



Physical activity and sedentary behavior of adolescents in public schools: a network analysis

Atividade física e comportamento sedentário de adolescentes da rede pública: uma análise de redes

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ABSTRACT

The School Health Program (SHP) and the National School Health Survey (PeNSE) deserve to be highlighted among actions to promote and monitor the health of Brazilian students. In this context, the promotion of physical activity in schools represents part of the School Health Program (SHP) actions, in addition to being monitored by the PeNSE. The present study verified the association between individual and socioeconomic characteristics, and actions to promote physical activity and health in school, including school adherence to the SHP, with the active and sedentary behaviors of Brazilian students enrolled in public schools, participants of the PeNSE – 2019. This is a study with secondary data, of 48,204 adolescents, aged between 13 and 18 years. The variables were collected using a questionnaire. The school's adherence to the SHP is one of the variables with the highest centrality in the network, with emphasis on its measure of strength (1.433); however, it was poorly connected to indicators of physical activity and sedentary behavior in young people. Network analysis showed that females participate less in physical activities in Physical Education classes (-0.176) and in free time (-0.283). In addition, having internet at home was the main variable associated with longer exposure time to sedentary behaviors (0.225). The results point to the importance of school adherence to the SHP and the need to develop effective actions to promote physical activity as a health promotion strategy within the scope of the SHP.

Keywords: Exercise; Motor activity; Health promotion; Lifestyle; School health services.

RESUMO

O Programa Saúde na Escola (PSE) e a Pesquisa Nacional de Saúde do Escolar (PeNSE) merecem destaque entre as ações de promoção e monitoramento da saúde de estudantes brasileiros. Nesse contexto, a promoção da atividade física em escolas integra as ações do PSE, além de ser monitorada pela PeNSE. O presente estudo verificou a associação entre características do indivíduo, socioeconômicas, de ações de promoção da atividade física e da saúde na escola, incluindo a adesão escolar ao PSE, com os comportamentos ativo e sedentário de estudantes brasileiros matriculados em escolas públicas, participantes da PeNSE – 2019. Trata-se de estudo com dados secundários. A amostra contou com 48.204 adolescentes, com idades entre 13 e 18 anos. As variáveis foram coletadas através de questionário. A adesão da escola ao PSE é uma das variáveis de maior centralidade da rede, com destaque para a sua medida de força (1,433); entretanto, apresentou-se pouco conectada aos indicadores de atividade física e ao comportamento sedentário dos jovens. A análise de redes mostrou que o gênero feminino participa menos das atividades físicas em aulas de Educação Física (-0,176) e em tempo livre (-0,283), assim como ter internet em casa foi a principal variável associada com o maior tempo de exposição aos comportamentos sedentários (0,225). Os resultados apontam para a importância da adesão escolar ao PSE e para a necessidade do desenvolvimento de ações efetivas de promoção da atividade física como estratégia de promoção da saúde no âmbito do PSE.

Palavras-chave: Atividade motora; Estilo de vida; Exercício; Promoção da saúde; Serviços de saúde escolar.

Introduction

The health of young people is a target of concern around the world, especially regarding chronic non-communicable diseases, which has motivated the development of public education and health promotion policies that contribute to better understanding and promote en-

gagement in healthy behaviors¹⁻³. In this context, the habitual level of physical activity and the time of exposure to sedentary behaviors among adolescents have received attention in the literature^{4,5}. In Brazil, the prevalence of insufficiently active adolescents is 71.1%, while 44.3% of adults do not comply with the World

Health Organization's recommendations^{6,7}. Furthermore, 53.1% of adolescents spend too much time on screens, i.e., more than 3 hours of sedentary behavior per day^{8,9}.

When considering young people, school appears to be a favorable environment for the development of strategies for education and health promotion, considering its inherent role in the development of students. Health promotion in the school environment is characterized by a set of actions aimed at maintaining quality of life and well-being through coordination between different actors and strategies, inside and outside the school¹⁰, and its relevance is highlighted considering the epidemiological scene of physical activity of young Brazilians¹¹.

In this context, the Health at School Program (SHP), an intersectoral action of the Ministry of Health and Ministry of Education, consists of creating links between public health and education centers, such as schools, health units, and leisure places. The program proposes a line of operation specific to physical activity, which aims to position "... the subject at the center of the care, understanding them in the physical, psychological, social, and cultural dimensions"¹², and, as an expected result, an increase in students' physical activity levels at school¹². However, since its creation in 2007, there is still little evidence on the implementation and effectiveness of the proposed initiatives^{2,13}.

On the one hand, the number of schools that adhered to physical activity, according to the SHP guidelines, grew throughout the national territory, in the period from 2014 to 2020¹⁴. However, weaknesses are identified with regard to the implementation of the proposed initiatives, especially due to limitations in the intersectoral integration of actions from different domains and areas, making it difficult to assess the impacts on the student's lifestyle².

