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Effects of ActTeens intervention on physical activity and health indicators in Brazilian adolescents: a pilot study

Efeitos da intervenção ActTeens sobre atividade física e indicadores de saúde em adolescentes brasileiros: um estudo piloto

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ABSTRACT

Objective**:** To evaluate the effect of 12 weeks of the ActTeens program on physical activity (PA) practice at different intensities, health-related physical fitness, and cardiometabolic indicators in Brazilian adolescents. Methods: The sample comprised 55 adolescents (37.5% female; mean age 13.84 [0.62]years) from two secondary private schools were included and divided by simple randon allocation into intervention (IG = 31 students) or control group (CG = 24 students). This pilot study of the ActTeens Program was conducted during the COVID-19 pandemic restrictions and included three components: (1) structured PA sessions delivered within Physical Education, (2) self-monitoring plus goal setting by a pedometer, and (3) healthy lifestyle guidance (mHealth). PA was assessed using Actigraph hip-worn accelerometer (model GT3X+), muscular fitness was mensured by 90-push-up, sit-to-stand, and Cardiorespiratory fitness was assessed using the 20-m PACER shuttle run test, following standardized procedures, as well as cardiometabolic profile indicators (glucose; blood pressure and waist circumference). Intragroup analyzes were performed using generalized estimating equations, and intergroup by ANCOVA using the intention-to-treat principle with adjustment for the covariates of age, maturation, sex, and baseline values. Results**:** Adolescents in the IG showed significant increase for moderate (mean difference: 11.2 minutes/day; 95% CI: 2.9; 21.0) and moderate-to-vigorous (mean difference: 18.9 minutes/day, 95% CI: 5.9; 32.1) PA in comparison to the CG. No effect of the intervention was observed in sencondary outcomes (physical fitness and cardiometabolic indicators). The IG presented a significant increase in muscular and cardiorespiratory fitness, and decreased blood pressure after 12 weeks of the intervention. Conclusion: The strategies used in the ActTeens intervention were effective to promote the increase in PA and improve physical fitness in these adolescents during the COVID-19 pandemic.

Keywords: Intervention; Students; Lifestyle; Physical exercise; Accelerometry.

RESUMO

Objetivo: avaliar o efeito de 12 semanas do programa ActTeens sobre a prática de atividade física (AF) em diferentes intensidades, aptidão física relacionada à saúde, e indicadores cardiometabólicos em adolescentes brasileiros. Métodos: A amostra foi composta de 55 adolescentes (37,5% feminino; média de idade 13,84 (0,62) anos) de duas escolas particulares de ensino fundamental, divididos por meio da alocação aleatório simples em grupo intervenção (GI = 31 estudantes) ou controle (GC = 24 escolares). Este estudo piloto do ActTeens Program foi conduzido durante a restrição da pandemia COVID-19 e incluiu três componentes: (1) sessões estruturadas de AF nas aulas de Educação Física; (2) auto-monitoramento associado com estabelecimento de metas diárias; (3) orientação sobre um estilo de vida saudável (mHealth). A AF foi avaliada usando o acelerômetro de quadril Actigraph (modelo GT3X+) e aptidão muscular foi avaliada através do teste de flexão de 90^0 e o teste sentar e levantar, a aptidão cardiorrespiratória foi mensurada por meio do teste Pacer de 20-m seguindo os procedimentos padronizados, bem como indicadores de perfil cardiometabólico (glicose, pressão arterial e circunferência de cintura). As análises intragrupos foram realizadas por meio da equações de estimativas generalizadas e as intergrupos por meio do ANCOVA usando o princípio de intenção de tratar com ajuste pelas covariáveis: idade, maturação, sexo e valores da linha de base. Resultados: Os adolescentes do GI apresentaram aumentos significativos em AF moderada (média da diferença: 11,2 minutos/dia; IC 95%: 2,9; 21,0) e moderada à vigorosa (média da diferença: 18,9 minutos/dia, IC 95%: 5,9; 32,1) em comparação ao GC. Nenhum efeito da intervenção foi encontrado para os desfechos secundários (indicadores de aptidão física e cardiometabólico). O GI apresentou aumento significativo na resistência de membros inferiores, na aptidão cardiorrespiratória e redução na pressão arterial após 12 semanas de intervenção. Conclusão: As estratégias utilizadas na intervenção ActTeens foram eficaz para promover o aumento da prática de AF, melhorar a aptidão nestes adolescentes durante a pandemia COVID-19.

Palavras-chave*: Intervenção; Escolares; Estilo de vida; Exercício físico; Acelerometria.*

Introduction

The Coronavirus (COVID-19) pandemic was declared[1] in March 2020, due to the rapid spread of the SARS-CoV-2 virus. During the COVID-19 pandemic, social distancing restrictions and school closures were imposed by the government across many countries, and this severely limited adolescent's access to regular physical activity (PA) opportunities (eg, sports clubs, swimming pools, gyms,community centers, and physical education lessons), which directly impacted in PA[2].

