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Short title: Aggressive Behavior Clustering in Adolescents

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ABSTRACT

Objective: To evaluate whether bullying, physical aggression, and peer rejection cluster among Brazilian adolescent students and whether aggressive-behavior cluster pairs are associated with leisure-time physical activity according to sex.

Methods: This cross-sectional study analyzed data from PeNSE 2019, including 157,921 adolescents aged 13 to 17 years. Bullying, physical aggression, and rejection in the previous 30 days were dichotomized as present or absent. Clustering was assessed using observed/expected ratios (O/E) and 99% confidence intervals. Logistic regression models estimated associations between aggressive-behavior cluster pairs and sufficient leisure-time physical activity, defined as ≥300 min/week.

Results: Bullying, physical aggression, and rejection were reported by 39.41%, 14.60%, and 26.69% of adolescents, respectively. The simultaneous occurrence of all three behaviors exceeded expectation in the overall sample (O/E = 127.69), boys (O/E = 122.05), and girls (O/E = 170.23). In boys, physical aggression plus rejection was associated with lower odds of sufficient leisure-time physical activity (aOR = 0.99, 99%CI: 0.97-0.99). In girls, physical aggression plus rejection (aOR = 0.88, 99%CI: 0.86-0.89), bullying plus rejection (aOR = 0.97, 99%CI: 0.96-0.98), and bullying plus physical aggression (aOR = 0.98, 99%CI: 0.97-0.99) were associated with lower odds of sufficient leisure-time physical activity.
Conclusion: Aggressive behaviors clustered among Brazilian adolescents and were associated with leisure-time physical activity, particularly among girls. Because this study was cross-sectional and several effect sizes were small, findings should be interpreted as associations rather than causal effects.
Keywords: Cluster analysis; motor activity; violence; adolescent health.

1. INTRODUCTION

Violence among adolescents is a global health problem that impairs their physical and psychological well-being.[1-3] Contrary to common sense, aggression is not an exclusively physical act. Besides physical aggression, aggressive behaviors are also manifested in subtle harmful actions, such as personal rejection, public humiliation, and social exclusion; these behaviors can be identified in the relationships between adolescents.[3,4] Aggressive behaviors directly affect victims and also influence other aspects of their lives, such as physical activity, which is crucial to overall health.

Physical activity is recognized as “people moving, acting and performing within culturally specific spaces and contexts, and influenced by a unique array of interests, emotions, ideas, instructions, and relationships”.[5] Globally, participation in physical activity is positive for young people because it improves several aspects of their health. However, the relationship between physical activities and aggressive behaviors presents conflicting results, as some activities are more prone to the reproduction of these behaviors. For example, a systematic review showed that boys who engage in physical activities with direct physical contact (e.g., soccer and martial arts) tend to be more involved and tolerant of

physical aggression.[6] Conversely, girls are less physically aggressive than boys but are more involved in verbal and psychological bullying and rejection.[6,7] Therefore, aggressive behaviors differ between girls and boys, and the relationship of these behaviors with the practice of physical activity may also vary according to sex. Furthermore, studies on aggressive behaviors among young people focused more on their individual manifestations, excluding the possible interactions of these behaviors.

Despite the vast literature on aggressive behaviors,[4,6-9] most of this evidence focuses on isolated single behaviors. Little is known about the potential for aggressive-behavior clusters among adolescents. A cluster analysis is based on the rationale that multiple behaviors coexist in the lives of people.[10-13] For example, Lourenço et al. (2020),[11] found that modifiable risk factors for cardiovascular disease (e.g., alcohol consumption and smoking) among adolescents are more likely to occur together than isolated. Given the complexity of the characteristics that involve the aggressive profile among young people,[14] whether in physical,[6] or social/relational aggressions,[7] it is plausible to assume that some aggressive behaviors, such as bullying, physical aggression, and rejection, can coexist, leading to a cluster. Moreover, the relationship that potential aggressive-behavior clusters may have on the practice of physical activity in the leisure of adolescents is unknown.

Thus, this study aimed to evaluate the association between the clusters of aggressive behaviors (i.e., bullying, physical aggression, or rejection) and the level of leisure-time physical activity among adolescents of both sexes using data from a representative sample of Brazilian adolescent students.

