



Association of different physical activity indicators with social isolation measures in adolescents: a cross-sectional study

Associação de diferentes indicadores de atividade física com medidas de isolamento social em adolescentes: um estudo transversal

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ABSTRACT

Introduction: Social isolation (SI) is recognized as a detrimental factor to mental health, however, evidence on the relationship between physical activity (PA) and SI among adolescents remains scarce. **Objective:** To analyze the association between PA indicators and measures of SI in adolescents. **Methods:** This was a cross-sectional study conducted in 2022 with adolescents from public high schools in Pernambuco, Brazil. Data were collected using the adapted version of the Global School-based Student Health Survey. The dependent variables were feelings of loneliness and having few friends. The independent variables were total PA level, sports participation, leisure-time physical activity (LTPA), and participation in Physical Education (PE) classes. Binary logistic regression was used for the statistical analysis (OR; 95% CI). **Results:** A total of 4,514 adolescents participated in the study, of whom 28.7% reported feeling lonely and 20.2% reported having few friends. Positive associations were observed between PA indicators and SI. Insufficient PA levels (loneliness: OR = 1.50 [95% CI: 1.32 – 1.72]; few friends: OR = 1.26 [95% CI: 1.07 – 1.50]); absence of sports participation (loneliness: OR = 2.05 [95% CI: 1.71 – 2.45]; few friends: OR = 1.52 [95% CI: 1.21 – 1.91]); absence of LTPA (loneliness: OR = 1.45 [95% CI: 1.25 – 1.69]; few friends: OR = 1.39 [95% CI: 1.17 – 1.64]); and non-participation in PE classes (loneliness: OR = 1.59 [95% CI: 1.35 – 1.86]; few friends: OR = 1.32 [95% CI: 1.17 – 1.61]) were associated with SI, with differences according to sex. **Conclusion:** Insufficient PA levels, not participating in sports, not participating in PE classes, and not engaging in LTPA increased the odds of SI among adolescents.

Keywords: Adolescent; Physical activity; Social isolation; Sports activities.

RESUMO

Introdução: O isolamento social (IS) emerge como fator prejudicial à saúde mental, sendo escassas evidências da relação entre atividade física (AF) e IS entre adolescentes. **Objetivo:** Analisar a associação de indicadores de AF com medidas de IS em adolescentes. **Métodos:** Estudo transversal (2022) com adolescentes da rede pública do Ensino Médio de Pernambuco. Utilizou-se a versão adaptada do Global School-based Student Health Survey para obtenção dos dados. As variáveis dependentes foram sentimento de solidão e ter poucos amigos. As independentes foram nível de AF total, prática esportiva, Atividade física no lazer (AFL) e participação nas aulas de Educação Física (EF). Para a análise estatística, utilizou-se a regressão logística binária (OR; IC 95%). **Resultados:** Participaram 4.514 adolescentes, dos quais 28,7% relataram sentir-se sozinhos e 20,2% ter poucos amigos. Observaram-se associações positivas dos indicadores de AF com o IS. Nível insuficiente de AF (solidão: OR = 1,50 [IC95%: 1,32 – 1,72]; poucos amigos: OR = 1,26 [IC 95%: 1,07 – 1,50]); ausência de prática esportiva (solidão: OR = 2,05 [IC95%: 1,71 – 2,45]; poucos amigos: OR = 1,52 [IC95%: 1,21 – 1,91]); ausência de AFL (solidão: OR = 1,45 [IC95%: 1,25 – 1,69]; poucos amigos: OR = 1,39 [IC 95%: 1,17 – 1,64]); não participar de EF (solidão: OR = 1,59 [IC 95%: 1,35 – 1,86]; poucos amigos: OR = 1,32 [IC 95%: 1,17 – 1,61]), diferindo por sexo. **Conclusão:** Nível de AF insuficiente, não praticar esportes, não participar de EF e não realizar AFL aumentaram as chances de IS em adolescentes.

Palavras-chave: Adolescente; Atividades esportivas; Atividade física; Isolamento social.