Global data revealed that boys and girls of all ages and baseline activity levels experienced reductions in daily PA during COVID-19[3,]. Findings from Brazilian adolescents reported a reduction in the prevalence of physically active individuals from 28.7% (before the pandemic) to 15.7% (during the pandemic) and an increase in sedentary behavior (e.g., screen time and sitting activies)[4]. Similarly, a meta-analysis demonstrated that the duration of engagement in total daily PA decreased by 20% during the pandemic, in addition, this reduction was larger for PA at higher intensities, approximately 17 minutes per day[3]. Such restrictions did not only impact the level of PA since the decrease in PA in the months following the pandemic negatively affected the physical fitness of adolescents[5].

Further previous studies have also shown that low cardiorespiratory and muscular fitness levels are related to an higher risk of developing various chronic diseases (high blood pressure, hyperglycemia, and dyslipidemia)[6]. Importantly, physical fitness in childhood and adolescence has been considered a powerful predictor of health later in life[7]. As such, creating opportunities for PA practices that will promote an active lifestyle in adolescents should be one of the public health priorities.

Multicomponent PA interventions including strategies both inside and outside the school context, have found positive effects on PA levels[8,9], improving cardiorespiratory[9] and muscular fitness[10,11], skill competency[10,11], and reduction in screen time[10,11]. In Brazil, some school-based interventions have been developed with a focus on the promotion of PA in adolescents[8,12], however, most of these studies have offered predominantly aerobic activities, and included predominantly within-school strategies.

A previous review[13] investigated the impact of a variety of interventions (e.g single and multicomponent; face-to-face and online/remote) during the COVID-19 pandemic on body mass index, PA, screen time, dietary, physical fitness and mental outcomes, with all interventions including a PA component. Their results showed a significantly increased PA level in 8/23 included studies in the review, however, only one study (1/8) objectively assessed PA.

Therefore, considering the benefits of PA for health and the decrease in PA levels in adolescents during the COVID-19 pandemic, the current pilot study aimed to evaluate the effects of the multicomponent PA intervention (ActTeens Program*)* on the practice of PA at different intensities, health-related physical fitness and cardiometabolic indicators in Brazilian adolescents. It was hypothesized that the ActTeens Program intervention would be positively related to health-related physical fitness as well as with different cardiometabolic indicators.

Methods

Study design and participants

The multicomponent intervention (ActTeens Program) was evaluated via a 12 weeks randomised pilot study following CONSORT recommendations[14]. ActTeens included multiple components to promote PA and physical fitness in adolescents. This pilot study was conducted to assess the preliminary efficacy of ActTeens Program. The protocol for this pilot study was approved by the human research ethics committee of the States University of Northen of Parana, Brazil (n° 4.452.513) and registered in the protocol of Clinical Trials (NCT05070377).

The intervention was conducted in a school environment between August and November 2021, during the COVID-19 pandemic, in the second half of 2021, private schools in the state of Paraná returned to in-person learnig with some restrictions such as: maintaining distance, not sharing materials, using masks and alcohol gel. Data were collected at two-time points in the school term (baseline [July 2021] and post-intervention [December 2021]). The inclusion criteria of the schools were: (i) having classes in the eighth and ninth years of secondary school; (ii) having at least two Physical Education classes on different days; (iii) Physical Education teacher agreeing to include the structured session in the class. Of the 4 eligible schools, 2 agreed to participate in the program and were cluster randomized allocated to either a control or an intervention condition. Eligible participants were grade 8 or 9 adolescents of both sexes aged between 13–15 years. A total of 55 students from two secondary private schools were assessed for eligibility and agreed

to participate in the study. Parents provided written informed consent and adolescents provided written assent to participate. During the intervention period, two female participants withdrew from the study for personal reasons related to switching schools (Figure 1; CONSORT flow diagram).

