What school environment characteristics influence the physical fitness of low-income schoolchildren?

¿Qué características del entorno escolar influyen en la aptitud física de los escolares de bajos ingresos?

Authors

Douglas Eduardo Ferreira Maia[1]
Rostand de Souza Lira Filho[1]
Tércio Araújo do Rego Barros[1]
Igor Rodrigues de Souza Sobral[1]
Ana Beatriz Felix Lourenço[1]
Nayara Souza de Oliveira[1]
Paulo Felipe Ribeiro Bandeira
Marcos André Moura dos Santos
Thaliane Mayara Pessôa dos Prazeres
Rafael dos Santos Henrique

[1] Federal University of Pernambuco (Brazil)
[2]University of Pernambuco (Brazil)
[3]Regional University of Cariri (Brazil)

Corresponding author:
Rafael dos Santos Henrique
rafael.shenrique@ufpe.br

How to cite in APA

Eduardo Ferreira Maia, D., de Souza Lira Filho, R., Araújo do Rego Barros, T., Rodrigues de Souza Sobral, I., Felix Lourenço, A. B., Souza de Oliveira, N., ... dos Santos Henrique, R. (2025). What school environment characteristics influence the physical fitness of low-income schoolchildren?. *Retos*, *66*, 679–689. https://doi.org/10.47197/retos.v66.114142

Abstract

Introduction: Physical fitness (PF) is a key health determinant, linked to cardiometabolic risk, cognitive performance, and mental health.
Objective: This study examines how school environment characteristics, physical structures, and policies influence PF in children and adolescents from vulnerable contexts.
Method: A total of 1,359 students (707 boys), aged 5–15 years, from 12 public schools in Lagoa do Carro, Pernambuco, Brazil, were assessed. PF was measured using 20-m shuttle run, handgrip strength, sit-and-reach, standing long jump, 20m-dash and shuttle run tests. School environmental characteristics (e.g., physical structure of school and policies and practices related to physical activity and sports) were also obtained. One-way MANOVAs were performed using PF tests as dependent variables, with age, sex, and body mass index as covariates.
Results: Urban students outperformed rural peers in handgrip strength and standing long jump. Student from schools with courtyard pillars showed better performance in the 20-m dash, shuttle run, and handgrip strength. The absence of physical obstacles and the presence of larger playgrounds (>50 m^2) were associated with superior handgrip and SLJ scores. Intermediate-sized playgrounds (30–49 m^2) favored 20-m dash performance. Schools offering extracurricular activities, sports programs, or inter-school competitions consistently exhibited higher aerobic endurance, muscular strength, and agility among students.
Conclusion: Physical and policy-driven characteristics of school environments significantly influence PF outcomes in vulnerable youth. Findings highlight the importance of targeted investments in school infrastructure and structured physical activity programs to reduce health and fitness disparities.

Keywords

Physical fitness; school environment; vulnerable populations; youth.

Resumen

Introducción: La aptitud física (AF) es un determinante esencial de la salud, asociada al riesgo cardiometabólico, al rendimiento cognitivo y al bienestar mental.
Objetivo: Este estudio analiza cómo las características del entorno escolar, las estructuras físicas y las políticas influyen en la AF de niños y adolescentes en contextos vulnerables.
Método: Se evaluaron 1.359 estudiantes (707 varones), de 5 a 15 años, de 12 escuelas públicas de Lagoa do Carro, Pernambuco, Brasil. La AF se midió mediante pruebas de carrera de 20 m, fuerza de prensión manual, flexión del tronco, salto horizontal, carrera de velocidad y agilidad. También se recopilaron datos sobre la infraestructura escolar y políticas relacionadas con la actividad física. Se aplicaron MANOVAs unidireccionales, utilizando las pruebas de AF como variables dependientes, controlando por edad, sexo e índice de masa corporal.
Resultados: Los alumnos urbanos superaron a los rurales en fuerza de prensión y salto horizontal. Aquellos de escuelas con pilares en el patio obtuvieron mejores resultados en velocidad, agilidad y fuerza. La ausencia de obstáculos físicos y la presencia de patios mayores a 50 m^2 se asociaron con mejores resultados en fuerza y salto. Patios intermedios (30–49 m^2) favorecieron el rendimiento en velocidad. Las escuelas con actividades extracurriculares o competiciones interescolares mostraron mejores niveles de resistencia, fuerza y agilidad.
Conclusión: Las condiciones físicas y políticas del entorno escolar influyen significativamente en la AF de jóvenes vulnerables. Se destaca la necesidad de inversiones estratégicas en infraestructura y programas estructurados de actividad física.

Palabras clave

Aptitud física; entorno escolar; niños; poblaciones vulnerables.

Introduction

Physical fitness (PF) is widely recognized as a fundamental determinant of health across all age groups (Ortega et al., 2008). It is well-established that PF is inversely associated with cardiometabolic risk factors (Stoner et al., 2020) and other comorbidities (Zhou et al., 2021), which may emerge as early as childhood (Akseer et al., 2020). In addition to its role in disease prevention, contributes significantly to motor competence (Barnett et al., 2016; Burton et al., 2023), cognitive performance (Lubans et al., 2022; Santana et al., 2017), and mental health (Lema-Gómez et al., 2021). Furthermore, it is a strong predictor of lifelong engagement in physical and sports activities (García-Hermoso et al., 2020).