2. METHODS

2.1 Study design and research context

This cross-sectional epidemiological study used data from the Pesquisa Nacional de Saúde do Escolar [National Survey of School Health] (PeNSE) 2019. PeNSE is a national survey conducted by the Brazilian Institute of Geography and Statistics (IBGE) in partnership with the Ministry of Health and with support from the Ministry of Education of Brazil, providing information for the surveillance system of risk factors and protection for the health of students.[15] The data

collection for the PeNSE 2019 occurred between April and September 2019. The present study was reported following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) recommendations.[16]

2.2 Definition of population and sample

The study population included students aged 13 to 17 years who were enrolled and attended from the 7th to the 9th year of elementary school and from the 1st to the 3rd year of high school (morning, afternoon, and evening shifts). These students came from public and private schools, and classes needed to have at least 20 students enrolled. In 2019, PeNSE reached 4,242 schools and 6,612 classes from the following geographical levels: Brazil, large regions, Federal Units, capitals, and the Federal District.

The sampling plan of the PeNSE 2019 was established using a double-stage cluster sampling method. Schools were selected in the first stage, and the classes of enrolled students represented the second stage. Thus, the sample of students was formed by the set of students from the selected classes. The sample size considered a simple random sampling technique within each stratum, with the aim of estimating a prevalence of 50% with a coefficient of variation of 4%. Given the complex sampling design, PeNSE 2019 performed sample calculations considering weights for schools, classes, and students; these weights were calibrated using data from the School Census 2019. These characteristics allowed the findings from the PeNSE sample to be extrapolated to the entire population of Brazilian adolescent students. All students who attended class on the day of data collection were invited to answer the questionnaire. More details on sample sizing are in a previous publication.[15]

2.3 Data source and collection instrument

The data used in this study are publicly available on the IBGE website (https://www.ibge.gov.br) in Brazilian Portuguese. PeNSE data was collected via a self-administered questionnaire that was applied using smartphones. The questionnaire had 14 central themes, including questions on socioeconomic status, diet, physical activity, risk behaviors, drug use, and mental and sexual

health. The questionnaire contained completion guidelines, and an IBGE technician was available to resolve possible doubts.

2.4 Study variables

The dependent variable was the leisure-time physical activity, categorized as insufficiently active (< 300 min/week) and sufficiently active (≥ 300 min/week). The students indicated the number of days (0 to 7 days) and the amount of time spent on daily physical activity. The categorization of the variable considered adolescents performing 60 minutes of leisure-time physical activity on at least five days per week.[17] For the analyses, the reference category was sufficiently active.

The independent variables were the adolescents having been victims of bullying, physical aggression, or rejection by colleagues. These variables were assessed considering the past 30 days using the following questions, respectively:

- "*How many times has one of your schoolmates mocked you, made fun of you, ridiculed you, intimidated you, or teased you to the point that you felt hurt, bothered, upset, offended, or humiliated?*";
- "*How many times has one of your schoolmates hit you (punched, slapped, kicked) or hurt you physically in another way?*"; and,
- "*How many times has one of your schoolmates refused to talk to you, deliberately left you out without reason, or encouraged other classmates to stop talking to you?*". The response options for all questions were *not once*, *once,* or *twice or more*.

For each variable, responses indicating *once* or *twice or more* (coded as 1) were considered indicative of aggressive behaviors; the *not once* option was coded as 0. The variables were dichotomized to identify whether adolescents had experienced each type of aggressive behavior at least once in the previous 30 days. This decision was intended to support surveillance-based epidemiological analysis and to enable the estimation of co-occurrence patterns across the three aggressive-behavior indicators. However, this coding does not capture frequency, severity, chronicity, or perceived impact of victimization.

Covariates were selected based on their potential confounding effects on the relationship between independent and dependent variables. Therefore, the

covariates of this study included sociodemographic (school age, education level of the mother), teaching (grade), geographic (geographic region of the country), school organization (administrative dependence, number of physical education classes), and behavioral (time of physical activity during commuting and physical education classes) variables.

