scientific reports

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Opportunities for physical activity in the school environment and their association with physical activity and sedentary behavior in Brazilian adolescents

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The school environment (SE) plays a crucial role in determining adolescents' physical activity (PA), including physical education classes, sports spaces and facilities, and active recreation. This study aimed to evaluate the association between the SE and indicators of PA and sitting time (ST), while exploring Brazilian sociodemographic differences. The SE was characterized by PA practices, PA outside regular class hours, running/athletic track condition, use of the courtyard for PA with a professional, participation in inter-school games or physical-sports competitions, and the number of physical education classes per week. PA and ST were assessed via self-report questionnaires, categorizing participants as active or insufficiently active for PA and as having low or excessive ST. The study included a nationally representative sample of 155,019 Brazilian adolescents (50.9% female). Among them, 28.5% were classified as active and 47.3% had adequate ST. Taking two or more physical education classes was positively associated with being active (OR: 1.669; 95% CI: 1.665–1.673) and with having low ST (OR: 1.050; 95% CI: 1.048–1.052). The association between SE characteristics and PA varied by region and school type (rural/urban, public/private), emphasizing that SE impacts PA and ST differently depending on the sociodemographic context of the adolescents.

Keywords Physical activity, Sedentary behavior, Adolescent, School environment, Health behavior, School health services

Physical activity (PA) is an important protective behavior for the physical and mental health of children and adolescents[1]. At the same time, physical inactivity is a major concern for health authorities worldwide, as it represents a significant risk factor for non-communicable diseases, with effects comparable to those of smoking and obesity[2,3]. Despite this importance, it is estimated that 81% of adolescents between 11 and 17 years of age are insufficiently active worldwide[4]. In Brazil, this prevalence is even higher, reaching 83.6% (78.0% boys and 89.4% girls)[4]. Furthermore, more than 50% of teenagers spend 3 or more hours engaged in sedentary behavior (sitting time, ST)[5]. Therefore, promoting PA in adolescents in and outside school contexts, is a global priority and challenge.

In this sense, research has been conducted to identify possible barriers and facilitators of PA, aiming to support the development of strategies and public policies[6–8]. Among the main determinants of PA in young people, the school environment (SE) stands out as a crucial space, as adolescents spend a significant portion of their day on school grounds[9]. Physical education classes, sports spaces and facilities, and active recreation have been consistently associated with higher levels of PA[9,10].

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Systematic reviews have highlighted the influence of the school environment on physical activity in various international studies[11–13]. While some national studies[10,14] have examined this relationship in Brazil, they were limited to a single state (São Paulo) and just two cities (São Paulo and São Caetano do Sul), representing a socioeconomic reality that differs significantly from the rest of the country. Furthermore, the association between the SE and sitting time remains underexplored. Additionally, previous research has not fully accounted for the country's regional and sociodemographic diversity, limiting the understanding of how the SE influences PA and ST across different contexts.

While the role of the SE in promoting physical activity is well established, little is known about how these associations vary by region, school location (urban or rural), and administrative dependency (public or private). We hypothesize that the SE is associated with PA and that this relationship may differ based on sociodemographic factors. This study examines the association between the SE, PA, and ST in a nationally representative sample, allowing for the analysis of regional and sociodemographic variations that have not been previously explored. By encompassing all Brazilian regions and diverse sociodemographic contexts, this research provides a broader understanding of how school-related factors influence adolescent behaviors, addressing the limitations of prior studies that were restricted to specific locations or focused solely on physical activity.

Methods

This is a cross-sectional study based on data from the National School Health Survey (PeNSE) conducted in 2019, in partnership with the Brazilian Institute of Geography and Statistics (IBGE) and supported by the Ministry of Education (MEC)[15].

PeNSE aims to identify both risk and protective factors for chronic non-communicable diseases in Brazilian schoolchildren, as well as to monitor these factors across all regions and states in Brazil, including the capital (Federal District). This research aligns with the World Health Organization's recommendation to implement and maintain surveillance systems for adolescent health risk factors. All data are publicly accessible and available on the IBGE website (https://www.ibge.gov.br/)[16].

Ethics approval and consent to participate

Participants provided consent by agreeing to the Free and Informed Consent Form, and the research was approved by the responsible institutions and secretaries. PeNSE 2019 was approved by the National Research Ethics Commission (CONEP), under opinion no. 3,249,268, on 04/08/2019[15]. All methods were performed in accordance with the relevant national ethical guidelines and regulations for research involving human participants[15].