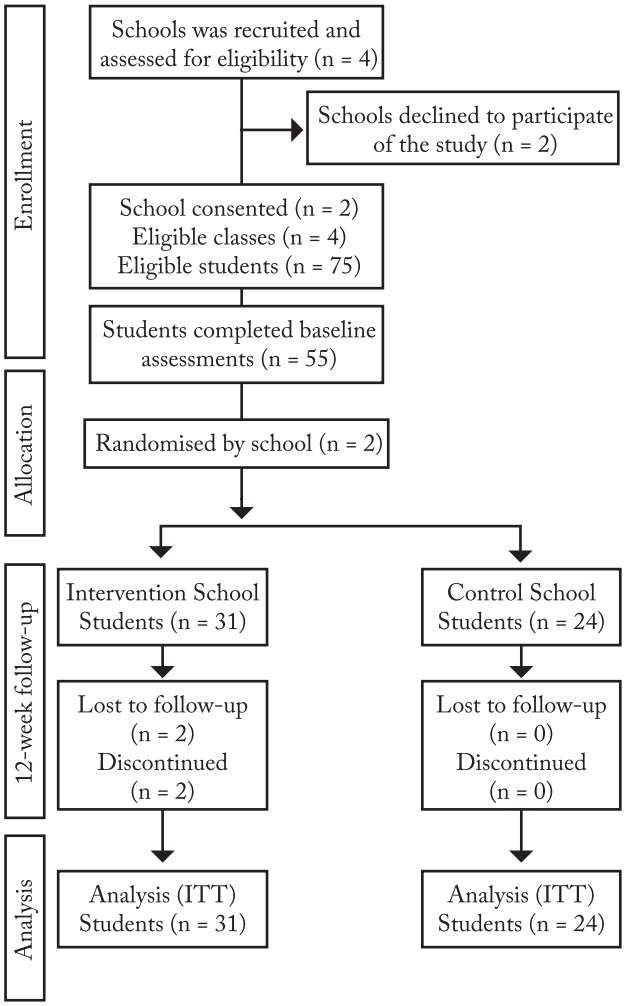

Figure 1 – Flow diagram throughout the course of the study

Intervention

The multicomponent intervention to promote PA was implemented over 12 weeks and included three components: (1) structured PA sessions delivered within Physical Education, (2) self-monitoring plus goal setting by a pedometer, and (3) healthy lifestyle guidance by via mobile health (mHealth). The strategies were guided by self-determination[15] and social cognitive theory[16].

The structured PA sessions were focused on resistance training, adapted from the Resistance Training for Teens[10] program (i.e. this pilot study did not include modified game involving fitness infusion, boxing, or core strength activity). The structured PA session was designed for satisfying participants' basic psychological needs which include autonomy, competence, and relatedness of the students, and to promote autonomous motivation and self-efficacy for PA (including resistance training). The structured PA sessions were delivered within Physical Education lessons, twice a week, for 20-minutes per lesson.

The structured PA program consisted of a combination of muscle-strengthening and aerobic exercise[10]. The session followed a specific format including i) warm-up including movement-based games and dynamic stretching; ii) Resistance training skill development; iii) high-intensity workout (resistance training plus aerobic exercise), and iv) cool-down (static stretching) with messages reinforcing healthy behavior[17]. In each session, participants were divided into small groups (between 4-5 people) and they had the autonomy to choose their exercise, within a variety of cards pre-selected by the teacher/research staff. The level of intensity for each session component was guided by Borg's rating of perceived exertion scale[18]. Thus, the classes in the intervention group (IG) were composed of the "ActTeens session" lasting approximately 20-30 minutes of the usual activities focused largely on traditional competitive team games and sports, twice a week.

To promote active behavior out of school, a pedometer plus goal setting was used for 10 weeks. Each adolescent within the IG received personalized goals (based on the number of steps measured in the baseline week) prescribed by the research team, which must be achieved weekly. These goals were predetermined following the protocol of the Kantanista study[19], with new goals (steps/days) being set and progressively delivered to students every two weeks. To encourage the increase in the number of steps/day across the week, a graph was sent via WhatsApp® for adolescents, which showed daily performance versus predetermined goals during the last week.

Guidance on healthy behavior (mHealth) was performed through weekly messages (video or infographic) by the WhatsApp® app, to both adolescents and their parents (i.e. social support). The messages were specific to promote and encourage active behavior and provide guidance on healthy eating habits[17].

Adolescents and their parents in the control group (CG) received the same messages about healthy behavior via the WhatsApp® app as the IG. However, the adolescents in the control condition continued with

their Physical Education classes as usual activities lasting approximately 50 minutes, twice a week.

Measures and data collection

All assessments were conducted in the study school by trained research assistants, who were blinded to group allocation at all time points (baseline and post-intervention). The baseline assessments were conducted before the group's allocation, and the post-intervention assessments were conducted after the end of the 12-weeks intervention program. Self-report information was assessed using specific questionnaires. Anthropometric assessments(weight, height and waist circumference) were conducted by two researchers of both sexes. Body mass was measured to the nearest 0.1 kg in light clothing without shoes using a portable digital scale (Welmy®, Santa Bárbara do Oeste, São Paulo, Brazil) and height was recorded using a portable stadiometer (Welmy®, Santa Bárbara do Oeste, São Paulo, Brazil). Body mass index was calculated according to American College of Sports Medicine[20].

The research assistants were provided a brief verbal description and demonstration of each fitness test before commencement.

Primary outcome

- Physical activity: Was assessed using Actigraph hip-worn accelerometer (model GT3X+; Pensacola, Florida, USA). Adolescents were instructed to wear the accelerometer on the hip at the height of the anterior iliac spine for seven consecutive days (except when bathing, swimming ativities, or sleeping). Raw data were sampled at 30 Hz and downloaded into 15 second epochs for analysis. Participants with three days (including one weekend) of valid wear time (at least 8 hours) or more were included in the data analysis. According to previous studies, it was defined time as "non-wear" if there was no detection of an acceleration signal for more than 60 consecutive minutes. Age-specific thresholds were used to determine time spent in PA at different intensities (light, moderate, vigorous, and moderate to vigorous)[21]. The output was expressed as average of minutes spent in moderate-to-vigorous PA, and as counts per minute, consistent with previous interventional studies[10].

