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ORIGINAL ARTICLE / *ARTIGO ORIGINAL*

Environment modification at school to promote physical activity among adolescents: a cluster randomized controlled trial

Modificação do ambiente para a promoção da atividade física em adolescentes brasileiros: ensaio controlado randomizado em cluster

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ABSTRACT: ***Objective:*** To assess the effect of modifications of the school environment on physical activity in Brazilian adolescent students. ***Methods:*** Seven public schools in Duque de Caxias (Brazil) were randomized into control and intervention groups. The intervention group underwent modifications in the school environment (painting of hopscotch and school courts) and the provision of sports equipment (balls, basketball table, soccer goalpost, volleyball nets, and others) to stimulate physical activity. Additionally, footsteps towards the court and materials were painted, and a superhero character called Super Active was introduced. Total physical activity was measured using a validated questionnaire for adolescents. Generalized linear models were used to evaluate the effect of the intervention, adjusted by sex. ***Results:*** The sample consisted of 975 adolescents, with a mean age of 11.52 years (standard deviation — SD 1.43), and 56.7% were boys. After the one-month intervention, both groups' total physical activity time increased. The estimated changes from baseline were not different between the intervention and control groups (Δ=102.75 and Δ=99.76, respectively; p=0.52). ***Conclusion:*** The painting, supply of equipment and other strategies to encourage physical activity in the school environment did not promote a positive effect on improving physical activity among adolescents. Future research is necessary to evaluate the effect of the intervention in the long-term period, particularly in other population contexts in middle-income countries.

Keywords: Physical activity. Health behavior. Recreation. Adolescent. Physical education.

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RESUMO: ***Objetivo:*** Avaliar o efeito da modificação do ambiente escolar sobre a atividade física em estudantes adolescentes brasileiros. ***Métodos:*** Sete escolas públicas em Duque de Caxias (Brasil) foram aleatorizadas em grupos controle e intervenção. O grupo de intervenção sofreu modificações no ambiente escolar (pintura de quadra esportiva e amarelinhas) e no fornecimento de equipamento esportivo (bolas, tabela de basquete, gol, rede para vôlei e outros) para estimular a atividade física. Além disso, foram pintados passos em direção à quadra e materiais, e foi introduzida uma personagem de super-herói chamada Super Ativa. A atividade física total foi medida com o uso de um questionário validado para adolescentes. Foram utilizados modelos lineares generalizados para avaliar o efeito da intervenção, ajustados por sexo. ***Resultados:*** A amostra consistiu em 975 adolescentes, com idade média de 11,52 anos (desvio padrão — DP 1,43) e 56,7% eram meninos. Após a intervenção de um mês, o tempo total de atividade física aumentou em ambos os grupos. Contudo, as mudanças estimadas em relação à linha de base não foram diferentes entre os grupos de intervenção e controle (Δ=102,75 e Δ=99,76, respectivamente; p=0,52). ***Conclusão:*** A pintura, o fornecimento de equipamentos e as demais estratégias de estímulo à prática de atividade física no ambiente escolar não promoveram efeito positivo na melhoria da atividade física entre os adolescentes. São necessários estudos futuros para avaliar o efeito da intervenção em longo prazo, particularmente em outros contextos populacionais, em países de média renda.

Palavras-chave: Atividade física. Comportamento de saúde. Recreação. Adolescente. Educação física.

INTRODUCTION

Physical inactivity is one of the major risk factors for premature death worldwide because it is associated with many non-communicable diseases[1]. There is evidence that some healthy habits, such as regular physical activity (PA), tend to be maintained throughout life when stimulated in early life[2,3]. Despite this fact, approximately 80% of worldwide students aged 11–17 do not meet the PA recommendation of at least 60 minutes of daily moderate-to-vigorous PA intensity[4-6]. Likewise, approximately 35% of school-aged children from low and medium human development index (HDI) countries reported engaging in regular PA practice inside the school[7]. In Brazil, the current estimate reported that 62% of students between 13 and 17 years of age enrolled in public and private schools do not reach the minimum PA recommended levels for age[8].

