunities for leisure and interaction between neighbors and thereby favor healthier lifestyles [40]. Nevertheless, the evidence between built environment and obesity is still limited and should be analyzed with caution. The current study did not identify significant associations with many of the target variables. One hypothesis that could explain this lack of more associations is that obesity is considered an outcome influenced more distally by the target variables from the built environment, as compared, for example, to physical activity [15,41]. Likewise, many of the explanations for the relationship between the built environment and obesity relate to concepts that involve local social and cultural aspects, which were also not measured directly in the exposures analyzed here.

The fact that better street connectivity only showed an association for older men may be due to gender differences in exposure to the neighborhood environment. In younger adulthood, it is common for women to interact more with their environment when compared to men, since they tend to perform multiple tasks that involve shopping, accompanying children to and from school, and more frequent involvement with physical and leisure-time activities [42]. Meanwhile, older women spend more time on household activities as the result of retirement and lower participation in paid work activities [43]. In addition, with advancing age, women show lower prevalence of diseases (including obesity) and lower mortality rates [44,45] which could contribute to their longer survival and greater difficulties in maintaining healthy behaviors, which would include walking and social interaction in the neighborhood itself.

Although they were beyond the scope of this study, it is important to note the differences found in the prevalence rates of overall and abdominal obesity, where overall was nearly double that of abdominal in both sexes. These results are similar to those of other population studies in older Brazilians [46,47] and underscore the importance of considering both indicators (BMI and WC) in the classification of obesity, since older adults with overall obesity can also present excess body fat and thus greater exposure to factors that determine morbidity and mortality [48].

Another finding that indicates the interrelationship in the use of the two anthropometric indicators involves the fact that abdominal obesity only showed significant associations in women. There are known differences between the sexes in body fat patterns in older adults, with a greater tendency for women to accumulate central fat. In men, fat tends to concentrate more in peripheral areas of the body [49]. These disparities indicate that both WC and BMI are relevant and complementary in the analysis of obesity, with WC more efficient for predicting risk of endocrine and metabolic diseases and BMI for identifying energy reserves and estimating total body fat [50,51].

In addition, although a strong correlation exists between WC and BMI as indicators for estimating obesity, the correlation proves less intense in women than in men, since even with normal weight, women tend to accumulate more abdominal fat. Thus, although subtle, such differences could explain the loss of association between BMI and street paving in women [52]. Meanwhile, for men, BMI was associated with street connectivity and intermediate commerce, while the same was not observed with WC. We believe that in addition to the reasons already cited, BMI, especially when analyzed in older adults, tends to suffer the heterogeneity that accompanies the aging process, which underscores the fact that it should not be used as the only measure of obesity in this age group [53].

The current study's strengths feature the fact that as far we know, this is the first study in Brazil that aimed to investigate the association in older adults between overall and abdominal obesity and different objective variables in the built environment. As for the chosen methodology, in addition to the high response rate, the use of directly measured BMI and WC contributed to the data's quality, eliminating the inherent bias of self-reported outcomes. Likewise, the use of objective contextual variables obtained from the Geographic Information System (GIS) must have expressed the built environment in more detail. And although the cross-sectional design may have impacted the cause and effect relations, it can indicate the magnitude of associations and point to new hypotheses for future studies [54]. The potential limitations include the fact that the data were not originally collected to be associated with obesity, and that the dimension analyzed was the census tract, viewed in this study as representing the neighborhood. However, this measure may not have accurately represented the environment to which older adults were exposed.

Even with the few associations observed in the study, it is clear that the built environment exerts some influence on the prevalence of obesity in older adults. The fact that older adults are the fastest growing age group in Brazil and in the world 1 and the intense use that older adults make of the neighborhood environment [21] highlight the importance of promoting policies to improve socioeconomic conditions and infrastructure in communities, aimed at better opportunities for older adults to maintain healthy habits where they live [55]. New studies on this theme are necessary to investigate the long-term influence of living in favorable versus unfavorable environments for the prevention of obesity.