Introduction

Social isolation is a significant problem at various stages of life, such as in old age or adolescence¹, and has been associated with various aspects of health², such

as depression, anxiety, sleep disorders^{3,4}, and obesity⁵. Among adolescents from low- and middle-income countries, the prevalence of feelings of loneliness is 12%⁶, while in Brazil it reaches 15.5%, being higher

among girls (20.5%) than boys (10.6%)⁷. In Pernambuco, a study conducted in 2006 identified that 19.5% of adolescents reported having few friends, with this percentage being higher among girls than boys⁸.

Sociodemographic factors, such as the female sex and lower maternal education, are associated with a higher prevalence of feelings of loneliness among adolescents⁷. Furthermore, behavioral and school-related aspects, such as the level of physical activity, participation in Physical Education classes, and engaging in active leisure activities, appear to play a protective role, mitigating feelings of loneliness and the likelihood of having few friends^{9,10-12}. Studies have indicated that participating in sports promotes social skills and a sense of belonging¹³ and that physical activity during leisure time is associated with well-being¹⁴. Regarding physical education classes, a recent systematic review identified associations with better mental health¹⁵. However, the literature presents inconsistent results^{8,16,17}, which may be related to different evaluation methods, cultural contexts, geographical areas, or the age groups analyzed.

Despite the importance of the topic, there is still little evidence on the relationship between different indicators of physical activity and social isolation measures in Brazilian adolescents. There is a need to better understand these relationships in order to support public policies and actions that prioritize physical activity indicators, which are strongly linked to psychosocial well-being in adolescence.

Given this gap in the existing knowledge, the present study aims to analyze the association between different indicators of physical activity and measures of social isolation in adolescents.

Method

This is a cross-sectional, school-based, state-representative epidemiological study, conducted using data from the 2022 survey of the project “Exposure to alcoholic beverages, tobacco and other drugs and screening for common mental disorders in adolescents in the state of Pernambuco: an epidemiological study to support a proposal for ‘school - RAPS’ integration (Attitude Project). The project was approved by the Research Ethics Committee of the Hematology and Hemotherapy Foundation of Pernambuco, under opinion number 4,449,705.

The target population of the study consisted of adolescents aged 14 to 19, of both sexes, enrolled in schools

in the Pernambuco state public school system. All schools distributed across the 16 Regional Education Offices of the state were eligible, taking into account the differences in the number of students enrolled in each institution. For participant selection, two-stage cluster sampling (school and classes) was used. All adolescents from the 84 selected schools were invited to participate voluntarily, and data collection began only after the adolescents themselves had signed the Informed Assent Form and their guardians had signed the Informed Consent Form, when applicable.

An adapted version of the School-Based Student Health Survey was applied. This instrument was developed by the World Health Organization with contributions from other institutions. The instrument presents face and content validity, with reliability tested by test-retest reproducibility (κ ranging from 0.77 to 1.00). Test-retest values were obtained through a pilot study conducted prior to data collection. The dependent variables in the study were assessed using the following questions from the instrument: “During the last 12 months, how often have you felt lonely?” and “How many close friends (people you can count on if you need them) do you have?”. The response options were, respectively: never, rarely, sometimes, most of the time, and always (feeling lonely); and 0, 1, 2, or 3 or more friends (close friends). Feeling lonely was considered present in adolescents who reported feeling lonely most of the time or always. Adolescents who reported having none or only one close friend were classified as having few friends.

The independent variables analyzed were: level of physical activity, participation in Physical Education classes, sports practice, and physical activity during leisure time. The level of physical activity was obtained based on three questions from the instrument, which asked about the number of days per week the adolescent practiced physical activity, the daily time dedicated to this practice in hours, and additionally in minutes. To calculate the level of physical activity, the number of days per week (0-7 days) was multiplied by the daily minutes dedicated to physical activity, classifying participants, based on the result, as having a sufficient level of physical activity (≥ 300 min/week) or an insufficient level (<300 min/week). Although current recommendations suggest at least 60 minutes of physical activity per day, a cut-off point of 300 minutes per week was chosen to consider possible changes in routine on weekends, aiming to represent a scenario more com-