Sample

The PeNSE 2019 sample was designed to estimate population parameters for adolescents enrolled from the 7th year of elementary school to the 3rd year of high school (ages approximately 13 to 17) in public and private schools, covering the following geographic levels: Brazil, Major Regions, Federation Units, Capital Municipalities, and the Federal District. The research used a complex two-stage sampling technique, with the first stage involving the selection of schools and the second stage involving the selection of classes. Initially, 4,242 schools and 6,612 classes were included in the PeNSE sample, but there was a loss of 15.2%[15]. Data collection occurred on school premises, where students completed a self-administered questionnaire via electronic devices. The questionnaire was adapted from international instruments, including the Health Behavior in School-aged Children, the Youth Risk Behavior Surveillance System, and the Global School-based Student Health Survey[17–19]. Further details are available in another publication[15]. Questions about the SE were answered by the school principal or designated representative.

Exclusion and inclusion criteria

Individuals with incomplete answers and students without data on the SE (provided by the school principal or designated representative) selected for this study were excluded. The final sample included 155,019 participants who met all inclusion criteria, such as providing complete responses and answering questions about the school environment.

School environment

To characterize the school environment, the variables considered were related to the provision of: PA practices for students (athletics/running; dance; fights; gymnastics; others), PA outside regular class hours, running track /athletics in usable conditions, use of the playground to practice PA with a professional, participation in games or physical-sports competitions between schools and the holding of games between classes and groups within the school itself, as well as the number of physical education classes at school during the week[15]. The responses were categorized as 'yes' or 'no,' in accordance with the questionnaire[15]. The number of physical education classes was categorized as: "2 or more times per week" or "none or 1 day per week"[20]. For analysis purposes, each characteristic was associated individually.

Physical activity and sitting time

The level of PA was measured according to the sum of physical activities carried out in the week prior to the survey, including three domains: commuting between home and school, physical education classes at school and extracurricular physical activities (activities carried out at school, but outside physical education classes, and physical activities in other spaces, such as clubs, associations, squares, etc.)[21]. The responses were multiplied by the number of days reported and the duration (time spent in each domain), resulting in the total accumulated

PA for the week[21]. Students were then classified as insufficiently active (0 to 299 min/week) or active (300 min or more per week)[15,21].

ST was used as an indicator of sedentary behavior and measured based on the time spent in sedentary positions, such as watching television, playing video games, and using electronic devices like computers, cell phones, or tablets. Other sitting activities were also included. Time spent sitting on Saturdays, Sundays, holidays, or during school hours was excluded from this measure. ST was categorized as "excessive" for durations exceeding three hours per day and as "low ST" for durations of three hours or less[15,21].

Sociodemographic characteristics

The questionnaires completed by principals and students also provided data on gender, age, region, situation (urban or rural) and administrative dependency of the school (public or private)[15].

Statistical analysis

Descriptive results were presented as percentages and confidence intervals (95%). The characteristics of the SE were considered for analysis as an independent variable, the level of PA and ST as dependent variables. The following sociodemographic factors were also included in the analyses: region (north, northeast, southeast, south and central-west), situation (urban or rural) and administrative dependence (public or private).

Logistic regression was used to analyze the association between the characteristics of the SE and being physically active or having low ST, as well as their relationships with sociodemographic characteristics. The association was expressed through odds ratios (OR) and their respective confidence intervals (95% CI). Values were expressed adjusted for sex and age. The significance level was set at $p \leq 0.001$. The IBM SPSS Statistics software, version 22, was used for the analyses. All analyzes considered the expansion technique and sample weight in accordance with the selection process and population representativeness conducted by PeNSE-2019[15].

Results

The sample was made up of 155,019 students, 50.9% female, 51.5% aged between 13 and 15 years old, 40.0% from the southeast region of Brazil, 92.4% studied in an urban school and 84.4% belonged to public administration schools (Table 1). Of the total, 28.5% of students were classified as active, and 47.3% had adequate ST. The prevalence of active people was higher in the groups: male, aged 13 to 15 years, in the southern region of Brazil, in urban schools, and in private administrative dependency schools (Table 1).

Table 2 shows the association of SE with being active and having low ST. The results showed positive associations between the SE and being active and negative associations with low ST. Taking two or more physical education classes was associated with being active (OR: 1.669; 95% CI: 1.665–1.673) and having low ST (OR: 1.050; 95% CI: 1.048–1.052).