The ecological model proposes that the environment influences the adoption of habits and behavior[9,10]. The literature suggests a positive association between more access, proximity, equipment availability, or open space with PA time, regardless of age group[11]. Regarding adolescent students as a target population, the school environment stands out as the greatest place for developing PA interventions due to the possibility of reaching many people and maintaining the bond between teachers, students, and family members for extended periods[8,12]. Physical education classes and the recess period are good opportunities to stimulate PA practice during school days, although physical education classes have a small contribution to increasing total PA[13]. Furthermore, despite children and adolescents

spending on average four hours per day in schools, only 30.5 % of daily moderate-to-vigorous PA is achieved[14].

Although the physical environment is one of the most important determinants of PA levels[11,15], some studies focusing on school environment modifications to promote PA in adolescents have shown discrepant results, probably explained by different interventions and measurement methods[16-19]. Also, studies investigating school-based environment interventions to promote PA in low and middle-income countries usually comprise various combined approaches, making it difficult to evaluate the actual effect of the environment modification on PA levels[20]. Moreover, multi-component approaches are economically expensive and problematic for poor populations during a long-term period[21]. It is noteworthy that studies investigating the effect of school environment modifications in lower and middle-income countries are scarce[22] and present inconsistent results[23].

The present study aimed to evaluate the effect of school environment modification on total PA time in adolescents enrolled in public schools in Brazil. The central hypothesis of this study is that the intervention group would increase the PA time compared to the control group.

METHODS

STUDY DESIGN AND SETTINGS

This study is a parallel school-based randomized trial designed to investigate the short-term effect of environment modification on total PA levels in adolescents included in more extensive previous research. The previous study, called "Parents, students, community health workers, and teachers for healthy eating" (PAPPAAS), aimed at preventing excessive weight gain among adolescents by combining interventions at school and in primary health care. In this previous study, 18 public schools with 5th and 6th grades were randomly assigned to three groups. The first received educational material about healthy lifestyle habits. The second received this same material and had the school environment modified. The third, the control group, received none of the above-mentioned interventions. More information about PAPPAAS can be found in another paper[24].

The present study was developed one year after PAPPAAS, in 2017. This research was conducted in seven public schools from Duque de Caxias, Rio de Janeiro, Brazil. Three schools from the first PAPPAAS group were allocated to the control group, and four schools from group 2 were allocated to the intervention group. The allocation sequence was concealed from the investigator involved in recruitment and the schools were assigned to the groups using opaque envelopes.

The municipality of Duque de Caxias has 467,319 km^2 and an estimated population of 929,449 inhabitants[25]. According to the Brazilian Institute of Statistics and Geography, Duque de Caxias has a median human development index (HDI: 0.711), being characterized as an

impoverished region. Brazilian public schools generally work on a half-time period, from 07:00 to 11:30 or from 13:00 to 17:30.

STUDY PARTICIPANTS AND SAMPLE SIZE

All students enrolled in the 5th and 6th grades in 2017 were invited to participate in the study. Exclusion criteria were adolescents with physical or mental disabilities and pregnancy. The sample size required for this study was 360 adolescents for each group. The sample size was estimated considering a mean difference of 10 minutes of total PA per day, with an α of 0.05 (2-sided) and β of 0.20, assuming a refusal rate of 20%[26].

INTERVENTION

School courts and hopscotch were painted to encourage the participants from the intervention group to increase their PA levels. Sports equipment (soccer, basket, and volley balls, basketball table, soccer goalpost, hopscotch, volleyball nets, hula-hoops, shuttlecocks, and ropes) was also provided in the school playground area, and students were granted free access to them for four weeks. Footsteps were painted over the school to nudge participants to the materials. See Supplementary Materials Figure 1.

Furthermore, a super-hero character named Super Active was created, and its picture was exposed on a banner fixed in the schoolyard to stimulate PA practice. Every week the researchers replaced the materials if necessary. No intervention was implemented in the control group. Baseline data collection took place from March to May of 2017. The modifications in the school environment were performed during the middle-year school vacation (July). When returning to classes in August, the students had their first contact with the proposed intervention that was carried out until the end of the month. The follow-up measure was performed at the end of September of the same school year, allowing for at least one month of intervention.

MEASUREMENTS

Total PA time was assessed through a validated self-reported questionnaire for the adolescent population[27]. It included six questions about the duration and frequency of different PA domains performed in the seven days prior to the application of the questionnaire. The PA domains were commuting to school, physical education classes, and leisure PA.