Monitoring PF from an early age and identifying its key determinants are fundamental to effective health promotion strategies. Among these factors, contextual influences, particularly those related to the school environment, deserve special attention (García-Hermoso et al., 2020; Henrique et al., 2018; Santos et al., 2018). Schools play a pivotal role in children's development by fostering both individual and collective competencies (van Sluijs, McMinn, & Griffin 2008), besides being a critical environment for health education initiatives (Story, Kaphingst, & French, 2006). Given that students spend a substantial portion of their daily time at school, this environment provides critical opportunities for engagement in activities that may shape PF outcomes and influence long-term health behaviors (Santos et al., 2018; Prazeres et al., 2025). These factors underscore the growing recognition of school-based correlations in shaping youth PF.

Previous research highlights the significant influence of school characteristics on students' PF. These characteristics include the quality and frequency of physical education classes (García-Hermoso et al., 2020), availability of safe and accessible play spaces (Cradock et al., 2007; Lo et al., 2017), implementation of curricular and extracurricular activities (Andrade et al., 2014; Isensee et al., 2018), specific infrastructural and pedagogical practices (Prazeres et al., 2025), and the school's geographical context, whether urban or rural (Castillo et al., 2016; Chillón et al., 2011; Drenowatz et al., 2020; Jiang et al., 2023).

For instance, Chillón et al. (2011) found that rural Spanish youths exhibited higher cardiorespiratory fitness and muscular strength, whereas their urban counterparts performed better in agility and flexibility assessments. Similarly, Drenowatz et al. (2020), in a study involving over 18,000 Austrian children (6–11 years), reported that rural children had superior performance in muscular power, speed, and cardiorespiratory fitness, while urban students demonstrated greater flexibility. In Brazil, Prazeres et al. (2025) observed that students attending schools with favorable infrastructural conditions (e.g., without obstacles, pillars or floor irregularity) and practices (e.g., physical education classes, extracurricular sports or inter-school competitions) outperformed peers in varied PF tests, even after adjusting for individual-level variables. Finally, Lo et al. (2017), analyzing a large Taiwanese adolescent sample (649,442 students) reported that access to gymnasiums, athletic tracks, and larger playgrounds was positively associated with better cardiorespiratory and muscular fitness outcomes.

These findings underscore an important gap: few studies have examined how specific school environment characteristics, such as playground size, the availability of sports courts, and particular features of recreational areas (e.g., obstacles, pillars, floor irregularities), as well as the presence of physical education classes and other sport school practices, influence PF outcomes. This gap is especially critical in socioeconomically disadvantaged settings, where socioeconomic barriers often limit opportunities for physical activity outside the school environment (Rivera-Ochoa et al., 2020; Drenowatz et al., 2020).

To address this gap, the present study aims to investigate how specific school environment characteristics (area and number of students), physical structure (playground area, presence of obstacles, floor irregularity and multi-sports court) and policies and practices related to physical activity and sports (extracurricular sports or sport competitions between schools) influence health- and performance-related PF (20-m Shuttle Run, handgrip strength, standing long jump, sit and reach, 20-m dash, and 4x10-m shuttle run) in children and adolescents from socially vulnerable contexts.

Method

The data for this study were collected as part of Healthy Life in Lagoa do Carro: A Family-Based Study, which investigated multiple aspects of the health of children and adolescents, as well as the impact of family and school factors on these variables.

Participants

This cross-sectional sample consisted of 1,359 youths (707 boys) aged 5 to 15 years (mean age: 9.52 ± 2.67), enrolled in 12 public schools of Lagoa do Carro, Pernambuco, Brazil. Data collection took place between April and November 2018, with a participation rate exceeding 90% of the children in the municipality. No seasonal variations were expected, as the weather conditions remained stable throughout the data collection period. The children were assessed individually over two days, starting with anthropometric measurements followed by physical fitness tests in the following order: sit and reach, handgrip strength, standing long jump, 20-m dash, shuttle run, and 20-m shuttle run. When necessary, the missing data was collected on an additional visit.

Participants were selected based on the following criteria: (i) aged 5 to 15 years; (ii) regularly enrolled in the municipal public schools; and (iii) parental or guardian consent provided through a signed informed consent form. The study was approved by the local Ethics Committee (CAAE: 83143718.3.0000.5192; Process: 2.520.417). Participants who were absent on evaluation days or had osteoarticular conditions preventing them from completing the measurements and tests were excluded from the sample.

Instruments and Procedures

Anthropometry

Height was measured using a portable stadiometer (Sanny, São Paulo, Brazil) with a precision of 0.1 cm, and body mass was measured using a portable scale (Filizola, São Paulo, Brazil) with an accuracy of 0.1 kg. All procedures adhered to the standardization protocols outlined by Lohman, Roche, and Martorell (1988). Body mass and height values were subsequently used to calculate body mass index (BMI) as known [body mass (kg)/height (m^2)].

Physical Fitness

PF was evaluated using tests of FitnessGram (2010) (Meredith & Welk, 2010) and AAHPERD (1985) (Pate, 1985) batteries:

- 20-m Shuttle Run: Participants run between two parallel lines set 20 meters apart, following increasing speeds dictated by an audio signal at each stage. The speed increases progressively by 0.5 km/h per minute. The test concludes when the participant is unable to maintain the required pace or voluntarily withdraws. The number of laps completed, and the final stage reached were recorded to determine the total distance in meters covered.

- Handgrip strength: Participants were instructed to exert maximum force with their dominant hand on a portable dynamometer (TKK, model 5001) for 2 to 5 seconds. Two attempts were performed, with an interval of approximately 10 seconds between them. The force produced in each attempt was recorded in kilograms-force (kgf), and the arithmetic mean of the three measurements was used for analysis.

