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ORIGINAL RESEARCH

Effects of Implementing 15-Minute Physical Exercise Sessions During Physical Education Classes on Physical Fitness and Anthropometric Indicators in Rural Adolescents

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Background: The prevalence of overweight, obesity, and low physical fitness is associated with minimal engagement in physical exercise (PEx) and has increasingly affected children and adolescents in rural areas. This study examines the effects of a 15-minute PEx intervention on the levels of physical fitness and anthropometric indicators of overweight and obesity among rural school students. ***Methods:*** A total of 245 school students (135 boys and 110 girls), aged between 11 and 17 years, were randomly allocated into intervention and comparator groups. The intervention lasted for 12 weeks, comprising 24 PEx sessions. Physical fitness was measured through cardiorespiratory fitness, muscular strength/endurance, handgrip strength, lower limb power, flexibility, speed, and agility. The measured anthropometric indicators of overweight and obesity included body mass index, waist circumference, and the sum of subscapular and triceps skinfolds. ***Results:*** Generalized estimating equations analysis, performed with an intention-to-treat approach, indicated significant group × time interaction ($P < .05$) for flexibility, muscular strength/endurance, handgrip strength, cardiorespiratory fitness (only for boys), and waist circumference. For these 5 variables, there were no differences between groups at the baseline ($P > .05$), and the intervention group showed significantly greater improvements compared with the comparator group at the postintervention time ($P < .05$). ***Conclusion:*** An intervention program consisting of 15 minutes of PEx during PE classes, conducted twice a week for 12 weeks, improves cardiorespiratory fitness, flexibility (only for boys), muscular strength/endurance, handgrip strength, body mass index (only for girls), and waist circumference of rural adolescent school students.

Keywords: intervention, school students, fitness assessment, obesity

Key Points

- 15 minutes of moderate to vigorous physical exercises during physical education classes improve the physical fitness of adolescent students.
- Implementing 15 minutes of physical exercises during physical education classes can help control the anthropometric indicators of obesity in adolescents.
- Implementation of intervention programs by physical education teachers is promising for improving the health markers of adolescent students.

The prevalence of overweight, obesity, and low physical fitness (PF) in children and adolescents has been increasing globally,[1,2] with Brazil following the same trend.[3,4] This situation is concerning, as these conditions are associated with the development of several health problems both during adolescence and later in adulthood.[1,5–9]

Prevention of overweight and obesity and improving adolescents' PF involves multiple factors, with physical exercise (PEx) playing a vital role in this process. There is a need to increase opportunities for physical activity within this population. From this perspective, schools, and particularly physical education (PE) classes, are ideal settings for implementing intervention programs aimed at preventing overweight and obesity and promoting PF.[10,11] In addition to improving students' health markers, implementing interventions in PE classes can improve the quality of the class itself.[11] These intervention programs besides improved recent meta-analyses have shown that implementing various moderate to vigorous intensity PEx programs during PE classes leads to improvements in anthropometric indicators of overweight and obesity (AIO) and the PF of students.[11]

Although the results of PEx programs implemented during PE classes are promising in improving AIO and PF of students,[11] it is essential to consider that PE is responsible for a range of other content associated with developing various skills and competencies related to human movement culture. Therefore, using the entire class period for

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these programs may limit their practical application in school PE. In this regard, some studies have tested the effects of PE programs conducted during only part of the PE class (10–15 min), suggesting that this strategy can be effective in improving AIO and PF.[12–19]

Despite the positive results found in previous studies, methodological limitations did not report sample size calculations,[12,16–19] random group allocation,[12,18] blinding of assessment teams,[12–14,16–19] or intention-to-treat analyses,[12–14,16–19] and the heterogeneity in exercise protocols indicate that further research is needed to understand better the potential of PEx programs conducted during only part of the PE class for improving PF and AIO. Moreover, few studies have simultaneously analyzed different components of PF and AIO,[15,16,18] and some results suggest that analyses should be performed by sex because there is a difference in the PF and AIO between girls and boys, which may influence the results' interpretation of the intervention programs.[16,18]

Additionally, the context in which schools are situated is another essential factor. To our knowledge, no interventions involving the incorporation of PEx into PE classes for rural students have been performed. Evidence suggests an increase in obesity and a reduction in PF within this population.[20] In Brazil, cross-sectional studies indicate that, for some components, the PF of rural students is lower than that of their urban counterparts.[21,22] This scenario suggests that interventions aimed at controlling and preventing obesity and improving PF in this population are necessary. In addition, no studies have implemented the intervention by the PE teachers themselves. This approach could increase the practical and ecological application of the intervention program. To address existing gaps and contribute to a better understanding of the effects of interventions incorporating PEx into part of PE classes, this study aimed to identify the effects of a 15-minute PEx program conducted during PE classes on PF and AIO in students from the final years of elementary school in rural areas.

