

eISSN: 2452-5812
<http://jmh.pucv.cl/>

Received: 24/11/2022

Accepted: 11/01/2023

Online-first: 23/01/2023

Published: 01/06/2023

Original article

Effect of an after-school physical activity program on physical fitness and academic performance of socioeconomically vulnerable children

Efecto de un programa de actividad física extraescolar sobre la condición física y el rendimiento académico de niños y niñas en situación de vulnerabilidad socioeconómica

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Abstract

Aim: To promote the practice of physical activity (PA) after school hours and verify the effects on the physical fitness and academic performance of children with socioeconomic vulnerability. **Methods:** The non-randomized experimental study was carried out in a school in a vulnerable area. Eighteen children performed 60 minutes of moderate-vigorous PA and 15 minutes of circuit exercise (muscle and bone strengthening) three times a week. The control group (n=10) only had school physical education as a weekly PA routine. To assess the program's impact, physical aptitude tests (pre- and post-test) were carried out in accordance with the recommendations of PROESP-Br and the School Performance Test, which assesses learning in three categories: reading, writing, and arithmetic. **Results:** Abdominal strength, flexibility, sprint, and lower limb power increased (d-Cohen>0.20). Regarding academic performance, the effect was moderate (d-Cohen>0.50) for reading and total scores. The effect size was small (d-Cohen<0.50) for arithmetic and writing. **Conclusion:** An after-school PA program positively impacts physical fitness and academic performance in socioeconomically vulnerable children. The level of impact varies between small and medium according to different physical fitness capacities. School is an enabling environment for children to meet the World Health Organization PA recommendations.

Keywords: physical fitness; school-based program; health promotion; sport; young people.

Resumen

Objetivos: Promover la práctica de actividad física (AF) fuera del horario escolar y verificar los efectos en la condición física y el rendimiento académico de niños y niñas con vulnerabilidad socioeconómica. **Métodos:** Se llevó a cabo el estudio experimental no aleatorizado en una escuela de zona de vulnerabilidad. Dieciocho escolares realizaron 60 minutos de AF moderada-vigorosa, y 15 minutos de circuito de ejercicio (fortalecimiento muscular y óseo) tres veces por semana. El grupo de control (n=10) solo tenía educación física escolar como rutina semanal de AF. Para evaluar el impacto del programa, se realizaron pruebas de aptitud física (pre y post-test) de acuerdo con las recomendaciones del PROESP-Br y el Test de Rendimiento Escolar que evalúa el aprendizaje en tres categorías: lectura, escritura y aritmética. **Resultados:** La fuerza abdominal, la flexibilidad, el sprint y la potencia de los miembros inferiores aumentaron (d-Cohen>0,20). En cuanto al rendimiento académico, el efecto fue moderado (d-Cohen>0.50) para lectura y puntajes totales. El tamaño del efecto fue pequeño (d-Cohen<0,50) para aritmética y escritura. **Conclusión:** Un programa de AF extraescolar tiene un impacto positivo en la condición física y el rendimiento académico en niños y niñas en situación de vulnerabilidad socioeconómica. El nivel de impacto varía entre pequeño y mediano según las diferentes capacidades físicas. La escuela es un entorno propicio para que los niños cumplan con las recomendaciones de la AF de la Organización Mundial de la Salud.

Palabras clave: condición física; programa basado en la escuela; promoción de la salud; deporte; jóvenes.

Key points

- School is an enabling environment for children to meet the World Health Organization physical activity recommendations.
- It is essential to insert muscle and bone-strengthening activities in children's physical activity routine.
- Physical education classes and physical exercise at school are important strategies for health promotion.

Introduction

Regular physical activity is strongly recommended for all children and adolescents by different institutions¹⁻³. The World Health Organization (WHO)⁴ on a global scale and the Brazilian Ministry of Health⁵ on a national scale recommend that, from 6 to 17 years of age, all people should meet at least 60 minutes of moderate-vigorous physical activity daily, in addition to performing vigorous activities, with an emphasis on muscle and bone-strengthening at least three times a week. Even so, evidence shows that for more than 10 years, about 80% of the young people population has not complied with these recommendations⁶.