- Standing long jump: Participants performed a standing horizontal jump, starting from a static position with both feet together. Two attempts were allowed, with intervals of 5 to 10 seconds between jumps. The distance for each attempt, measured in centimeters from the starting line to the closest point of contact with the ground, was recorded.

- Sit and reach: Participants must sit with fully extended knees, placing the plantar region of their feet completely on the Wells bench. They were instructed to flex their trunk and reach forward as far as possible along a centimeter scale affixed to the top of the bench. The distance reached was recorded in centimeters and the arithmetic mean of the two measurements was used for analysis.

- 20-m dash: Participants performed a maximal-effort sprint between two parallel lines set 20 meters apart. Starting from a standing position with one foot just behind the starting line, they were instructed to sprint as fast as possible and fully cross the finish line. The test concluded when the participant crossed the second line, and the completion time was recorded in seconds. The arithmetic meaning of the two measurements was used.

- 4x10-m Shuttle run: Participants performed a maximal-effort run between two parallel lines set 10 meters apart. Two wooden or foam blocks were placed beyond one of the lines. Participants ran to retrieve the first block, returned to the starting line to place it down, and then repeated the task to retrieve the second block. The time taken to complete the test was recorded in seconds and the arithmetic mean of the two measurements was

School Information

School environment characteristics and practices related to physical activity and sports were assessed using an adapted version of the ISCOLE questionnaire (Katzmarzyk et al., 2013). The questionnaire was administered to school directors and researchers conducted direct observations of the school environment. The questionnaire includes items related to general school characteristics (e.g., area and number of students), physical structure (e.g., playground area, presence of obstacles, floor irregularity and multi-sports court) and policies and practices related to physical activity and sports (e.g., attendance of physical education classes, extracurricular sports and competitions between schools). To ensure data quality, all questionnaires were reviewed during data collection.

Data quality control

Data quality control was conducted in three stages. First, the project coordinators provided comprehensive training to the research team on all methodological procedures. Second, a pilot study was conducted at a school in Lagoa do Carro to estimate the time required for data collection. Third, a reliability-in-field procedure was implemented: three to five students from each school (a total of 42 students) were randomly selected on alternating assessment days and re-tested one week later. The reliability-in-field procedure yielded technical error of measurement values of 0.2 cm for height, 0.1 kg for body mass, and 0.1 cm for sitting height. The test-retest reliability for physical fitness (PF) tests ranged from 0.81 for the shuttle run to 0.95 for the sit-and-reach test. The final stage involved double entry of data and a thorough review to identify any errors or inconsistencies.

Data analysis

Descriptive statistics were used to summarize the data, including mean and standard deviation (SD) for numerical variables and frequency distributions (absolute and relative) for categorical variables. Differences between sexes were assessed using the Student's t-test, with effect sizes expressed as Cohen's d (Cohen, 1988). To examine differences in PF tests among children and adolescents based on school environment characteristics, we applied MANOVA's one-way, considering the PF tests as dependent variables, and chronological age, sex and body mass index as covariates. The Bonferroni post-hoc test was used to identify significant differences. Effect sizes were calculated as partial eta squared (η^2p), with values of 0.01, 0.04, and 0.16 considered small, medium, and large effects, respectively (Cohen, 1988). All analyses were conducted using SPSS 23.0, with the significance level of $p < 0.05$.

Results

Table 1 presents the descriptive data of the participants. Boys performed better in all physical fitness tests, except for the sit-and-reach test, in which girls outperformed boys ($p < 0.05$). However, these differences were of low to moderate magnitude. No significant differences were observed for age or anthropometric variables.

Table 1. Descriptive data of the participants, according to sex

Variables	Girls (n= 652)		Boys (n= 707)		*t*	Cohen's d
	Mean	SD	Mean	SD		
Age (years)	9.40	2.58	9.64	2.75	-1.633	-0.09
Height (cm)	135.98	16.18	137.21	16.81	-1.375	-0.08
Body mass (kg)	34.52	13.51	35.23	13.63	-0.964	-0.05
BMI (kg/m^2)	17.96	3.72	18.08	3.72	-0.587	-0.03
20-m Shuttle run (m)	317.09	164.55	397.38	252.02	-6.274*	-0.38
Handgrip strength (kgf)	14.93	6.29	17.41	8.45	-6.086*	-0.33

Horizontal jump (cm)	101.84	25.64	115.45	29.72	-8.510*	-0.49
Sit and reach (cm)	26.18	5.97	25.74	6.38	1.260	0.07
20-m dash (s)	5.10	0.68	4.69	0.63	10.791*	0.63
4x10-m Shuttle run (s)	15.75	1.98	14.75	2.08	8.555*	0.49

Note: BMI, body mass index. *p<0,001

Table 2 presents the characteristics of the school environment. A balanced distribution of schools between urban and rural areas was observed. Although most schools have large playground spaces (41.7%), many of them have obstacles, pillars, or irregularities in the playground surface (66.7%, 50.0%, and 58.3%, respectively). Additionally, only a small proportion of schools have multi-sports courts (16.7%), offer physical education classes (16.7%), extracurricular activities (16.7%), have inter-school sports competitions (25.0%), and policies or practices related to physical activity (25.0%).

Table 2. Descriptive data of school environment characteristics (n=12).