Methods

Design and Setting

Our study is a parallel 2-arm experimental study, with students from sixth to ninth grades in rural elementary schools in southern Brazil randomly assigned to either an intervention group (IG) or a comparator group (CG). The intervention, a 15-minute PEx session at the start of PE classes, was implemented in accordance with the CONSORT[23] recommendations. Importantly, the study was approved by a Research Ethics Committee (protocol: 5,843,236) and registered on the Clinical Trials platform (NCT 05879900), underscoring its credibility and transparency. Detailed methodological procedures can be found in a previous publication.[24]

The study was conducted in rural education schools that operate full-time in rural areas of the municipality. Currently, there are 10 of these rural education schools, serving approximately 1380 students. Of these, 495 are enrolled in classes from the sixth to the ninth grades and are considered the study population. The municipality (Canguçu) has about 50 thousand inhabitants and is 275 km away from the capital (Porto Alegre) of the state (Rio Grande do Sul). It is characterized by the fact that the majority of its population resides in rural areas, and it is considered the largest smallholding region in Latin America, with an economy based on family farming and an emphasis on tobacco cultivation.

In this context, rural education schools have emerged with a proposal to align the primary curriculum with projects focused on the realities of rural life for students in the countryside. Rural education schools hold classes 4 days a week. The schedule is divided into 7 periods of 50 minutes each, with 3 periods dedicated to the student pedagogical construction, a planning process developed jointly by students and teachers. The students' daily routine is organized according to the local characteristics of each school, with the following structure being standard: Upon arriving at school, students receive a morning snack before classes begin; during the break between shifts, students receive lunch and have a 30-minute postlunch break; and 15 minutes before the end of the school day, students receive another snack before returning to their homes. Most students commute via municipal school transportation.

Sample and Sampling Process

The sample selection and operationalization of the study was a collaborative effort with the Municipal Secretariat of Education, Sports, and Culture, and the school administration teams. We presented the proposal and requested authorization to conduct the study, and together, we identified that each of the 10 rural education schools has a PE teacher responsible for the subject for all sixth to ninth grade classes. The PE teachers were then contacted, presented with the objectives and procedures, and invited to participate in the study.

To determine the number of participants, the sample size was calculated considering the following parameters: (1) a 2-way ANOVA for repeated measures with intragroup and intergroup interaction as the statistical test and (2) an effect size of 0.1 (low). The choice of this effect size was due to the study comprising different dependent variables, one of which is body mass index (BMI). This variable has shown low sensitivity to PEx interventions involving children and adolescents,[17] (3) a statistical significance (alpha) of .05, (4) a power (beta) of 0.80 (80%), (5) 2 groups and 2 measures, (6) a minimum correlation between repeated measures of .5, (7) a sphericity correlation of 1.0, and (8) an addition of 15% to account for potential losses and refusals. Using these parameters, the estimated sample size was 230 participants, divided into IG and CG.

Considering the sample size calculation and the information provided by school principals regarding the number of students enrolled in sixth to ninth grade classes, it was necessary to select 6 schools to participate in the study. A simple random was performed (1:1 ratio), and 3 schools were allocated to IG and the other 3 to CG. The PE teachers associated with the 6 selected schools (1 from each) agreed to participate in the study and signed the informed consent form. Subsequently, the study's objectives and procedures were presented in all the classrooms to the sixth to ninth grade students of the selected schools. The students received an informed consent form to deliver to their legal guardians and an assent form to formalize their interest in participating in the study. Interested and authorized students were included in the study and participated in the baseline measurements, the 12-week intervention (only the IG participants), and the postintervention measurements. At the end of the sampling process, 245 students from sixth to ninth grade classes of 6 rural education schools were included in the study (Figure 1).

Teachers from the schools assigned to the IG had all their sixth to ninth grade classes also allocated to the IG (total of 123 students), and the same applied to the CG (total of 123 students). The teachers in the IG were responsible for implementing the intervention program during their PE classes. To this end, they underwent an 8-hour theoretical and practical training session on the intervention program and received educational materials containing the structure and organization of the 24 sessions. Additionally, to standardize the implementation of the PEx, the IG teachers received weekly demonstration videos via an instant messaging app at the beginning of each week. The training for the IG PE teachers took place the week before the intervention started, during which the baseline data collection with the students was also conducted. The CG teachers received training in sports praxeology and were instructed to continue conducting their PE classes according to the previously developed teaching plan. After the intervention, the CG teachers (and all other PE teachers in the municipal education network) received training on the PEx intervention program.

Intervention Program

The intervention program was conducted twice a week on nonconsecutive days over 12 weeks, consisting of approximately 15 minutes of PEx involving natural body movements such as running, jumping, pulling, squatting, rotating, and pushing, with the addition of adapted weights, immediately following the warm-up session of the classes.