2.5 Analytical plan

The prevalence of independent and dependent variables was described using weighted relative frequencies and 99% confidence intervals (99%CI). Inferential analyses were performed in two stages.

In the first stage, cluster analysis was used to examine whether specific combinations of aggressive behaviors occurred more frequently than expected. The presence of clustering was defined when the observed/expected ratio (O/E) was greater than 1, with 99%CI. The observed prevalence (%O) corresponded to the weighted prevalence of each behavioral pattern, considering the presence or absence of bullying, physical aggression, and rejection. The expected prevalence (%E) was estimated for each corresponding pattern based on the pattern-specific occurrence of the aggressive behavior(s) in the presence or absence of the remaining behavior(s). Cluster analyses were performed using a Microsoft Excel spreadsheet developed for this study.

This observed/expected approach was chosen because the objective was not to derive latent subgroups of adolescents, but to test whether predefined aggressive-behavior patterns occurred more frequently than expected. Alternative exploratory methods, such as latent class analysis or hierarchical clustering, may be useful to identify latent profiles or similarity-based groups. However, they were not selected because the present study focused on the excess occurrence of three theoretically defined victimization indicators.

In the second stage, binary logistic regression models were used to estimate the association between aggressive-behavior cluster pairs and sufficient leisure-time physical activity. For each cluster pair, absence of the cluster was used as the reference category. The dependent variable was sufficient leisure-time physical activity, coded as 1 for adolescents reporting ≥300 min/week and 0 for those

reporting <300 min/week. Therefore, odds ratios below 1 indicate lower odds of being sufficiently active among adolescents exposed to the cluster pair.

Crude odds ratios (cOR) and adjusted odds ratios (aOR), with 99%CI, were estimated for the overall sample and separately for boys and girls. Adjusted models included sociodemographic variables (school age and maternal education), teaching-related variables (grade), geographic region, school organization variables (administrative dependence and number of physical education classes), behavioral variables (time spent in physical activity during commuting and physical education classes), and an interaction term between physical activity during commuting and physical education classes. The analyses accounted for the complex sampling design of PeNSE 2019 using sample weights. Logistic regression analyses were performed using SPSS® (version 26.0); statistical significance was set at $p < 0.05$.

2.6 Ethical aspects

The project PeNSE 2019 was approved by the national research ethics committee (CONEP) on April 8, 2019 (no. 3,249,268). Before data collection, the municipal Departments of Education and the management teams of the selected schools in each municipality were contacted. Students were informed about the study procedures, and an informed consent form was available on the first page of the questionnaire; only those who signed it participated.

3. RESULTS

This study included 157,921 adolescents who provided valid data for all aggressive-behavior indicators. Slightly more than half of the sample were girls (50.83%) and 54.73% were aged 13 to 15 years. In the overall sample, bullying was the most frequently reported aggressive behavior (39.41%, 99%CI: 39.06-39.77), followed by rejection (26.69%, 99%CI: 26.54-27.19) and physical aggression (14.60%, 99%CI: 14.34-14.86). Bullying and rejection were more frequent among girls, whereas physical aggression was more frequent among boys (Table 1).

Table 1. Weighted relative frequencies of aggressive behaviors among Brazilian school adolescents, aged between 13 and 17, of both sexes. Brazil, PeNSE 2019 (N = 157 921 adolescents).

Violent behaviors	All sample (N = 157 921)		Boys (N = 77 650)		Girls (N = 80 271)	
	%w[a]	99%CI[b]	%w	99%CI	%w	99%CI
Bullying						
Yes	39.41	(39.06-39.77)	35.76	(35.27-36.27)	42.94	(42.43-43.75)
Physical aggression						
Yes	14.60	(14.34-14.86)	18.03	(17.63-18.44)	11.28	(10.95-11.61)
Rejection						
Yes	26.69	(26.54-27.19)	22.32	(21.89-22.76)	31.27	(30.79-31.75)

Source: Prepared by the authors from data from the Brazilian Institute of Geography and Statistics (15).
[a] %w = weighted relative frequencies.
[b] 99%CI = 99% confidence intervals.