In this context, since 2009, the National School Health Survey (PeNSE) has been an important health surveillance tool for Brazilian schoolchildren. In recent years, numerous publications about the active and sedentary behaviors of Brazilian adolescents have been made available in the literature based on PeNSE data¹⁵⁻²³.

Studies that used PeNSE data stand out, including the validation of the instrument used to assess physical activity and sedentary behavior¹⁹, investigations into the factors associated with both the practice of physical activity^{15-17,20,21} and sedentary behavior^{15,16,21}, indicators of the habitual level of total physical activity²², tem-

poral trend analysis of active behavior throughout the four editions of the PeNSE¹⁸, and a narrative review with the purpose of analyzing the main problems and challenges for the implementation of public policies to promote physical activity for the young Brazilian population²³.

That said, the literature lacks investigations regarding the different axes of action of the SHP, including the promotion of physical activity²⁴. The data are even more scarce when considering the axis of monitoring and evaluating student health based on PeNSE data²³. In view of the above, the objective of the present study was to verify the association between individual and socioeconomic characteristics, and school participation in actions to promote physical activity and health, including school adherence to the SHP, with active and sedentary behaviors of Brazilian students enrolled in public schools participating in the PeNSE.

Methods

This is a cross-sectional study, which used information obtained from the fourth edition of the PeNSE (PeNSE - 2019). The data collection period began in April 2019 and extended until September of the same year. The PeNSE - 2019 was approved by the National Research Ethics Committee (Conep), under report no. 3.249.268.

The PeNSE - 2019 was designed to estimate population parameters in different geographic domains, covering each of the 26 capitals of the Federation Units and the Federal District, in addition to 26 non-capital cities of each state, totaling 189,857 enrolled students and 183,264 students assessed⁹. The information was obtained in the school environment, through questionnaires applied to school representatives and students, individually and anonymously. In a study carried out with the purpose of testing the validity of the instrument, with regard to the PeNSE physical activity and sedentary behavior indicators, the performance of the physical activity indicators was superior to that of sedentary behavior, including the accuracy index, which fluctuated between 73.1% and 92.4% among physical activity indicators and 72.4% to 84.4% among sedentary behavior indicators, considering that the condition was met in at least one 24-hour recall¹⁹.

The sampling process and data collection procedures can be found in greater detail in the report of the fourth edition of the PeNSE⁹. In the present study, only students from public schools were considered. Af-

ter excluding individuals with missing data in at least one of the variables of interest, the sample included 48,204 adolescents of male and female genders, aged between 13 and 18 years.

Table 1 presents information about the study variables. For analysis purposes, it was decided to preserve both the way the data were obtained in the research questionnaire, as well as their original categorization and coding in the PeNSE - 2019. However, the codes of some of the variables with dichotomous answers were adapted, i.e., in cases where the “NO” answer had a higher coding value than the “YES” answer in the original research data. Furthermore, it was also decided to invert the coding of the answers to questions which

had a higher coding for the qualitative ordinal answer “WORST” than the qualitative answer “BEST”. Both adjustments were made with the aim of facilitating understanding of the relationships between the variables in the analyses carried out, mainly regarding the interpretation of the direct and inverse relationships established between the study variables in the network analysis.

Initially, a descriptive analysis was conducted to characterize the sample considering its absolute and relative frequencies (%), with their respective 95% confidence intervals (95% CI), for the total sample and stratified by whether or not the school adheres to the SHP. Active behavior, in its respective indicators, was dichotomized for the descriptive analysis into: (0) NO

Table 1 – Respondents, characterization, categorization, and coding used for descriptive and network analysis of all study variables.

Respondents	Domain	Variable characterization	Variable according to the questionnaire (PeNSE 2019)	Categorization in the questionnaire (PeNSE 2019)	Coding for descriptive analysis	Coding for network analysis
Students	Individual	Gender	What is your sex?	Male	1	1
				Female	2	2
		Age	What is your age?	Under 13 years	1	1
				13 to 15 years	2	2
				15 to 18 years	3	3
		Self-perceived health	How would you rate your health status?	Very poor	1	1
				Poor	2	2
				Fair	3	3
				Good	4	4
				Very good	5	5
	Socioeconomic	Mother's education level	What education level (degree) has your MOTHER studied or is studying?	Did not study	1	1
				Did not complete Elementary School	2	2
				Completed Elementary School	3	3
				Did not complete High School	4	4
				Completed High School	5	5
				Did not complete Higher Education	6	6
				Completed Higher Education	7	7
				Active and sedentary behaviors	Cell phone	Do you have a cell phone?
Yes	1	1				
Internet access at home	Do you have internet access at your home?	No	0		0	
		Yes	1		1	
Weekly travel time between home and school	Weekly travel time in minutes between home and school	In minutes	(0) No (1) Yes		Continuous variable	
Weekly physical activity time in Physical Education class	Weekly physical activity time in minutes in Physical Education class	In minutes	(0) No (1) Yes		Continuous variable	
Weekly physical activity time outside of Physical Education class	Weekly physical activity time in minutes outside of Physical Education class	In minutes	(0) No (1) Yes	Continuous variable		

Continue...