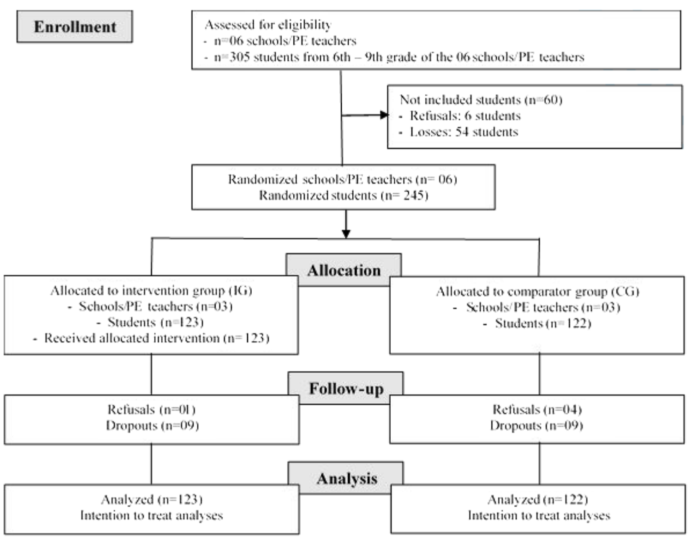

Figure 1 — CONSORT flow diagram of reporting of participant flow. PE indicates physical education.

The warm-up and the remaining class time followed the plans developed by the subject teachers and the schools' pedagogical coordination. The PEx of the intervention program were performed at stations. Students were distributed proportionally across each station. The PEx intervention was divided into 4 cycles: preparation, progression, maintenance of progression, and final progression, with the progression stages achieved by increasing the intensity, volume, and complexity of the PEx. The PEx program sessions occurred in the same spaces where the PE classes are regularly performed. Table 1 describes the intervention program over the 12 weeks according to periodization cycles, the number of stations, repetitions per station, the interval between PEx execution and station changes, and the intensity control based on perceived exertion.[25] Students received orientation about how to express their perceived exertion during the sessions of the first 3 weeks of the intervention (cycle 1—preparation). The duration of approximately 15 minutes for each PEx program session was controlled considering the number of exercise stations, the time performed at each station, the number of executions at each station, and the interval time between stations (Table 1).

Table 2 provides examples of the organization of the PEx (cardiorespiratory and muscular strength and endurance) used in the intervention, considering the progression in execution complexity. The materials used for the exercise's preformation were provided to the schools at the end of the intervention.

The classes that participated in the CG had their PE lessons according to the plan previously developed by the subject teachers and the schools' pedagogical coordination, which is part of the annual curriculum for these classes. Generally, the PE lessons for the CG classes were organized as follows: (1) an initial part (warm-up) lasting approximately 5 minutes, (2) structured games (formal or adapted) of various sports for 20 to 25 minutes, (3) exercises aimed at improving the technical skills of sports modalities (specific motor skills) for about 15 to 20 minutes, and (4) a cooldown period of approximately 5 minutes. After the intervention period ended, the CG classes also had the opportunity to perform the PEx activities to provide them with the experience and benefits of the proposed intervention activities. This experience was facilitated by training the CG teachers and other teachers in the municipal education network, who then conducted the PEx activities with the students.

Table 1 Description of the Intervention Program

Cycles	Cycle 1 Preparation	Cycle 2 Progression	Cycle 3 Maintenance of progression	Cycle 4 Final progression
Number of weeks	3 wk (weeks 1–3)	3 wk (weeks 4–6)	3 wk (weeks 7–9)	3 wk (weeks 10–12)
Number of station	4 stations	4 stations	5 stations	5 stations
Types of exercises by station	1 cardiorespiratory exercise station; 3 strength exercise stations	1 cardiorespiratory exercise station; 3 strength exercise stations	2 cardiorespiratory exercise station; 3 strength exercise stations	2 cardiorespiratory exercise station; 3 strength exercise stations
Exercise execution time	1 min	1 min	1 min	1 min
Number of executions at each station	2 executions	2 executions	2 executions	2 executions
Interval time between stations	1 min	45 s	30 s	30 s
Control exercise intensity		Borg scale—6 moderate	Borg scale—7 moderate to intense	Borg scale—8 intense

Variables

The variables in this study were organized into covariates, dependent variables, and the CG and IG as independent variables. Covariates were used for sample characterization and stratification (gender) in the statistical analysis. Sociodemographic and anthropometric information was collected. The sociodemographic variables included gender (male or female), age (difference between birth date and data collection date), and school year (sixth to ninth grade). The anthropometric variables were measured following standard procedures,[26] including height (in centimeters), body mass (in kilograms), sitting height (in centimeters), and somatic maturation. Somatic maturity was measured based on the method proposed by Mirwald et al,[27] which involves estimating the distance in years from an individual's peak growth velocity. This estimate used the variables of age, height, body mass, sitting height, and lower limb length (difference between height and sitting height).

The dependent variables were PF and AIO. PF was operationalized through the following components: cardiorespiratory fitness (CRF), muscular strength/endurance (MSE), maximum strength, lower limb power (LLP), speed (Spd), agility (Agil), and flexibility (Flex). The included AIO were BMI, waist circumference (WC), and the sum of triceps and subscapular skinfolds (Table 3).