For commuting to school, PA time was estimated, taking into account the frequency and duration of active transport (walking or cycling) to school, according to the following questions:

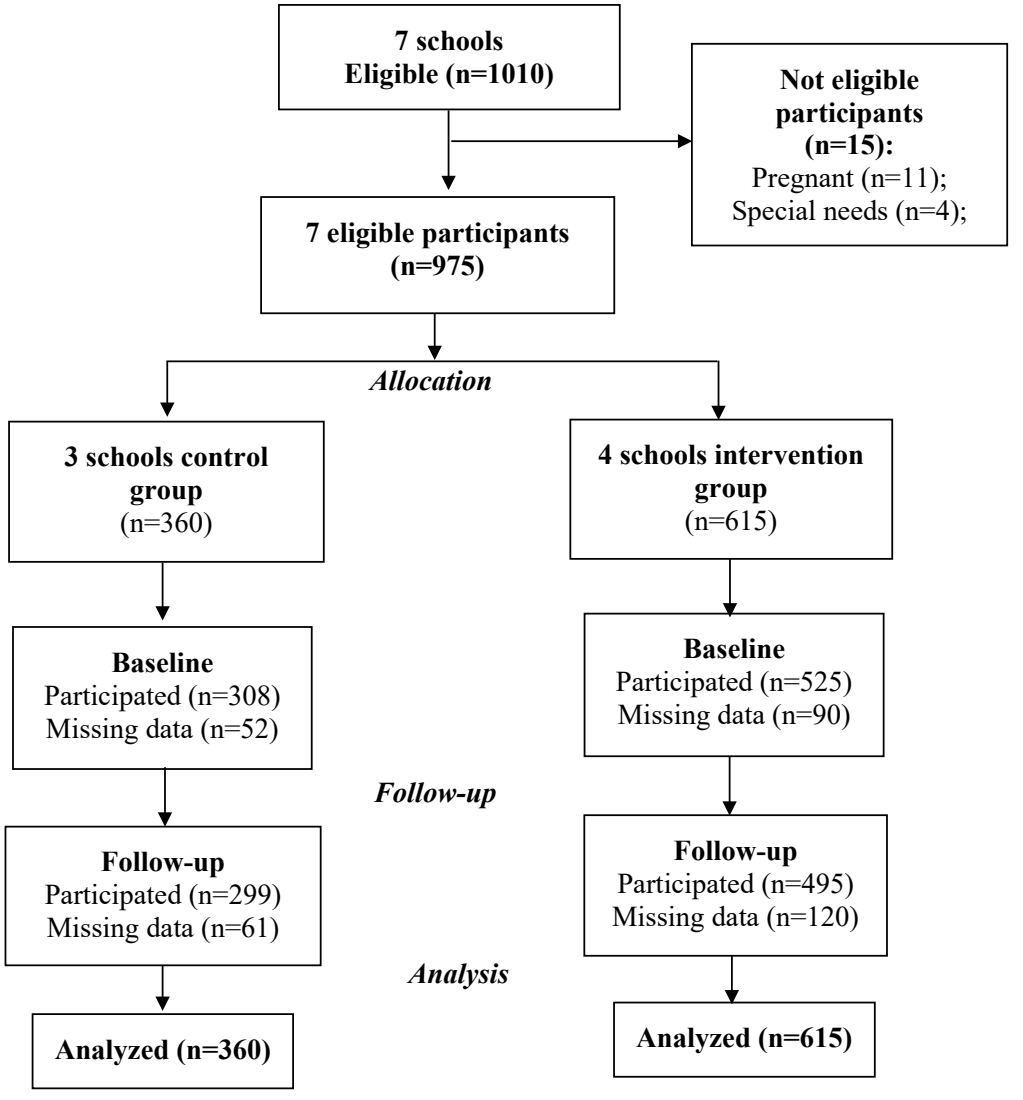

Figure 1. Flow chart of study participants.

1. *"In the last 7 days, how many days did you go to school on foot or by bicycle?"*;
2. *"In the last 7 days, how many days did you get back home from school on foot or by bicycle?"*;
3. *"How much time did you spend going to school on foot or by bicycle?"*; and
4. *"How much time did you spend going back home from school on foot or by bicycle?"*.