Continue of Table 1 – Respondents, characterization, categorization, and coding used for descriptive and network analysis of all study variables.

Respondents	Domain	Variable characterization	Variable according to the questionnaire (PeNSE 2019)	Categorization in the questionnaire (PeNSE 2019)	Coding for descriptive analysis	Coding for network analysis				
Students	Active and sedentary behaviors	Time spent sitting per day	How many hours per day do you usually spend sitting, watching TV, playing video games, using a computer, cell phone, tablet, or doing other sitting activities? (DO NOT count Saturdays, Sundays, holidays, or the time spent sitting at school)	Up to 1 hour per day		1				
				More than 1 hour up to 2 hours per day	1	2				
				More than 2 hours up to 3 hours per day	2	3				
				More than 3 hours up to 4 hours per day		4				
				More than 4 hours up to 5 hours per day	5					
				More than 5 hours up to 6 hours per day	6					
				More than 6 hours up to 7 hours per day	3	7				
				More than 7 hours up to 8 hours per day	8					
				More than 8 hours per day	9					
				School administration	Physical activity and health policies	Provision of physical activity outside regular class hours	Does the school offer physical activity practice for students outside regular class hours?	No	0	0
								Yes, free		
								Yes, paid	1	1
Yes, free and paid										
Participation in sports and active games and competitions between schools	Does the school participate in physical and sports games or competitions between schools?	No	0			0				
		Yes	1			1				
School council deliberation on the topic "Physical Activity Practice"	IN THE LAST 12 MONTHS, has the school council had any deliberation on the topics? - Physical activity practice	No	0			0				
		Yes	1			1				
Committee responsible for coordinating health-related actions	Does the school have a group or committee responsible for guiding or coordinating health-related actions and/or activities?	No	0			0				
		Yes	1			1				
Participation in the School Health Program	Does the school participate in the School Health Program (SHP)?	No	0			0				
		Yes	1			1				
Actions in conjunction with the Basic Health Unit or Family Health Team or Primary Care Team	IN THE LAST 12 MONTHS, has the school carried out joint actions with the Basic Health Unit or the Family Health Team or the Primary Care Team?	No	0	0						
		Yes	1	1						
Promotion of healthy eating and obesity prevention actions	IN THE LAST 12 MONTHS, which of the following actions has the school developed? - Promotion of healthy eating and obesity prevention	No	0	0						
		Yes	1	1						

PeNSE = National School Health Survey.

(individuals who reported not practicing physical activity once in the week prior to the survey) and (1) YES (individuals who reported practicing some physical activity in the week prior to the survey)¹⁵. The sedentary behavior variable was recategorized for descriptive analysis into: a) up to two hours; b) three to four hours; c) more than four hours²⁵. Finally, the variable “offering physical activity outside regular hours” was dichotomized (NO and YES) based on the original answers in which individuals who answered “NO” were coded with (0), while students who answered any other option were grouped into affirmative responses and coded with (1).

Subsequently, network analysis was used to analyze the complex relationship between individual variables, socioeconomic, active, and sedentary behaviors, and physical activity and health policies at school. For network analysis, the coding presented in Table 1 was considered, except for physical activity indicators, which were analyzed as continuous variables (minutes spent in the previous week).

The “Fruchterman-Reingold” algorithm was applied²⁶. The “random Markov fields” algorithm was used to improve the network’s accuracy. The algorithm adds an “L1” penalty (regularized neighborhood regression). Regularization is estimated by a less complete selection and contraction operator (Lasso) that controls the sparse network²⁷. The extended Bayesian information criterion (EBIC) for selecting the Lambda of the regularization parameter was observed. EBIC uses a hyperparameter (γ) that determines the number of EBICs that select sparse models. The γ value was determined to be 0.25 (range 0 to 0.5).