Procedures

Preintervention and postintervention measurements were conducted by a team of evaluators consisting of undergraduate and graduate students in PE. The team underwent a 4-hour theoretical and practical in-person training on the procedures and standardization of the variables included in the study. Preintervention measurements took place 1 week before the start of the intervention at the school facilities. Anthropometric measurements were performed in designated rooms provided by the schools, and PF tests were conducted in areas used for PE practice. The same procedure was followed 1 week after the end of the intervention period. Blinding was applied to the evaluation, tabulation, and data analysis teams; however, blinding the sample was not feasible due to the study's participant group's clarity and understanding of the intervention.

Statistical Analysis

For the statistical analyses, the data were digitized using Excel software, then exported and analyzed in the SPSS statistical software package version 20.0. Initially, the normality of the distributions of the covariates numerical variables was confirmed using the Shapiro–Wilk test ($P > .05$). Numerical variables were described using the mean ($\bar{x}$) and SD, while categorical variables were described using absolute (n) and relative frequencies (%).

Table 2 Description of the Complexity of the Execution of Physical Exercises

Weeks (cycles)	Cardiorespiratory exercises	Muscular strength and endurance exercises		
		Upper limbs	Lower limbs	Trunk
Weeks 1–3 (first cycle)	Stationary running	Wall push-ups	Squat	Knee forearm plank
Weeks 4–6 (second cycle)	Suicide running	Knee push-ups	Rotational squat	Forearm plank
Weeks 7–9 (third cycle)	Zigzag running	Bench push-ups	Squat with weight carrying the backpack	Plank
Weeks 10–12 (fourth cycle)	Continue running	Push-ups	Squat plus vertical jump	Hand to shoulder plank

Table 3 Dependent Variables, Measurement Instruments, and Operationalization

Variables	Instruments	Operationalization
Dependent variables—physical fitness		
Cardiorespiratory fitness	6-min run/walk test[26]	- Distance covered during 6 min recorded in meters.
Muscular strength and endurance	1-min sit-up test[26]	- Number of complete movements performed in 1 min.
Maximal strength	Handgrip strength (dynamometer)[28]	- The best result of 3 measurements taken with both hands (left/right) for maximum handgrip strength (in kilogram-force).
Lower limb power	Long jump test[26]	- The best result of 2 attempts recorded in seconds.
Speed	20-m run test[26]	- The best result of 2 attempts recorded in seconds.
Agility	$4 \times 4\text{-m}^2$ test[26]	- The best result of 2 attempts recorded in seconds.
Flexibility	Sit-and-reach test[26]	- The best result of 2 attempts recorded in seconds.
Dependent variables—anthropometric indicators of overweight and obesity		
BMI	BMI equation[26]	- Result of the calculation of the ratio (division) between body mass and height (in meters) squared (in kilograms per square meter).
Waist circumference	Anthropometric tape[26]	- Result of the measurement taken at the midpoint between the lower edge of the last rib and the upper edge of the iliac crest in centimeters.
Subscapular and triceps skinfolds	Scientific adipmeter[29]	- They were measured by the fold of a double thickness of skin and adjacent adipose tissue in the subscapular and triceps regions, recorded in millimeters.

Abbreviation: BMI, body mass index.

The independent samples *t* test and the chi-square test were used for numerical and categorical variables to compare covariates between groups. Generalized estimating equations and the Bonferroni post hoc test were utilized to compare time (preintervention and postintervention periods) and the groups and to identify the group × time interaction. The analyses were conducted on an intention-to-treat basis to increase the study's ecological and external validity by including all participants allocated to the groups, regardless of adherence to the intervention program or participation in all measurements. The generalized estimating equations automatically imputed missing data (Bayesian stochastic regression imputation method). In addition, effect sizes were estimated using Cohen *d* and categorized as small (0.20–0.49), medium (0.50–0.79), and large (≥0.80).[30] A significance level of 5% was adopted for all statistical analyses.

Results

The characterization of the 245 study participants is presented in Table 4. The majority are male (55.1%) and in the recommended nutritional status (eutrophic 64.5%). Regarding the comparison between the IG and the CG, no significant differences were identified at the baseline for any of the variables analyzed ($P > .05$).

The results regarding the effects of the intervention on the PF of the students are presented in Table 5. The generalized estimating equations analyses for intention-to-treat indicated a significant group × time interaction ($P < .05$) for MSE, handgrip strength (HS; right and left hand), and Flex. For these 4 variables, no differences were observed between the groups at the baseline ($P > .05$). Although both the IG and the CG showed improvements over time ($P < .05$), the IG exhibited higher values compared with the CG at the postintervention stage ($P < .05$). No significant group × time interaction was found for LLP and CRF variables ($P > .05$). Agil and Spd showed a significant group × time interaction ($P < .05$). For Agil, the IG had better results than the CG at the preintervention stage ($P < .001$). Although both groups improved over time ($P < .05$), no difference was observed between the groups at the postintervention stage ($P = .874$). For Spd, the IG also performed better than the CG at the preintervention stage ($P < .001$). However, only the CG showed a significant reduction in the test execution time between stages ($P < .001$), with the difference between the groups at the postintervention stage becoming marginal ($P = .054$).

