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ORIGINAL ARTICLE / *ARTIGO ORIGINAL*

Spatial analysis of leisure-time physical activity in an urban area

Análise espacial da prática de atividade física no lazer em área urbana

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ABSTRACT: ***Objective:*** To analyze the spatial distribution of the prevalence of leisure-time physical activity (LTPA) in a Brazilian urban area and its association with the characteristics of the physical and social environments. ***Methods:*** A cross-sectional study conducted with data from the Surveillance System for Risk and Protective Factors for Chronic Diseases from the years 2008–2010, in Belo Horizonte, state of Minas Gerais, Brazil. The outcome was the practice of LTPA and the independent variables were residential and population density, the density of places for physical activity, homicide rates, average family income, and health vulnerability index. The spatial scanning technique was employed to identify clusters with a high prevalence of PA at leisure time. The Mann-Whitney test was used to compare variables inside and outside the cluster. ***Results:*** The sample included 5,779 participants, 33.3% (SE = 0.73) of whom reported sufficient PA during leisure time. We identified a significant cluster of a high prevalence of LTPA. After adjustments, the cluster presented a radius of 3,041.99 meters and 603 individuals, and 293 (48.6%) of them reported sufficient LTPA. The probability of performing sufficient LTPA in the cluster was 27% higher (PR = 1.27; p = 0.002) than in the coverage areas of primary healthcare units outside the cluster. There was a higher density of places for LTPA practice, higher population and residential density, and higher family income in the cluster. ***Conclusion:*** The results evidenced a cluster of high prevalence of LTPA in a privileged physical and socioeconomic environment in Belo Horizonte, even after adjustments, demonstrating that reducing inequalities can increase LTPA.

Keywords: Spatial analysis. Motor activity. Prevalence. Built environment. Social environment.

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RESUMO: ***Objetivo:*** Analisar a distribuição espacial da prevalência da prática de atividade física (AF) no lazer suficiente em uma área urbana brasileira, no período de 2008 a 2010, e verificar se ela é influenciada por características dos ambientes físico e social. ***Métodos:*** Estudo transversal com dados do sistema de Vigilância de Fatores de Risco para doenças crônicas não transmissíveis, realizado em Belo Horizonte (MG), entre os anos 2008 e 2010. O desfecho foi a realização de AF no lazer e as exposições foram densidade residencial e populacional, densidade de locais de prática de AF no lazer, taxa de homicídio, renda familiar média e índice de vulnerabilidade da saúde. Foi empregada a técnica de varredura espacial para identificar *clusters* de alta prevalência de AF no lazer. Utilizou-se o teste de Mann-Whitney para comparar variáveis ambientais dentro e fora do *cluster*. ***Resultados:*** A amostra foi constituída de 5.779 participantes, dos quais 33,3% referiram praticar AF no lazer suficientemente. Identificou-se um *cluster* significativo de alta prevalência de prática de AF no lazer. Após ajustes, ele apresentou raio de 3.041,99 m e 603 indivíduos, dos quais 293 (48,6%) realizavam AF no lazer suficiente. A probabilidade de um indivíduo praticar AF no lazer suficiente no *cluster* foi 27% maior (razão de prevalência — RP = 1,27; p = 0,002) do que nas áreas de abrangência das unidades básicas de saúde não pertencentes a ele. Esse *cluster* teve maior densidade de locais para a prática de AF no lazer, maior densidade populacional e residencial e maior renda familiar. ***Conclusão:*** Constatou-se *cluster* de alta prevalência de AF no lazer em um contexto físico e econômico privilegiado de Belo Horizonte, o que demonstra que diminuir desigualdades pode aumentar a prática de AF no lazer.

Palavras-chave: Análise espacial. Atividade motora. Prevalência. Ambiente construído. Meio social.

INTRODUCTION

Chronic noncommunicable diseases (NCDs) are a global public health issue, considering that they promote premature deaths, disabilities, and high costs to the health system. In 2016, 71% (41 million) of the total deaths were caused by NCDs[1].