patible with the classification of physical activity levels in school-age children. Participation in Physical Education classes was assessed through a question with the answer options 0, 1, 2, 3 or more classes per week, subsequently categorized into ≥ 1 class/week and 0 classes/week. Sports participation was assessed through a question with the following response options: practices during Physical Education classes, during school recess, in training offered by the school outside of Physical Education classes, outside of school, or does not practice, subsequently categorized as practicing or not practicing. Physical activity during leisure time, in turn, was assessed through a question with “yes” or “no” answer options, and was also categorized as practicing or not practicing.

The potential confounding factors were: age group (14 to 16/17 to 19 years), area of residence (urban/rural), race/color (white and yellow/black and brown/indigenous), living with at least one parent (yes/no), working (yes/no), maternal education ($<8/\geq 8$ years of schooling), and religious practice (yes/no).

Sample XS software, provided by the World Health Organization, was used to calculate the minimum sample size. For the sample size calculation of the Attitude Project, the following parameters were considered: target population of 258,540; estimated prevalence of 50% (option adopted due to the multiple factors analyzed in the Attitude Project¹³); a sample design effect of 2.0, as recommended in the literature¹⁸, maximum tolerable error of 2 percentage points, and confidence interval of 95%. Based on these parameters, a minimum sample size of 4,758 participants was obtained. To compensate for potential losses, 20% was added. Considering the calculated sample size, the measures of association have sufficient power to detect OR values of 1.35 as significant, considering a confidence level of 95% and a statistical power of 80%.

Data tabulation was performed using SPHYNX® (Sphynx Brazil) and analysis was conducted using IBM SPSS Statistics for Windows (version 26). Descriptive analyses (absolute/relative frequencies) were performed. The chi-square test was used to compare the prevalence of social isolation measures among the categories of independent variables. To assess the association between the variables, binary logistic regressions were employed, with the magnitude of the association expressed as odds ratios (OR) and the respective 95% confidence interval (95% CI). In the adjusted analyses, the hierarchical method was used to include con-

founding variables in the model, adopting $p > 0.20$ as the criterion for excluding variables during modeling. Biological sex was considered a moderating factor in the association analyses. The direction and magnitude of the associations were classified based on Oleckno¹⁹, who classifies associations estimated by OR as weak (1.1-1.5), moderate (1.6-3.0), and strong (≥ 3.1).

Results

Data were collected from 4,569 adolescents. For the present study, 55 students who did not fall within the 14-19 age range were excluded, resulting in a final sample of 4,514 participants. The adolescents had an average age of 16 years (± 1.18), with a predominance of the female sex (54.6%). Table 1 presents the socio-demographic characteristics of the sample.

Of the adolescents evaluated, 28.7% reported feeling lonely most of the time or always, with this prevalence being statistically higher ($p < 0.001$) among girls (36.4%) compared to boys (19.4%). The proportion of adolescents who reported having few friends was 20.2%, being significantly higher ($p = 0.024$) among girls (21.4%) compared to boys (18.7%).

In addition, 52.3% of the sample presented an insufficient level of physical activity. The prevalence of non-participation in any Physical Education class was 17.8%, while 12.7% reported not practicing sport. Regarding leisure-time physical activity, 32.3% of adolescents reported not practicing. These proportions were statistically higher among girls compared to boys in all independent variables analyzed ($p < 0.001$).

Table 2 presents the prevalence of feelings of loneliness by category of independent variables. Adolescents who reported feeling lonely most of the time or always showed a higher proportion of insufficient physical activity, not participating in Physical Education classes, not playing sports, and not engaging in leisure-time physical activity. After stratification by sex, the patterns remain, except for the level of physical activity and leisure activity in girls ($p = 0.125$ and $p = 0.081$, respectively).

Table 3 shows the prevalence of having few friends by category of independent variables. It can be observed that adolescents who reported having few friends had a higher proportion of insufficient levels of physical activity ($p = 0.001$). Additionally, these adolescents also demonstrate a higher prevalence of non-participation in Physical Education classes ($p < 0.001$). Similar results were found for the variables of sports practice

Table 1 – Distribution of sociodemographic characteristics of high school students in the public school system of Pernambuco, 2022.