Secondary outcomes

- Muscular fitness (MF): Upper body muscular endurance was assessed by using a 90-degree push-up[22] and lower body was measured by a 30 second sit-to-stand test[23]. In the 90-degree push-up test, the participant should lower their body until a 90-degree angle is formed at the elbow before pushing back up, using a cadence of 40 beats per minute. The test was concluded when the participant either fails to do a push-up in the angle required on two non-consecutive repetitions (warning verbalized by an assessor, repetitions counted), fails to maintain movement in time with the metronome, fails to maintain appropriate technique (back straight) or on the volitional failure of the test. To assess lower body muscular endurance, participants were asked to go from a sitting to a standing position and back to a sitting position for 30 seconds as many times as possible.
- Cardiorespiratory fitness (CRF): Was assessed using the 20-m PACER shuttle run test, following standardized procedures[22], which have excellent validity and reliability with a reliability coefficient of 0.78 to 0.93 in this population. A 20-m course was set up indoors on a hard surface with students instructed to run back and forth between 2 sets of lines following an accompanying audio file. Test administrators provided verbal encouragement to participants to maximize motivation. The test was terminated when the participants fail to complete two consecutive laps in the allotted time or voluntarily dropped out due to fatigue. The last successful stage was recorded and converted into the number of 20m laps completed, and the total number of laps was used to estimate maximal aerobic capacity (VO_2max) using an equation by Mahar[24].
- Cardiometabolic profile indicators**,** such as capillary fasting blood glucose was measured from finger-pick blood drops using an Accu-Chek Active monitor (Roche Diagnostics, São Paulo, Brazil). In addition, blood pressure was measured in the right arm after the subject had been sitting for at least 5 minutes using an automatic blood pressure monitor (OMRON HEN-742, São Paulo, Brazil) with cuffs according to the arm circumference of each participant, which has excellent validity and reliability in the study population[25]. Waist circumference was measured twice at the midpoint between the last rib and the iliac crest using steel tape[20].

Control variables

Biological maturation was estimated through the eval-

uation of somatic maturation by determining the distance in years of the individual from the baseline peak height velocity (PHV) using sex-specific mathematical models[26]. Adolescents were asked about their age, gender, and socioeconomic status (parent education and family income). Information on sports practice among adolescents was obtained by one question: "Do you do any sports?" in a dichotomous manner (yes or no).

Process evaluation

A detailed process evaluation was conducted and included the following: 1) reach (the number of students who agreed to participate in the program); 2) retention rate (referring to the 3-month follow-up).

Statistical Analyses

Descriptive statistic was composed of mean values and its respective standard deviations (SD) for continuous variables, and proportions for the categorical data. Prior to analysis, tests for normality were conducted on the indicators of primary and secondary outcomes. Chi-square and t-tests were used to identify the possible differences between participants within the intervention and control groups at baseline. All analyses subscribed to the intention-to-treat principle, whereby all participants were included in the analysis in the group to which they were randomized.

To evaluate the influence of the intervention program on the changes in the primary: (PA) and secondary (muscular fitness, cardiorespiratory fitness, and cardiometabolic profile indicators) outcomes, generalized estimating equations models were constructed. These are considered appropriate models for continuous response variables and repeated measures, reflecting the association between the response and the independent variables, adjusted for sex, chronological age, peak height velocity, organized sport participation, and accelerometer wearing time (only for primary outcomes). Generalized estimating equations model was constructed for each outcome variable, and the corrected quasi-likelihood under the independence model criterion was used to evaluate the fit of the model to the data. The lower the Corrected Quasi-likelihood under Independence Model Criterion, the better the fit of the model.

Analysis of covariance (ANCOVA) and adjustments for sex, chronological age, peak height velocity, and baseline values were employed to compare the effects of interventions on the primary and secondary outcomes between the groups investigated at the post-intervention moment. The Bonferroni post hoc was used to locate the differences between the means. For this latter analysis, the robustness of our result was confirmed by computing 95% confidence intervals using the bootstrapping method (1,000 re-sample). Effect sizes between groups were calculated using *Eta Squared* (h^2),The thresholds considered were: insignificant (< 0.19); small (0.20; 0.49); moderate (0.50; 0,79); and large (> 0.80). The analyses were performed using the statistical software package SPSS Version 23 (IBM, New York, NY, USA), with significance set at 5%.

Results

The baseline characteristics of the study sample can be seen in Table 1. After the 12 weeks at the initial screening, 2 adolescents dropped out for personal reasons.

The intragroup comparison for the primary and secondary outcomes is shown in Table 2. Adolescents of the IG presented higher levels of light PA (mean difference 37.6 minutes/day - 95% CI: 12.4; 62.8), as well as moderate (mean difference: 8.4 minutes/day, 95% CI: 3.8; 13.1), and moderate-to-vigorous PA levels (mean difference: 13.0 minutes/day, 95% CI: 7.8; 18.8) in comparison with baseline values.

Analyzing the individual outcomes, significantly increase in lower body muscular fitness was observed after 12 weeks of intervention (mean difference: 6.7 repetitions, 95% CI: 4.7; 8.8). For cardiorespiratory fitness, the IG presented significantly increase in the number of laps performed (mean difference: 7.2 laps, 95% CI: 3.4; 11.0) and VO_2máx. (mean difference: 2.3 mL.kg.min., 95% CI: 0.92; 3.7).