An important factor for the promotion of health and prevention of NCDs is the practice of physical activity (PA), as it is associated with the improvement of cardiorespiratory endurance, body composition, control of blood pressure and glycemic levels, reduction of total cholesterol, incidence of breast and colon cancer, depression, among others[2]. Studies show that the prevalence of PA in the Brazilian population is low. In a national study, the authors demonstrated that 22.5% of Brazilian adults perform sufficient leisure-time physical activity (LTPA), with a lower prevalence among women and the rural population (18.4 and 13.8%, respectively)[3]. Trend results based on analyses of surveillance systems showed that, in the period from 2006 to 2016, the percentage of LTPA ranged from 30.3 to 37.6%. This increase was greater in women aged 25 to 34 years, and with higher level of education[4].

In recent years, proposals to tackle NCDs have been implemented in Brazil aiming at increasing PA practice through policies and programs[4] such as: *Política Nacional de Promoção da Saúde* (Health Policy); *Plano de Ações Estratégicas para o Enfrentamento das DCNT* (Strategic

Action Plan to Tackle NCDs); *Programa Academia da Saúde* (Health Academy Program)[3]; the increase in activities offered by the Brazilian Unified Health System, such as Lian Gong, Tai Chi Chuan, and weight training; and the creation of *Núcleo de Apoio à Saúde da Família* (Family Health Support Center).

Studies on factors associated with the sufficient practice of LTPA have shown the importance of individual determinants such as age, sex, education level, and income[5]. However, it is observed that this approach is insufficient to explain the adoption of PA and increase its population levels. Thus, attention has been paid to aspects of the context in which the individual resides, such as a built and social environment, as they can offer opportunities or barriers to the practice of PA[6] in addition to being determinants that may demand intervention[7,8].

Studies on urban contexts in Brazil indicate that living in places with greater access to urban recreational equipment for PA – such as green areas, squares, facilities for doing activities, gyms –, mixed land-use, the perception of security, and the best socioeconomic conditions are factors associated with higher levels of LTPA[5,9,10]. In populations of countries with socioeconomic diversity, the association between increased PA practice and higher residential density, greater number of crosswalks accessible to pedestrians, higher density of public transport, and greater number of parks has been demonstrated[11].

Urban areas with high population density can systematically influence the distribution of diseases and aggravations. Thus, the identification of characteristics of the context in which individuals live can be useful to identify health vulnerabilities[12]. In this scenario, spatial analysis techniques have emerged as an important tool for identifying patterns of occupation of geographical space and their association with health outcomes[13].

Knowledge of the spatial distribution of PA is essential for better understanding this behavior. Furthermore, it is important for the formulation and implementation of public policies aimed at developing effective strategies, focusing on expanding programs that include aspects of built and social environments, which have the potential to influence healthy behaviors and lifestyles.

It is noteworthy that studies on the spatial distribution of diseases and aggravations in specific areas are still lacking, such as small urban areas, which are essential to understand how the practice of LTPA is distributed in urban spaces and to enable local strategies aimed at health promotion. Therefore, the objectives of this study were to analyze the spatial distribution of the prevalence of LTPA in a Brazilian urban area, from 2008 to 2010, and whether it is influenced by characteristics of the physical and social environments or not.

METHODS

This is a cross-sectional epidemiological study carried out with database of the Surveillance System for Risk and Protective Factors for Chronic Diseases by Telephone Survey (Vigitel),

from the years 2008 to 2010, in the city of Belo Horizonte, state of Minas Gerais, Brazil. This city is the capital of one of the states in the Southeast of Brazil, the most developed region in the country, with an area of 331 km², a population density of 7,177 inhabitants per km², and a population of 2,365,151 inhabitants[14].

Vigitel is a nationwide survey and is promoted by the Secretariat of Health Surveillance (*Secretaria de Vigilância em Saúde* – SVS) of the Brazilian Ministry of Health. Data were collected through telephone interviews conducted with an adult population (aged 18 years or older) residing in the 26 capitals and in the Federal District. Probabilistic samples from the adult population were used based on the registration of residential fixed telephone lines in cities and post-stratification weights. The Vigitel questionnaire contains 94 questions about NCDs and their risk factors. Detailed information on the Vigitel system can be found in a previous publication[15].

Between 2008 and 2010, 6,034 individuals were interviewed in the city of Belo Horizonte. Pregnant women (n=43), women who did not know if they were pregnant at the time of the interview (n=4), and non-georeferenced data (n=208) were excluded from the sample. Thus, the final sample consisted of 5,779 adults.