Some studies in different countries indicate that of the entire population that does not comply with the physical activity recommendations, the most affected is the one that is socially vulnerable⁷. Evidence⁸ indicates that in Brazil, but also in South America, social inequality is an important barrier to the regular practice of physical activity. This context has implications for different areas of human development; some evidence suggests that children in situations of social vulnerability tend to have lower levels of physical fitness, implying a less healthy profile. On the other hand, some evidence indicates that in this context, the level of academic performance is constantly lower, implying a lower general academic development⁹.

Although there is controversy in some results, more recent evidence suggests that the lack of access to sports clubs, quality materials (e.g., sneakers, clothing, sports equipment), and access to qualified education are factors associated with less time for physical activity⁷. In this context, the school is a potentially favorable environment for young people to meet the WHO recommendations for regular physical activity². However, even recognizing that the recommendations are of public interest and relevant for collective encouragement, the dose-response of physical activity recommendations on important variables for healthy school development is not clear¹⁰. Among these variables, the physical fitness components represent physical development, and academic performance represents cognitive development. Thus, the regular assessment of physical fitness and academic performance components is a strategy for monitoring and diagnosing the child's development¹¹.

These diagnostic strategies are the basis for targeted interventions; however, it is necessary to understand how much physical activity is sufficient for effects to be obtained and ¹²⁻¹⁴ other interventions are also incorporated (e.g., sexual orientation, reading, eating habits, etc.). Our study started from the hypothesis that children who meet the WHO recommendations improve all components of physical fitness and academic performance. For this, our study aimed to promote the practice of general physical activity (e.g., exercises, plays, and games) after school hours and verify its effects on physical fitness and academic performance of children with socioeconomic vulnerability.

Methods

Design and Participants

This quasi-experimental study took place at Escola Professora Branca Diva de Souza, a public school in Porto Alegre, Brazil. The school is located in an area of socioeconomic vulnerability and serves children in this situation on a full-time basis. The research protocol was approved by the school's management and community team and by the Ethics Committee in Research with Humans of the Universidade Federal do Rio Grande do Sul, under number 1.445.846. As it is a report of good practices, all those involved with the study authorized the disclosure of the school's name and the financial support that the research received.

Participants

The intervention group (PA group) had the participation of 18 children whose parents/guardians registered to perform physical activities after school hours (one of many school projects). The control group consisted of 10 children whose parents/guardians authorized participation in the proposed assessments (Figure 1). The allocation of groups was based on the availability of the school to provide space for the intervention. Thus, after all, baseline evaluations, the school was informed it would be possible to carry out the intervention during the morning shift. This group normally performed physical education at school (sports, motor development activities, and dance). Table 1 describes the anthropometric characteristics and the equity between the variables in the two groups. Considering the small sample size, we performed a post-hoc sample calculation. Considering that linear regression models would be performed (T-family tests), the sample size of the two groups (PA group=18 and control group=10), a residual standard deviation of 2, and an alpha of 0.05. The power analysis ($1-\beta$) identified was 0.29.

For both groups, the inclusion criteria were being between 6 and 13 years old, being regularly enrolled and attending regular classes, in addition to not having a medical diagnosis that made it impossible to practice any type of physical activity and/or to carry out the evaluations in compliance with the criteria established by physical and academic performance tests. The exclusion criteria adopted were: 75% of absences during the intervention, not showing up on one of the assessment days and/or not performing the physical and academic performance tests with the minimum understanding that the test requires. Following these criteria, four children from the PA group were excluded from the analysis because they had less than 75% of attendance at the intervention, and two children from the control group because they did not attend the last day of academic performance assessments.

Physical activity intervention

The intervention protocol was carried out entirely on the school premises. For six months (June to November), five days a week in the morning, the 60-minute intervention took place. The school's general schedule included arrival at 8 a.m. and breakfast for all the children. After the meal and oral hygiene, the "pedagogical principle of the day" moment took place through tales and stories. All these activities took an hour and a half. The physical activity intervention occurred between 9:30 a.m. and 10:30 a.m., and after the intervention, the children had complementary activities (e.g., board games, reasoning games, readings, and playground) according to the school schedule, followed by lunch and regular class.