For the cardiometabolic outcomes, significant interaction (time x group) was observed in the fasting blood glucose for the CG (data not shown). For the hemodynamic variables, significant reductions were found in the IG for the systolic blood pressure (mean difference: -7.7mmHg, 95% CI: -12.3; -3.0) and diastolic blood pressure (mean difference: -10.1mmHg, 95% CI: -14.5; - 5.8).

Analyzing the primary outcome between the groups Table 3), significant intervention effect was found for the PA. The IG presented an increase in time spent in higher intensity levels of PA (moderate PA: 11.2 minutes/day) (moderate-to-vigorous PA: 18.9 minutes/day) compared with the control group. For the secondary outcomes, no significant intervention effects were found (p > 0.05).

Table 1 – Baseline characteristics of the study sample.

	Intervention group (n = 31)	**Control group** (n = 24)	**Total** (n = 55)
Age (years), mean (SD)	14.0 (0.67)	13.5 (0.43)*	13.8 (0.62)
Females, n (%)	17 (54.8)	4 (16)*	21 (37.5)
BMI (Kg/m²), mean (SD)	22.0 (3.5)	22.0 (4.9)	22.0 (4.2)
WC (cm), mean (SD)	71.7 (9.2)	70.7 (11.6)	71.3 (10.2)
PHV (years), mean (SD)	1.3 (0.91)	0.16 (0.71)*	0.83 (1.02)
Nutritional status, n (%)			
Normal weight	18 (58.1)	13 (54.2)	31 (56.4)
Overweight	13 (41.9)	11 (45.8)	24 (43.6)
Sports practice, n (%)			
Yes	11 (35.5)	15 (62.5)	26 (47.3)
No	20 (64.5)	9(37.5)*	29 (52.7)
Parent education, mother, n (%)			
Secondary education	3 (9.7)	2 (8.3)	5 (9.1)
High school	3 (9.7)	8 (33.3)	11 (20.0)
College	25 (80.6)	13 (54.2)	38 (69.1)
Parent education, father, n (%)			
Secondary education	2 (6.5)	2 (8.3)	4 (7.3)
High school	5 (16.1)	7 (29.2)	12 (21.8)
College	22 (71.0)	14 (58.3)	36 (65.5)

SD = standard deviation; n = sample; BMI = body mass index; WC = waist circumference; PHV = peak height velocity; * p < 0.05 significant difference between groups.

Table 2 – Intragroup comparison in the primary and secondary outcomes with intention-to-treat analysis.

	Intervention group		Control group	
	Baseline (n = 24)	12 weeks (n = 24)	Baseline (n = 14)	12 weeks (n = 14)
Primary outcome (n = 38)				
Light PA (minutes/day)	130.3 (116.5; 144.1)	168.0 (146.1; 189.8)*	175.7 (141.6; 209.8)	178.5 (150.0; 207.0)
Moderate PA (minutes/day)	6.4 (3.9; 9.0)	14.9 (10.8; 19.0)*	18.8 (13.4; 24.2)	16.3 (10.3; 22.2)
Vigorous PA (minutes/day)	----------	6.8 (4.4; 9.0)	6.9 (4.1; 9.7)	6.8 (3.7; 10.0)
Moderate-to-vigorou PA (minutes/day)	6.4 (4.5; 8.3)	19.5 (13.6; 25.3)*	29.0 (19.6; 38.4)	26.0 (15.4; 36.6)
	Baseline (n = 31)	12 weeks (n =31)	Baseline (n =24)	12 weeks (n=24)
Secondary outcomes (n = 55)				
Sit-to-stand (repetitions)	20.2 (18.5; 21.9)	27.0 (25.3; 28.7)*	24.0 (22.4; 25.7)	27.4 (25.2; 29.5)
Push-up (repetitions)	4.1 (2.6; 5.5)	6.1 (4.4; 7.9)	5.4 (2.5; 8.2)	5.1 (2.2; 7.9)
PACER (laps)	20.1 (17.4; 22.8)	27.3 (23,42; 31,35)*	2.9 (18.0; 27.9)	32.6 (27.1; 38.2)
$VO_{2máx}$ (mL.kg.min)	36.9 (35.9; 37.8)	39.2 (37.8; 40.6)*	38.7 (36.7; 40.6)	4.,6 (39.2; 44.0)
Fasting glucose (mg/ dL)	83.8 (79.7; 87.9)	83.5 (78.9; 88.1)	94.4 (89.9; 99.9)	75.6(71.2; 80.0)*
SBP (mmHg)	115.2 (111.6; 118.8)	107.5 (103.9; 111.0)*	116.4 (110.7; 122.1)	112.5 (108.7; 116.2)
DBP (mmHg)	71.9 (69.0; 74.9)	61.7 (59.1; 64.4)*	69.1 (63.4; 74.9)	6.,5 (60.9; 68.1)
Waist circumference (cm)	70.0 (63.5; 76.4)	69.1 (62.8; 65.3)	74.7 (55.1; 94.3)	75.0 (55.4; 94.6)

PACER = Progressive aerobic cardiovascular endurance run; VO_2máx = maximal oxygen consumption; SBP = Systolic blood pressure; DBP = diastolic blood pressure. Data are expressed as mean and 95% confidence interval.*p < 0.05 intragroup compared with baseline adjusted for the covariates age, peak height velocity.