The outcome variable of this study was the sufficient practice of LTPA, defined by at least 150 minutes per week of light- or moderate-intensity exercises or at least 75 minutes per week of vigorous-intensity activities[2]. For its characterization, the following questions of the Vigitel questionnaire were adopted: "In the past three months, did you do any type of physical exercise or sport?"; "What was the main type of physical exercise or sport that you did?"; "Do you exercise at least once a week?"; "How many days a week are you used to exercise or play sports?"; and "On the day that you exercise or play sports, how long does this activity last?". The following light- or moderate-intensity PA were considered: walking, walking on a treadmill, weight training, water aerobics, gymnastics in general, swimming, martial arts and fighting, cycling, dancing, and volleyball/footvolley. The following vigorous-intensity PA were considered: running, running on a treadmill, aerobic gymnastics, soccer/futsal, basketball, and tennis[15].

To characterize the environment, a geocoded base with environmental data was developed, in which the individual data of the participants were incorporated. The following environmental variables were selected for this study:

- population density: population of the coverage area/area in km² of the coverage area of the primary healthcare units (CAPHC);
- residential density: number of households in the coverage area/area in km² of CAPHC;
- density of places for PA practice: number of parks, squares, and public lanes, gyms in the city, education institutions of sports, dance, sportive social clubs in the coverage area/area in km² of the CAPHC;
- density of private places for PA practice: number of education institutions of sports, dance, gyms, sportive social clubs in the coverage area/area in km² of the CAPHC;
- density of public places for PA practice: number of parks, public squares and lanes, gyms in the city of the coverage area/area in km² of the CAPHC;

- homicide rate: number of homicides in the coverage area/population of the CAPHC multiplied by 10,000;
- CAPHC average family income: total income of people aged 10 years or over residing in the CAPHC;
- health vulnerability index (HVI): this is an indicator composed of socioeconomic variables (residents per household, percentage of illiterate people, percentage of private households with per capita income of up to half the minimum wage, average nominal income of the responsible people, percentage of mixed-race, black, and indigenous people), and sanitation variables (sewage, water supply, and solid waste disposal)[16]. Each variable in its dimension has a weight and, in the end, a score is generated. The HVI value ranges from 0 to 1, with values close to 1 indicating high social vulnerability and worse living conditions of the population, and values close to zero indicating low or nonexistent social vulnerability. HVI was used to analyze the characteristics of population groups that live in certain geographic areas and to show the inequalities in the epidemiological profile of different social groups[16].

The variables sex (women and men), age (<60 years and ≥60 years), education level (<12 years of formal education and ≥12 years of formal education), and marital status (with partner and without partner) were used as adjustment variables.

For the description of results, the proportion and confidence intervals of 95% (95%CI), measures of central tendency, and dispersion were used. Descriptive analyses were performed using the Stata program, version 14.0.

For spatial analysis, the adopted geographical unit was CAPHC. CAPHC are composed of census tracts and constitute one of the forms of territorial organization of the public system for provision of healthcare services.

The spatial scanning technique was employed to identify clusters with a high prevalence of PA during leisure time.[17]. This technique seeks to identify contiguous regions, in which the occurrence of a certain event of interest is statistically superior when compared with a spatial pattern of randomness[18]. Moreover, a spatial scanning analysis adjusted for covariates (sex, age, education level, and marital status) was performed[19]. According to Kulldorff[19], the adjustment can be performed after using the Poisson regression model to estimate the expected number of cases per each area, considering its population at risk. The estimated coefficients for the covariates are used to re-estimate the reference population in each area. Thus, covariates are not directly included in the spatial scanning method, but rather in the adjusted population estimate. The relative risk (RR) estimated for the high-incidence cluster represents the ratio between the incidence rate of the event of interest in the cluster and the incidence rate of the event of interest outside it. As it is a prevalent event, in this study the denomination "prevalence ratio" (PR) will be used instead of RR.

For cluster identification, the software was programmed to perform purely spatial analysis (when cases occur in the same region or space), according to Bernoulli's probability

distribution model, and considering the following factors: annual data interval; maximum cluster size equal to 50% of the population at risk; cluster with circular shape; geographic non-overlapping of clusters. The spatial scanning technique was performed using the SaTScan software, version 9.2, and a value of $p<0.05$ was adopted.

The Mann-Whitney U test was used to compare the values of the environmental variables according to the presence of a cluster, as the variables did not present a symmetrical distribution. The differences were considered significant when the p-value was lower than 0.05.

