The Influence of Neighborhood Social Capital on Leisure-Time Physical Activity: a Population-Based Study in Brazil

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Abstract Environmentally targeted approaches to promote physical activity are emerging in recent years as a complementary strategy to the traditional individual approaches. This study explored the relation between community social capital and leisure-time physical activity in an adult population-based sample in Brazil. We applied a generalized estimating equation approach to analyze a cross-sectional survey of 3667 adults living in 149 neighborhoods. Social capital was assessed by scales that measured collective efficacy and social cohesion in the neighborhood. We find that individuals living in areas with higher level of social cohesion were more likely to be physically active even after controlling for potentially confounding individual and area-level covariates (PR = 1.56; 95% CI = 1.13, 2.16). Collective efficacy was not significantly associated with leisure-time physical activity. Interventions to strengthen social cohesion in the community may be an avenue for promoting physical activity.

Keywords Social capital · Physical activity · Brazil · Neighborhood effects

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Introduction

Noncommunicable diseases (NCD) are the biggest cause of deaths worldwide, and cardiovascular diseases (CVD) account for almost 14 million premature deaths among people before the age of 70 [1]. About three quarters of the world's deaths from CVDs occur in low- and middle-income countries [1]. In Brazil, CVD is the leading causes of death, and lower socioeconomic groups have higher prevalence of risk factors for CVD [2, 3].

While deaths from NCD mainly occur in adulthood, exposure to risk factors begins in childhood and accumulates throughout life. Physical inactivity, defined as a state in which body movement is minimal, is an important risk factor for CVD and about 3.2 million deaths annually can be attributed to insufficient physical activity [4]. Worldwide, 31.1% (95% CI 30.9–31.2) of adults are physically inactive [5]. The assessment of physical activity specifically in leisure-time domain is relevant because current evidence suggests that while occupational physical activity tends to be declining, leisure-time physical activity appears to be increasing [5].

Environmentally targeted approaches to promote physical activity (PA) are emerging in recent years as a complementary strategy to the traditional individual approaches [6]. Physical activity is one of the health behaviors most likely to be influenced by residential contexts because it is a predominantly outdoor activity [7]. While attributes of the physical “built” environment have been intensively investigated, the role of the social environment in facilitating physical activity has received far less attention [8]. Interventions to reduce disparities in physical

activity need to address not only the physical environment, but also social processes favorable to physical activity [9].

Social capital is one feature of the social environment that has been studied with respect to promoting healthy behaviors such as physical activity [10]. Social capital is defined as the resources that individuals access through their social networks [11]. Examples of resources derived through social networks that are relevant to promoting physical activity include: (a) information (e.g., about the benefits of regular exercise), (b) social support from others to engage in physical activity, (c) maintenance of healthy norms within the community (e.g., people who are seen to be exercising outdoors), (d) the ability of the community to undertake collective action (e.g., to pressure municipal authorities to build more bike lanes in the community, or to upgrade recreational facilities), and (e) exercising informal social control over deviant behavior (e.g., keeping pet dogs on a leash so as not to threaten joggers).

Social capital can be further operationalized along different dimensions, viz., structural versus cognitive dimensions [12]. The cognitive dimension of social capital refers to what individuals *perceive* about the quality of their social relations—e.g., levels of trust between neighbors, or perceptions of mutual help among neighbors. The structural dimension of social capital refers to how individuals actually *behave*—e.g., patterns of informal socializing and social participation.

Notwithstanding the diversity of approaches by which social capital has been measured and operationalized, the preponderance of evidence suggests a positive correlation between it and physical activity in adults and adolescents [13–15]. The literature is however still relatively recent with regard to the association of contextual social capital and physical activity (as opposed to examining individual perceptions of social capital) [16]. Besides that, although we have examples of interventions using public spaces to promote physical activity and increase the perception of social capital in Latin America, the majority of studies so far have been conducted in developed countries and questions remain about the generalizability of findings to Latin America [17, 18].