School characteristics	Mean ± SD
Number of students per school	164.67±115.82
	n (%)
Area	
Rural	6 (50.0)
Urban	6 (50.0)
Recreation area and Infrastructure	
Less than 30m (m^2)	3 (25.0)
Between 30m^2 and 49m^2 (m^2)	4 (33.3)
More than 50m^2 (m^2)	5 (41.7)
Presence of obstacles (yes)	8 (66.7)
Presence of pillars (yes)	6 (50.0)
Floor irregularity (yes)	7 (58.3)
Multi-sports court (yes)	2 (16.7)
Policies and practices	
Physical education classes (yes)	2 (16.7)
Extracurricular sports (yes)	2 (16,7)
Competitions between schools (yes)	3 (25,0)
Related to physical activity (yes)	3 (25,0)

Note: SD, standard deviation.

Table 3 shows comparisons of school context characteristics for each PF test. Children living in urban areas showed better performance in the handgrip strength (mean difference = 16.82; 95% CI: 16.37 to 17.27; ES = 0.013) and the standing long jump test (mean difference = 110.39; 95% CI: 108.69 to 112.09; ES = 0.005).

Table 3. Values of descriptive (Mean ± SD) and inferential statistics for physical fitness variables, according to the school environment characteristics.

Variables	20-m SR (m)	Handgrip (kgf)	SLJ (cm)	Sit and reach (cm)	20-m dash (s)	4x10-m Shuttle run (s)
Area	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Urban	359.18±216.45	14.73±5.44	108.92±26.61	25.85±6.19	4.89±0.65	15.21±1.99
Rural	341.43±204.83	12.87±4.40	101.62±31.03	26.17±5.43	4.93±0.84	15.45±2.45
F	0.007	14.314***	5.345*	0.050	0.067	0.024
η^2 p	0.000	0.013	0.005	0.000	0.000	0.000
Playground area						
Less than 30m^2	319.39±193.26	11.16±4.42	97.31±38.25	25.64±5.46	5.05±0.95	15.79±3.09
30m^2 to 49m^2	370.63±229.25	15.54±5.83	109.11±27.03	25.81±6.19	4.80±0,66	15.06±1.97
More than 50m^2	349.65±206.36	17.47±8.83	110.39±28.14	26.13±6.30	4.97±0,67	15.33±1.99
F	1.255	15.543***	12.842**	0.921	3.200*	1.815
η^2 p	0.002	0.027	0.023	0.002	0.006	0.003
Presence of obstacles						
Absent	366.68±219.62	15.40±5.18	111.29±25.60	25.67±6.30	4.83±0.63	14.99±1.83
Present	316.54±189.81	10.72±4.25	94.25±29.96	26.78±5.06	5.13±0.81	16.26±2.55
F	2.748	20.960***	3.074	0.119	0.039	2.930
η^2_p	0.002	0.019	0.003	0.000	0.000	0.003
Presence of pillars						
Absent	356.87±222.22	14.99±5.68	109.33±27.81	25.86±6.16	4.94±0.69	15.18±2.17
Present	362.27±207.78	18.04±9.48	107.88±30.14	26.10±6.25	4.78±0.67	15.33±1.94
F	14.897***	33.718***	1.841	0.001	63.30***	0.201
η^2_p	0.013	0.030	0.002	0.000	0.054	0.000
Floor irregularity						
No	370.59±221.92	17.50±7.60	113.59±26.88	25.71±6.45	4.82±0.64	14.92±1.85
Yes	312.74±195.32	10.82±4.55	91.03±27.98	26.94±4.91	5.16±0.81	16.41±2.50

F	3.074	1.309	5.737*	0.466	0.711	2.136
η^2_p	0.003	0.001	0.005	0.000	0.001	0.002
Multi-sports court						
Absent	347.82±205.17	15.68±7.90	105.53±28.74	26.09±6.03	4.95±0.70	15.52±2.06
Present	391.80±250.71	18.29±5.87	120.03±25.25	25.43±6.74	4.70±0.61	14.26±1.91
F	14.866***	9.810**	2.592	2.221	9.403**	0.005
η^2_p	0.013	0.009	0.002	0.002	0.008	0.000
Physical education classes						
No	345.70±201.96	13.27±4.50	104.22±26.87	26.05±5.86	4.95±0.70	15.55±2.01
Yes	393.07±249.90	18.46±5.93	120.07±25.47	25.35±6.78	4.70±0.59	14.21±1.88
F	15.228***	10.211***	4.623*	1.845	14.582***	0.421
η^2_p	0.014	0.009	0.004	0.002	0.013	0.000
Extracurricular sports						
No	345.70±201.96	13.27±4.50	104.22±26.87	26.06±5.86	4.95±0.70	15.55±2.01
Yes	393.07±249.89	18.46±5.93	120.07±25.47	25.35±6.77	4.70±0.59	14.21±1.88
F	15.228***	10.221***	4.652*	1.845	14.582***	0.421
η^2_p	0.014	0.009	0.004	0.002	0.013	0.000
Competitions between schools						
No	345.41±202.57	13.28±4.54	103.80±26.61	26.12±5.85	4.96±0.70	15.59±1.99
Yes	391.02±245.78	18.09±5.94	120.37±25.89	25.21±6.72	4.68±0.59	14.18±1.88
F	19.416***	0.003	4.719*	1.047	12.743***	0.265
η^2_p	0.017	0.000	0.001	0.001	0.011	0.000
Policies and practices						
None	347,80±204,61	12.51±4.47	100.45±27.92	26.33±5.73	4.90±0.75	15.85±3.58
Only practices	362,00±220,73	15.64±5.48	112.35±26.07	25.63±6.28	4.89±0.64	14.88±2.13
F	10.749***	36.561***	4.864*	0.272	32.958***	9.840**
η^2_p	0.010	0.032	0.004	0.000	0.029	0.009

Note: SD, standard deviation; m: meters; s: seconds; kgf: kilogram/force. ***p<0,001, **p<0,01, *p<0,05

Children from schools with larger playgrounds (over 50 m^2) demonstrated superior performance in the handgrip strength (mean difference = 17.47; 95% CI: 16.80 to 18.14; ES = 0.027) and standing long jump tests (mean difference = 110.39; 95% CI: 108.02 to 112.77; ES = 0.023) compared to those with intermediate playground spaces (30 m^2 to 49 m^2). Interestingly, students from schools with intermediate-sized playgrounds (30–49 m^2) demonstrated better performance in the 20-meter dash (mean difference = 4.80; 95% CI: 4.74–4.85; ES = 0.006) compared to those from schools with smaller playgrounds (<30 m^2) and larger playgrounds (>50 m^2).