Variables	All (n = 4,514)		Male (n = 2,050)		Female (n = 2,464)		p
	n	%	n	%	n	%	
Age range							
14 to 16 years	2,294	50.8	980	47.8	1,314	53.3	<0.001
17 to 19 years	2,220	49.2	1,070	52.2	1,150	46.7	
Maternal education							
≥ 8 years	2,647	71.1	1,237	73.7	1,410	68.9	0.001
< 8 years	1,077	28.9	441	26.3	636	31.1	
Race/color							
White and Yellow	1,261	27.9	556	27.1	705	28.6	0.233
Black and Brown	3,129	69.3	1,430	69.8	1,699	69.0	
Indigenous	124	2.7	64	3.1	60	2.4	
Working							
Yes	435	9.6	313	15.3	122	5.0	<0.001
No	4,079	90.4	1,737	84.7	2,342	95.0	
Residential zone							
Urban	3,432	76.0	1,582	77.2	1,850	75.1	0.102
Rural	1,082	24	468	22.8	614	24.9	
Religious practice							
Yes	2,599	57.6	1,117	54.5	1,482	60.1	<0.001
No	1,915	42.4	933	45.5	982	39.9	
Lives with parents							
Yes	4,120	91.3	1,888	92.1	2,232	90.6	0.005
No	394	8.7	162	7.9	232	9.4	

Table 2 – Proportion of adolescents who report feeling lonely most of the time or always, according to the independent variables.

Variable	All (n = 1,295)			Male (n = 397)			Female (n = 898)		
	n	%	p	n	%	p	n	%	p
Level of physical activity									
≥ 300 min/wk	522	24.2	<0.001	225	17.4	0.001	299	34.3	0.125
< 300 min/wk	773	32.8		172	22.8		606	37.4	
Participation in Physical Education classes									
≥ 1 class/wk	996	26.8	<0.001	336	18.3	<0.001	668	34.9	0.007
0 classes/wk	299	37.2		66	27.8		237	41.0	
Sports practice									
Yes	1,046	26.5	<0.001	353	18.2	<0.001	704	34.4	<0.001
No	249	43.4		49	36.0		201	45.2	
Physical activity in leisure time									
Yes	787	25.7	<0.001	281	17.2	<0.001	509	34.9	0.081
No	508	34.9		121	27.2		396	38.3	

and leisure-time physical activity. After stratification by sex, among girls, this similarity remained only for sports practice ($p = 0.015$), while among boys the pattern observed in the total sample was maintained.

Tables 4 and 5 present the OR values for the crude and adjusted analyses, as well as their respective 95%CI. There were positive associations with weak to moderate magnitude of physical activity level, participation in physical education classes, sports practice,

and leisure-time physical activity with both feelings of loneliness and having few friends.

Adolescents with insufficient levels of physical activity were 50% more likely to report feelings of loneliness and 26% more likely to report having few friends, compared to adolescents with sufficient levels of physical activity, while among boys these chances were 41% and 73%, respectively.

Not participating in sports was associated with a

Table 3 – Proportion of adolescents who report having no or only one friend, according to the independent variables.

Variable	All (n = 910)			Male (n = 383)			Female (n = 527)		
	n	%	p	n	%	p	n	%	p
Level of physical activity									
≥ 300 min/wk	389	18.1	0.001	206	15.9	<0.001	183	21.3	0,958
< 300 min/wk	521	22.1		177	23.5		344	21.7	
Participation in Physical Education classes									
≥ 1 class/wk	709	19.1	<0.001	316	17.4	<0.001	393	20.7	0.152
0 classes/wk	201	25.0		67	28.6		134	23.6	
Sports practice									
Yes	755	19.2	<0.001	340	17.7	<0.001	415	20.5	0.022
No	155	27.0		43	32.1		112	25.5	
Physical activity in leisure time									
Yes	556	18.2	<0.001	268	16.6	<0.001	288	20.0	0.044
No	354	24.3		115	26.5		239	23.4	

Table 4 – Odds Ratio (OR) values and confidence intervals (95% CI) for associations of independent variables with feelings of loneliness.