Network analysis uses regularized least absolute shrinkage and selection operator (LASSO) algorithms to obtain the precision matrix (weight matrix). When standardized, this matrix represents the associations between variables in the network. The network is presented in a graph (network topology) that includes variables (nodes) and relationships (lines). Blue lines represent direct associations and red lines represent inverse associations. The thickness and intensity of the lines represent the magnitude of the associations. The weight matrix quantifies the associations considering the correlations between the variables. In addition to the topology and the weight matrix, network analysis also provides centrality measures, namely betweenness (indicates a node on the average path between other pairs of nodes), proximity (indicates the relationship of the node with all other nodes of the network, taking

into account the indirect connections of that node, a high proximity index indicates a short average distance from a specific node to all others), strength (the sum of the weighted number and the strength of all connections of a specific node in relation to all other nodes), and the expected influence (variable with the greatest sensitivity in the network, thus being the measure with the greatest power to change the network)²⁸. Analyses were performed using JASP software (version 18.1).

Results

Table 2 presents the characteristics of the total sample, stratified by whether or not the school adheres to the SHP. The study included 48,204 participants, 53% (95% CI: 52.5 - 53.4) female. In total, 52.4% (95% CI: 52.0 - 52.9) of the sample consisted of young people between 13 and 15 years of age. Regarding the mother’s education, 26.3% (95% CI: 25.9 - 26.7) completed secondary education and only 18.3% (95% CI: 17.9 - 18.6) completed higher education. Regarding having a cell phone and internet at home, 81.9% (95% CI: 81.6 - 82.3) and 86.8% (95% CI: 86.4 - 87.1), respectively, answered positively to the questions. Regarding the practice of physical activity in the week prior to the survey, 36.2% (95% CI: 35.7 - 36.6) of students reported not engaging in active commuting, 43.0% (95% CI: 42.6 - 43.5) did not engage in physical activities in the context of the Physical Education class, and 36.6% (95% CI: 36.1 - 37.0) did not perform any physical activity in free time. A total of 79.8% of participants reported spending more than 2 hours a day in sedentary activities during the week. Regarding physical activity and health policy actions at school, it is worth highlighting that 53.5% of students are enrolled in schools that adhere to the SHP, which stand out in relation to schools that did not adhere to the SHP in terms of participation in games and physical-sports competitions between schools (85.3%; 95% CI: 84.8 - 86.0), formation of a committee responsible for coordinating health-related actions (52.2%; 95% CI: 51.5 - 52.7), actions in conjunction with the family health team (86.7%; 95% CI: 86.3 - 87.1), and promotion of healthy eating and obesity prevention actions (70.2%; 95% CI: 69.6 - 70.8).

The results of the network analysis are described in the set composed of Figure 1, Table 3 and Table 4, which represent the network topology, weight matrix, and centrality measures, respectively. The analysis of the network topology allows us to visualize the rela-

Table 2 – Characteristics of the total sample (n = 48,204) and stratified by schools that did not join the School Health Program (n = 22,390) and schools that joined the School Health Program (n = 25,814).