Tables 3 and 4 present the associations between SE characteristics and being active and having low ST, stratified by sociodemographic characteristics. We observed different directions and intensities of associations according to region, situation and administrative dependence. Only the characteristics "the school participates in games or physical-sports competitions between schools" and "having two or more physical education classes per week" showed a positive association with being active in all regions of Brazil. In relation to the situation and administrative dependence, several environmental characteristics were positively associated with being active in urban, rural, public and private spheres. In general, the associations of SE with being active or having low ST presented higher values in private schools compared to public schools.

Discussion

The aim of the study was to evaluate the association between the SE and the levels of PA and ST in Brazilian adolescents, exploring sociodemographic differences across Brazilian regions. The results indicated that characteristics of the SE are associated with adolescents' PA and ST, with these associations varying according to sociodemographic factors, including the region, school situation (urban or rural) and administrative dependency of the school (public or private).

Of the total sample, 28.5% were active, which represents the lowest prevalence of PA since PeNSE was created[21]. Males had a higher prevalence of active compared to females. These findings align with previous studies, demonstrating that Brazilian boys engage in more PA than girls. This may be explained by the fact that female participants report more barriers to PA than their male counterparts[22,23]. This highlights the significant disparity in PA levels between the sexes, justifying adjustments in the analyses by sex. The data also show that in Brazil, this difference has increased since 2012[21]. Additionally, a study that analyzed data on PA in Brazilian adolescents from 2009 to 2015 demonstrated a higher prevalence of leisure-time PA (≥ 300 min/week: 5 days × 60 min) in adolescents from private schools compared to public schools. On the other hand, PA resulting from active commuting to school was higher for public school students[24]. In another study conducted in the northeastern region of Brazil, it was found that the general practice of PA (≥ 10 min/week) was higher among public school students. However, when considering different domains of PA, a higher prevalence of physical exercise (callisthenic exercises, walking, running, weight training, and gymnastics in a gym) was observed in private school students. Conversely, greater active commuting (walking or biking as a means of transportation to school, friends' houses, supermarkets, and other locations) was found among public school students[25]. These data reinforce the differences in PA levels according to sociodemographic characteristics.

The characteristics of the SE were associated with being physically active, which has been corroborated by the literature on the subject. In a study that investigated the association between PA facilities and access to school with total PA and specific PA domain, it was shown that having sports courts, a swimming pool, an athletics track and bicycle parking was positively associated with total PA. Furthermore, favorable security conditions