The aim of this study was to examine whether community social capital (measured by collective efficacy and social cohesion) is associated with leisure-time physical activity in an adult population-based sample in Brazil. In assessing the association between social capital and leisure-time physical activity, we simultaneously investigated the effects of age, gender, education, socioeconomic position, community violence, and perception of adequate places to perform physical activity in the neighborhood. The

conceptual basis of our study is that health behaviors are influenced by factors operating at multiple levels, including individual and social environment. The approach of this paper is to provide insight for public health policies in terms of potential actions to increasing physical activity behavior.

Setting and Study Design

A cross-sectional survey was conducted in the municipality of Belo Horizonte, capital of the State of Minas Gerais, located in Brazil's southeastern region. The city planned to house 200,000 people, according to the 2016 Demographic Census there are 2,513,451 inhabitants. Uncontrolled urbanization, among other factors, has led the city to be considered one of the most violent capitals in Brazil, although there has been an important drop in the rates of violence in recent years [19]. Since 2006, Belo Horizonte has an innovative health promotion project, the Academia da Cidade Program [20]. It provides the general community the opportunity to engage in regular exercise, by offering free physical activity classes in public places, through 75 sites across the city.

Data collection was conducted in two of Belo Horizonte's nine public health districts, Barreiro and Oeste from 2008 to 2009. Each has a population of about 250,000 inhabitants that is highly heterogeneous with regard to several demographic, socioeconomic, and health indicators.

The two health districts studied were subdivided into strata according to the health vulnerability index (HVI), a composite indicator developed by the Belo Horizonte City Health Department. The HVI is a summary measure which captures the inequalities in the epidemiological profile of distinct social groups within the census tracts taking into account components such as sanitation, housing, education, income, and health.

The sample was proportionally distributed across four strata defined by the HVI. Within each stratum, selection was carried out by a three-stage probability sampling. In the first stage, 149 census tracts with different probabilities and a sample size proportional to the population of all tracts in the stratum were selected. In the second stage, 7,942 households were randomly selected from households registered in the Belo Horizonte City Health Department database. After deleting vacant lots, institutional and commercial buildings, and those who were not found after three attempts, 5171 households remained eligible. Finally, one adult resident (18 years or older) was randomly selected from each household.

The refusal rate was about 22.0%, resulting in a total of 4048 adults that answered the face-to-face questionnaire conducted by trained interviewers. Our analyses were restricted to subjects aged 18–69 years old (3667 adults), in which the international physical activity questionnaire (IPAQ) was applied with 5.8% of missing responses.

The study was approved by the Ethics in Research Committee of the Federal University of Minas Gerais (ETCI 017/07 and ETCI 253/006). Participants were informed about the study’s objectives and signed an informed consent form.

Outcome

Self-reported physical activity was assessed with a 7-day recall using the leisure-time section of the long version of the IPAQ. The IPAQ was developed by researchers from various countries, with the support of the World Health Organization (WHO) and the Centers for Disease Control (CDC). Craig et al. compared IPAQ against a reference method, the CSA accelerometer in 12 countries. The authors used Spearman’s correlation coefficients (r_s) to show that in Brazil IPAQ reliability was ($r_s = 0.69$) and validity ($r_s = -0.27$) [21]. The IPAQ has advantages compared to other instruments, especially regarding the possibility of comparability between the studies [22].

Inactivity (the reference category) was defined as a physical activity score below 150 min per week which was built by adding up the weekly time spent walking, the weekly time spent on moderate-intensity physical activity, and twice the weekly time spent on vigorous-intensity physical activity, in accordance with the recommendations from the U.S. Surgeon General’s Report [23], American College of Sports Medicine, and CDC [24].

Neighborhood Level Variables

Social Capital

A contextual social capital variable is rarely directly observed at the collective level. In general, assessments of neighborhood social capital are based on individuals’ perceptions that are then aggregated up to the neighborhood construct.

Three individual social capital scales were generated by factor analysis but only two dimensions were used (social cohesion and collective efficacy) based on acceptable internal consistency reliability (see the

statistical analysis section for further detail). Table 1 shows the items in each scale.

Then they were aggregated at the neighborhood level (defined by census tracts). Census tracts are the smallest unit of information available from the Brazilian census. They include an average of 300 households and 1000 people. The mean number of respondents per neighborhood was 24.6.

Community Violence and Spaces for Sports and Leisure in the Neighborhood

Both variables were assessed through self-perception of respondents through the following questions: Violence is a

Table 1 Social capital items and scales. Belo Horizonte Health Study. Belo Horizonte, Brazil, 2008–2009.