Table 2 presents the cluster analysis of aggressive behaviors in the overall sample and by sex. The simultaneous occurrence of bullying, physical aggression, and rejection was substantially higher than expected in the overall sample (O/E = 127.69), among boys (O/E = 122.05), and among girls (O/E = 170.23). Cluster pairs also occurred more frequently than expected. In the overall sample, bullying plus rejection showed the highest O/E among cluster pairs (O/E = 7.95), followed by bullying plus physical aggression (O/E = 7.45) and physical aggression plus rejection (O/E = 6.68). In sex-stratified analyses, bullying plus physical aggression showed the highest O/E among cluster pairs in both boys (O/E = 7.31) and girls (O/E = 8.50). The absence of all three aggressive behaviors occurred less frequently than expected in the overall sample (O/E = 0.67), boys (O/E = 0.70), and girls (O/E = 0.63).

Table 2. Cluster analysis of aggressive behaviors among Brazilian adolescent students. Brazil, PeNSE 2019 (N = 157,921 adolescents).

no	Agressive behaviors			All sample (N = 157 921)				Boys (N = 77 650)				Girls (N = 80 271)			
	Bullying	Physical aggression	Rejection	%O[c]	%E[d]	O/E[e]	99%CI[f]	%O	%E	O/E	99%CI	%O	%E	O/E	99%CI
3	●[a]	●	●	5.40	0.04	127.69	(127.69-127.69)	5.79	0.05	122.05	(122.03-122.07)	5.37	0.03	170.23	(170.18-170.23)
2	⌀[b]	●	●	1.28	0.19	6.68	(6.67-6.69)	1.57	0.24	6.48	(6.47-6.49)	0.92	0.13	7.17	(7.16-7.18)
	●	⌀	●	11.38	1.43	7.95	(7.95-7.95)	7.62	1.08	7.04	(7.04-7.05)	15.04	1.81	8.29	(8.29-8.30)
	●	●	⌀	3.55	0.48	7.45	(7.44-7.45)	4.68	0.64	7.31	(7.31-7.32)	2.60	0.31	8.50	(8.50-8.51)
1	●	⌀	⌀	18.08	16.13	1.12	(1.12-1.12)	16.37	14.60	1.12	(1.12-1.12)	19.73	17.58	1.12	(1.12-1.12)
	⌀	●	⌀	2.87	2.16	1.33	(1.33-1.33)	4.20	3.27	1.28	(1.28-1.29)	1.71	1.24	1.37	(1.37-1.38)
	⌀	⌀	●	8.15	6.48	1.26	(1.26-1.26)	6.90	5.53	1.25	(1.25-1.25)	9.35	7.38	1.27	(1.27-1.27)
0	⌀	⌀	⌀	49.02	73.08	0.67	(0.67-0.67)	52.43	74.59	0.70	(0.70-0.70)	44.90	71.52	0.63	(0.63-0.63)

Source: Prepared by the authors from data from the Brazilian Institute of Geography and Statistics (15).
The O/E ratios are presented using a color gradient, with values above 1 indicating higher-than-expected co-occurrence and values below 1 indicating lower-than-expected co-occurrence.
[a] ● = presence of behavior.
[b] ⌀ = absence of behavior
[c] %O = observed prevalence of the combination.
[d] %E = expected prevalence of the combination.
[e] O/E = ratio of the observed prevalence of the combination (%O) to the expected prevalence (%E). Some %E values are rounded, so some %O/E have discrepant values in direct proportion.
[f] 99%CI = 99% confidence intervals.

Table 3 shows the crude and adjusted associations between aggressive-behavior cluster pairs and sufficient leisure-time physical activity. In the overall sample, physical aggression plus rejection (aOR = 0.92, 99%CI: 0.92-0.93) and bullying plus rejection (aOR = 0.85, 99%CI: 0.84-0.85) were associated with lower odds of being sufficiently active after adjustment. Conversely, bullying plus physical aggression showed a very small positive association with sufficient leisure-time physical activity in the overall sample (aOR = 1.02, 99%CI: 1.01-1.03).