	Total % (95%CI)	Active % (95%CI)	Low sitting time % (95%CI)
Total		28.5 (28.1–29.0)	47.3 (46.7–47.8)
Sex			
Female	50.9 (48.5–49.6)	18.4 (17.9–19.0)	46.4 (45.7–47.2)
Male	49.1 (48.5–49.6)	39.0 (38.3–39.8)	48.2 (47.4–48.9)
Age (Years)			
Under 13	13.1 (12.7–13.4)	29.5 (28.3–30.8)	54.4 (53.0–55.8)
13 to 15	51.5 (51.0–52.0)	29.1 (28.4–29.8)	45.8 (45.1–46.5)
16 to 17	28.7 (28.2–29.2)	27.6 (26.7–28.6)	45.0 (44.0–46.0)
18 or over	6.7 (6.5–7.0)	26.5 (24.8–28.3)	54.4 (52.4–56.4)
Region			
North	10.6 (10.3–10.8)	27.4 (26.3–28.6)	56.8 (55.6–58.1)
North East	28.5 (28.0–28.9)	24.4 (23.7–25.1)	53.7 (52.8–54.5)
Southeast	40.0 (39.4–40.6)	30.1 (29.1–31.1)	41.5 (40.4–42.5)
South	13.1 (12.8–13.4)	33.1 (31.9–34.4)	43.8 (42.5–45.1)
Midwest	7.8 (7.7–8.0)	29.5 (28.7–30.5)	46.6 (45.6–47.6)
Situation			
Urban	92.4 (92.1–92.7)	29.1 (28.6–29.6)	45.5 (44.9–46.1)
Rural	7.6 (7.3–7.9)	21.4 (19.9–22.9)	68.8 (67.1–70.4)
Administrative dependence			
Public	84.4 (84.2–84.6)	28.4 (27.8–28.9)	48.9 (48.2–49.5)
Private	15.6 (15.4–15.8)	29.5 (28.9–30.1)	38.7 (38.0–39.3)
Environmental characteristics			
Does the school offer physical activity practices for students?			
Yes	96.1 (95.9–96.2)	28.7 (28.2–29.2)	46.9 (46.3–47.4)
No	3.9 (3.8–4.1)	24.8 (23.0–26.6)	56.8 (54.8–58.8)
Does the school offer physical activity to students outside of regular class hours?			
Yes	53.3 (52.7–53.8)	29.3 (28.6–29.9)	45.9 (45.2–46.6)
No	46.7 (46.2–47.3)	28.0 (27.2–28.8)	48.0 (47.2–48.9)
Does the school have a running/athletics track IN USABLE CONDITION?			
Yes	4.6 (4.4–4.9)	30.5 (28.0–33.1)	42.1 (39.3–44.9)
No	95.4 (95.1–95.6)	28.4 (27.9–28.9)	47.5 (47.0–48.1)
Is the school yard frequently used for physical activity with an instructor?			
Yes	52.1 (51.6–52.6)	28.9 (28.2–29.5)	46.9 (46.2–47.6)
No	47.9 (47.4–48.4)	28.2 (27.5–28.9)	47.7 (46.9–48.5)
Does the school participate in games or physical-sports competitions between schools?			
Yes	79.1 (78.7–79.6)	28.8 (28.3–29.4)	47.2 (46.6–47.8)
No	20.9 (20.4–21.3)	28.2 (26.1–30.4)	51.0 (48.7–53.3)
Does the school hold games or physical-sports competitions between classes, groups or shifts?			
Yes	91.9 (91.6–92.1)	28.1 (26.9–29.3)	45.7 (44.4–47.0)
No	8.1 (7.9–8.4)	25.4 (23.2–27.7)	50.5 (47.9–53.0)
Physical education classes at school?			
2 or more times a week	37.3 (36.8–37.8)	35.2 (34.4–36.1)	48.2 (47.3–49.1)
None or 1 day a week	62.7 (62.2–63.2)	24.5 (24.0–25.1)	46.7 (46.1–47.4)

Table 1. Sample characteristics. sociodemographic and school environment.

around the school promoted active movement[14]. In another study, which aimed to examine indicators of the SE with different intensities of PA, associations were found between access to the school's physical facilities and an increase in light and vigorous PA, in addition to an increase in the chances of meeting PA recommendations[10]. All these findings support the literature on the importance of the SE in PA promotion in adolescent population.

On the other hand, contrary to our hypothesis, our data showed that most characteristics of the SE were inversely associated with low ST. These findings align with a study that analyzed the weekly frequency of physical education classes and leisure-time sitting among adolescents from 73 countries[26]. The authors hypothesize that adolescents who attend more physical education classes tend to be more active and compensate for the rest of the time with greater sedentary behavior[26]. Although physical education classes were not associated with sedentary time in the results found here, these findings help to highlight that the impact of school characteristics may not always be extrapolated to the entire routine of young people. However, PeNSE measures total sedentary time by asking students to report the total time spent sitting, excluding the time spent sitting inside the school. We can

School environment	Active OR (95%CI)	p	Low sitting time OR (95%CI)	p
Does the school offer physical activity practices for students? (ref. No)	1.239 (1.231–1.247)*	< 0.001	0.671 (0.668–0.675)*	< 0.001
Does the school offer physical activity to students outside of regular class hours? (ref. No)	1.060 (1.058–1.063)*	< 0.001	0.915 (0.913–0.917)*	< 0.001
Does the school have a running/athletics track IN USABLE CONDITION? (ref. No)	1.055 (1.049–1.061)*	< 0.001	0.812 (0.808–0.815)*	< 0.001
Is the school yard frequently used for physical activity with an instructor? (ref. No)	1.022 (1.019–1.024)*	< 0.001	0.964 (0.962–0.966)*	< 0.001
Does the school participate in games or physical-sports competitions between schools? (ref. No)	1.070 (1.067–1.073)*	< 0.001	1.034 (1.032–1.036)*	< 0.001
Does the school hold games or physical-sports competitions between classes, groups or shifts? (ref. No)	1.104 (1.099–1.109)*	< 0.001	0.872 (0.869–0.875)*	< 0.001
Physical education classes at school? (ref. None or 1 day a week)	1.669 (1.665–1.673)*	< 0.001	1.050 (1.048–1.052)*	< 0.001

Table 2. Association of characteristics of the school environment with being physically active and having low sitting time. * $p \leq 0.001$ Analyzes adjusted for sex and age.