Collective Efficacy
In your neighborhood, the neighbors:
Would join to intervene in conflicts or problems with other neighborhoods
Would join to improve neighborhood safety
Would join to reclaim better health services to authorities
Would join to improve the look of the neighborhood
Would join to prevent garbage dump in the neighborhood
Would join to prevent drug use in public places
Would join to reclaim better schools to authorities
Social Cohesion
In your neighborhood, there are:
Neighbors who would give advice if something bad happens
Neighbors who would help financially
Neighbors who would inform about an interesting opportunity of job
People that you trust to leave the keys
People that you trust to leave a family member in case of emergency
People that you trust to lend things
You feel part of your neighborhood
Social Participation
In your neighborhood, you participate in any of these organizations:
Neighborhood association
Informal social control groups of public health system
Cultural, sports, or dance groups
How often do you go to health care groups ^a

Answering categories into (0) no and [1] yes
^a Answering categories into (0) annually, rarely, never [1] daily, weekly, monthly

problem in your neighborhood (0: no; 1: yes); and what is your assessment regarding the sports and leisure spaces in your neighborhood (0: very good/good; 1: bad/very bad).

Then, the answers were aggregated as the average of the corresponding individual measures in each census tract and were later divided into tertiles. The higher the tertile, the higher the level of perceived violence as well as the worse the evaluation of public spaces in the neighborhood.

Individual Level Variables

Demographic characteristics: age (years), sex, marital status (single, married/living together, divorced/separated, widow(er), socioeconomic: educational attainment (no schooling, able to read/primary school equivalency, first to fourth grades not completed, first to fourth grades completed, fifth to eighth grades not completed, fifth to eighth grades completed, high school not completed, high school graduate/technical school/attended university, university graduate, post-undergraduate studies), socioeconomic position score (as detailed below), length of residence in the neighborhood (years), and the individual social capital scales mean-centered.

The socioeconomic position score was estimated through principal components analysis using the following 13 indicators: number of residents per bedroom; residence property title: rented, owned, borrowed, other. For the other indicators, responses were categorized as Yes/No: do you have a DVD, VCR, cable TV, microwave oven, washing machine, wash basin, motorcycle, newspaper and/or magazine subscription, computer, Internet access, car, and sleep-in maid/housekeeper. It ranged between 0 and 3.39 and the higher the score, the better the socioeconomic position of the individual [25].

Statistical Analysis

The descriptive analysis revealed that 28.2% of the participants had at least one missing response on the social capital items. The variables with the highest level of missing data were items pertaining to the perception of whether neighbors would help financially (10.3%) and whether neighbors would join to intervene in conflicts/problems with other neighbors (8.2%).

To avoid bias by listwise deletion, a Hot-Deck multiple imputation (HD-MI) procedure was applied. Factor analyses was applied to the imputed social capital items using the program FACTOR [26]. The HD-MI replaces

missing values with observed values from donors in the same data set to create K complete data sets. The selection of donors was made taking into consideration all the individuals of the sample that produced responses for the same set of items as the donee. Once the data were multiply imputed, each copy was independently analyzed using exploratory factor analysis, from a polychoric correlation matrix. The value of the Kaiser-Meyer-Olkin (KMO) index was 0.88, which indicated that the correlation matrix was suitable for factor analysis. Optimal parallel analysis suggested that three factors could be extracted. We extracted the three factors using minimum rank factor analysis (Table 2). To maximize factor simplicity, we computed oblique procrustes rotation. The psychometric property proved to be adequate for only two factors (factor 1 Cronbach's $\alpha = 0.76$ and factor 2 = 0.88). These groupings were adopted and two subscales were created: social cohesion and collective efficacy (Table 3). Lastly, the neighborhood scales were generated by the mean of the corresponding individual measures in each census tract and was divided into quintile. The higher the quintile, the higher the community social capital. Ecometric approaches were used to test the reliability of the neighborhood scales using linear three-level models [27, 28]. The reliability of the neighborhood level measure was calculated as a function of the neighborhood variation and the neighborhood sample size. The values range from 0 to 1, where 1 represents the higher reliability indicating either that the neighborhood mean varied substantially across neighborhoods or the sample size per neighborhood was large. The social cohesion and collective efficacy scales have good reliability.