Table 3. Crude (cOR) and adjusted (aOR) analysis of associations between clusters of aggressive behaviors and the level of leisure-time physical activity (≥ 300 min/week) among Brazilian adolescent students. Brazil, PeNSE 2019 (N = 157 921 adolescents).

Clusters of aggressive behaviors	Crude analysis (cOR[a], 99%CI[c])						Adjusted analysis (aOR[b], 99%CI)					
	All sample (N = 157 921)		Boys (N = 77 650)		Girls (N = 80 271)		All sample (N = 157 921)		Boys (N = 77 650)		Girls (N = 80 271)	
Physical aggression + rejection												
Absence	Ref[d]		Ref		Ref		Ref		Ref		Ref	
Presence	0.89*	(0.89-0.90)	0.94*	(0.93-0.95)	0.84*	(0.83-0.86)	0.92*	(0.92-0.93)	0.99*	(0.97-0.99)	0.88*	(0.86-0.89)
Bullying + rejection												
Absence	Ref		Ref		Ref		Ref		Ref		Ref	
Presence	0.81*	(0.81-0.82)	0.94*	(0.93-0.95)	0.94*	(0.93-0.95)	0.85*	(0.84-0.85)	1.00	(0.99-1.01)	0.97*	(0.96-0.98)
Bullying + physical aggression												
Absence	Ref		Ref		Ref		Ref		Ref		Ref	
Presence	1.03*	(1.03-1.04)	1.00	(0.99-1.01)	0.97*	(0.96-0.99)	1.02*	(1.01-1.03)	1.00	(1.00-1.01)	0.98*	(0.97-0.99)

Source: Prepared by the authors from data from the Brazilian Institute of Geography and Statistics (15).
* = p < 0.001.
[a] cOR = crude odds ratio: model including each aggressive-behavior cluster pair as the independent variable.
[b] aOR = adjusted odds ratio: model adjusted for school age, maternal education, grade, geographic region, school administrative status, number of physical education classes, physical activity during commuting and physical education classes, and the interaction term between commuting physical activity and physical education classes.
[d] Ref = absence of each aggressive-behavior cluster pair. The dependent variable was sufficient leisure-time physical activity, defined as ≥300 min/week.

In boys, only physical aggression plus rejection was associated with lower odds of sufficient leisure-time physical activity after adjustment (aOR = 0.99, 99%CI: 0.97-0.99), although the magnitude was close to the null. In girls, all cluster pairs were associated with lower odds of sufficient leisure-time physical activity: physical aggression plus rejection (aOR = 0.88, 99%CI: 0.86-0.89), bullying plus rejection (aOR = 0.97, 99%CI: 0.96-0.98), and bullying plus physical aggression (aOR = 0.98, 99%CI: 0.97-0.99). Overall, several statistically significant associations had small magnitudes and should be interpreted with attention to effect size, not only p-values.

4. DISCUSSION

This study evaluated the clustering of aggressive behaviors and their association with leisure-time physical activity among Brazilian adolescent students. Three main findings emerged. First, bullying, physical aggression, and rejection clustered in the overall sample and in both sexes, with the simultaneous occurrence of all three behaviors being substantially higher than expected. Second, cluster pairs involving rejection were generally associated with lower odds of sufficient leisure-time physical activity, particularly in the overall sample and among girls. Third, although several associations were statistically significant, some effect sizes were small, which is expected in large population-based samples and requires cautious interpretation.

The high O/E ratios for the simultaneous occurrence of bullying, physical aggression, and rejection indicate that adolescents reporting one form of victimization were not randomly distributed across the remaining forms. Rather, aggressive experiences tended to concentrate in specific behavioral patterns. In the overall sample, bullying plus rejection showed the highest O/E among cluster pairs, whereas bullying plus physical aggression showed the highest O/E among boys and girls. This suggests that peer victimization among adolescents should not be understood only as isolated events. In school contexts, bullying, physical aggression, and rejection may reflect overlapping peer dynamics involving social vulnerability, group status, exclusion, and repeated exposure to unsafe interactions.