Variables	Total			Schools that did not adhere to the SHP			Schools that adhered to the SHP		
	n	%	CI 95%	n	%	CI 95%	n	%	CI 95%
Gender									
Male	22,662	47.0	46.6 – 47.5	10,563	47.2	46.5 – 47.8	12,099	46.9	46.3 – 47.5
Female	25,542	53.0	52.5 – 53.4	11,827	52.8	52.2 – 53.5	13,715	53.1	52.5 – 53.7
Age									
Under 13 years	5,114	10.6	10.3 – 10.9	1,952	8.7	8.4 – 9.1	3,162	12.2	11.5 – 12.6
13 to 15 years	25,266	52.4	52.0 – 52.9	10,694	47.8	47.1 – 48.4	14,572	56.5	55.8 – 57.0
16 to 18 years	17,824	37.0	36.5 – 37.4	9,744	43.5	43.0 – 44.2	8,080	31.3	30.7 – 31.9
Self-perceived health									
Very poor	767	1.6	1.5 – 1.7	353	1.6	1.4 – 1.7	414	1.6	1.5 – 1.8
Poor	2,178	4.5	4.3 – 4.7	1,103	5.0	4.6 – 5.2	1,075	4.2	3.9 – 4.4
Fair	13,208	27.4	27.0 – 27.8	6,326	28.2	27.8 – 28.9	6,882	26.7	26.1 – 27.2
Good	16,902	35.1	34.6 – 35.5	8,047	35.9	35.3 – 36.6	8,855	34.3	33.7 – 34.9
Very good	15,149	31.4	31.0 – 31.8	6,531	29.3	28.6 – 30.0	8,588	33.2	32.7 – 33.8
Owens a cell phone									
No	8,717	18.1	17.7 – 18.4	3,679	16.4	16.0 – 16.9	5,038	19.5	19.0 – 20.0
Yes	39,487	81.9	81.6 – 82.3	18,711	83.6	83.1 – 84.0	20,776	80.5	80.0 – 81.0
Internet access at home									
No	6,386	13.2	12.9 – 13.5	2,771	12.4	12.0 – 12.8	3,615	14.0	13.6 – 14.4
Yes	41,818	86.8	86.4 – 87.1	19,619	87.6	87.2 – 88.0	22,199	86.0	85.6 – 86.4
Mother's education									
Did not study	2,604	5.4	5.2 – 5.6	988	4.4	4.1 – 4.7	1,616	6.3	6.0 – 6.6
Did not complete Elementary School	11,520	24.0	23.5 – 24.3	5,093	22.7	22.2 – 23.3	6,427	24.9	24.4 – 25.4
Completed Elementary School	4,128	8.5	8.3 – 8.8	1,893	8.4	8.1 – 8.8	2,235	8.7	8.3 – 9.0
Did not complete High School	4,822	10.0	9.7 – 10.3	2,276	10.2	9.8 – 10.6	2,546	9.9	9.5 – 10.2
Completed High School	12,681	26.3	25.9 – 26.7	6,246	28.0	27.3 – 28.5	6,435	24.9	24.4 – 25.5
Did not complete Higher Education	3,633	7.5	7.3 – 7.8	1,741	7.8	7.4 – 8.1	1,892	7.3	7.0 – 7.6
Completed Higher Education	8,816	18.3	17.9 – 18.6	4,153	18.5	18.0 – 19.1	4,663	18.0	17.6 – 18.5
Active Commuting									
No	17,437	36.2	35.7 – 36.6	8,487	37.9	37.3 – 38.5	8,950	34.7	34.1 – 35.2
Yes ^a	30,767	63.8	63.4 – 64.2	13,903	62.1	61.5 – 62.7	16,864	65.3	64.7 – 65.9
Physical activity in Physical Education class									
No	20,748	43.0	42.6 – 43.5	9,986	44.6	43.9 – 45.2	10,762	41.7	41.1 – 42.3
Yes ^a	27,456	57.0	56.5 – 57.4	12,404	55.4	54.7 – 56.0	15,052	58.3	57.7 – 58.9
Physical activity outside of Physical Education class									
No	17,632	36.6	36.1 – 37.0	8,544	38.2	37.5 – 38.9	9,088	35.2	34.6 – 35.8
Yes ^a	30,572	63.4	63.0 – 63.5	13,846	61.8	61.2 – 62.5	16,726	64.8	64.2 – 65.4
Sedentary behavior^b									
Up to 2 hours	9,743	20.2	19.9 – 20.6	7,099	31.8	31.1 – 32.3	9,107	35.3	34.7 – 35.9
From 2 to 4 hours	12,763	26.5	26.1 – 26.9	5,764	25.7	25.2 – 26.3	6,307	24.4	23.9 – 25.0
More than 4 hours	25,698	53.3	52.9 – 53.8	9,527	42.5	41.9 – 43.2	10,400	40.3	40.0 – 41.0
Provision of physical activity outside regular class hours									
No	22,010	45.7	45.2 – 46.1	10,480	46.8	46.1 – 47.5	11,530	44.7	44.1 – 45.3
Yes	26,194	54.3	53.9 – 54.8	11,910	53.2	52.5 – 53.9	14,284	55.3	54.7 – 56.0

Continue...

Continue of Table 2 – Characteristics of the total sample (n = 48,204) and stratified by schools that did not join the School Health Program (n = 22,390) and schools that joined the School Health Program (n = 25,814).

Variables	Total			Schools that did not adhere to the SHP			Schools that adhered to the SHP		
	n	%	CI 95%	n	%	CI 95%	n	%	CI 95%
Participation in physical and sports games and competitions between schools									
No	8,927	18.5	18.2 – 18.9	5,124	22.9	22.3 – 23.4	3,803	14.7	14.3 – 15.2
Yes	39,277	81.5	81.1 – 81.8	17,266	77.1	76.6 – 77.7	22,011	85.3	84.8 – 86.0
School council deliberation on the topic “Physical Activity Practice”									
No	35,584	73.8	73.4 – 74.2	16,895	75.5	74.9 – 76.0	18,689	72.4	71.8 – 73.0
Yes	12,620	26.2	25.8 – 26.6	5,495	24.5	24.0 – 25.1	7,125	27.6	27.1 – 28.1
Committee responsible for coordinating health-related actions									
No	29,084	60.3	59.9 – 60.8	16,730	74.7	74.1 – 75.3	12,354	47.8	47.2 – 48.5
Yes	19,120	39.7	39.2 – 40.1	5,660	25.3	24.7 – 25.8	13,460	52.2	51.5 – 52.7
Actions in conjunction with Basic Health Unit (UBS) or Family Health Team or Primary Care Team									
No	14,041	29.1	28.7 – 29.5	10,618	47.4	46.8 – 48.1	3,423	13.3	12.8 – 13.7
Yes	34,163	70.9	70.5 – 71.3	11,772	52.6	51.9 – 53.2	22,391	86.7	86.3 – 87.1
Promotion of actions for healthy eating and obesity prevention									
No	17,429	36.2	35.7 – 36.6	9,740	43.5	42.8 – 44.1	7,689	29.8	29.3 – 30.3
Yes	30,775	63.8	63.4 – 64.3	12,650	56.5	55.8 – 57.1	18,125	70.2	69.6 – 70.8