Variable	All (n = 4,514)				Male (n = 2,050)				Female (n = 2,464)			
	Crude OR (95% CI)	p	Adjusted OR (95% CI)	p	Crude OR (95% CI)	p	Adjusted OR (95% CI)	p	Crude OR (95% CI)	p	Adjusted OR (95% CI)	p
PAL (min/wk)												
≥300	1		1		1		1		1		1	
<300	1.52 (1.34 - 1.74)	<0.001	1.50 (1.32 - 1.72)	<0.001 ^a	1.45 (1.16 - 1.80)	0.001	1.43 (1.15 - 1.80)	0.002 ^c	1.14 (0.96 - 1.36)	0.125	1.10 (0.92 - 1.31)	0.284 ^e
PPE												
≥1 class/wk	1		1		1		1		1		1	
0 classes/wk	1.62 (1.38 - 1.90)	<0.001	1.59 (1.35 - 1.86)	<0.001 ^a	1.73 (1.27 - 2.35)	0.001	1.64 (1.20 - 2.23)	0.002 ^d	1.30 (1.07 - 1.57)	0.007	1.27 (1.05 - 1.55)	0.015 ^e
SP												
Yes	1		1		1		1		1		1	
No	2.12 (1.77 - 2.54)	<0.001	2.05 (1.71 - 2.45)	<0.001 ^a	2.53 (1.75 - 3.66)	<0.001	2.35 (1.62 - 3.41)	<0.001 ^d	1.57 (1.28 - 1.94)	<0.001	1.53 (1.24 - 1.90)	<0.001 ^a
LTPA												
Yes	1		1		1		1		1		1	
No	1.54 (1.35 - 1.77)	<0.001	1.45 (1.25 - 1.69)	<0.001 ^b	1.79 (1.40 - 2.29)	<0.001	1.73 (1.35 - 2.21)	<0.001 ^c	1.16 (0.98 - 1.37)	0.081	1.11 (0.94 - 1.31)	0.234 ^e

PAL = Level of physical activity; PPE = Participation in Physical Education classes; SP = Sports practice; LTPA = Leisure-time physical activity. ^a Adjusted binary logistic regression for age group, living with parents, and religious practice. ^b Adjusted binary logistic regression for age group, living with parents, working, maternal education, and religious practice. ^c Adjusted binary logistic regression for living with parents and religious practice. ^d Adjusted binary logistic regression for race/color, living with parents, and religious practice. ^e Adjusted binary logistic regression for age group, living with parents, working, and religious practice.

higher likelihood of reporting feelings of loneliness and having few friends, especially in the male sex. Among boys, those who do not participate in sports were 134% more likely to report feeling lonely and 114% more likely to report having few friends; among girls, the likelihood of reporting feelings of loneliness was lower (for example, 54%). It was also observed that

not participating in Physical Education classes and not engaging in physical activity during leisure time showed stronger associations among boys. Boys who do not participate in any Physical Education classes are 66% more likely to feel lonely and 68% more likely to report having few friends.

Table 5 – Odds Ratio (OR) values and confidence intervals (95% CI) for associations of independent variables with having few friends.