We are also analyzed the reliability of community violence and spaces for sports and leisure in the neighborhood variables which were 0.51 and 0.85 respectively, indicating moderate to good reliabilities.

We applied generalized estimating equation (GEE) to estimate the association of community social capital with leisure-time physical activity, adjusted for individual and contextual level covariates. The GEE modeling approach can appropriately account for the nonindependence of observations within a clustered unit [29]. GEE was used with log link function and binomial distribution incorporating the correlation structure between the observations. We used log-binomial regression because the outcome (Inactivity) had a prevalence of greater than 10%, causing the odds ratio to deviate from the true risk ratio [30]. The exchangeable correlation matrix was chosen based on the nature of the data.

Table 2 Factor analysis and matrix of rotated factor loadings. Belo Horizonte Health Study. Belo Horizonte, Brazil, 2008–2009.

Item	Components		
	1	2	3
In your neighborhood, there are:			
Neighbors who would give advice if something bad happens	0.788		
Neighbors who would help financially	0.659		
Neighbors who would inform about an interesting opportunity of job	0.716		
People that you trust to leave the keys	0.914		
People that you trust to leave a family member in case of emergency	0.857		
People that you trust to lend things	0.756		
You feel part of your neighborhood	0.401		
In your neighborhood, the neighbors:			
Would join to intervene in conflicts/problems with other neighborhoods		0.407	
Would join to improve neighborhood safety		0.916	
Would join to reclaim better health services to authorities		0.949	
Would join to improve the look of the neighborhood		0.938	
Would join to prevent garbage dump in the neighborhood		0.892	
Would join to prevent drug use in public places		0.975	
Would join to reclaim better schools to authorities		0.942	
In your neighborhood, you participate in any of these organizations:			
Neighborhood association			0.862
Informal social control groups of public health system			0.853
Cultural, sports, or dance groups			0.682
How often do you go to health care groups			0.607
Percentage of explained variance	43.7	17.2	14.5

Parallel analysis based on minimum rank factor analysis and oblique procrustes rotation

1: social cohesion; 2: collective efficacy; 3: social participation

The multilevel data structure comprised 3453 individuals (level 1) nested within 149 neighborhoods (level 2). The first model included demographic variables (sex, age, marital status); the second model then added individual-level socioeconomic characteristics (educational attainment and socioeconomic position score); the third model added the variable for duration of residence in the neighborhood; the fourth model added the

individual social capital scale scores (centered on the mean to make the individual responses orthogonal to the aggregated community-level scores); the fifth model added the neighborhood social capital scales, and the final model added the remaining two contextual variables (violence and presence of places for sport and leisure), as the last potential confounders. If these variables significantly reduce the strength of association between social capital and leisure-time physical activity, they may be considered possible mediators of this association.

We added the individual social capital scales in the model to evaluate the “pure” contextual effects of social capital on physical activity. Centering the individual social capital scales at its neighborhood average overcomes the problem of collinearity between individual perceptions of social capital and the neighborhood averages of social capital (aggregated from individual responses) and thereby allows us to disentangle the compositional effects from the contextual differences between neighborhoods in physical activity [31].

The magnitude of the association was estimated by the prevalence ratio and its 95% confidence interval (95% CI).

All statistical analyses were performed using version 13 of the Stata statistical software package (Stata Corp, College Station, Texas, USA).

Results

Table 4 presents descriptive statistics of the study participants. The average age was 41.0 years (SD = 14.0) and well over half (59.0%) were women. Just over half (54.2%) were married or living together. In terms of schooling, 1.3% never attended school and 11.3% had an undergraduate/graduate degree.

Overall, 16.0% of the survey respondents reported performing leisure-time physical activity, with those from higher socioeconomic backgrounds (higher schooling and higher economic score) reporting higher exercise levels. Regarding the perception of places in the neighborhoods to perform physical activity, there was a small difference in prevalence between the best perception (33.5%) and worse perception (28.8%). On the other hand, the prevalence of physical activity was lower in places perceived as more violent (28.8%) compared to those considered safer (37.0%).