Note: 95% CI = 95% Confidence Interval; UBS = Basic Health Unit; a = Physical activity performed at least once a week in the last 7 days; b = Time spent sitting, watching TV, using a computer, playing video games, chatting with friends, or doing other sitting activities, not including Saturdays, Sundays, holidays, and time spent sitting at school.

tionships between variables, considering the type and strength of the relationships. The organization of variables into two clusters (Figure 1) can be clearly seen, indicating that a group of variables are more connected (individual, socioeconomic and active and sedentary behavior variables, numbered from 1 to 10), while they establish more distant relationships with another group of variables (variables from physical activity and health policies at school, numbered 11 to 17).

Table 3 presents the weight matrix of the relationships between the study variables. The time spent practicing physical activity in the context of Physical Education classes was inversely associated with the female gender (-0.176) and age (-0.168), and directly associated with the time spent practicing physical activity outside Physical Education classes. (0.163). This, in turn, also showed an inverse relationship with females (-0.283). Regarding physical activities in the context of commuting, the data point to an inverse relationship with the student's socioeconomic level, which can be represented by the inverse association values with the variables of having a cell phone (-0.069), and mother's education (-0.036), i.e., students who spend more time on physical activities in this indicator are those who belong to a lower socioeconomic level. Regarding sedentary behavior, the direct association with internet access at home stands out (0.225).

Concerning the variables related to actions to pro-

mote physical activity and health at school, we identified direct relationships between the school adhering to the SHP, the formation of a committee responsible for coordinating actions related to health (0.307), and the actions in conjunction with the Basic Health Unit (UBS) or family health team or primary care team (0.496). On the other hand, the school joining the SHP had an inverse relationship with the school council's deliberation on the topic “Practice of Physical Activity” (-0.054) and with the offer of physical-sports activities after school (-0.147). The provision of physical activities after school was directly associated with participation in competitions (0.503).

The school's adherence to the SHP is one of the variables with the highest centrality in the network (Table 4), with emphasis on its measure of strength (1.433). The school's actions in conjunction with the UBS or family health team or primary care team are also worth highlighting, with the highest values of intermediation (2.550) and proximity (1.373), in addition to having the internet at home, which was the variable with the greatest expected influence in the model (1.331).

Discussion

The network analysis showed that the variables linked to actions to promote physical activity and health at school, including the school's adherence to the SHP and the development of the school's actions in con-

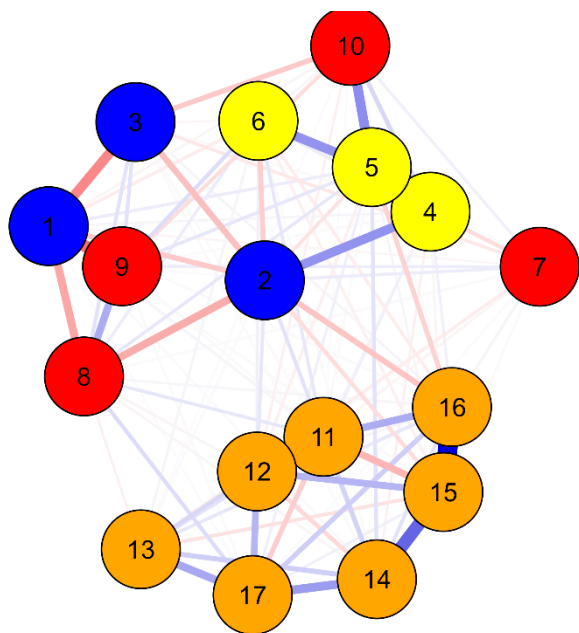


Figure 1 – Network topology for association among individual, socioeconomic, active, and sedentary behaviors, and physical activity (PA) and health policy variables in Brazilian adolescents attending public schools (n = 48,204).