Regarding infrastructure, children attending schools with courtyard pillars outperformed their peers in the 20-meter dash (mean difference = 4.78; 95% CI: 4.73 to 4.83; ES = 0.054). Furthermore, students enrolled in schools with courtyard pillars demonstrated superior performance in the 20-m shuttle run (mean difference = 362.27; 95% CI: 340.20 to 384.34; ES = 0.013) and handgrip tests (mean difference = 18.04; 95% CI: 17.24 to 18.84; ES = 0.030). Students from schools with courtyards devoid of ground irregularities showed better performance in the standing long jump (mean difference = 113.59; 95% CI: 111.88 to 115.29; ES = 0.005). Children attending schools without courtyard obstacles performed better only in the handgrip test (mean difference = 15.40; 95% CI: 15.08 to 15.75; ES = 0.019).

Students from schools with a court (open or multipurpose) in the courtyard excelled in the 20-m shuttle run (mean difference = 391.79; 95% CI: 361.92 to 421.67; ES = 0.013), handgrip (mean difference = 18.28; 95% CI: 17.59 to 18.97; ES = 0.009), and 20-meter dash (mean difference = 4.70; 95% CI: 4.63 to 4.77; ES = 0.008).

With respect to policies and practices for physical activity, children attending schools with only practices showed better performance in the 20-m shuttle run (mean difference= 362.00; 95% CI: 346.01 to 378.04; ES = 0.010), handgrip strength (mean difference = 15.64; 95% CI: 15.26 to 16.03 ; ES = 0.032), standing long jump (mean difference = 112.35; 95% CI: 110.35 to 114.35 ; ES = 0.004), 20-meter dash (mean difference = 4.89; 95% CI: 4.84 to 4.94 ; ES = 0.029), and 4x10-m shuttle run (mean difference = 14.88; 95% CI: 14.73 to 15.03; ES = 0.009).

Discussion

This study investigated how school environmental characteristics influence the components of PF in youth. The novelty lies in examining this relationship within a developing country context, focusing on children and adolescents from socially vulnerable backgrounds. The findings reveal a significant impact of school environment characteristics on PF components.

Children and adolescents from urban areas exhibited superior performance in handgrip and standing long jump tests compared to their rural counterparts, though these differences lacked significant effect sizes. Disparities in PF between urban and rural settings have been widely examined across various countries; however, the findings remain inconsistent (Chillón et al., 2011; Drenowatz et al., 2020; Howe et al., 2018; Rivera-Ochoa et al., 2020). For example, research conducted in Ecuador and Mexico reported higher cardiorespiratory fitness and muscular strength among urban children and adolescents (Howe et al., 2018; Rivera-Ochoa et al., 2020). Conversely, studies from Austria and Spain have associated urban environments with lower PF levels in the same demographic (Chillón et al., 2011; Drenowatz et al., 2020). These inconsistencies may reflect contextual differences in socioeconomic status, geographic setting, and cultural practices.

In socially vulnerable contexts, especially in developing countries, school environment characteristics pose particular challenges to the development of PF compared to developed nations. Schools in these regions often lack adequate infrastructure, such as suitable spaces for physical activities or well-maintained recreational areas, which are common in developed countries (Rivera-Ochoa et al., 2020; García-Hermoso et al., 2020). Socioeconomic inequalities exacerbate these limitations, as access to extracurricular sports programs or structured physical education is restricted, highlighting the important role of schools in compensating for these problems (Santos et al., 2018; Lema-Gómez et al., 2021).

Unlike the consistent funding and active policies promoting physical activity in developed countries, vulnerable communities often face external barriers, such as unsafe neighborhoods or limited access to community recreational spaces, which significantly limit opportunities for physical activity outside of school (Drenowatz et al., 2020; Jiang et al., 2023; Pereira et al., 2021). These conditions underscore the need for context-specific interventions that not only address structural deficits but also integrate strategies to overcome broader socioeconomic barriers that limit children's participation in physical activities. Recent research also emphasizes the importance of collaborative strategies among educators, policymakers, and community leaders to promote inclusive and sustainable opportunities for physical activity in disadvantaged regions (Cradock et al., 2017; García-Hermoso et al., 2020). Such initiatives may help bridge health disparities by fostering PF development and aligning outcomes with those in more advantaged settings.

Students who attended schools that offered PE classes and were equipped with multi-sport courts performed better in the 20-m shuttle run, handgrip, and standing long jump tests. In contrast, schools with irregular surfaces underperformed in the standing long jump. These findings suggest that the quality of PE classes and the availability of appropriate spaces for physical activities play an essential role in promoting health and PF in this population. These results align with previous studies (García-Hermoso et al., 2020; Santos et al., 2018) that reported similar results. A meta-analysis of 56 studies involving over 48,000 children and adolescents showed that both the frequency and quality of PE classes are associated with improvements in various PF components (García-Hermoso et al., 2020). Additionally, the availability of basic PE materials, such as balls and hoops, was linked to increased muscular strength in Portuguese children aged 5 to 10 years, although no significant associations were observed with other PF components (Santos et al., 2018).