The active time during physical education classes was estimated through the following questions:

1. *"How many days did you have physical education classes at school in the last 7 days?"*, and
2. *"How much time per day did you do physical activity or sports during the physical education classes at school in the last 7 days"*.

Frequency and duration of leisure-time PA were estimated through the questions:

1. *"In the last 7 days, except for school physical education classes, how many days did you engage in any physical activity such as sports, dance, gymnastic, weightlifting, wrestling or other activity?"*; and
2. *"Usually, how much time did you spend doing these activities (such as sports, dance, weightlifting, wrestling or other activity) per day?"*.

Total PA time (minutes) per week was calculated based on the sum of the time spent on each PA domain multiplied by its respective frequency per week. For descriptive analysis, the population was classified according to World Health Organization (WHO) guidelines for PA[28]. Adolescents who practiced 300 or more minutes of PA per week were considered physically active.

Body weight was measured using a portable electronic scale with a maximum capacity of 150 kg and 100 g precision (Tanita BCC-778, Japan). A portable stadiometer measured height with 200 cm amplitude and 0.1 cm variation (Altura exata, Brazil)[29].The classification of nutritional status was based on z-scores of the body mass index (BMI kg/m^2) for age cutoff points recommended by the WHO[30]. The race was self-reported and categorized as white or non-white[31].

STATISTICS ANALYSIS

For descriptive analysis, means and standard deviation for continuous variables and frequency and percentages for categorical variables were calculated at baseline.

Intention-to-treat analysis was performed to evaluate the difference in the rate of change for total PA time per week between groups. The analysis was performed using generalized linear models, with log function and gamma distribution. The model included the terms time, group (control and intervention), and the interaction term (time×group) adjusted by sex. All analyses were performed in SAS On demand for Academics.

The Ethics Committee of the Institute of Social Medicine approved the study (Certificate of Presentation for Ethical Consideration: 42928115.0.0000.5260). All students included in this study and their parents signed the informed consent form before the randomization.

RESULTS

Of the 1,010 students invited, 15 were removed according to the exclusion criteria — four adolescents with physical or mental disabilities, 11 pregnant, and 20 students who refused

to participate. The final sample consisted of 975 adolescents, 615 and 360 in the intervention and control groups, respectively (Figure 1).

Table 1 describes the baseline characteristics of participants for each group. The mean age of the adolescents was 11 years in both groups. The control group had more boys (57.5%) than the intervention group (51.4%). Regarding the nutritional status, the control group showed a relatively higher prevalence of adolescents with normal weight than the intervention group (69.0 *vs* 63.9%, respectively). Moreover, the intervention group demonstrated a slightly higher prevalence of adolescents with overweight (17.9 *vs* 14.7%) and obesity (14.2 *vs* 12.1%) than the control group. About 74% of adolescents in both groups declared themselves as non-white. Finally, 27.2% of the intervention and 33.1% of the control group declared having practiced at least 300 minutes of PA in the previous seven days.

Table 1. Descriptive baseline characteristics of the study population.

Variables	Control (n=360)		Intervention (n=615)	
	n	%	n	%
Sex				
Male	177	57.5	270	51.4
Female	131	42.5	255	48.6
Race				
White	78	25.3	118	25.5
Non-white	228	74.7	503	74.5
Nutritional status				
Underweight	13	4.2	21	4.0
Normal weight	212	69.0	334	63.9
Overweight	45	14.7	94	17.9
Obesity	37	12.1	74	14.2
Physical activity				
Insufficiently active (<300 min/week)	241	66.9	441	72.8
Physically active (≥300 min/week)	119	33.1	167	27.2
	Mean (SD)		Mean (SD)	
Age (years)	11.3±1.4		11.7±1.4	
BMI (kg/m^2)	18.7±3.9		19.4±4.3	

BMI: body mass index; SD: standard deviation

Table 2 shows the estimated mean change in PA for each group by gender. During one month of exposure to environment modification, boys in the exposure group declared an increase of 94.4 weekly minutes of PA and girls declared an increase of 104.6 minutes. At the same time, the control group of boys reported an increase of 116.9, and that of girls, of 92.1 weekly minutes of PA.

Considering the weekly recommendation of 300 minutes, both groups increased their proportion of boys and girls (Figure 2). In the intervention group, the proportion increased by approximately 10% for both genders. In the control group, boys increased 8% and girls 13%.