Table 5 shows the results of GEE analysis with six sets of models. From model 1, we found that women

Table 3 Description of the social capital scales. Belo Horizonte Health Study, Belo Horizonte, Brazil, 2008–2009

Scales	No. of subjects	No. of items	Range of score	Mean score	Standard deviation	Cronbach's alpha	Reliability of the neighborhood-level scale
Social cohesion	3667	7	−2.23–1.97	−0.09	0.82	0.76	0.74
Collective efficacy	3667	7	−2.15–1.50	−0.06	0.85	0.88	0.59
Social participation	3667	4	−2.74–3.05	−0.02	0.65	0.36	0.33

were less likely to be engaged in leisure-time physical activity than men (PR = 0.64; 95% CI = 0.53, 0.77) and that married or co-habiting individuals had a lower likelihood of being active than those who were single (PR = 0.70; 95% CI = 0.56, 0.87).

Model 2 shows a strong positive association between the practice of leisure-time physical activity and the socioeconomic position. Compared with individuals with lower socioeconomic score, those with the highest position were more likely to engage in leisure-time physical activity (PR = 1.32; 95% CI = 1.16, 1.51). This association was maintained in the other models without significant changes.

Model 4 does not show an association between individual (mean-centered) social capital perceptions and leisure-time physical activity.

Model 5 shows a graded association between contextual social cohesion and leisure-time physical activity even controlling for all the individual level potential confounding factors. Compared with individuals in the first quantile of social cohesion, those in the second (PR = 1.44; 95% CI = 1.05, 1.97), fourth (PR = 1.45; 95% CI = 1.05, 1.98), and fifth (PR = 1.60; 95% CI = 1.16, 2.21) quantiles were statistically significantly more likely to be engaged in leisure-time physical activity. By contrast, contextual collective efficacy showed no association with leisure-time physical activity.

In the final model, adding contextual neighborhood violence and perceived availability of spaces for sport and recreation did not decrease the strength of association between social cohesion and leisure-time physical activity, suggesting that the associations are not mediated by these factors. This model also revealed that compared with the reference group, those living in more violent areas were less likely to be physically active (2nd tertile: PR = 0.81; 95% CI = 0.64, 1.01 and 3rd tertile: PR = 0.76; 95% CI = 0.61, 0.95).

Discussion

Our findings suggest that people living in communities with higher levels of social cohesion are more likely to be physically active even after controlling for potentially confounding individual and contextual-level variables.

These findings are in agreement with studies carried out in developed countries that show an association between high contextual social capital and less chance of physical inactivity [14, 16]. Inverse associations were found between residence in a high social capital state and physical inactivity in the USA [16]. Pabayo et al. using social capital measured at the school level in Canada, also showed that students attending schools with the highest cohesion were less likely to be physically inactive [14].

The social cohesion scale can be decomposed into three dimensions: sense of belonging, mutual support among neighbors, and trust in neighbors. Powell et al. suggest that sense of belonging and network support affect the risk of becoming overweight or obesity through their influence on health behaviors such as physical activity. Both, sense of belonging and social support, are believed to provide individuals with structure, encouragement, and purpose in relation to physical activity [32]. Legh-Jones and Moore showed that higher network diversity was associated with a decreased likelihood of physical inactivity [33]. Lindström reported a positive association between low generalized trust in other people and low leisure-time physical activity in Swedish adults [34].

Suggested pathways for this association include diffusion of information about healthy lifestyles [35]. Social cohesion may increase one's access to information about opportunities to perform physical activity or the importance of physical activity for health. Residents in cohesive neighborhoods may be better able to exercise informal social control over "deviant" behaviors—for example, ensuring that pet dogs are kept on a leash so

Table 4 Descriptive statistics of leisure-time physical activity and individual and contextual variables. Belo Horizonte Health Study, Belo Horizonte, Brazil, 2008–2009.