In addition to PE classes and multi-sports court availability, the present results also showed that schools offering extracurricular sports, inter-school competitions, or even partial initiatives ("only practices") consistently demonstrated higher levels of PF on multiple tests. These data support previous evidence that structured programs supported by school policies may promote both habitual engagement in physical activities and the development of critical motor competencies (García-Hermoso et al., 2020; Santos et al., 2018). In low-resource contexts, coordinated strategies, ranging from modest practices to formal sports events, may compensate for otherwise limited recreational opportunities. Consequently, adopting school-wide policies that encourage a culture of regular, varied physical activity appears particularly beneficial for enhancing health and performance outcomes among children and adolescents in socially vulnerable conditions.

Recent studies highlight the relevance of physical literacy, particularly its cognitive domain, in low-income populations (Gonçalves et al., 2024). Although not assessed in the present study, evidence suggests that children with greater knowledge and understanding of cardiorespiratory and musculoskeletal fitness, and that knowledge how to incorporate it into their daily lives are the ability to apply them tend to be more physically fit (Gonçalves et al., 2024). Future studies should incorporate measures of physical literacy to better understand how individual and contextual variables interact in shaping PF among vulnerable populations.

An unexpected finding was que a presence of courtyard obstacles and improved handgrip and 20-m shuttle run performance. While prior studies have not explored this difference, it is plausible that such environmental features encourage physical challenges, such as climbing or navigating through confined spaces, which enhance musculoskeletal development (Yolcu et al., 2024). Future research should further investigate these variables to gain deeper insights into the potential benefits of courtyard obstacles on PF. Another noteworthy finding from this study is the significant differences in PF performance based on school playground size among children and adolescents. Students from schools with larger playgrounds (>50 m^2) outperformed those with smaller or intermediate areas in strength and power tests. However, students from intermediate-sized playgrounds performed better in the 20-m dash, a surprising result that may reflect differences in space usability or activity organization. Additionally, supervision levels during recess, the involvement of physical education teachers, and the availability of supplementary resources may also contribute to the observed differences in PF levels across groups.

Our findings highlight the need for targeted investment in the developing and adapting the school environment to support physical activities and sports both in and out of the school curriculum. While physical infrastructure exerts a modest impact on PF, pedagogical practices related to sports show moderate to high impacts, especially on musculoskeletal fitness tests. Nevertheless, investments should also focus on improving playground conditions, ensuring obstacle-free surfaces and adequate space, and installing multipurpose courts. These results underscore the importance of an integrated approach that combines structural improvements and pedagogical strategies to foster a supportive school environment conducive to PF development.

Despite its relevance, this study has limitations that should be acknowledged. Its cross-sectional design prevents the establishment of causal inferences, and the exclusive focus on school-level variables overlooks other influential factors, such as family dynamics and community environments. Future longitudinal studies should examine how individual, school, family, and neighborhood characteristics interact over time to shape PF trajectories in youth.

Nonetheless, it offers important contributions to the fields of physical education and school health promotion. With a large and diverse sample from multiple schools in socially vulnerable settings, the findings provide robust evidence on how specific school characteristics and pedagogical actions are associated with PF outcomes. Furthermore, this study is pioneering in examining the influence of school environment characteristics on the PF of children and adolescents in socially vulnerable situations. This approach not only helps fill a gap in scientific literature, particularly in socially vulnerable populations, but also offers relevant indicators for monitoring and elaborate public policy aimed at ensuring healthy PF levels and reducing contextual disparities for children and adolescents.

Conclusions

This study underscores the critical role of school environment characteristics about PF among children and adolescents from socially vulnerable contexts. Children attending schools with larger, obstacle-free playgrounds, multipurpose courts, and structured physical activity programs, including PE classes, extracurricular sports, and inter-school competitions, demonstrated superior performance in several PF tests. These findings highlight the urgent need for integrated investments in school infrastructure and programming as cost-effective, equity-oriented strategies to enhance PF and reduce health disparities. Policymakers, educators, and planners should prioritize school-based interventions, while future longitudinal research should explore how environmental and sociocultural factors interact to shape PF trajectories over time.

Acknowledgements

The authors thank all children and parents for their participation in the study, and to the schools who participated in this study. Also, we thank all the team members of the Healthy Life Project in Lagoa do Carro: a family-based study who contributed to the data collection.

Financing

This study was supported by the National Council for Scientific and Technological Development (CNPq) under grant 303621/2023-0 and the Foundation for Science and Technology Development of the State of Pernambuco (FACEPE) under grant APQ-1762-4.09/22 and APQ-0742-4.09/22.