	Active OR (95%CI)					Low sitting time OR (95%CI)				
	North	Northeast	Southeast	South	Midwest	North	Northeast	Southeast	South	Midwest
Does the school offer physical activity practices for students? (ref. No)	1.007 (0.992–1.021)	1.385 (1.372–1.398)*	1.077 (1.055–1.101)*	0.897 (0.885–0.910)*	1.238 (1.212–1.265)*	0.620 (0.612–0.629)*	0.634 (0.629–639)*	1.603 (1.570–1.636)*	1.262 (1.245–1.278)*	0.934 (0.917–0.951)*
Does the school offer physical activity to students outside of regular class hours? (ref. No)	1.003 (0.995–1.010)	1.059 (1.054–1.063)*	0.976 (0.972–0.979)*	1.279 (1.270–1.287)*	1.211 (1.201–1.221)*	0.766 (0.761–0.771)*	0.928 (0.924–0.931)*	0.866 (0.863–0.869)*	0.934 (0.928–0.940)*	0.962 (0.955–0.969)*
Does the school have a running/athletics track IN USABLE CONDITION? (ref. No)	0.947 (0.912–0.983)*	1.088 (1.061–1.115)*	0.974 (0.968–0.981)*	0.903 (0.894–0.913)*	0.844 (0.821–0.868)*	0.547 (0.529–0.565)*	0.680 (0.666–0.695)*	0.993 (0.987–0.999)	0.986 (0.977–0.996)	1.060 (1.035–1.086)*
Is the school yard frequently used for physical activity with an instructor? (ref. No)	0.903 (0.896–0.909)*	1.109 (1.104–1.114)*	1.010 (1.006–1.013)*	0.857 (0.852–0.863)*	1.022 (1.014–1.030)*	0.922 (0.916–0.928)*	0.867 (0.864–0.870)*	1.048 (1.044–1.051)*	1.050 (1.044–1.057)*	0.980 (0.973–0.987)*
Does the school participate in games or physical-sports competitions between schools? (ref. No)	1.094 (1.083–1.104)*	1.101 (1.095–1.107)*	1.029 (1.025–1.033)*	1.040 (1.029–1.051)*	1.201 (1.186–1.215)*	0.627 (0.622–633)*	0.987 (0.982–0.992)*	1.085 (1.081–1.089)*	1.022 (1.012–1.032)*	0.882 (0.873–0.892)*
Does the school hold games or physical-sports competitions between classes, groups or shifts? (ref. No)	1.095 (1.082–1.108)*	1.156 (1.148–1.165)*	1.038 (1.030–1.045)*	0.997 (0.987–1.008)	1.099 (1.072–1.127)*	0.603 (0.597–0.610)*	0.971 (0.965–0.977)*	1.097 (1.089–1.104)*	0.826 (0.818–0.833)*	0.919 (0.898–0.940)*
Physical education classes at school? (ref. None or 1 day a week)	1.740(1.727-1.753)*	1.780 (1.771–1.788)*	1.455 (1.449–1.460)*	1.785 (1.774–1.796)*	1.608 (1.595–1.622)*	1.215 (1.207–1.224)*	1.227 (1.222–1.232)*	1.106 (1.102–1.110)*	0.952 (0.946–0.957)*	1.174 (1.166–1.183)*

Table 3. Association of characteristics of the school environment with being physically active and having low sitting time according to region. * $p < 0.001$ Analyzes adjusted for sex and age.