The Vigitel survey was approved by the National Committee of Ethics in Research (CONEP) of the National Health Council of Brazil, and this research is part of a project entitled "Inequalities in small geographical areas of indicators of chronic noncommunicable diseases, violence and their risk factors," approved by the Research Ethics Committee of Universidade Federal de Minas Gerais (opinion No. 3.258).

RESULTS

The sample consisted of 5,779 participants, of which 53.9% were women and 35.2% had between 9 and 11 years of formal education. The mean age was 42 years old (standard error [SE]=0.24). Regarding skin color, 54.1% of participants reported being mixed-race. LTPA practice was reported by 33.3% (SE=0.73) of the individuals. Figure 1 shows the distribution of the prevalence of LTPA according to the CAPHC.

The spatial analysis identified a significant cluster of high prevalence of LTPA (Figure 2). This cluster has a population of 1,215 individuals, of which 505 (41.6%) performed LTPA. The probability of finding a participant who performs LTPA in the cluster was 33% higher (PR=1.33; $p<0.001$) compared with areas outside the cluster (Table 1).

After adjusting for sex, age, education level, and marital status, there were no changes in the location of the cluster (Figure 3). There was only a change in its extension, considering that some CAPHC are no longer part of it. This cluster had a radius of 3,041 m and 603 individuals, of which 293 (48.6%) reported the practice of LTPA. The probability of finding a participant who performs LTPA in the cluster was 27% higher (PR=1.27; $p<0.002$) compared with areas outside the cluster (Table 1).

When comparing the contextual characteristics of the cluster with those of CAPHC that are not part of it, there is a higher density of places for PA practice; higher density of private places for PA practice; higher population and residential density; and higher family income (Table 2).

DISCUSSION

This study verified the spatial distribution of LTPA in an urban area of Brazil, using data from the Vigitel survey. The prevalence of sufficient LTPA was 33.3% and a significant

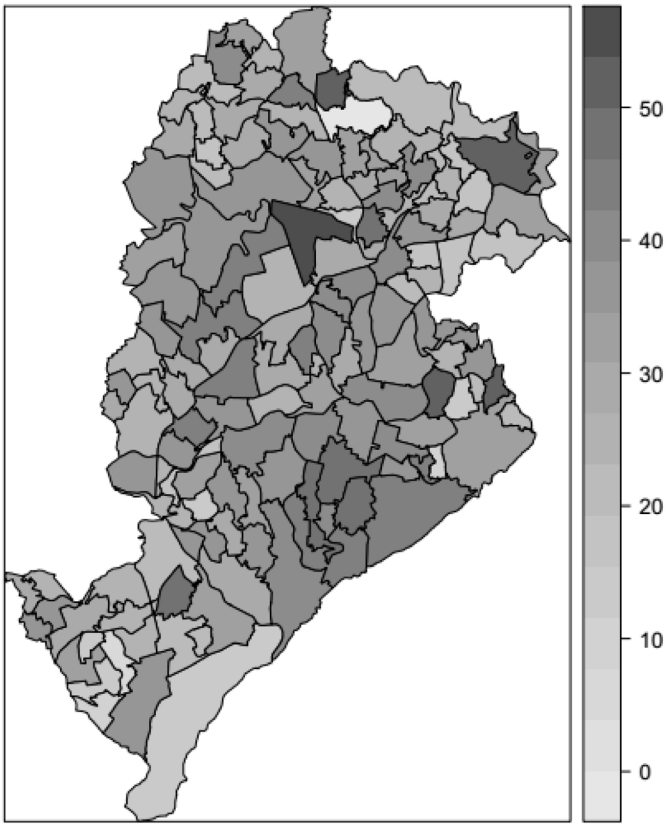
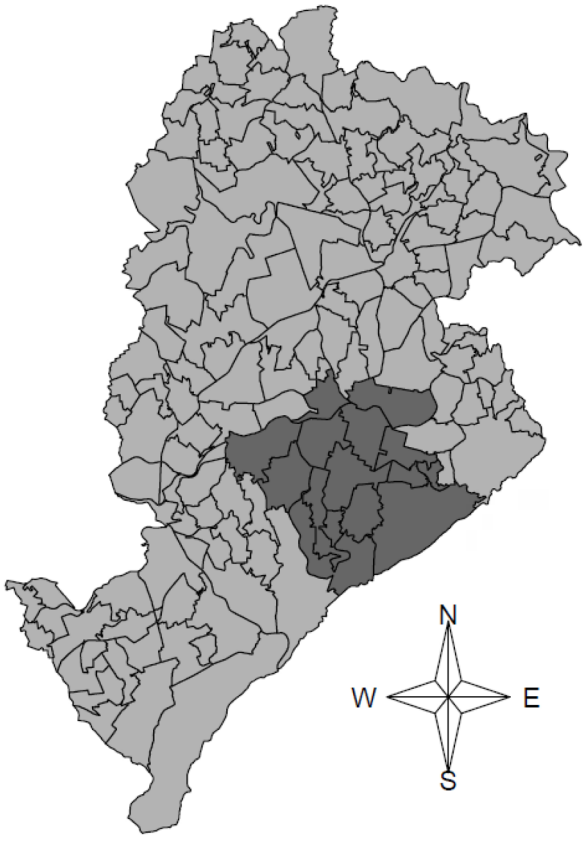