References

Akseer, N., Mehta, S., Wigle, J., Chera, R., Brickman, Z. J., Al-Gash, S., Sorichetti, B., Vandermorris, A., Hipgrave, D. B., Schwalbe, N., & Bhutta, Z. A. (2020). Non-communicable diseases among adolescents: current status, determinants, interventions and policies. BMC Public Health, 20(1). https://doi.org/10.1186/s12889-020-09988-5

Andrade, S., Lachat, C., Ochoa-Aviles, A., Verstraeten, R., Huybregts, L., Roberfroid, D., Andrade, D., Camp, J. Van, Rojas, R., Donoso, S., Cardon, G., & Kolsteren, P. (2014). A school-based intervention improves physical fitness in Ecuadorian adolescents: A cluster-randomized controlled trial. International Journal of Behavioral Nutrition and Physical Activity, 11(1). https://doi.org/10.1186/s12966-014-0153-5

Barnett, L. M., Lai, S. K., Veldman, S. L. C., Hardy, L. L., Cliff, D. P., Morgan, P. J., Zask, A., Lubans, D. R., Shultz, S. P., Ridgers, N. D., Rush, E., Brown, H. L., & Okely, A. D. (2016). Correlates of Gross Motor Competence in Children and Adolescents: A Systematic Review and Meta-Analysis. Sports Medicine, 46(11), 1663–1688. Springer International Publishing. https://doi.org/10.1007/s40279-016-0495-z

Burton, A. M., Cowburn, I., Thompson, F., Eisenmann, J. C., Nicholson, B., & Till, K. (2023). Associations between motor competence and physical activity, physical fitness and psychosocial characteristics in adolescents: A systematic review and meta-analysis. Sports Medicine, 53(11), 2191–2256. https://doi.org/10.1007/s40279-023-01886-1

Castillo, E. R., Sang, M. K., Sigei, T. K., Dingwall, H. L., Okutoyi, P., Ojiambo, R., Otárola-Castillo, E. R., Pitsiladis, Y., & Lieberman, D. E. (2016). Physical fitness differences between rural and urban children from western Kenya. American journal of human biology: the official journal of the Human Biology Council, 28(4), 514–523. https://doi.org/10.1002/ajhb.22822

Cohen, J. (1988). Statistical power analysis for the behavioral sciences (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates.

Chillón, P., Ortega, F. B., Ferrando, J. A., & Casajus, J. A. (2011). Physical fitness in rural and urban children and adolescents from Spain. Journal of Science and Medicine in Sport, 14(5), 417–423. https://doi.org/10.1016/j.jsams.2011.04.004

Cradock, A. L., Melly, S. J., Allen, J. G., Morris, J. S., & Gortmaker, S. L. (2007). Characteristics of school campuses and physical activity among youth. American Journal of Preventive Medicine, 33(2). https://doi.org/10.1016/j.amepre.2007.04.009

Drenowatz, C., Hinterkörner, F., & Greier, K. (2020). Physical fitness in upper Austrian children living in urban and rural areas: A cross-sectional analysis with more than 18,000 children. International Journal of Environmental Research and Public Health, 17(3). https://doi.org/10.3390/ijerph17031045

García-Hermoso, A., Alonso-Martínez, A. M., Ramírez-Vélez, R., Pérez-Sousa, M. Á., Ramírez-Campillo, R., & Izquierdo, M. (2020). Association of physical education with improvement of health-related physical fitness outcomes and fundamental motor skills among youths: A systematic review and meta-analysis. JAMA Pediatrics, 174(6). American Medical Association. https://doi.org/10.1001/jamapediatrics.2020.0223

Gomes Gonçalves, J., Luz, L., Bandeira, P. F., dos Prazeres, T., Lima, V., Maia, D., … Henrique, R. (2024). Propiedades psicométricas del cuestionario de conocimiento y comprensión de la evaluación canadiense de alfabetización física-2 en niños brasileños de baja renta (Psychometric properties of the knowledge and understanding questionnaire of the canadian assessment of physical literacy-2 in low-income brazilian children). *Retos*, *58*, 291–298. https://doi.org/10.47197/retos.v58.106747

Henrique, R. S., Gomes, T. N., Tani, G., & Maia, J. A. R. (2018). Association between body mass index and individual characteristics and the school context: a multilevel study with Portuguese children. Jornal de Pediatria, 94(3), 313–319. https://doi.org/10.1016/j.jped.2017.06.017

Howe, C. A., Casapulla, S., Shubrook, J. H., Lopez, P., Grijalva, M., & Berryman, D. E. (2018). Regional variations in physical fitness and activity in healthy and overweight Ecuadorian adolescents. Children, 5(8). https://doi.org/10.3390/children5080104

Isensee, B., Suchert, V., Hansen, J., Weisser, B., & Hanewinkel, R. (2018). Effects of a school-based pedometer intervention in adolescents: 1-Year follow-up of a cluster-randomized controlled trial. The Journal of school health, 88(10), 717–724. https://doi.org/10.1111/josh.12676

Jiang, Q., Huang, X., & Cui, D. (2023). Rural–urban differences in physical fitness and overweight prevalence of children and adolescents from central south China. International Journal of Environmental Research and Public Health, 20(3). https://doi.org/10.3390/ijerph20032390

Katzmarzyk, P. T., Barreira, T. V., Broyles, S. T., Champagne, C. M., Chaput, J.-P., Fogelholm, M., Hu, G., Johnson, W. D., Kuriyan, R., Kurpad, A., Lambert, E. V., Maher, C., Maia, J., Matsudo, V., Olds, T., Onywera, V., Sarmiento, O. L., Standage, M., Tremblay, M. S., Tudor-Locke, C., Zhao, P., & Church, T. S. (2013). The international study of childhood obesity, lifestyle and the environment (ISCOLE): Design and methods. BMC Public Health, 13, 900. https://doi.org/10.1186/1471-2458-13-900

Lema-Gómez, L., Arango-Paternina, C. M., Eusse-López, C., Petro, J., Petro-Petro, J., López-Sánchez, M., Watts-Fernández, W., & Perea-Velásquez, F. (2021). Family aspects, physical fitness, and physical activity associated with mental-health indicators in adolescents. BMC Public Health, 21(1). https://doi.org/10.1186/s12889-021-12403-2

Lo, K. Y., Wu, M. C., Tung, S. C., Hsieh, C. C., Yao, H. H., & Ho, C. C. (2017). Association of school environment and after-school physical activity with health-related physical fitness among junior high school students in Taiwan. International Journal of Environmental Research and Public Health, 14(1). https://doi.org/10.3390/ijerph14010083

Lohman, T.G., Roche, A.F. and Martorell, R. (1988) Anthropometric standardization reference manual. Human Kinetics Books, Chicago.