	Active OR (95%CI)				Low sitting time OR (95%CI)			
	Urban	Rural	Public	Private	Urban	Rural	Public	Private
Does the school offer physical activity practices for students? (ref. No)	1.193 (1.185–1.201)*	1.094 (1.078–1.111)*	1.243 (1.235–1.251)*	1.096 (0.065–1.129)*	0.768 (0.764–0.773)*	0.676 (0.667–0.685)*	0.694 (0.690–0.697)*	1.112 (1.082–1.143)*
Does the school offer physical activity to students outside of regular class hours? (ref. No)	1.043 (1.041–1.046)*	1.041 (1.030–1.051)*	1.052 (1.050–1.055)*	1.117 (1.109–1.125)*	0.956 (0.954–0.958)*	0.859 (0.851–0.866)*	0.918 (0.916–0.920)*	0.982 (0.976–0.988)*
Does the school have a running/athletics track IN USABLE CONDITION? (ref. No)	1.027 (1.022–1.033)*	1.111 (1.067–1.156)*	1.041 (1.034–1.047)*	1.106 (1.096–1.117)*	0.861 (0.857–0.865)*	0.743 (0.719–0.769)*	0.784 (0.779–0.788)*	1.111 (1.101–1.121)*
Is the school yard frequently used for physical activity with an instructor? (ref. No)	1.041 (1.038–1.043)*	0.774 (0.767–0.781)*	1.002 (0.999–1.004)	1.122 (1.116–1.129)*	0.962 (0.960–0.964)*	0.985 (0.977–0.993)*	0.920 (0.918–922)*	0.987 (0.982–0.993)*
Does the school participate in games or physical-sports competitions between schools? (ref. No)	1.057 (1.054–1.060)*	1.063 (1.052–1.074)*	1.053 (1.050–1.056)*	1.173 (1.166–1.181)*	1.110 (1.107–1.113)*	0.675 (0.669–0.681)*	1.013 (1.010–1.016)*	1.048 (1.042–1.055)*
Does the school hold games or physical-sports competitions between classes, groups or shifts? (ref. No)	1.081 (1.076–1.085)*	1.081 (1.067–1.095)*	1.087 (1.082–1.092)*	1.214 (1.197–1.230)*	1.111 (1.108–1.114)*	1.243 (1.229–1.257)*	0.898 (0.894–0.901)*	0.889 (0.879–0.900)*
Physical education classes at school? (ref. None or 1 day a week)	1.649 (1.645–1.653)*	1.836 (1.819–1.853)*	1.647 (1.643–1.651)*	1.921 (1.909–1.933)*	1.059 (1.057–1.061)*	1.181 (1.171–1.191)*	0.998 (0.995–1.000)	1.132 (1.126–1.139)*

Table 4. Association of characteristics of the school environment with being physically active and having low sitting time according to the situation and administrative dependency of the school. * $p < 0.001$ Analyzes adjusted for sex and age.

hypothesize that the SE impacts the level of PA of the students and that a large part of the total PA of adolescents is carried out within the school or through active transport to it; however, time spent outside of school is more related to sedentary behavior. Following the same reasoning, students who do not have a SE conducive to PA tend to spend more time being sedentary outside of school. Similar results have already been observed in a study with schoolchildren from São Caetano do Sul (Brazil), where the characteristics of the SE were associated with PA, but were not associated with reduced time spent in sedentary behavior[10]. Interventions to reduce sedentary behavior among adolescents must consider, in addition to the SE, the home environment (including screen time, television in the bedroom, among other factors), the community, and efforts to reduce barriers to PA[27,28].

The most significant associations between SE and being active were found in the variable related to the number of physical education classes. Although the total PA time accounted for the PA performed during school physical education classes, the result emphasizes the importance of these classes in students' overall PA levels. Physical education classes were associated with being active in all regions, situation and administrative dependency. Several studies have demonstrated the importance of physical education in adolescents' PA levels, recognizing it as a key public health strategy for this population[29,30]. A review of 14 studies showed that increasing PA through physical education classes was more effective than increasing PA outside of school. Furthermore, a study that analyzed the association of PA with the number of physical education classes in 65 countries worldwide found that adolescents who attended physical education classes (≥ 3 days/week) were twice as likely to be sufficiently active compared to those who did not attend[29]. The study also indicated that the strength of these associations decreased according to the country's income, with low-income countries showing the highest estimates[29]. Our findings also revealed that physical education classes were associated with lower ST.

When analyzing the associations between the characteristics of the SE and being physically active according to sociodemographic characteristics, we observed different associations based on region. However, the associations were consistent across urban, rural, public and private schools. Offering PA to students can be an important strategy for promoting PA among young people, regardless of the school's administrative situation or dependency. Investing in infrastructure and spaces to support these strategies in schools, particularly in poorer regions, is essential. A previous study, using data from PeNSE 2015, characterized the school PA environment of public and private schools in Brazil, and found that private schools had more sports courts and sports equipment compared to public schools[31]. According to the results, private schools received higher scores in the "Availability of structures and materials" analysis compared to public schools[31].