Blue node = Individual domain; Yellow node = Socioeconomic domain; Red node = Active and sedentary behavior domain; Orange node = PA and health policy domain; Blue edge = Positive association; Red edge = Inverse association; 1 = Gender; 2 = Age; 3 = Self-perceived health; 4 = Owns a cell phone; 5 = Internet access at home; 6 = Mother's education; 7 = Active commuting; 8 = PA in Physical Education class; 9 = PA outside of Physical Education class; 10 = Sedentary behavior; 11 = Provision of physical activity outside regular class hours; 12 = Participation in physical and sports games and competitions between schools; 13 = School council deliberation on the topic "Physical Activity Practice"; 14 = Committee responsible for coordinating health-related actions; 15 = Participation in the School Health Program; 16 = Actions in conjunction with UBS or Family Health Team or Primary Care Team; 17 = Promotion of actions for healthy eating and obesity prevention.

junction with the UBS, are positively interrelated in the PeNSE – 2019, which is in line with the implementation policy of the SHP itself. Furthermore, these variables stand out, together with having internet access at home, for presenting the highest centrality values in the model, which denotes the high potential of these variables as targets for future actions with the purpose of changing the network topology. On the other hand, the variables promoting physical activity and health at school were poorly connected with the other variables in the network, including indicators of physical activity and sedentary behavior. In this context, attention is drawn to the inverse relationships observed between schools that joined the SHP with the school council's deliberation on the topic "Practice of Physical Activi-

ty" and with the offering of physical activities outside regular class hours. Regarding active and sedentary behaviors, the results corroborate the evidence in the literature^{4,29} and the findings of previous editions of the PeNSE itself,¹⁵, which point out that girls have a lower weekly physical activity time than boys in Physical Education classes and in free time, in addition to demonstrating an association between internet access at home and a longer period of exposure to sedentary behaviors, offering clues that the access to social networks, online games, and streaming services can impact young people's free-time choices.

Considering the possible gap between actions arising from public policies on physical activity and health at school, such as the SHP, and the time in which students are engaged in physical activities in the contexts of Physical Education classes and in free-time, including considering physical-sports activities during school hours, the need to construct health promotion and education proposals at school within a pedagogical perspective is highlighted, incorporating, but overcoming, the strictly biological view of health in the design of these proposals, focused on the prevalence of behaviors and the idea of individual responsibility for one's own health^{30,31}. From this perspective, a pedagogical approach to health at school is not something restricted to Physical Education, but something that permeates the entire school community, so that understanding of health can be given new meaning and the social vulnerabilities that prevent its promotion can be addressed^{32,33}.

The SHP is inserted in this context, however its implementation and the development of health actions have been the target of criticism that identifies its actions with the reductionist vision of health^{30,31,34}. Different publications have identified the prevalence of individual assistance actions to the detriment of health promotion actions, integration difficulties between the health and education sectors, and, also, with regard to the promotion of physical activity, a low rate of actions when compared to other axes of the program³⁵⁻³⁷. These findings corroborate the results presented in the current study, although they only allow, at this moment, the elaboration of explanatory hypotheses that school adherence to the SHP was not related to active and sedentary behaviors.

In relation to physical activity indicators, as is constantly observed in the literature, data from the present study point to lower engagement of girls in physical activities, both in the context of Physical Education

Table 3 – Associations among study variables from a network analysis perspective.

Variáveis	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Gender (1)	-																
Age (2)	-0.103	-															
Self-perceived health (3)	-0.228	-0.126	-														
Owens a cell phone (4)	0.012	0.209	-0.006	-													
Internet access at home (5)	0.038	-0.051	0.000	0.463	-												
Mother's education (6)	-0.039	-0.093	-0.011	0.039	0.213	-											
Active commuting (7)	-0.011	0.038	-0.041	-0.069	0.006	-0.036	-										
Physical activity in Physical Education class (8)	-0.176	-0.168	0.056	0.000	0.041	0.035	0.010	-									
Physical activity outside of Physical Education class (9)	-0.283	0.006	0.059	-0.005	0.046	0.063	0.036	0.163	-								
Sedentary behavior (10)	-0.014	0.000	-0.100	0.079	0.225	0.011	0.029	0.000	-0.061	-							
Provision of physical activity outside regular class hours (11)	0.016	0.055	-0.008	0.011	0.009	0.045	-0.015	0.046	0.007	0.003	-						
Participation in physical and sports games and competitions between schools (12)	0.000	0.048	0.000	0.000	-0.029	0.027	0.006	-0.016	0.000	-0.021	0.503	-					
School council deliberation on the topic "Physical Activity Practice" (13)	0.000	0.007	0.000	0.000	0.000	0.017	-0.036	-0.021	0.000	0.003	0.055	0.071	-				
Committee responsible for coordinating health-related actions (14)	-0.010	0.011	-0.009	-0.022	0.060	0.008	0.000	-0.014	0.000	0.000	0.089	-0.076	0.097	-			
Participation in the School Health Program (15)	0.006	-0.067	0.010	-0.017	0.011	-0.027	-0.009	0.000	0.000	0.000	-0.147	0.146	-0.054	0.307	-		
Actions in conjunction with UBS or Family Health Team or Primary Care Team (16)	-0.005	-0.113	0.013	0.026	-0.088	-0.037	0.020	0.011	0.000	-0.007	0.159	0.015	0.047	0.056	0.496	-	
Promotion of actions for healthy eating and obesity prevention (17)	0.002	-0.036	0.000	0,024	0.030	-0.003	0.003	0.066	-0.010	0.000	-0.095	0.141	0.174	0.198	0.024	0.094	-