Overall, the reach of the ActTeens intervention was 73.3% (55/75 eligible adolescents) with an adherence rate of 96.3% (53/55). Furthermore, 89% of the structured sessions in the Physical Education lessons were delivered, and 27 adolescents in the IG had 100% attendance.

Table 3 – Intervention effects on the primary and secondary outcomes between the groups with intention-to-treat analysis.

	Intervention group vs Control group	h^2	F	p
	Mean difference (95% CI)			
Primary outcome				
Light PA (minutes/day)	5.6 (-27.5;38.9)	0.04	0.121	0.73
Moderate PA (minutes/day)	11.2 (2.9; 21.0)*	0.21	8.380	0.04
Vigorous PA (minutes/day)	4.8 (-1.4; 11.1)	0.07	2.482	0.12
Moderate-to-Vigorous PA (minutes/day)	18.9 (5.9; 32.1)*	0.19	7.426	0.01
Secondary outcomes				
Sit-to-stand (repetitions)	2.8 (-0.31; 6.5)	0.06	3.169	0.12
Push-ups (repetitions)	2.5 (- .04; 5.8)	0.06	3.444	0.09
PACER (laps)	- 1.7 (-8.5; 4.8)	0.005	0.257	0.65
VO_{2max} (mL.kg.min)	-1.6 (-6.0; 3.1)	0.01	0.755	0.48
Fasting glucose (mg/ dL)	7.2 (-1.7; 16.2)	0.05	2.613	0.11
SBP (mmHg)	-5.4 (-12.3; 1.4)	0.04	2.487	0.12
DBP (mmHg)	- 0.56 (-5.7; 4.7)	0.01	0.058	0.81
Waist circumference (cm)	- 0.76 (-2.4; 0.96)	0.01	0.741	0.39

LPA = light physical activity; MPA = moderate physical activity; VPA = vigorous physical activity; MVPA = moderate-to-vigorous physical activity; PACER = progressive aerobic cardiovascular endurance run; $VO_{2máx}$ = maximal oxygen consumption; SBP = systolic blood pressure; DBP = diastolic blood pressure. h^2, *eta squared* – effect size; Data are expressed as mean and 95% confidence interval; *p < 0.05 intergroup comparison of post-12weeks values adjusted for the covariates sex, age, sports practice, peak height velocity, and baseline values.

Discussion

The results of the current research show that ActTeens intervention effects were observed for PA at moderate and moderate-to-vigorous intensities, confirming our primary hypothesis. Furthermore, after 12 weeks of intervention, lower body muscular endurance, cardiorespiratory fitness, and blood pressure significantly improved within the IG. To the best of our knowledge, this was the first study to explore the effects of implementing a multicomponent intervention to promote PA in adolescents during reductions in social distancing restrictions due to the COVID-19 pandemic in Brazil.

Previous interventions conducted on adolescents from Brazil have found inconsistent effects regarding habitual PA[8,12]. Evidence[27] have shown an insignificant effect of school-based interventions on PA, especially when measured by accelerometers. Promoting active behavior is a complex pathway, and multi-component strategies appear to be more effective[27]. In addition, Van Sluijs et al.[27]. suggest that PA interventions focused on active behavior change should implement strategies in contexts other than school. In this perspective, the ActTeens intervention used multi-component strategies to promote and encourage the practice of PA both inside and outside the school. A range of strategies were included at school context, such as delivery of structured PA (muscle-strengthening and aerobic exercise) sessions within Physical Education. This was aligned to the providing of opportunities for PA practices that did not involve physical contact (e.g.: sports), sharing equipment (ex: balls) and respecting physical distance during the period of return to face-to-face classes during the COVID-19 pandemic. In addition, current trial also included strategies such as self-monitoring and individualized goal-setting through pedometer use, healthy lifestyle counselling (mHealth), and parent involvement (social support), wich were designed to promote active behavior of the adolescents out-of-school.

In the present study, the IG´s PA behaviour improved, on average, 11.2 minutes/day (2.9; 21.0; h^2 = 0.21) and 18.9 minutes/day (5.9; 32.1; h^2 = 0.19) minutes per day in moderate and moderate-to-vigorous, respectively, when compared to the CG (Table 3). These findings have relevant implications because implementing strategies to encourage active behavior is crucial, especially after the negative impact of the COVID-19 pandemic[4] on the adolescents´ lifestyle. Multicomponent PA program developed prior to COVID-19 pandemic, also observed an increase in moderate-to-vigorous PA in Brazilian[8] adolescents,

but these studies used self-report measure to assess PA, thus limiting their comparability with the current study. Conversely, Costa et al.[12] found a reduction in PA during the school hours after the "Move yourself" intervention in Brazilian students, however, the strategies included in that intervention were only within the school settings.