The AIO of the IG and the CG at the preintervention and postintervention moments are presented in Table 6. The effects attributed to the intervention found in the intention-to-treat analysis indicated a significant group × time interaction only for WC, where

Table 4 Characterization of Participants at the Baseline According to Sex, Age, School Year, Anthropometric Variables, and Somatic Maturation

	Total (N = 245)	IG (n = 123)	CG (n = 122)	*P*
Sex[a]				
Male, n (%)	135 (55.1)	71 (57.7)	64 (52.5)	.407
Female, n (%)	110 (44.9)	52 (42.3)	58 (47.5)	
Age ($\bar{x}$ [SD]),[b] y	13.15 (1.46)	13.17 (1.48)	13.14 (1.43)	.867
Age (complete),[a] y				
11 y, n (%)	39 (15.9)	20 (16.3)	19 (15.6)	.982
12 y, n (%)	50 (20.4)	24 (19.5)	26 (21.3)	
13 y, n (%)	42 (17.1)	22 (17.9)	20 (16.4)	
14 y, n (%)	81 (33.1)	39 (31.7)	42 (34.4)	
15 y, n (%)	19 (7.8)	11 (8.9)	8 (6.6)	
16 y, n (%)	9 (3.7)	4 (3.3)	5 (4.1)	
17 y, n (%)	5 (2)	3 (3.4)	2 (1.6)	
School year[a]				
Sixth grade, n (%)	57 (23.3)	24 (19.5)	33 (27)	
Seventh grade, n (%)	57 (23.3)	29 (23.6)	28 (23)	.558
Eighth grade, n (%)	55 (22.4)	29 (23.6)	26 (21.3)	
Ninth grade, n (%)	76 (31)	41 (33.3)	35 (28.7)	
Body weight ($\bar{x}$ [SD]),[b] kg	54.1 (14.8)	54.5 (14.9)	53.8 (14.7)	.710
Height ($\bar{x}$ [SD]),[b] cm	161.1 (11.2)	162.3 (11.3)	159.9 (11.0)	.099
BMI ($\bar{x}$ [SD]),[b] kg/m^2	20.6 (4.2)	20.4 (4.2)	20.7 (4.2)	.578
BMI classification[a]				
Low weight, n (%)	26 (10.6)	18 (14.6)	8 (6.6)	
Eutrophy, n (%)	158 (64.5)	77 (62.6)	81 (66.4)	
Overweight, n (%)	48 (19.6)	21 (17.1)	27 (22.1)	.189
Obesity, n (%)	13 (5.3)	7 (5.7)	6 (4.9)	
Somatic maturity,[b] $\bar{x}$ (SD)	0.51 (1.47)	0.48 (1.46)	0.54 (1.49)	.769

Abbreviations: BMI, body mass index; CG, comparative group; IG, intervention group.
[a]Independent samples *t* test. [b]Pearson chi-square test.

Table 5 Physical Fitness of the Intervention and Control Groups at Preintervention and Postintervention Times—Intention-to-Treat Analysis

Physical fitness components	n	Preintervention x̄	Preintervention SD	Postintervention x̄	Postintervention SD	Group P	Time P	Group × time P	Effect size
Flexibility, cm						.166	<.001	<.001	
Intervention	123	29.15	11.53	33.72	12.86				0.21
Control	122	29.03	12.39	30.80	14.41				
MSE, repetition/min						<.001	<.001	<.001	
Intervention	123	27.13	11.66	34.55	12.79				0.53
Control	122	25.89	11.55	28.06	11.61				
HS right hand, kg/F						.054	<.001	.002	
Intervention	123	29.83	14.30	32.40	14.93				0.22
Control	122	28.20	13.69	29.18	13.83				
HS left hand, kg/F						.105	<.001	.027	
Intervention	123	27.89	13.73	29.49	15.16				0.17
Control	122	26.41	12.96	27.06	12.79				
LLP, cm						.019	<.001	.194	
Intervention	123	145.77	43.12	150.88	43.02				0.24
Control	122	139.24	37.54	141.43	34.88				
CRF, m						.396	.001	.107	
Intervention	123	885.34	238.29	923.45	238.77				0.13
Control	122	880.36	248.55	894.26	224.70				
Agility, s						.066	<.001	<.001	
Intervention	123	7.07	0.75	6.85	0.92				0.01
Control	122	7.35	1.02	6.84	0.85				
Speed, s						<.001	<.001	<.001	
Intervention	123	3.98	0.67	3.93	0.67				0.18
Control	122	4.34	0.74	4.05	0.66				

Abbreviations: CRF, cardiorespiratory fitness; HS, handgrip strength; LLP, lower limb power; MSE, muscular strength/endurance.