Although studies specifically examining clusters of aggressive victimization among school adolescents remain scarce, related evidence helps contextualize these findings. Pascual-Sagastizabal *et al*. identified clusters based on anger, empathy, aggression, cortisol, and testosterone among school-aged children.[14] Belgrave *et al*. described profiles combining prosocial and aggressive behaviors among adolescents, showing that poorly adjusted profiles were characterized by higher aggressive behaviors and lower prosocial behaviors.[18] In addition, Romeiro et al. found that physical aggression among Brazilian 9th-grade students was associated with several behavioral and psychosocial factors, including illicit drug use, alcohol consumption, smoking, unexcused school absences, physical inactivity, insomnia, loneliness, perceived insecurity at school

and at home, and family aggression.[19] Taken together, these studies suggest that aggressive behaviors and victimization experiences may be embedded in broader psychosocial and developmental risk patterns, rather than occurring as isolated events.

The clustering of aggressive behaviors observed in this study is consistent with broader evidence that adolescent health and risk behaviors often co-occur. Previous studies have shown clustering of obesogenic behaviors,[10] cardiovascular risk factors,[11] and substance use, including cigarettes and alcohol,[12] among adolescents. From a developmental psychiatry perspective, this co-occurrence may reflect broader psychosocial vulnerability during a period marked by sensitivity to peer evaluation, identity formation, emotional regulation challenges, and increased exposure to risk behaviors. Therefore, aggressive-behavior clusters should not be interpreted only as school-discipline problems, but also as potential markers of developmental and social vulnerability that may require integrated prevention strategies.[20-22]

Regarding the relationship between aggressive behaviors and physical activity, the present findings are partially aligned with previous evidence. A meta-analysis by García-Hermoso *et al*. reported that not meeting physical activity recommendations was associated with greater bullying victimization, although sex-stratified analyses did not show significant associations among either girls or boys.[23] The present study adds to this literature by suggesting that the relationship between peer victimization and leisure-time physical activity may depend not only on isolated aggressive behaviors, but also on how these behaviors co-occur. This distinction is relevant because adolescents exposed to multiple forms of victimization may experience different social and emotional barriers to physical activity than those exposed to a single behavior.

The association analyses showed that cluster pairs involving rejection were generally associated with lower odds of sufficient leisure-time physical activity. In boys, only physical aggression plus rejection remained associated with lower odds after adjustment, and the magnitude was close to the null. In girls, all cluster pairs were associated with lower odds of sufficient leisure-time physical activity, although some estimates were also small. These findings reinforce the

importance of interpreting both statistical significance and effect size, particularly in large population-based samples.

The small positive association between bullying plus physical aggression and sufficient leisure-time physical activity in the overall sample should be interpreted cautiously. This result should not be understood as evidence that this cluster promotes physical activity. Previous literature has suggested a complex, and sometimes positive, relationship between participation in physical activity and aggressive behaviors,[9,24] with relevant differences between sexes.[25] Team and contact sports, such as soccer and wrestling, may create contexts in which peer interaction, competition, and physical contact increase opportunities for aggressive exchanges.[6] These activities also appear to be more common or preferred among boys,[26] and physically active boys may be more likely to be simultaneously victims and perpetrators of aggressive behaviors, especially bullying and physical aggression.[25] Therefore, the small positive association observed in the overall sample may reflect residual confounding, sex-specific patterns, or characteristics of some physical activity contexts, rather than a protective or causal effect of aggressive-behavior clustering.

This interpretation may also help explain why some associations between aggressive-behavior clusters and physical activity were weaker or absent among boys. Social norms related to peer status, group acceptance, and hegemonic masculinity may contribute to the normalization of some aggressive interactions in physical activity contexts.[27] However, this explanation remains hypothetical because the present study did not assess the type of physical activity, sport modality, supervision, competitive context, or whether adolescents were victims, perpetrators, or both in the same peer environments.