Figure 1. Distribution of physical activity practice during leisure time, according to the areas covered by the primary healthcare units, Belo Horizonte (MG), 2008–2010.

cluster of high prevalence of this event was found, remaining significant after adjustments. The geographical area of this cluster had higher population and residential density, higher family income, and higher density of places for PA practice.

The cluster of high prevalence of sufficient LTPA was located in the vicinity of the central region and in the neighborhoods of the highest socioeconomic level in the city, which is consistent with the hypothesis that good environmental conditions are determinant for the adoption of healthy behaviors such as LTPA[6].

The geographical area where the cluster was identified presented better urban equipment such as higher density of places for PA practice. The proximity of places in the neighborhood conducive to this practice is one of the factors associated with higher levels of PA in other urban contexts[7,9-11], considering that these places are visual stimuli and motivate this practice[20]. It is worth noting that no difference was found for public places, only for private ones. A possible explanation for these findings is the small number of



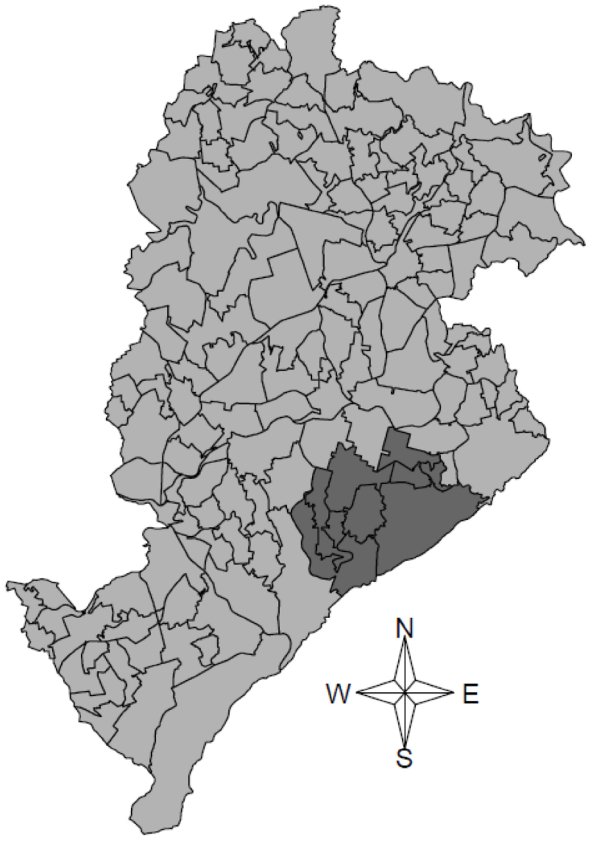
*The dark color represents the cluster of high prevalence of physical activity practice during leisure time.

Figure 2. Cluster of high prevalence of sufficient physical activity practice during leisure time, Belo Horizonte (MG), 2008–2010*.

Table 1. Characteristics of the spatial cluster with high prevalence of sufficient physical activity practice during leisure time, Belo Horizonte (MG), 2008–2010.

Cluster characteristics	No adjustments	With adjustments*
Radius (m)	3,477	3,041
Population	1,215	603
Observed cases	505	293
Expected cases	406	239
Percentage of cases in the area	41.6	48.6
Prevalence ratio (active/inactive)	1.33	1.27
p-value	<0.001	0.002

*Adjusted for sex, age, education level, and marital status.



*The dark color represents the cluster of high prevalence of physical activity practice during leisure time.