Table 2. Mean estimate changed (Δ) for intervention group by genders.

Physical activity (min/week)	Intervention				Control			
	Boys (Mean/SD)	Δ	Girls (Mean/SD)	Δ	Boys (Mean/SD)	Δ	Girls (Mean/SD)	Δ
Baseline	297.3 (302.6)	94.4	193.1 (236.1)	104.6	310.5 (300.2)	116.9	251.5 (257.8)	92.1
Follow-up	391.7 (327.3)		297.7 (299.6)		427.4 (339.6)		343.6 (312.3)	

SD: standard deviation

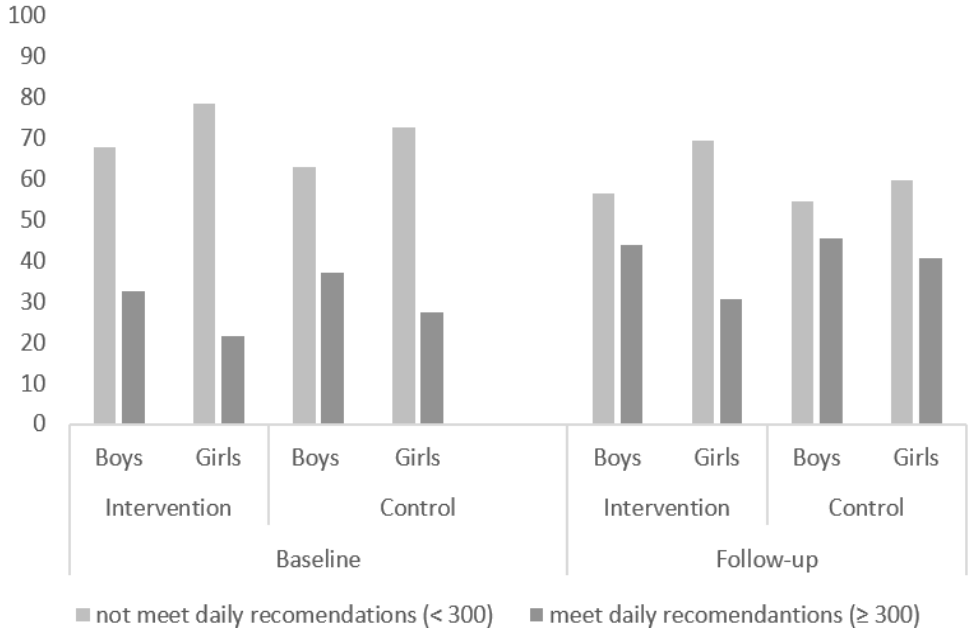

Figure 2. Proportion of meeting of physical activity guidelines by group and gender.

Both control and intervention groups increased total PA time compared to baseline values ($p<0.001$ for time), but the rate of change was not different between groups (Table 3). The estimated change from baseline in the intervention group was $\Delta=102.75$ min/week, while in the control group, it was $\Delta=99.76$ min/week (Table 3 and Supplementary Material Figure 2).

DISCUSSION

The study aimed to investigate the short-term effect of a school-based environment modification and sports equipment availability on total PA time in adolescents. Although both groups showed increased PA time, no difference was observed between groups, demonstrating no intervention effect.

These results are similar to those of previous studies[17,18] that showed no effects of school-based environment interventions on PA levels. However, some others have demonstrated a positive intervention effect[16,19,22].

Positive effects studies shared some conditions, like being multicomponent and using environment modification to promote PA. Morais et al.[22] developed a cluster randomized trial that assessed the effect of multicomponent intervention on children's healthy behavior. A randomized cluster trial carried out at Fortaleza, a Northeastern Brazilian state, which evaluated the effect of multicomponent intervention in the PA of adolescents enrolled in public schools, reported an increase of 5.3% of the proportion meeting the guidelines[16]. However, some studies adopted a multicomponent intervention and did not report a positive intervention effect. Costa et al.[18] evaluated the effect of multicomponent intervention in total school-time, physical education, and recess PA. The authors identified that the adolescents enrolled on the school intervention group reported less time of PA at each of these moments. Some features of the studies, such as age and size sample, baseline PA amount, measure outcome instrument, and time and frequency of follow-up measure can explain these mixed findings.

Table 3. Crude means and adjusted estimated changes (Δ) according to intervention groups.