The intervention with physical activity was initially organized considering general activities of moderate-vigorous intensity (Monday, Tuesday, and Friday), which consisted of a physical education class with 15 minutes of vigorous physical exercise, and moderate-intensity activities (Wednesday and

Thursday) consisting of physical education classes. The intensity was not evaluated, only activities were programmed so that, hypothetically, the children would reach the desired intensities.

During the five days of the week, the general PAs during the classes included small games, regional games, initiation to sports (basketball, handball, and football), and games proposed by the children. At the end of each class, there was a moment of evaluation and feedback addressing elementary pedagogical principles. These are character, unity, sowing and reaping, individuality, self-government, stewardship, and sovereignty.

The musculoskeletal strengthening activities were in accordance with the PROFIT-BR proposal¹⁵ and took place three times a week, during days of moderate-vigorous physical activity. In the initial 15 minutes, neuromuscular exercises were progressively introduced aimed at the child's overall training¹⁶. The activities were organized in a circuit of four stations, where the children performed the exercise at each station for one minute and rested for 30 seconds (while changing stations in the circuit). There were always two laps around the circuit. Each station had a characteristic, namely: 1) activities for lower limbs, strength, and power, specifically plyometrics in levels 1 and 2¹⁷; 2) activities for upper limbs, strength, and power; 3) core, strength, and endurance activities; and 4) active flexibility, speed and agility activities. All PAs were conducted by a Physical education teacher, a member of the research team.

The stipulated "playground time" (period of free activity and communion) and afternoon recess complemented the weekly protocol of the program with all periods outlined, including more than 300 minutes of directed physical activity, following the recommendations of the WHO⁴.

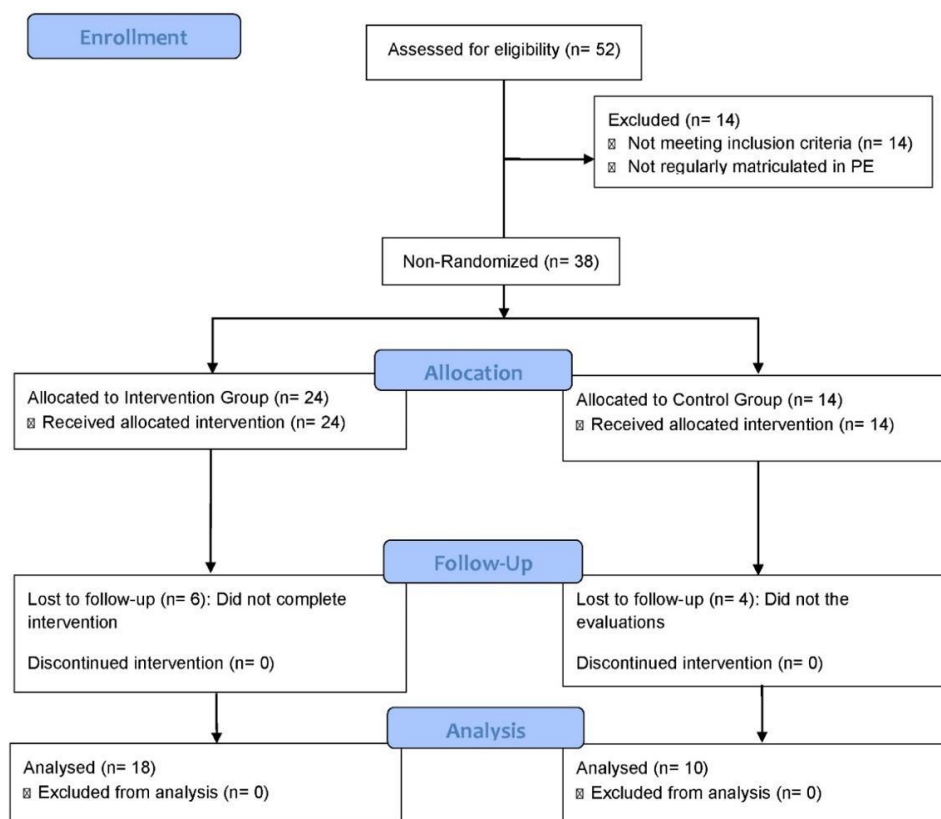


Figure 1. CONSORT Flow Diagram.