Variable	All (n = 4.514)				Male (n = 2.050)				Female (n = 2.464)			
	Crude OR (95% CI)	P	Adjusted OR (95% CI)	P	Crude OR (95% CI)	P	Adjusted OR (95% CI)	P	Crude OR (95% CI)	P	Adjusted OR (95% CI)	P
PAL (min/wk)												
≥300	1		1		1		1		1		1	
<300	1.29 (1.11 - 1.49)	0.001	1.26 (1.07 - 1.49)	0.005 ^a	1.60 (1.28 - 2.00)	<0.001	1.73 (1.34 - 2.22)	<0.001 ^b	1.00 (0.82 - 1.22)	0.966	0.93 (0.74 - 1.16)	0.526 ^c
PPE												
≥1 class/ wk	1		1		1		1		1		1	
0 classes/ wk	1.41 (1.28 - 1.70)	<0.001	1.32 (1.07 - 1.62)	0.008 ^a	1.86 (1.37 - 2.53)	<0.001	1.68 (1.18 - 2.40)	0.004 ^b	1.20 (0.97 - 1.50)	0.099	1.14 (0.89 - 1.46)	0.311 ^c
SP												
Yes	1		1		1		1		1		1	
No	1.56 (1.28 - 1.91)	<0.001	1.52 (1.21 - 1.91)	<0.001 ^a	2.14 (1.46 - 3.13)	<0.001	2.14 (1.38 - 3.31)	0.001 ^b	1.34 (1.06 - 1.70)	0.015	1.30 (0.99 - 1.70)	0.061 ^c
LTPA												
Yes	1		1		1		1		1		1	
No	1.44 (1.24 - 1.68)	<0.001	1.39 (1.17 - 1.64)	<0.001 ^a	1.76 (1.37 - 2.26)	<0.001	1.73 (1.31 - 2.29)	<0.001 ^b	1.20 (0.99 - 1.46)	0.059	1.14 (0.92 - 1.42)	0.224 ^c

PAL = Level of physical activity; PPE = Participation in Physical Education classes; SP = Sports practice; LTPA = Leisure-time physical activity. ^a Adjusted binary logistic regression for living with parents, maternal education, and religious practice. ^b Adjusted binary logistic regression for maternal education and religious practice. ^c Adjusted binary logistic regression for living with parents, working, maternal education, and religious practice.

Discussion

The current study analyzed the association between different indicators of physical activity and measures of social isolation in adolescents. The main findings highlight that when analyzed in the total sample, the four indicators analyzed (level of physical activity, involvement in Physical Education classes, sports practice, and leisure-time physical activity) were associated with feelings of loneliness and having few friends among adolescents. These associations were more consistent among boys, revealing the moderating role of biological sex.

The results of this study identified that insufficient levels of physical activity, and a lack of participation in sports and leisure-time physical activity, increase the likelihood of feelings of loneliness among adolescents. These findings corroborate the results of Khan et al.⁶ and Pinto et al.⁹. However, a Brazilian study did not identify a statistically significant association between the level of physical activity and feelings of loneliness or having few friends, which differs from the results of the current study⁸. The increased feeling of loneliness among adolescents and different indicators of physical activity may reflect lower participation in structured social contexts, where the practice of physical activi-

ties, especially group activities, fosters the building of bonds, a sense of belonging, and the development of psychosocial skills²⁰.

In this study, it was found that not participating in sports increases the likelihood of feeling lonely and having few friends among teenagers, corroborating previous studies^{21,22}, which analyzed the association between sports practice and feelings of loneliness. These results can be explained by the fact that organized activities, such as sports, improve social interactions through the perception of social competence²⁰. When stratified by sex, these results held true for feelings of loneliness in both sexes; however, they did not show statistical significance for girls in relation to having few friends. These findings may reflect sex differences in socialization processes, since sport tends to play a more central role in building social relationships among boys, while girls often establish bonds in more conversational and affective contexts²³. Furthermore, personal and contextual barriers can limit the participation of girls in sports, reducing its socializing potential²³.

It has been observed that not engaging in physical activity during leisure time increases the likelihood of exhibiting indicators of social isolation. It has already

been pointed out that physical activity during leisure time is associated with social indicators, and a possible explanation for this is that physical activity is related to autonomous motivation²⁴, which could lead to greater satisfaction and engagement. However, no statistically significant association was observed for girls, which differs from the findings of Dos Santos et al.¹⁰ and Werneck et al.¹⁶, who identified these associations with feelings of loneliness and having few friends for both girls and boys. These results can be explained by the choice of individual physical activities, commonly adopted by girls, which do not necessarily promote social interaction.