In girls, all aggressive-behavior cluster pairs were associated with lower odds of sufficient leisure-time physical activity. This pattern may be related to the social and relational nature of some forms of aggression. Moretti *et al*. emphasized that aggression is not limited to physical acts and may include more hidden forms that harm peers, such as social exclusion, public humiliation, and rejection.[4] National evidence also indicates that girls are increasingly involved in several aggressive behaviors,[1] although they appear to engage more frequently in relational aggression than in physical aggression.[2,4,28] In this context, clusters

involving rejection may be particularly relevant for understanding girls' participation in leisure-time physical activity, especially when such activities depend on peer acceptance, group belonging, and perceived social safety. Although girls may be more vulnerable than boys to the effects of interventions aimed at changing aggressive-behavior profiles,[9] they also seem to be frequent targets of several types of aggressive behavior.[7] This finding is concerning because girls are more likely to engage in lower levels of physical activity and to experience depressive symptoms than boys.[29]

The direction of the association between aggressive-behavior clusters and leisure-time physical activity cannot be established because of the cross-sectional design. One possibility is that exposure to multiple forms of victimization reduces adolescents' willingness to participate in leisure-time physical activity, especially when these activities require peer interaction. Conversely, adolescents who are less physically active may have fewer opportunities for social integration, potentially increasing vulnerability to rejection or bullying. A third possibility is that both victimization and physical inactivity share upstream determinants, such as school climate, family adversity, depressive symptoms, body image concerns, social isolation, or peer network position. Thus, the present findings should be interpreted as evidence of clustering and association, not causation.

These findings have practical implications for schools, families, and public health policies. Because aggressive behaviors clustered rather than occurring only in isolation, prevention strategies should address multiple forms of peer victimization simultaneously, including bullying, physical aggression, verbal aggression, social exclusion, rejection, and discriminatory behaviors.[30] School-based physical activity programs may be useful settings for prevention when they are structured around supervision, inclusion, cooperation, respect for diversity, and clear anti-bullying norms. Examples include cooperative games, supervised team sports with explicit prosocial rules, non-contact group activities, dance, martial arts taught with an emphasis on self-regulation rather than domination, and inclusive recreational programs adapted for students with different skill levels. Families should also be involved through guidance on recognizing signs of peer exclusion, encouraging participation in safe and enjoyable physical activities from childhood, and communicating with schools when victimization is

suspected. However, because this study is cross-sectional, these recommendations should be interpreted as public health implications, not as evidence that physical activity alone prevents aggressive behaviors.

This study has limitations. Despite the robust sample, the findings apply only to adolescents enrolled in PeNSE 2019, limiting extrapolation to the general adolescent population, particularly school dropouts. The cross-sectional design restricts causal inference between victimization by aggressive behaviors and physical activity. Moreover, data were based only on victims' reports rather than aggressors' reports, which may differ by sex.[25,31] The study also could not identify a minimum aggressor profile, although previous evidence highlights male sex, greater height, older age, and increased strength as common characteristics.[32] Cyberbullying was not assessed, despite its association with physical activity and co-occurrence with other aggressive behaviors in adolescents.[33,34] Additional limitations should be considered. First, dichotomizing the aggressive-behavior variables may have reduced the dimensional nature of victimization experiences and prevented the assessment of dose-response patterns. Adolescents reporting one episode were grouped with those reporting repeated victimization. Second, the observed/expected approach captures excess occurrence of predefined behavioral patterns, but it does not identify latent subgroups of adolescents as would be possible with latent class analysis. Third, the physical activity measure did not capture the type, intensity, social context, supervision, or perceived safety of leisure-time activities, which may be particularly relevant for interpreting sex-specific associations. Finally, given the large sample size, statistically significant associations with odds ratios close to 1 should be interpreted cautiously in terms of practical significance.

5. CONCLUSION

Bullying, physical aggression, and rejection clustered among Brazilian adolescent students, indicating that aggressive behaviors were more likely to occur in combined patterns than expected. Cluster pairs involving rejection were generally associated with lower odds of sufficient leisure-time physical activity, particularly among girls. In boys, associations were less consistent and generally closer to the null. These findings suggest that school-based and public health

interventions should address multiple forms of peer victimization simultaneously and promote safe, inclusive, and supervised opportunities for physical activity. Longitudinal studies are needed to clarify the direction of these associations and to determine whether reducing aggressive-behavior clusters can improve adolescents' participation in physical activity.

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Conflict of Interest

The authors have no conflicts of interest to disclose.

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