Physical Fitness Evaluation

Physical fitness was assessed based on the recommendations of the PROESP-Br Measurements and Tests Manual¹⁸. The anthropometric variables height, body mass, arm span, and waist circumference were evaluated. From these variables, the BMI (mass kg/height cm * height cm) was calculated. Maturity offset (MO), defined as the time before/after PHV, was calculated using the predictive equations established by Moore et al.¹⁹. For girls, $MO = -7.709133 + 0.0042232 \cdot CA \cdot \text{height}$; $R^2 = 0.90$, Standard Error of the Estimate = 0:52. For boys, $MO = -7.999994 + 0.0036124 \cdot CA \cdot \text{height}$; $R^2 = 0.90$, Standard Error of the Estimate = 0:54. (Height in cm and CA = chronological age).

For physical fitness, localized abdominal strength was evaluated with the one-minute sit-up test, flexibility with the sit-and-reach test, aerobic capacity with the six-minute run/walk test, sprint with the 20-meters running test, agility with the 4x4 meters square test, lower limb power with the horizontal jump test and upper limb power with the 2kg medicine ball throw test. The detailed protocol for each test can be found in previously published studies or the official PROESP-Br manual¹⁸. A team of six physical education academics from the researchers' university administered these tests. The training took place at the university and was carried out by the main researcher with the support of didactic material and the PROESP-Br team (see www.proesp.ufrgs.br).

Academic Performance Evaluation

To assess academic performance, the School Performance Test (TDE) was applied, which broadly measures learning through three subtests: reading, writing, and arithmetic, in addition to having a total score. This test presents good parameters of psychometric properties validated by the Item Response Theory²⁰.

The pedagogical test was applied during the school curriculum period. The students were removed individually from the classes and sent to separate rooms. A volunteer pedagogue applied the test with an estimated time of 30 minutes. Previously, training was carried out, where the teacher became familiar with the assessments. The training was carried out in 3 sessions. During the test, the children answered a book of questions whose scores could be calculated later.

Statistical Analysis

For data analysis, we used the descriptive analysis with mean and standard deviation values for each group, and the differences between groups in baseline were tested using a T-test for independent groups. In addition, we calculated the difference mean (Δ) between groups (PA group – Control group). For evaluating the intervention effect, we calculated Cohen's d effect size, and these results can be classified as small ($d = 0.20 - 0.49$), medium ($d = 0.51 - 0.79$), and large ($d > 0.80$)²¹. To calculate the interaction between time and group, a 2°-order polynomial model was used from generalized linear models (GLM). For the physical fitness variables, these models were also tested, considering an adjustment for the maturity offset, to investigate the effects of maturation on the time-group interaction.

Even with the sample calculation pointing to very low power, we adopted as a standard a significant difference of 0.05; however, we recommend that the effect size initially analyzes the intervention effect. All analysis was made in the SPSS 20.0, licensed by Universidade Federal do Rio Grande do Sul.

Results

The PA group, composed of 12 boys and six girls, did not differ in any of the anthropometric variables and maturity offset from the control group (five boys and five girls). Equivalence between groups was also observed for physical fitness and academic performance (all differences >0.05).

Table 1. Baseline characteristics of the sample.