Table 6 AIO in the Intervention and Control Groups at Preintervention and Postintervention Times—Intention-to-Treat Analysis

AIO	n	Preintervention x̄	Preintervention SD	Postintervention x̄	Postintervention SD	Group P	Time P	Group × time P	Effect size
BMI, kg/m^2						.452	<.001	.055	
Intervention	123	20.47	5.95	20.79	5.79				0.09
Control	122	20.77	5.95	21.29	5.95				
WC, cm						.157	<.001	<.001	
Intervention	123	71.84	15.34	72.92	15.18				0.21
Control	122	72.92	17.37	76.46	17.84				
∑SF, mm						.114	<.001	.195	
Intervention	123	23.76	17.06	23.08	16.12				0.12
Control	122	26.49	18.31	25.05	15.18				

Abbreviations: AIO, anthropometric indicators of overweight and obesity; BMI, body mass index; ∑SF, sum of triceps and subscapular skinfolds; WC, waist circumference.

the CG showed a more significant average increase compared with the IG (3.5 cm vs 1.5 cm). The results for BMI ($P = .055$) and the sum of triceps and subscapular skinfolds ($P = .195$) did not show a significant group × time interaction.

When the analyses were performed by sex, some changes were observed in the total sample results. For Flex and HS of the left hand, the significant group × time interaction remained only for boys ($P < .01$ for both). For Agil, the significant group × time interaction remained only for girls in which the IG had better results than the CG at the preintervention time ($P < .01$), and only CG improved over time ($P < .01$), with no difference between the groups at the postintervention time ($P = .197$). CRF and BMI, which did not show any significant group × time interaction in the analyses with the total sample, began to show significant interaction effects ($P < .05$) in the analysis by sex. For CRF, boys in both groups showed no differences at preintervention ($P = .709$), and only the boys in the IG improved ($P < .001$) at postintervention. For BMI, girls in both groups showed no differences at preintervention ($P = .525$), and only those from CG showed a significant increase at postintervention ($P < .001$; Table 7).

Discussion

Our study analyzed the effects of a 15-minute PEx intervention implemented during PE classes on the PF and AIO of adolescents in the final years of elementary school in rural areas. The main results showed positive effects attributed to the intervention protocol on CRF, Flex (both only for boys), MSE, HS, WC, and BMI (only for girls) among participants in the IG compared with the CG. Our findings reinforce the feasibility of incorporating 15 minutes of moderate to vigorous PEx during PE classes as an effective alternative to improve adolescents' PF. PF is associated with various health markers during adolescence and later in

Table 7 Physical Fitness and Anthropometric Indicators of Overweight and Obesity of the IG and CG at Preintervention and Postintervention Times, by Sexes—Intention-to-Treat Analysis

	Male (IG: n = 71/CG: n = 64)					Female (IG: n = 52/CG: n = 58)				
	Preintervention		Postintervention			Preintervention		Postintervention		
	$\bar{x}$	SD	$\bar{x}$	SD	ES	$\bar{x}$	SD	$\bar{x}$	SD	ES
Flexibility, cm										
Intervention	27.93	8.43	32.27[a,b,c]	9.61	0.69	30.81	8.36	35.70[b]	8.00	0.00
Control	26.13	7.68	26.21	9.04	32.19	8.776	35.72[b]	8.83		
MSE, repetition/min										
Intervention	29.83	7.84	37.21[a,b,c]	9.27	0.74	23.44	7.38	30.90[a,b,c]	7.34	0.79
Control	28.83	8.32	30.53	8.72	22.64	6.62	25.35[b]	6.67		
HS right hand, kg/F										
Intervention	33.35	11.31	36.22[a,b,c]	11.40	0.39	25.02	5.33	27.16[b,c]	6.21	0.13
Control	30.72	11.73	31.70	11.85	25.41	5.46	26.41[b]	5.59		
HS left hand, kg/F										
Intervention	31.32	10.62	33.59[a,b,c]	11.71	0.37	23.21	5.34	23.86	5.29	–0.12
Control	28.73	10.90	29.40[b]	10.92	23.84	5.68	24.47	5.21		
LLP, cm										
Intervention	157.77[a]	28.19	166.16[a,b]	26.05	0.55	129.38	25.75	129.99	22.35	0.04
Control	147.31	27.50	152.81[b]	22.62	130.33	22.15	128.87	20.46		
CRF, m										
Intervention	941.97	251.08	1005.21[b,c]	142.87	0.27	808.02	125.96	812.10	131.54	–0.02
Control	953.09	171.15	966.02	147.65	800.10	141.86	815.10	131.28		
Agility, s										
Intervention	6.90	0.49	6.58[b]	0.72	–0.08	7.32[a]	0.49	7.21	0.61	0.25
Control	7.05	0.58	6.63[b]	0.53	7.69	0.70	7.06[b,c]	0.58		
Speed, s										
Intervention	3.80[a]	0.45	3.72[a]	0.40	–0.41	4.23[a]	0.40	4.22	0.42	–0.07
Control	4.17	0.46	3.88[b,c]	0.38	4.52	0.53	4.25[b,c]	0.46		
BMI, kg/m^2										
Intervention	20.56	4.53	20.98[b]	4.47	–0.04	20.35	3.61	20.52[c]	3.53	–0.25
Control	20.76	4.72	21.16[b]	4.72	20.79	3.66	21.43[b]	3.73		
WC, cm										
Intervention	74.35	11.54	75.41[b,c]	11.21	–0.20	68.42	8.80	70.57[b,c]	9.66	–0.41
Control	74.93	13.84	77.97[b]	14.08	70.70	9.75	74.76[a,b]	10.51		
$\sum$SF, mm										
Intervention	22.75	12.64	21.21	12.47	–0.18	26.52	10.67	25.65	9.16	–0.14
Control	24.83	14.56	23.34	11.68	27.23	10.89	26.96	9.44		