Note: UBS = Basic Health Units.

classes, in which engagement is, in a certain way, mandatory, as well as in the context of physical activities outside of Physical Education classes, which is asso-

ciated with leisure activities in free-time. Studies that looked at previous editions of the PeNSE came across similar results^{15,20}. Inequality between the genders con-

Table 4 - Centrality measures by study variable

Variable	Intermediation	Proximity	Strength	Expected influence
Gender	-0.582	-0.325	0.111	-2.156
Age	1.197	1.858	0.766	-1.345
Health perception	-0.724	-0.195	-0.865	-1.359
Owns a cell phone	0.272	0.776	0.246	0.879
Has internet at home	1.482	0.975	1.397	1.331
Mother's education	-0.867	-0.405	-0.734	-0.169
Active commuting	-0.867	-2.144	-1.925	-0.728
PA in Physical Education class	0.130	0.500	-0.317	-0.524
PA outside of Physical Education class	-0.795	-0.705	-0.620	-0.549
Sedentary behavior	-0.795	-0.120	-1.269	-0.296
Provision of physical activity outside regular class hours	-0.226	-0.268	1.228	0.851
Participation in physical and sports games and competitions between schools	-0.724	-0.573	0.655	1.021
School council deliberation on the topic "Physical Activity Practice"	-0.795	-1.420	-1.166	0.123
Committee responsible for coordinating health-related actions	0.130	0.042	0.151	0.780
Participation in the School Health Program	0.913	0.958	1.433	0.752
Actions in conjunction with UBS or Family Health Team or Primary Care Team	2.550	1.373	0.964	0.768
Promotion of actions for healthy eating and obesity prevention	-0.297	-0.327	-0.052	0.619

Note: PA = Physical Activity; UBS = Basic Health Units.

sidering access to and engagement in physical activities is a complex phenomenon of a social nature, which involves understanding and intervening at the different dimensions considered by ecological models adopted to explain active behavior in its different aspects³⁸. Therefore, public policies to promote physical activity and health centered on reductionist models have not been very effective³⁹ as they do not consider the different dimensions of the phenomenon and the inequalities in access to physical activity⁴⁰.

Regarding active commuting to school, in the current study a negative relationship was observed between active commuting and the mother's education. Thus finding corroborates the associations of these variables seen in previous editions of the survey, indicating the weight of the socioeconomic factor for greater active commuting in poorer children. However, there is a decrease in active commuting levels when compared with data from the last edition of the PeNSE, carried out in 2015²⁰.

Among the strengths of the present study, the fact that it uses data from the PeNSE - 2019 stands out, with a substantial sample of 48,204 participants, enrolled in public schools in all regions of the country. However, this is a cross-sectional study, which does not allow the establishment of causality between the study variables. Another important aspect is related to the fact that physical activity and health policy actions in

the school context were assessed via interviews with school representatives, while the other variables were collected through questionnaires to students, which can result in discrepancies between the answers given by the two groups of respondents, who have different perspectives of understanding the phenomenon which, therefore, may explain the low connectivity between both groups of variables in the model. Finally, in relation to sedentary behavior, the exposure time may be underestimated, considering that the only question that served to measure the variable did not consider the time spent in a sitting position in the school context. Furthermore, the question does not allow the assessment of different contexts of sedentary behavior.

Understanding the factors associated with active and sedentary behaviors in the young Brazilian population is essential for improving strategies that address health issues and encourage the development of appropriate public health policies for this age group. In this sense, much more than studying total physical activity, it is essential to understand the different relationships established between the different contexts of practice with a range of associated variables, from individual characteristics, through the socioeconomic level of the family and the environmental characteristics, to the action of public policies. The results of the present study are in line with the literature and point to inequalities

regarding gender and socioeconomic level in different contexts of physical activity and sedentary behavior. Furthermore, the findings highlight the need to carry out actions to promote physical activity aimed at the health and well-being of students in the school context.

Conflict of interest

The authors declare that there is no conflict of interest.

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

The manuscript did not use artificial intelligence tools for its preparation.

Availability of research data and other materials

The contents underlying the research text are contained in the manuscript.


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