	<i>N (%)</i>
Physical activity	
Active	555 (16.0)
Inactive	2171 (84)
Age (years) ^a	41.0 (14.0)
Sex	
Male	1507 (41.0)
Female	2160 (59.0)
Marital status	
Single	1185 (32.3)
Married, living together	1985 (54.2)
Divorced, separated	306 (8.3)
Widow(er)	191 (5.2)
Schooling	
No schooling	49 (1.3)
Able to read, primary school equivalency, 1st–4th grades not completed	419 (11.4)
1st–4th grades completed, 5th–8th grades not completed	886 (24.2)
5th–8th grades completed, high school not completed	604 (16.5)
High school graduate, technical school, attended university	1294 (35.3)
University graduate, post-undergraduate studies	414 (11.3)
Socioeconomic position score (SPE) ^b	1.51 (0.85)
Time residing in the neighborhood (years) ^a	19.2 (13.0)
Individual collective efficacy ^a	−0.06 (0.85)
Individual social cohesion ^a	−0.09 (0.82)
Evaluation of public places of sport and leisure in the neighborhood ^c	
1	1149 (31.3)
2	1268 (34.6)
3	1250 (34.0)
Violence is a problem in the neighborhood ^d	
1	1200 (32.7)
2	1223 (33.3)
3	1244 (33.9)
Contextual collective efficacy ^e	
1	696 (20.2)
2	699 (20.2)
3	684 (19.8)
4	695 (20.1)
5	679 (19.7)
Contextual social cohesion ^f	
1	750 (20.4)
2	733 (20.0)

Table 4 (continued)

	<i>N (%)</i>
3	719 (19.6)
4	763 (20.8)
5	702 (19.1)

Number of individuals = 3667; number of census tract = 149

^a Mean and standard deviation

^b Score ranges from 0 to 3.39; the greater the number of goods, the higher the score

^c The higher the tertile, the worse the evaluation of public spaces in the neighborhood

^d The higher the tertile, the higher the level of perceived violence

^e The higher the quintile, the higher the community collective efficacy

^f The higher the quintile, the higher the community social cohesion

that they do not threaten joggers, or ensuring that pet-owners scoop after their pets to maintain the esthetic quality of sidewalks [36]. A cohesive community is also better able to maintain shared norms around health behaviors—for example, by supporting older residents to exercise outdoors [37]. The healthy norms of physical activity could diffuse more easily in groups in which members are socially cohesive.

The mechanisms involved in the association between social capital and health may differ according to the unit of analysis chosen—individual or contextual [38]. This may justify the surprising lack of association between individual social cohesion and leisure-time physical activity in our study. The individual dimension can interfere in health through a psychological effect of increasing well-being, hope, self-esteem, perceptions of control, and conferring identity, which may not be the mechanisms responsible for stimulating the practice of physical activity in our study.

The perception of violence in the neighborhood was inversely associated with leisure-time physical activity. The feeling of insecurity and fear in Brazil is quite high because of high crime rates, excessive media coverage, and low confidence in the effectiveness of law enforcement institutions [39]. Previous studies found positive associations between time spending in sedentary behaviors such as TV viewing and perceived aspects of the neighborhood environment, including crime [40, 41]. This is possibly because communities characterized by higher perceptions of safety encourage outdoor activities like physical activity.

Table 5 Leisure-time physical activity in the final generalized estimation equation model. Belo Horizonte Health Study, Belo Horizonte, Brazil, 2008–2009