Abbreviations: BMI, body mass index; CG, comparative group; CRF, cardiorespiratory fitness; ES, effect size; HS, handgrip strength; IG, intervention group; LLP, lower limb power; MSE, muscular strength/endurance; $\sum$SF, sum of triceps and subscapular skinfolds; WC, waist circumference.
[a]Effect on group ($P < .05$). [b]Effect on time ($P < .05$). [c]Group × time interaction ($P < .05$).

adulthood.[7–9,22,24,25] Thus, improving of these components constitutes an essential means of disease prevention, health protection, and health promotion for this population in the short, medium, and long term.

Among PF components, CRF has the most evidence of benefits associated with various health markers during adolescence.[7,8] In our study, the effects of the intervention on CRF were found only in the sex-stratified analysis, with boys in the IG showing improvements compared with their peers in the CG. Previous studies[14–16,18] demonstrated that interventions including PEx as part of PE classes (up to 15 min) significantly improve students' CRF. Two of these studies[16,18] performed sex-stratified analysis and found positive effects on CRF in both boys and girls. Some reasons might be speculated that our PEx intervention did not affect the CRF of girls. Maybe the total volume of the PEx intervention in general and for specific aerobic exercises was not enough to improve CRF for girls. PEx interventions with longer periods, as conducted by Oliveira et al[16] and Pedretti et al,[18] may be necessary for girls' CRF improvement. Despite methodological differences among the studies, such as the duration of the intervention, the method of CRF measurement, the content and format of the exercises included in the intervention programs, and sample characteristics (number of participants, age, and the inclusion or exclusion of boys and girls), suggest that interventions consisting of moderate to vigorous intensity PEx conducted as part of PE classes can be effective in improving CRF.

Evidence from observational studies indicates that muscular fitness during adolescence is associated with adiposity, cardiometabolic health, bone health, and mental health during this period of life and later in adulthood.[7,9,31–34] The results of our intervention showed positive effects on MSE and HS of the participants in the IG compared with those in the CG. Along with results from previous studies[11,12,16,18] that also found improvements in muscular strength indicators, our findings reinforce the inclusion of PEx as part of school PE classes as a feasible and effective alternative for improving strength indicators in adolescents.

Flex is also a component of muscular fitness. However, it has been less analyzed than indicators of muscular strength in studies on the effects of PE interventions during school PE classes on students' PF.[11] Perhaps its inclusion in few studies can be explained by it being a component of PF in which its decline is less perceived for carrying out activities of daily living during adolescence compared with other age groups, such as the elderly, in which the reduction in Flex is associated with functional impairments.[35] Nevertheless, including this component as an outcome in such studies should be considered, as evidence suggests its association with lower back pain.[31,36,37] Previous studies have found improvements in Flex among participants in their interventions.[12,16,18] These results are important as they indicate that a PEx program conducted as part of PE classes can effectively improve the Flex of students. As found in previous studies,[12,16,18] we also found that, after the intervention period, participants in the IG showed more significant improvements in Flex than in the CG. This result remained only for boys in the sex-stratified analysis, while girls from both IG and CG improved Flex over the intervention time. These results suggest that PE classes structured with a warm-up, the practice of technical skills of sports, sports games, and a cooldown can effectively improve Flex in girls; but for boys, including PEx to improve this fitness component is necessary.

LLP was the only component of PF analyzed in the present study that did not show an effect attributable to the intervention, both in the analysis involving all participants and in the sex-stratified analysis. Although some previous studies have found improvements in this component after their intervention periods,[12,14] similar to what was found in the present study, other intervention programs also did not result in changes in LLP,[15] even when organized to improve bone health and consisting of different jumping exercises.[13] However, it is important to highlight that boys of both IG and CG improved LLP from preintervention to postintervention time, and although there was no significant group × time interaction, the magnitude of this improvement was higher for IG than CG, suggesting that the structured of the PE classes used in the CG can be effective to improve LLP in boys, but the inclusion of PEx during part of the classes can increase this improvement.