	PA group (n=18) $\bar{X} \pm SD$	Control (n=10) $\bar{X} \pm SD$	$\bar{X}$ difference	p-value
General characteristics				
Age (years)	8,72 $\pm$ 1,87	8,60 $\pm$ 1,174	0,12	0,854
Height (cm)	132,55 $\pm$ 12,32	130,40 $\pm$ 10,22	2,15	0,643
Weight (kg)	29,43 $\pm$ 8,14	32,39 $\pm$ 10,32	-2,95	0,411
Arm-span (cm)	133,44 $\pm$ 12,72	131,35 $\pm$ 10,79	2,09	0,664
Waist circumference (cm)	59,44 $\pm$ 9,22	61,29 $\pm$ 9,57	-1,84	0,621
Maturity offset*	-3,43 $\pm$ 1,36	-3,44 $\pm$ 1,04	0,001	0,998
Physical fitness				
BMI (kg/cm ²)	16,50 $\pm$ 2,72	18,62 $\pm$ 3,70	-2,12	0,094
Abdominal strength (rep/min)	27,22 $\pm$ 8,26	22,60 $\pm$ 9,51	4,62	0,190
Flexibility (cm)	31,89 $\pm$ 8,51	35,95 $\pm$ 4,90	-4,06	0,180
Aerobic capacity (m)	816,42 $\pm$ 119,52	758,57 $\pm$ 178,92	57,85	0,387
Sprint (s)	5,08 $\pm$ 0,94	5,54 $\pm$ 0,69	-,453	0,198
Agility (s)	8,29 $\pm$ 1,18	8,99 $\pm$ 1,24	-,699	0,154
Lower Limb Power (cm)	119,86 $\pm$ 33,03	112,35 $\pm$ 25,76	7,51	0,541
Upper Limb Power (cm)	197,22 $\pm$ 50,09	194,00 $\pm$ 33,69	3,22	0,858
Academic performance				
Reading	28,52 $\pm$ 25,93	29,10 $\pm$ 31,77	-0,57	0,960
Arithmetic	8,16 $\pm$ 3,89	5,90 $\pm$ 4,35	2,26	0,169
Writing	11,66 $\pm$ 8,87	9,50 $\pm$ 11,10	2,16	0,576
Total score	48,05 $\pm$ 37,02	44,50 $\pm$ 45,30	3,55	0,826

PA: physical activity; n: sample number; $\bar{X} \pm SD$: mean and standard deviation; p-value: probability value; BMI: body mass index; *: distance in years to peak growth velocity.

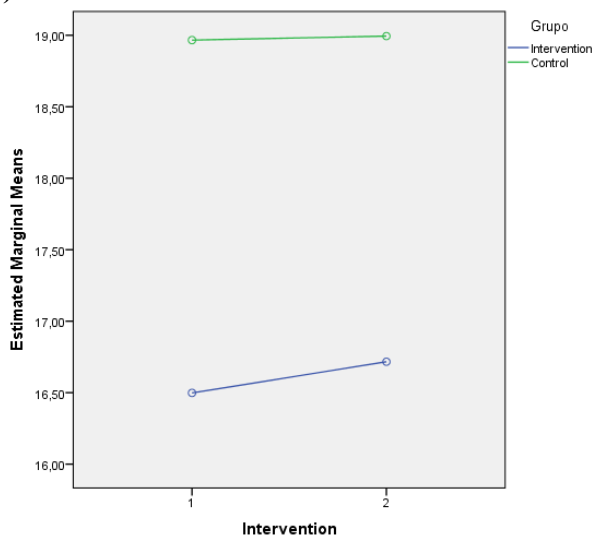
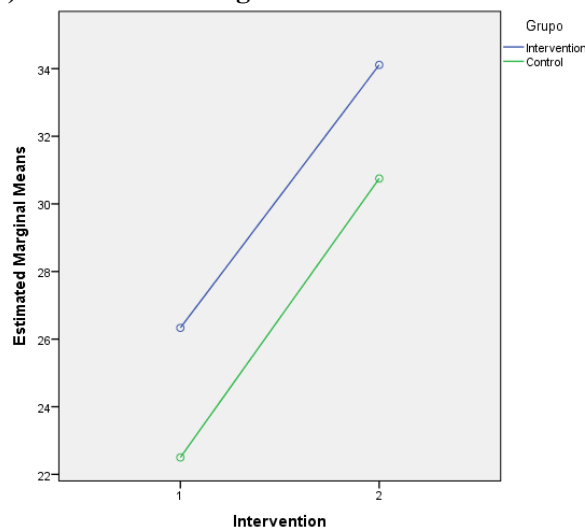
Considering the small sample size and the very small statistical power of the analyses, we present the effects of the intervention based on the calculation of Cohen's d effect size. For the physical fitness variables, the intervention had a small effect on flexibility, a medium effect on sprint, and lower limb power, in addition to a large effect on abdominal strength. For academic performance variables, the effects found were small for reading, arithmetic, and writing but had a medium effect on the total test score.