Variable	PR (95% CI)					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Age (years)	1.00 (0.99–1.00)	1.00 (0.99–1.00)	1.00 (0.99–1.00)	1.00 (0.99–1.00)	1.00 (0.99–1.00)	1.00 (0.99–1.00)
Sex						
Male	1.00	1.00	1.00	1.00	1.00	1.00
Female	0.64 (0.53–0.77)*	0.64 (0.53–0.78)*	0.64 (0.53–0.78)*	0.64 (0.53–0.78)*	0.64 (0.53–0.77)*	0.64 (0.53–0.77)*
Marital status						
Single	1.00	1.00	1.00	1.00	1.00	1.00
Married, living together	0.70 (0.56–0.87)*	0.75 (0.60–0.94)*	0.73 (0.58–0.92)*	0.73 (0.58–0.92)*	0.73 (0.58–0.92)*	0.72 (0.57–0.91)*
Divorced, separated	0.83 (0.57–1.20)	0.91 (0.62–1.33)	0.89 (0.61–1.32)	0.89 (0.61–1.31)	0.87 (0.59–1.28)	0.85 (0.58–1.26)
Widow(er)	0.83 (0.52–1.33)	0.98 (0.60–1.63)	0.97 (0.58–1.60)	0.97 (0.59–1.61)	0.97 (0.59–1.62)	0.97 (0.58–1.60)
Schooling						
No Schooling		1.00	1.00	1.00	1.00	1.00
Able to read, primary school equivalency, 1st–4th grades not completed		0.97 (0.36–2.58)	0.95 (0.35–2.53)	0.95 (0.35–2.53)	0.96 (0.36–2.57)	0.96 (0.36–2.58)
1st–4th grades completed, 5th–8th grades not completed		0.90 (0.34–2.34)	0.89 (0.34–2.33)	0.89 (0.34–2.34)	0.91 (0.35–2.39)	0.90 (0.34–2.37)
5th–8th grades completed, high school not completed		1.12 (0.42–2.98)	1.10 (0.41–2.91)	1.10 (0.41–2.94)	1.10 (0.41–2.93)	1.08 (0.40–2.88)
High school graduate, technical school, attended university		1.34 (0.51–3.54)	1.31 (0.50–3.46)	1.32 (0.50–3.49)	1.33 (0.50–3.51)	1.30 (0.49–3.43)
University graduate, post-undergraduate studies		1.65 (0.61–4.48)	1.59 (0.58–4.30)	1.60 (0.59–4.34)	1.56 (0.57–4.26)	1.51 (0.55–4.12)
Socioeconomic position score ^a		1.32 (1.16–1.51)*	1.32 (1.16–1.51)*	1.32 (1.16–1.51)*	1.30 (1.14–1.48)*	1.30 (1.14–1.49)*
Time residing in the neighborhood (years)			1.00 (0.99–1.00)	1.00 (0.99–1.00)	1.00 (0.99–1.00)	1.00 (0.99–1.00)
Individual collective efficacy				1.00 (0.89–1.14)	1.01 (0.89–1.14)	1.01 (0.89–1.15)
Individual social cohesion				0.91 (0.80–1.03)	0.91 (0.80–1.04)	0.91 (0.80–1.04)
Contextual collective efficacy ^b						
1					1.00	1.00
2					0.86 (0.64–1.16)	0.85 (0.63–1.15)
3					0.85 (0.62–1.16)	0.86 (0.63–1.16)
4					1.17 (0.87–1.58)	1.16 (0.86–1.56)
5					0.87 (0.63–1.19)	0.87 (0.64–1.19)
Contextual social cohesion ^c						
1					1.00	1.00

Table 5 (continued)

Variable	PR (95% CI)					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
2					1.44 (1.05–1.97)*	1.43 (1.05–1.95)*
3					1.21 (0.87–1.69)	1.24 (0.89–1.72)
4					1.45 (1.05–1.98)*	1.45 (1.06–1.99)*
5					1.60 (1.16–2.21)*	1.56 (1.13–2.16)*
Evaluation of public places of sport in the neighborhood ^d						
1						1.00
2						1.04 (0.82–1.31)
3						0.89 (0.70–1.13)
Violence is a problem in the neighborhood ^e						
1						1.00
2						0.81 (0.64–1.01)
3						0.76 (0.61–0.95)*

Number of individuals = 3453; number of census tract = 149

PR prevalence ratio, CI confidence interval

* $P < 0.05$ ^a Score ranges from 0 to 3.39; the greater the number of goods, the higher the score^b The higher the quintile, the higher the community collective efficacy^c The higher the quintile, the higher the community social cohesion^d The higher the tertile, the worse the evaluation of public spaces in the neighborhood^e The higher the tertile, the higher the level of perceived violence

Model 1: adjusted for demographic and socioeconomic variables; model 2: adjusted for demographic and socioeconomic variables; model 3: adjusted for demographic, socioeconomic and neighborhood time; model 4: adjusted for demographic, socioeconomic, neighborhood time and social capital individual scales mean-centered; model 5: social capital scales adjusted for individual variables; model 6: social capital scales adjusted for all potential confounders and mediators (violence and presence of places for sport and leisure)