The current study also identified that non-participation in Physical Education classes is associated with a higher likelihood of feeling lonely and having few friends, corroborating the findings of other studies^{9,10,12}. However, a different result was reported by Santos et al.⁸, who did not identify a statistically significant association between these variables. The authors highlight that the association between participation in Physical Education classes, feelings of loneliness, and having few friends can be explained by the opportunities provided in the classes, such as social interaction.

In the analysis stratified by sex, it was identified that there is an increased likelihood of feeling lonely and having few friends only among boys with insufficient levels of physical activity. This differs from the results of other studies, which maintain the pattern of an association between the level of physical activity and feelings of loneliness in both boys and girls^{6,8,9,17}. The more frequent habit among boys of getting together to engage in group physical activities, such as soccer games, compared to girls, may be considered an explanation for the study findings.

Previous studies also show a higher prevalence of feelings of loneliness among girls compared to boys^{16,10,25}. The current research identified a higher prevalence of feelings of loneliness than observed in other national^{7,10,16} and international studies^{26,27}. The differences observed in the percentages between girls and boys may be linked to the greater ease of girls in expressing their emotions²⁸.

Regarding the report of having few friends, the prevalence identified in this study is similar to that observed in another Brazilian study⁸. However, it differs from the findings of Werneck et al.¹⁶ and dos Santos et al.¹⁰, who did not identify a significant difference between boys and girls or identified that boys had fewer friends. In the current study, on the contrary, it was

found that girls had fewer friends than boys. During adolescence, especially in high school, girls tend to value the psychological resources of friendships, such as trust and emotional support, more than boys, who attribute greater importance to aspects related to leisure and recreation²⁰. These differences in valuation criteria can influence how adolescents perceive their friendships.

One possible explanation for these more evident findings in the associations between independent and dependent variables in boys could be the differences in the formation and maintenance of friendships between boys and girls. Physical activity practices can serve as a central social environment for boys, strengthening belonging and bonds with peers²⁹. Young women tend to value emotional support and intimacy more, while young men consider recreational moments and activities performed together to be more important³⁰. Therefore, by not sharing this environment of physical activity, male adolescents may experience greater perceptions of loneliness and have fewer friends.

The current study presents some limitations that should be considered when interpreting the results. Among them, the use of self-reported measures to obtain the information stands out, which may lead to underestimation or overestimation of the responses. Furthermore, since this is a cross-sectional study, the possibility of reverse causality cannot be ruled out. The use of a 2022 database is also acknowledged as a limitation, since the social context surrounding adolescents can undergo rapid transformations over time, and the minimum estimated sample size was not obtained. However, it should be noted that, at the time of analysis, this was the most recent and comprehensive dataset available, which allowed for capturing the reality of the post-COVID-19 pandemic period.

Despite these limitations, the study presents important strengths, such as the use of a large and representative sample of adolescents from the public high school system in a Brazilian state. Also noteworthy is the inclusion of different indicators of physical activity, associated with two indicators of social isolation, providing a comprehensive analysis of the topic.

Based on the findings of this study, it is suggested that interventions to promote physical activity should consider the differences observed between boys and girls. It is necessary to expand opportunities for girls to participate in physical activity by diversifying the types of activities and reducing sociocultural barriers that limit their engagement. For young men, the qual-

ification of structured collective contexts can strengthen support networks and a sense of belonging. Future research should investigate the mediating mechanisms of these associations, as well as use longitudinal designs and qualitative approaches to deepen understanding of social experiences associated with different domains and types of physical activity.

This study demonstrated that insufficient levels of physical activity, non-participation in sports and leisure-time physical activity, and non-participation in physical education classes are significantly associated with indicators of social isolation in adolescents. These findings highlight the protective role of physical activity for psychosocial well-being, especially sports for boys, and point to the need for approaches that address sex differences, in order to encourage physical activity and its contribution to sociability among adolescents.

These findings have crucial implications for society, reinforcing the urgency of public policies and educational initiatives that promote access to and engagement in physical activity as an essential tool in combating social isolation.

Conflict of interest

The authors declare no conflict of interest.