Lubans, D. R., Leahy, A. A., Mavilidi, M. F., & Valkenborghs, S. R. (2022). Physical activity, fitness, and executive functions in youth: Effects, moderators, and mechanisms. Current topics in behavioral neurosciences, 53, 103–130. https://doi.org/10.1007/7854_2021_271

Meredith, M. D., & Welk, G. J. (2010). Fitnessgram & activitygram test administration manual updated (4th ed.). The Cooper Institute for Aerobics Research.

Ortega, F. B., Ruiz, J. R., Castillo, M. J., & Sjöström, M. (2008). Physical fitness in childhood and adolescence: A powerful marker of health. International Journal of Obesity 32(1), 1–11. https://doi.org/10.1038/sj.ijo.0803774

Pate, R. R., American Alliance for Health, P. E., & Association for Research and Professional Councils and Societies. (1985). Norms for college students: health related physical fitness test. American Alliance for Health, Physical Education, Recreation and Dance.

Pereira, S., Bustamante, A., Santos, C., Hedeker, D., Tani, G., Garganta, R., Vasconcelos, O., Baxter-Jones, A., Katzmarzyk, P. T., & Maia, J. (2021). Biological and environmental influences on motor coordination in Peruvian children and adolescents. Scientific Reports, 11(1). https://doi.org/10.1038/s41598-021-95075-7

Pessôa dos Prazeres, T. M., dos Santos Henrique, R., Gomes de Oliveira Luz, L., Gominho Antunes Correia Junior, M., do Nascimento Sena Oliveira, M., Dantas Ribeiro, M., … Moura-dos-Santos, M. A. (2025). Semejanza entre hermanos en la aptitud física relacionada con la salud y el rendimiento entre los jóvenes brasileños . *Retos*, *66*, 491–504. https://doi.org/10.47197/retos.v66.110390

Rivera-Ochoa, M., Brazo-Sayavera, J., Vizmanos-Lamotte, B., Mañas, A., Ricardo López-Taylor, J., Gonzalez-Gross, M., & Guadalupe-Grau, A. (2020). Health-related factors in Rural and Urban Mexican adolescents: The HELENA-MEX Study. International Journal of Environmental Research and Public Health, 17(23), 8959. https://doi.org/10.3390/ijerph17238959

Santana, C. C. A., Azevedo, L. B., Cattuzzo, M. T., Hill, J. O., Andrade, L. P., & Prado, W. L. (2017). Physical fitness and academic performance in youth: A systematic review. Scandinavian Journal of Medicine and Science in Sports, 27(6), 579–603. https://doi.org/10.1111/sms.12773

Santos, C., Carolina Reyes, A., Moura-Dos-Santos, M. A., Pereira, S., Natacha Gomes, T., Tani, G., Vasconcelos, O., Chaves, R. N., Garganta, R., Barreira, T. V., Katzmarzyk, P. T., & Maia, J. (2018a). A multilevel analysis of individual- and school-level correlates of physical fitness in children. Annals of Human Biology, 45(6–8), 470–477. https://doi.org/10.1080/03014460.2018.1549684

Stoner, L., Pontzer, H., Barone Gibbs, B., Moore, J. B., Castro, N., Skidmore, P., Lark, S., Williams, M. A., Hamlin, M. J., & Faulkner, J. (2020). Fitness and fatness are both associated with cardiometabolic risk in preadolescents. Journal of Pediatrics, 217, 39-45. https://doi.org/10.1016/j.jpeds.2019.09.076

Story, M., Kaphingst, K. M., & French, S. (2006). The role of schools in obesity prevention. Source: The Future of Children, 16(1). http://www.jstor.orgURL:http://www.jstor.org/stable/3556553

Van Sluijs, E. M. F., McMinn, A. M., & Griffin, S. J. (2008). Effectiveness of interventions to promote physical activity in children and adolescents: Systematic review of controlled trials. British Journal of Sports Medicine, 42(8), 653–657. https://doi.org/10.1136/bmj.39320.843947

Yolcu, O., Hürmeriç Altunsöz, I., İnce, M. L., & Kriellaars, D. J. (2024). Use of parkour in primary school physical education to develop motor creativity, divergent thinking, movement competence, and perceived motor competence. Physical Education and Sport Pedagogy, 1-14. https://doi.org/10.1080/17408989.2024.2400094

Authors' and translators' details:

Douglas Eduardo Ferreira Maia	douglas.maia@ufpe.br	Author
Rostand de Souza Lira Filho	rostand.lirafilho@ufpe.br	Author
Tércio Araújo do Rêgo Barros	tercio.araujo@ufpe.br	Author
Igor Rodrigues de Souza Sobral	igor.sobral@ufpe.br	Author
Ana Beatriz Felix Lourenço	beatriz.felixl@ufpe.br	Author
Nayara Souza de Oliveira	nayara.soliveira@ufpe.br	Author
Paulo Felipe Ribeiro Bandeira	paulo.bandeira@urca.br	Author
Marcos André Moura dos Santos	mmoura23@gmail.com	Author
Thaliane Mayara Pessôa dos Prazeres	thalianemayara@hotmail.com	Author
Rafael dos Santos Henrique	rafael.shenrique@ufpe.br	Author & Translator