Contrary to our hypothesis, Spd and Agil showed more significant improvements for the CG than for the IG after the intervention period. Several hypotheses can be considered to explain these results. The 2 variables were the only ones where the baseline groups were different, with IG participants having better initial results, which could impact the postintervention outcome. The second hypothesis is that more than the number of stimuli with exercises involving maximum Spd displacement and changes in direction included in the intervention program may have been needed to enhance these components in the IG. The final hypothesis pertains to the structure and content of the PE classes during the intervention period. Including 15 minutes of PEx after the warm-up in the IG classes caused changes in the structure of the content. The classes in both groups focused on teaching team sports, organized in 2 parts: one with more time allocated for exercises of specific skills of each sport (passing, kicking, and dribbling; analytical–synthetic method) and the second part dedicated to formal or adapted games (global method). In the IG classes, the time allocated for sports skills exercises was maintained, while the time allocated for games was reduced. Team sports games have physical characteristics such as rapid direction changes and short-distance displacements at maximum Spd, stimulating the improvement of Agil and Spd.[38–40]

When analyzing the results related to AIO, intervention effects were observed for WC. In the sex-stratified analysis, the results for WC remained in both boys and girls, and BMI intervention effects were observed in girls. Previous studies have also not found changes in BMI and body fat markers after the intervention period,[13–16,18] indicating that AIO are less sensitive to PEx interventions as part of PE classes than PF indicators. Our sample composition might have influenced these results as about two-thirds were eutrophic participants. Regarding WC, both IG and CG showed increases in average values. This result was expected as it is associated with the natural physical growth process during adolescence. However, participants in the CG group showed a higher mean increase than those in the IG group, indicating that the intervention program reduced the increase in central fat in IG participants. A similar result was found in an intervention study that included moderate to vigorous PEx during part of PE classes conducted over 9 months with a sample of only girls.[14] These results are essential because WC is related to visceral abdominal adiposity, which is strongly associated with obesity and cardiometabolic problems,[41] suggesting that moderate to vigorous intensity PEx interventions conducted during part of PE classes can contribute to preventing of abdominal obesity.

Although the results found in our study have also been observed in previous studies, specific characteristics related to practical and methodological applications contribute to a better understanding of the contribution of PEx as part of PE classes to improve PF and AIO in students. Our study was designed with practical applicability to the school context, and several strengths can be highlighted. The first is to conduct the study with students from rural areas. The increase in obesity and the reduction in PF[3,4] indicate the need for attention to health in this population. The involvement of PE teachers from the schools in conducting the intervention empowers these professionals regarding the intervention program, increasing the likelihood of the PEx being maintained even after the study concludes, which is a significant strength of our study. In this perspective, some evidence[42,43] has shown that interventions conducted by school PE teachers contributed to increasing levels of moderate to vigorous physical activity, indirectly contributing to improvements in cardiometabolic, musculoskeletal, and psychosocial health indicators.

Another strength associated with the implementation and adaptation to the school environment was structuring the intervention program, which primarily used students' body mass as the primary strategy for load-bearing in the PEx. It utilized minimal materials such as polyethylene terephthalate plastic bottles, broom handles, ropes, and the students' backpacks. Supporting the methodology adopted for structuring our intervention program, a meta-analysis of school-based intervention studies aimed at increasing physical activity among adolescents aged 10–19 years concluded that it is necessary to develop sustainable and easily applicable intervention programs within the school context to improve PF levels.[44] One notable strength regarding practical application was the organization of execution time, the intervals between sessions, the progression, and the intensity of the PEx in our intervention proposal, which allowed for the maintenance of other curricular content during classes.

Regarding methodological characteristics, our study exhibits several strengths that mitigate the risk of bias and address gaps in previous research. The calculation of sample size, random allocation of groups, blinding of the evaluation team, data entry, tabulation and analysis, and implementation of intention-to-treat analyses are features that enhance the methodological quality and confer both internal and external validity to our study.

Despite the numerous strengths of our protocol, it is important to recognize that the implementation of the intervention program by the PE teachers in the IG may have been a limitation. Although quality control measures were in place, it may not be possible to ensure that the program was executed precisely as planned throughout all 24 sessions. Future studies may consider a qualitative approach to understand the implications of the intervention program on the teachers' and students' perceptions. This information may help provide a better understanding of the difficulties and positive points of the intervention from teachers' and students' perspectives, contributing to the improvement of the practical application of future PEx intervention programs. As mentioned above, including 15 minutes of PEx after warm-up changed the classes' content organization of the IG compared with CG. Specifically, participants from IG had about 15 minutes less involvement in sports games than the CG. As these activities require different, highly intense movements (sprints, sprints with direction change, jumping, etc), maybe the improvements for IG participants could be bigger if they instead insert the PEx intervention during the PE classes; it would be an additional time on classes. Nevertheless, these limitations are inherent to the methodological model we adopted, which was selected to prioritize the practical and ecological application of the intervention program, thereby enhancing its real-world relevance.

Conclusion

Including 15 minutes of moderate to vigorous PEx performed twice a week during PE classes in elementary school students from rural areas was effective in improving CRF and Flex in boys; MSE, HS, and WC in both sexes; and BMI in girls.

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