Strategies to increase the level of PA in the SE have been investigated. A longitudinal study conducted in two provinces in Canada showed that opening a gym or outdoor club, installing bicycle racks, including sports activities, providing greater access to sports fields, and improving court conditions were effective in increasing the level of PA[32]. In Brazil, there is a significant financial barrier to investments in this area, making interventions in the SE challenging. However, other intervention options that can contribute to a more conducive environment for PA at a lower cost include active recess, more physical education classes, additional time spent on movement during physical education classes, active commuting initiatives, and intramural and interscholastic sports programs[33,34]. In the present study, providing access to the school playground for PA was associated with a higher level of PA; however, the association varied according to sociodemographic characteristics.

Participating in games or physical-sports competitions between schools and also between classes within the school itself was positively associated with being active in almost all regions of Brazil (except in the South), in both urban and rural settings, and in both public and private schools. Therefore, this characteristic emerges as an important strategy for promoting PA among adolescents, as it supports all sociodemographic conditions.

A study using data from PeNSE from 2012 already demonstrated the potential of the SE to increase the likelihood of PA among adolescents[35]. Key features of the school environment, such as sports courts, running/athletics tracks, school yards with PA guided by teachers, swimming pools, changing rooms and extracurricular sports activities, were associated with higher levels of PA. The study also highlighted the impact of environmental characteristics on various domains of PA, including total PA, leisure-time PA, and participation in physical education classes[35]. The present study, in addition to supporting the existing literature on the importance of the SE for promoting PA, provides data on how these interactions vary according to sociodemographic characteristics. These findings underscore the importance of considering the region, situation (urban or rural) and administrative dependence (public or private) of schools in future analyzes of PA and SE, as these factors are often overlooked in favor of covariates such as sex and socioeconomic status.

This study has several limitations that should be considered: 1) PA and ST were assessed via questionnaire, which introduces the potential for bias. However, the PeNSE questionnaire has demonstrated high validity and accuracy in previous studies[36]; 2) since this is a cross-sectional study, causality between SE and PA cannot be established, though associations can still be identified; 3) the school teaching regime (full-time or part-time) was not measured by PeNSE. Since full-time schools may significantly influence PA, barriers to PA, and sedentary behavior, the lack of in-depth studies on these factors in Brazil represents a notable limitation[22]. Future studies should incorporate these variables to provide a more comprehensive understanding.

On the other hand, this study has several strengths that should be highlighted. First, the use of a large, representative sample of Brazilian adolescents supports the generalization of the results. Second, the sociodemographic diversity and national coverage of the PeNSE data, collected through standardized methods, enhance the study's reliability and validity.

Conclusion

The characteristics of the SE are associated with adolescents' PA and ST, with these associations varying across different sociodemographic factors, including Brazilian region, school situation, and administrative dependence.

Future research should aim to identify additional sociodemographic factors that may influence these associations and explore their underlying mechanisms. Public policies can leverage these findings by allocating

resources and implementing programs to strengthen school environments that promote PA among adolescents. For instance, increasing the number of physical education classes and organizing inter-school sports competitions are potential strategies with proven effectiveness. Additionally, further studies should consider variables such as school situation and administrative dependence to develop more targeted and impactful interventions.

Data availability

The database on which this article was based on is available in an open repository (Brazilian Institute of Geography and Statistics: National School Health Survey – PeNSE; available at: https://www.ibge.gov.br/estatisticas/sociais/populacao/9134-pesquisa-nacional-de-saude-do-escolar.html?edicao=31442&t=microdados

Received: 20 August 2024; Accepted: 12 March 2025
Published online: 18 March 2025

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Acknowledgements
We thank the National Council for Scientific and Technological Development (CNPq) (Conselho Nacional de Desenvolvimento Científico e Tecnológico—CNPq).

Author contributions
Conceptualization: ERV, GF; methodology, software, validation, formal analysis, investigation, resources, data curation, writing – original draft preparation: ERV, GF; DRPS; writing – review and editing, visualization: GF, DRPS, PFH, CFV and DS. All authors read and agreed to the published version of the manuscript.

Funding
This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior—Brasil (CAPES)—Finance Code 001.

Declarations

Competing interests
The authors declare no competing interests.

Ethics approval and consent to participate
Participants agreed to the Free and Informed Consent Form and the research was approved by the responsible institutions and secretaries. PeNSE 2019 was approved by the National Research Ethics Commission (CONEP), opinion no. 3,249,268, dated 04/08/2019.

Consent for publication
Not applicable.

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