Contributors

C. A. H. Araújo wrote the article and is responsible for all aspects of the work in ensuring the accuracy and integrity of any part of the work. M. W. C. Giehl contributed to the data analysis and interpretation. A. L. Danielewicz and P. G. Araujo contributed to the writing of the paper and data analysis and interpretation. E. d'Orsi wrote the article. A. F. Boing contributed to the writing of the paper and approval of the its final version.

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Resumo

O objetivo foi verificar a associação entre o ambiente construído, a renda contextual e a obesidade em idosos de Florianópolis, Santa Catarina, Brasil. Estudo transversal com amostra de 1.197 idosos (≥ 60 anos), avaliados na coorte EpiFloripa Idoso em 2013/2014. Os desfechos foram a obesidade geral, a obesidade abdominal, a circunferência da cintura (CC) e o índice de massa corporal (IMC). A renda contextual do setor censitário e as características do ambiente construído foram analisadas por meio dos dados do Instituto de Planejamento Urbano de Florianópolis (IPUF) e do Censo Demográfico de 2010. Utilizou-se modelos de regressão logística e linear multinível. Para as mulheres, a renda média intermediária foi associada às menores chances de obesidade abdominal e geral, e o maior percentual de ruas pavimentadas às menores chances de obesidade abdominal; o incremento de cada ponto percentual de comércio diminuiu 0,20cm a CC, e no de ruas pavimentadas diminuiu 0,43cm a CC e 0,22kg/m² o IMC. Para os homens, a maior conectividade das ruas e o percentual de comércio intermediário foram associados às menores chances de obesidade geral; o incremento na densidade de ruas diminuiu 0,34cm na CC e 0,10kg/m² no IMC; já no percentual de iluminação aumentou 0,51cm a CC e 0,11kg/m² o IMC. Verificaram-se associações distintas de acordo com o sexo e o desfecho analisado, fazendo-se necessárias novas pesquisas que explorem variáveis contextuais adicionais e relevantes a esses desfechos entre os idosos.

Obesidade; Idoso; Classe Social

Resumen

El objetivo fue verificar la asociación entre el ambiente construido, la renta contextual y la obesidad en ancianos de Florianópolis, Santa Catarina, Brasil. Estudio transversal con una muestra de 1.197 ancianos (≥ 60 años), evaluados en la cohorte EpiFloripa Idoso en 2013/2014. Los desenlaces fueron: obesidad general, obesidad abdominal, circunferencia de la cintura (CC) e índice de masa corporal (IMC). La renta contextual del sector censal y las características del ambiente construido se analizaron mediante los datos del Instituto de Planificación Urbana de Florianópolis (IPUF) y del Censo de 2010. Se utilizaron modelos de regresión logística y lineal multinivel. En el caso de las mujeres, una renta media intermedia se asoció a unas menores oportunidades de obesidad abdominal y general, y el mayor porcentaje de calles pavimentadas a unas menores oportunidades de obesidad abdominal; el incremento de cada punto porcentual de comercio disminuyó 0,20cm la CC, y en el de calles pavimentadas disminuyó a 0,43cm la CC y 0,22kg/m² el IMC. Para los hombres, la mayor conectividad de las calles y el porcentaje de comercio medio estuvieron asociados a unas menores oportunidades de obesidad general; el incremento en la densidad de calles disminuyó 0,34cm en la CC y 0,10kg/m² en el IMC; en el caso del porcentaje de iluminación aumentó 0,51cm la CC y 0,11kg/m² el IMC. Se verificaron asociaciones distintas, de acuerdo con el sexo y el desenlace analizado, haciéndose necesarias nuevas investigaciones que exploren variables contextuales adicionales y relevantes a estos desenlaces entre los ancianos.

Obesidad; Anciano; Clase Social

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