Figure 3. Cluster of high prevalence of sufficient physical activity practice during leisure time, adjusted for sex, age, education level, and marital status, Belo Horizonte (MG), 2008–2010*.

public facilities for PA in the city, which may have been insufficient to detect an association, even if such does exist.

There was an even higher residential and population density in the cluster. This result can be explained by the relationship of these variables with greater accessibility and proximity to different destinations, favoring walking or cycling[21,22], i.e., the higher population density would be associated with greater walkability, with more "walkable" destinations. Furthermore, it is believed that in denser locations there are more people on the streets, leading to less perception of insecurity23,24.

In this study, CAPHC inside the cluster had better socioeconomic status, determined by the average family income. Studies show that areas with lower income levels have poorer physical infrastructure, resulting in little supply of services, such as health care, in addition to having low availability of leisure areas, which can result in greater incidence of physical inactivity[25,26].

Table 2. Median and interquartile range of contextual variables according to the presence or not of the cluster* with high prevalence of physical activity practice during leisure time, Belo Horizonte (MG), 2008–2010.

Characteristics	Cluster*	Outside the cluster	p-value
	Median (IQR)	Median (IQR)	
Physical environment			
Density of places for PA practice (number/km²)	9.32 (4.15–12.41)	2.42 (0.91–4.05)	0.002
Density of public places for PA practice (number/km²)	0.41 (0.00–0.55)	0.44 (0.00–0.96)	0.849
Density of private places for PA practice (number/km²)	9.32 (3.63–11.49)	1.81 (0.47–3.27)	0.004
Population density (inhabitants/km²)	13,913 (8,953–15,997)	9,376 (7,109–11,498)	0.040
Residential density (household/km²)	4,277 (3,231–5,419)	2,952 (2,185–3,605)	0.017
Social environment			
Homicide rate (per 10 thousand inhabitants)	4.58 (3.51–6.82)	5.98 (4.04–8.64)	0.212
Average family income (BRL)	6,614 (2,916–12,234)	915 (574–1,757)	0.001
Health vulnerability index (HVI)	0.11 (0.08–0.31)	0.25 (0.21–0.30)	0.218

IQR: interquartile range; *cluster adjusted for sex, age, education level, and marital status; PA: physical activity.

In adults, positive associations were found between LTPA practice and better conditions of income, education level, and residence in environments with opportunities for PA practice[5]. Besides, greater availability of private facilities for PA and lower crime rates were also associated with the sufficient practice of LTPA[9,27].

In the present study, the prevalence of LTPA was 33.3%, exceeding the estimate found in the 2013 National Health Survey (*Pesquisa Nacional de Saúde* – PNS), in which 22.5% of adults followed the recommendations for PA during leisure time[3]. In comparison with the national estimates obtained from data from Vigitel between 2009 and 2016 (30.3 and 37.6%), Belo Horizonte had a prevalence of LTPA close to that found in this period for the Brazilian capitals and the Federal District[4]. Nevertheless, the practice of LTPA should be encouraged because, although there are programs in Belo Horizonte to promote the practice of PA, such as the Health Academy Program, they have been mostly used by people as secondary prevention[28]. This information demonstrates that the service deserves to be promoted as a space for health promotion for the entire population and also directed to primary health care.

In this study, some limitations must be acknowledged. One of them concerns the representativeness of the sample of households with a fixed telephone line. However, the coverage of fixed lines in the city is one of the highest in Brazil, which enables to reduce a possible selection bias[29]. Another limitation is the use of secondary data obtained from governmental and commercial sources to describe contextual characteristics, which may be subject to inaccuracies, in addition to being obtained between 2009 and 2012, whereas individual data were collected between 2008 and 2010. However, it is believed that these registration systems are not as dynamic in terms of their characteristics over time. An additional limitation refers to the use of self-reported data to assess the practice of LTPA, which can weaken the estimation of the levels and intensity of activities. Nevertheless, studies of validation of PA indicators that used data from Vigitel showed good performance in sensitivity and specificity analyses[30,31]. The cross-sectional nature of the data should also be considered, which limits any possibility of establishing causal relationships.

In conclusion, in this study a cluster of high prevalence of PA practice in leisure time was observed in a privileged physical and socioeconomic urban environment. Therefore, the reduction of inequalities in urban environments can increase the LTPA practice and reduce the risk of chronic diseases. The results of this research can assist in and facilitate the development and implementation of more effective public policies to make urban physical and social environments healthier.

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