PA interventions should adopt a whole-school approach, also known as a comprehensive school-based PA programme (CSPAP), which is considered the gold standard for increasing PA among youth[27]. The ActTeens intervention included components following: structured PA in Physical Education lessons, self-monitoring plus individualized step goals, and parental engagement, within CSPAP-based approach.

Regarding muscular fitness, the present study led to a significant group–time effect on lower body muscular endurance (sit-to-stand test) in the IG. Similar results were also observed in previous clinical trials[10,11]. This improvement on lower body muscular endurance has important implications for health, as this component of fitness has been inversely associated with clustered cardiometabolic risk factors[6] and positively associated with bone health[7]. As seen in *Resistance Training for Teens*[10], the inclusion of muscle-strengthening activities (e.g., resistance training) in Physical Education lessons is an applicable intervention, as the practical activities last 15 minutes.

In the present study, cardiorespiratory fitness significantly improved compared to baseline in IG adolescents. The inclusion of combined aerobic and resistance exercises in Physical Education lessons has shown an effective strategy to improve adolescents´ cardiorespiratory fitness[28]. This strategy was included in the ActTeens intervention. In addition, another component implemented in the present study was the pedometer assessment to encourage an increase of PA practice outside the school, which may also have promoted the improvement of cardiorespiratory fitness. Isensee et al.[9] performed a school-based intervention using only pedometer in adolescents. Similar to our study, the authors reported significant increases in VO_{2max} after 12 weeks of intervention and 1-year follow-up. Of note, both interventions only encourage increase steps/days, without defining a rate of steps/minute or intensity.

Importantly, the increase in muscular and cardiorespiratory fitness after 12 weeks of intervention in IG, especially when considering the negative impacts of the pandemic on physical fitness in adolescents[5], may-be a direct result of the reduction in PA in adolescents. Another source of variation which should be considered it is the maturational status of adolescents, as the cardiorespiratory and muscular components normally increase throughout the maturation process[29].

Regarding indicators of cardiometabolic health, there were significant reductions in systolic blood pressure and diastolic blood pressure in the IG, and in glucose in the CG compared to baseline. Wellman et al.[30], reported that encouraging adolescents to add at least 5 minutes of moderate PA per week to their usual practice reduces lower odds of having high blood pressure. Moreover, it is important to consider the clinical implication of reductions in blood pressure on cardiovascular disease.

In summary, to our knowledge, there was no similar intervention conducted with adolescents in Brazil during the pandemic. However, further clinical trials using strategies of the ActTeens program with longer follow-up periods, and investigating a larger sample of adolescents from different schools should be conducted. Strengths of this study include the design, high participant retention (93.5%), and participation in sessions (93.7%). Furthermore, the results found in the present study suggest that strategies of the ActTeens program were effective for promoting the increase of PA practice and physical fitness in these adolescents, which is particularly relevant during the COVID-19 pandemic, a period associated with increased physical inactivity. However, some limitations should be recognized , such as the small sample size may limit the generalization offindings of the present study, as the study was conducted in just two schools with more boys than girls; lack of control of the intensity of the structured activities delivered within Physical Education lessons.

Conclusions

The strategies proposed in the ActTeens program had positive effects on adolescents' PA practice, including an increasing on the time spent at moderate and moderate-to-vigorous intensities. In addition, 12 weeks of multicomponent intervention resulted in significant improvements in lower body muscle endurance, CRF, and blood pressure in IG Brazilian adolescents.

Conflict of interest

The authors declare no conflict of interest.

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 data of this study is available on demand from the corresponding author.

Authors contributions

Castilho dos Santos G: Conceptualization; Methodology; Supervision; Writing – original draft; Writing – review & editing; Approval of the final version. Silva JM: Formal analysis and investigation; Writing – review & editing; Approval of the final version. Correa R: Formal analysis and investigation; Writing – review & editing; Approval of the final version. Kennedy S: Methodology; Writing – review & editing; Approval of the final version. Sasaki JE: Formal analysis and investigation; Writing – review & editing; Approval of the final version. Machado-Rodrigues AM: Writing – review & editing; Approval of the final version. Stabelini Neto A: Conceptualization; Methodology; Formal analysis and investigation; Writing – original draft; Supervision; Funding acquisition; Writing – review & editing; Approval of the final version.

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Reviewers' assessment

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

Reviewer A

Anonimous

Format

- Does the article comply with the manuscript preparation guidelines for submission to the Revista Brasileira de Atividade Física e Saúde?
  Partially
- Regarding formal aspects, is the manuscript well-structured, containing the following sections: introduction, methods, results, and discussion (conclusion as part of the discussion)?
  Yes
- Is the language appropriate, clear, precise, and objective?
  Yes
- Was any indication of plagiarism observed in the manuscript?
  No

Suggestions/comments:

- Dear authors, the text should be revised to eliminate excessive spaces. Throughout the manuscript, there are instances of "double spaces" between words and other formatting errors.
- On page 5, line 14, the authors state that the program conducted in 2021 was approved by an ethics committee but do not specify which committee, nor do they provide the approval number or the registration number mentioned.