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Author contributions

Silva TM: Conceptualization; Methodology; Software development, implementation and testing; Data and experiment validation; Data analysis; Research; Project management; Data presentation design; Original manuscript writing; Writing - revision and editing; Approval of the final manuscript version. Barros MVG: Conceptualization; Supervision; Writing - revision and editing; Approval of the final manuscript version. Lima AA and Cardoso DS: Data analysis; Research; Data presentation design; Original manuscript writing; Writing - revision and editing; Approval of the final manuscript version. Queiroz DR: Methodology; Software development, implementation and testing; Data and experiment validation; Data analysis; Research; Data curation; Supervision; Writing - revision and editing; Approval of the final manuscript version. Hardman CM: Conceptualization; Meth-

odology; Software Development, Implementation and Testing; Data and Experiment Validation; Data Analysis; Research; Data Curation; Supervision; Project Management; Data Presentation Design; Original Manuscript Writing; Writing - Review and Editing; Approval of the Final Manuscript Version.

Statement regarding the use of artificial intelligence tools in the article writing process

The authors did not use artificial intelligence tools to prepare the manuscript.

Availability of research data and other materials

After publication, the data will be available upon reasonable request to the authors.

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Reviewers' assessment

The reviews of this article were originally conducted in Portuguese. This version has been translated using ChatGPT and subsequently reviewed by the Chief Editors.

Reviewer A

Anonymous

- Was any indication of plagiarism observed in the manuscript?
No
- Did the authors provide clarification regarding the ethical procedures adopted to conduct the research?
Yes

Comments to the author

- On behalf of RBAFS, I would like to thank you for trusting us with your work.
- However, in order to improve clarity for readers regarding the importance of discussing this topic, I invite you to reconsider the structure and content of the discussion section. I feel there is a lack of “translation” of these findings, the possible reasons behind them, and their potential implications.

Comments in the text

Title

- Page 1, line 1: Based on the comments throughout the text, I suggest reconsidering the title of the manuscript.

Abstract

- Page 1, line 6: According to the journal guidelines, the abstract must be structured, including the following sections: introduction, objective, methods, results, and conclusion.
- Page 1, line 8: Clearly state the objective of the study.

Introduction

- Page 3, line 21: Based on the results presented, do you believe this objective should be adjusted?

Results

- Page 7, line 5: As written, it suggests that the data from both tables will be discussed simultaneously, but they are actually presented one at a time. I suggest revising the wording in this section. First present the data from Table 2, and then mention and present the data from Table 3.

Discussion

- Page 9, line 13: I encourage you to begin the dis-

cussion by restating the study objective along with a presentation of the main findings.

- I also invite you to reconsider the structure and content of the discussion, as noted below.
- Page 9, line 14: I question whether a prevalence of 28.7% can truly be considered high, or whether this classification is based on comparisons with previous studies.
- Page 9, line 16: Even though you clearly cite the article, I believe it should also be numbered.
- Page 9, line 25: Perhaps using different terms would better convey the message regarding the prevalences observed in this study.
- Page 11, line 25: The discussion reads largely as a restatement of results and comparison with findings from other studies. This creates a sense that something is missing—beyond comparison. There is a lack of “translation” of these findings, the possible reasons behind them, and their implications.
- For example, looking at the results overall, it seems possible to infer that less physically active youth tend to feel more socially isolated, particularly boys. Based on the literature, what factors might explain this?
- Page 12, line 1: Do you consider the use of a 2022 dataset to be a limitation of your study?
- Is it because the dataset is from 2022 that most of the studies cited in the discussion are over five years old?

Conclusion

- Page 12, line 14: Particularly regarding sports, for boys.
- Page 16, line 16: The Attitude Project has been ongoing for just over 15 years in the state of Pernambuco, generating undergraduate theses, dissertations, theses, and articles. Have the findings accumulated over these years been compiled and presented to relevant authorities so that evidence-based actions can be taken toward the development of a local public policy on this topic?
- Table 1: In all tables, report the sample size (n) for each sex.

Final decision

- Major revisions required.

Reviewer B

Did not authorize the publication of the review.