In contrast to the social cohesion dimension of social capital, our study did not find an association between leisure-time physical activity and neighborhood collective efficacy (i.e., perceived readiness of residents to intervene to solve collective problems). According to Cohen et al. one of the mechanisms by which collective efficacy—viz., the willingness of people to intervene for the good of the community—operates is through the ability of residents to take collective action to solve problems, e.g., lobbying municipal authorities to improve the built environment [42]. The low trust in the government and official institutions can impair the actions of the community in influencing political decisions and fighting for access to more walkable neighborhoods. A study using data from the Brazilian Social Research, based on 2363 interviews in 2002, showed that stocks of trust in Brazilian society are generally low and practically limited to confidence in immediate family members [43]. Low levels of interpersonal trust correlate with low levels of trust and confidence in public institutions [44], low levels of political participation, and reduced efficacy of government institutions [45].

We did not find an association between leisure-time physical activity and the perceived availability of public spaces for sports as reported by others. Features of the physical environment—e.g., greater proximity and increase in the density of green spaces [46, 47] and high walkability neighborhoods [48, 49]—have been associated with a decrease in sedentary behavior time. It is possible that our results are due to the difficulty of accessing neighborhood spaces to perform activities as well as the high perception of neighborhood violence that makes it challenging to use public spaces.

Additionally, we found that low socioeconomic position was strongly associated with leisure-time physical inactivity. Other studies corroborate the association between sedentary behaviors and socioeconomic disadvantages [50–52]. This pattern of social factors influencing physical activity may help to explain the high socioeconomic disparities in cardiovascular mortality in developing countries. One explanation for the absence of association between education and leisure-time physical activity is high correlation between education and socioeconomic position score, which entered at the same time in the second model.

To our knowledge, this is the first Brazilian study to assess the two dimensions of contextual social capital with the practice of leisure-time physical activity through multilevel studies (subjects within neighborhoods). We found only one previous Brazilian study that attempted to link

social capital with health behaviors such as physical activity [53]. Using individual-level logistic regression, the authors reported that low social capital (an index made up of number of friends, number of people they could borrow money from when in need, extent of trust in community members, number of times members of the community help each other, community safety, and extent of membership in community activities) was associated with insufficient leisure-time physical activity (OR = 1.70; 95% CI: 1.07–2.70) in Brazilian adults.

Our study has several limitations. First, our study is based on cross-sectional survey data that does not permit temporality to be addressed, i.e., we cannot exclude the possibility of reverse causation. People exercising outdoors (e.g., playing soccer) might increase their social network and their feeling of belonging and cohesion in the neighborhood. Further studies using a longitudinal design are needed to exclude this possibility. Second, the use of self perception of the practice of physical activity can cause a social desirability bias that can lead to over-reporting of physical activity, besides the possible recall bias mainly among older individuals [54]. Third, the possibility of residual confounding by not including the variables functional disability and working hours during the week that may be confounders of the association between social capital and leisure-time physical activity. These variables lead to the difficulty of mobility and the shortage of time that can decrease both the achievement of leisure-time physical activity and participation in neighborhood social networks. Finally, we had focused only on leisure-time activity and did not include activity in others' life domains (i.e., transportation, occupation, and home activities). However, due to the reliability and validity of this variable, it is used in studies from several countries [34, 55, 56], and it shows more consistent association with CVD risk factor when compared to other domains such as occupational activities [57]. On the other hand, in the planning of the study, several measures were taken to prevent possible others biases; these included reliability assessments of the instruments used, the adoption of standardized procedures, rigorous training of the field personnel, in addition to intensive activities in the community to encourage participation in the study. These measures helped to ensure the quality of the information collected and the internal validity of the study.

In conclusion, our study suggests that even in middle income countries characteristics of the social environment can contribute to leisure-time physical activity behaviors. Approaches targeting the neighborhood social capital should include both structural improvements and local

interventions. Several structural factors are determinants of social capital as mobility patterns in a community, public investment in infrastructure, public policies that reduce residential segregation, or plan services in the community [31]. In addition, social capital seems to be a mediator of the association between income inequality and health [58]. As examples of local interventions, we would like to highlight the innovative Latin America programs like Academia da Cidade Program, Ciclovía, and Cicloruta Programs that decrease health inequalities by reaching high risk groups [17, 18, 59].

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