Physical Activity (min/week)	Baseline Mean (SD)	Follow-up Mean (SD)	Δ	Crude model			Adjusted model		
				β	e^{β}	*p*	β*	e^{β}	*p*
Intervention	246.6 (276.9)	346.2 (317.4)	102.7	0.04	1.04	0.5	0.05	1.05	0.5
Control	285.4 (284.0)	390.8 (330.1)	99.7						

SD: standard deviation. *time × treatment term from generalized linear model adjusted by sex.

In both short-term (up to six weeks)[32] and middle and long-term (up to six months) studies[19,33], this type of intervention was effective in increasing PA among school-aged children. A study intervention during 12 months found an increase in children's PA time during school recess[19]. Schools' playgrounds were separated into three PA zones, with each one specified for a type of PA. Zone one was "quiet" with non-activity games, such as chess; zone two was designated for motor skills improvement and physical fitness; zone three was designed for sports practice, such as football[19]. However, almost all studies reporting positive results with this approach were conducted with young children, mainly in the first years of elementary school (e.g., from 1st to 5th grade) and pre-school[19,32,34]. This can explain the difference in our results, since age is negatively associated with PA[34]. Additionally, the intervention could increase PA during school time and recess[19,34], but a compensatory effect could influence all-day PA, affecting the results[35]. Further studies should assess the intervention effects inside and outside the school rather than the total PA effect, as the latter can change due to the compensatory effect.

Our study observed the same rate of change between the intervention and control groups. Some features could increase the control group's rate during the study period, such as the extension of the regular recess, the physical education classes, the after-school period, external PA programs and vacant schedules, which are common in Brazilian schools[36]. These school features that were not considered in our study should be contemplated in future studies to support identifying other possible characteristics that can influence total and inside school PA properties.

Other studies found that school environment interventions could be more effective for light PA. In a quasi-experimental study conducted at Virginia elementary schools (US), Brittin et al.[37] showed that children exposed to a new activity-promoting school-built environment presented an increase in light PA time but a decrease in moderate-to-vigorous PA, after a 14-month follow-up. Similar results were also observed in a study that examined the effects of playground reconstruction on PA and sedentary levels in adolescents in the UK for one year[38]. The school environment intervention and the availability of sports materials could influence light PA instead of moderate-to-vigorous PA. The evaluation of the effect of the intervention on different PA intensities and different domains could be a better approach to answering this research question.

Generally, school-based PA intervention studies are based on multi-component programs and implement different combinations of PA strategies. Although a systematic review[39] demonstrated the effectiveness of some combined strategies for PA promotion, limited conclusions can be drawn regarding the specific role of the school environment[23,39]. Since multi-component interventions have become a complex approach in developing countries due to economic conditions[39], and few studies have assessed the impact of playground markings, game equipment, and physical structure in schools from low-income regions, our results fill the gap found in the literature regarding this scope in such countries[23].

The present study has some limitations. First, although PA was assessed using a validated questionnaire, accelerometers provide more reliable and accurate measurements. Given the

unavailability of a direct measurement device (accelerometers or pedometers), we know that the use of questionnaires can overestimate the effect measurement, so we recommend that the results presented here be interpreted with caution. Second, we could not evaluate the PA practice inside and outside of school and the effect of the intervention on different PA intensities. Third, due to the sample size, we could not assess the intervention effect separately by gender and grade, which could influence the effect observed. Evidence suggests that girls tend to spend less time doing PA than boys, but the former can be more influenced by "jumping activities" and socializing games than boys[40]. Fourth, this study was developed in public schools in a low-income area in a middle-income country, and the generalizability of findings is limited. Fifth, since baseline and follow-up were only one month apart, it was not possible to assess the effect of the intervention on long-term PA time. We reinforce the importance of future studies that include follow-up measures over time to understand this relationship better. Finally, we did not assess the intervention effect according to different PA intensities, which could show effects we did not observe. This is one of the few studies on the effects of only school environment modification plus the availability of sports material on PA practice in middle-income countries.

In conclusion, our findings showed that a school-based environment modification was not effective in increasing total PA time in adolescent students from a low-income area in Brazil. Further intervention studies are necessary to evaluate inexpensive strategies to promote PA in other scenarios and social contexts and to understand better the impact of this type of intervention on total PA practice.

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