Abstract

- Are the abstract and resumo appropriate (containing: objective, information on study participants, studied variables, main results, and a conclusion) and representative of the manuscript's content?
  Partially

Suggestions/comments:

- On page 1, line 19, the evaluation of the cardiometabolic profile is mentioned, but the results for these variables are not presented.
- On page 1, line 25, continuing on page 2, line 1, the authors state that the intervention group significantly improved muscular and cardiorespiratory fitness. While muscular fitness appears in the results, there is no prior mention of how it was assessed or which components were considered. Did these fitness measures significantly differ from the control group? Since this information was provided for physical activity, I believe it is important to mention whether fitness also differed from the control group.

Introduction

- Was the research problem clearly stated and delimited?
  Yes
- Is the research problem adequately contextualized in relation to existing knowledge, moving from general to specific?
  Yes
- Are the reasons justifying the study (including the authors' assumptions about the problem) well established in the writing?
  Yes
- Are the references used to support the research problem current and relevant to the topic?
  Yes
- Was the objective clearly presented?
  Yes

Suggestions/comments:

- Not applicable.

Methods

- Are the methodological procedures generally appropriate for studying the research problem?
  Yes
- Are the methodological procedures sufficiently detailed?
  Partially
- Was the procedure for selecting or recruiting participants appropriate for the research problem and described clearly and objectively?
  Yes
- Were details provided about the instruments used for data collection, their psychometric properties (e.g., reproducibility, internal consistency, validity), and, where relevant, the operational definition of variables?

Yes
- Is the data analysis plan appropriate and adequately described?
  Yes
- Were the inclusion and/or exclusion criteria for participants described and appropriate for the study?
  Partially
- Did the authors provide clarification on the ethical procedures adopted for the research?
  No

Suggestions/comments:
- On page 5, line 12, the authors mention that this is a randomized clinical trial (or a randomized controlled trial); however, as shown in Figure 1, four schools were invited to participate, two declined, and of the two that accepted, one became the intervention school and the other the control school. There is no description/justification for how these schools were assigned to intervention or control. What criteria were used? Also, randomizing schools does not characterize the study as a randomized clinical trial, as individual participants were not randomized.
- On page 5, line 11, the authors describe "Resistance Training for Youth" and cite Kennedy et al. (2017). In Table 1 of the cited article, Kennedy and colleagues detail all the components of their intervention. In this pilot study, line 11 mentions that the implemented program was adapted from the original model. What were these adaptations? They need to be clarified in the text.
- On line 15, it is stated that the 20-minute physical activity program was conducted during physical education classes. What was the total class duration? What else was covered in the classes besides the implemented program? The structure of the physical education class needs to be detailed.
- On page 7, line 11, the authors state that the control group received messages via WhatsApp. It is unclear to me, in detail, how the two groups differed. Did the control group have physical education classes? How many times per week? For how long? What were these classes like?

Results

- Is the use of tables and figures appropriate and do they facilitate proper dissemination of the study results?
  Yes
- Does the number of illustrations comply with the journal's submission guidelines?
  Yes
- Is the number of participants at each study stage, along with the number and reasons for losses and refusals, provided in the manuscript?
  Yes
- Are the participants' characteristics sufficiently presented?
  Partially
- Are the results adequately presented, highlighting key findings and avoiding unnecessary repetition?
  Partially

Suggestions/comments:
- On page 20, Table 1, the height and socioeconomic level variables mentioned in the methods were not presented.
- For clarification, among the 55 participating adolescents, did all have normal weight or obesity?
- On page 22, Table 3, the delta values do not match those in Table 2. Is the LPA delta of 5.6 correct, or should it be 10.5? The same applies to the other variables.

Discussion

- Are the study's key findings presented?
  Yes
- Are the study's strengths and limitations discussed?
  Partially
- Are the results discussed in the context of the study's limitations and existing knowledge?
  No
- Do the authors discuss the potential contributions of the study's key findings to scientific development, innovation, or practical applications?
  Partially

Suggestions/comments:
- Regardless of the statistical analysis strategy used, two aspects should be considered: baseline heterogeneity and gender imbalance in the control school. There is a significant gender discrepancy in the control group, which should be considered regarding engagement inside and outside school. Additionally, baseline means for all variables were higher in the control group, but no statistical analysis was presented comparing groups at baseline.

Conclusion

- Was the study's conclusion presented appropriately

and consistent with the study's objective?
Yes
- Is the study's conclusion original?
No

Suggestions/comments:
- The conclusion merely reiterates data already presented in the results/discussion.

References
- Are the references current and sufficient?
Yes
- Are most references from original research articles?
Yes
- Do the references comply with the journal's formatting guidelines?
Yes
- Are citations within the text appropriate, meaning that statements are properly supported by references?
Yes

Suggestions/comments:
- Not applicable.
- **Comments to the Author**
- This study has publication potential and provides relevant insights into the pandemic period. Since the base model used was proposed by Kennedy et al. (2017), it remains relevant for the current post-pandemic reality. I hope the constructive criticism is well received and helps improve the manuscript.

Final Decision
- Reject

Reviewer B
Did not authorize the publication of their review.