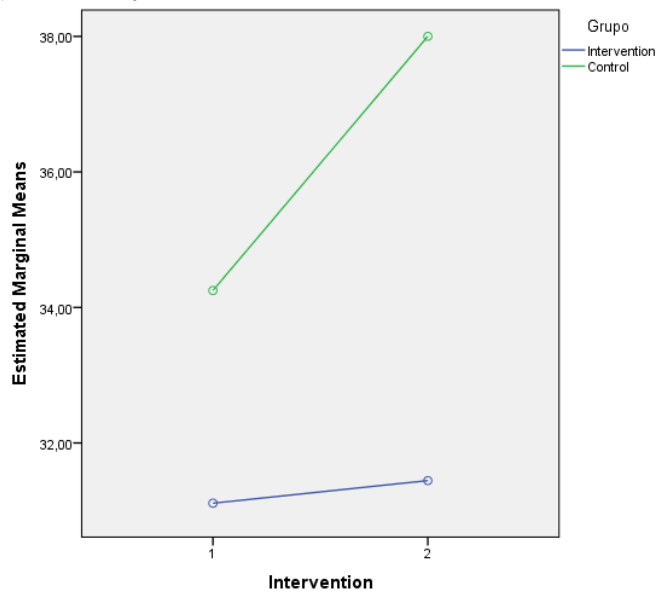
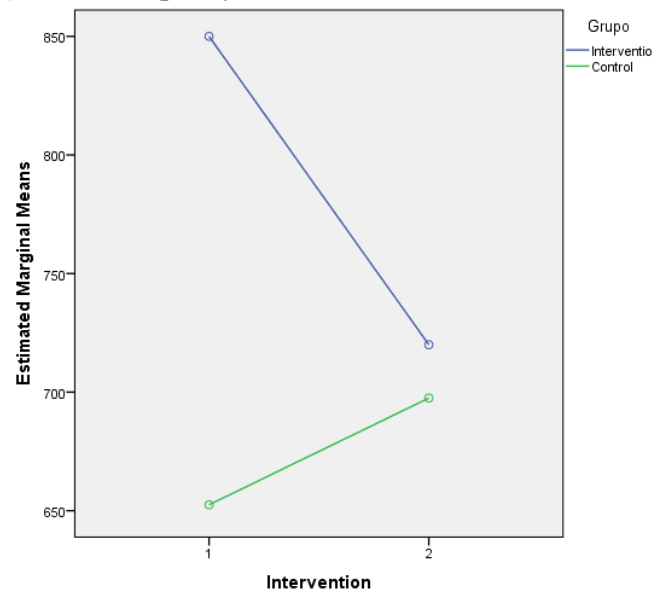
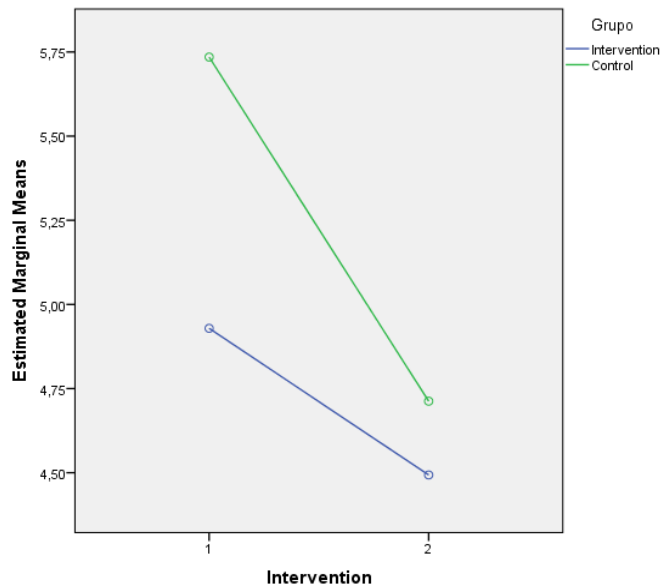
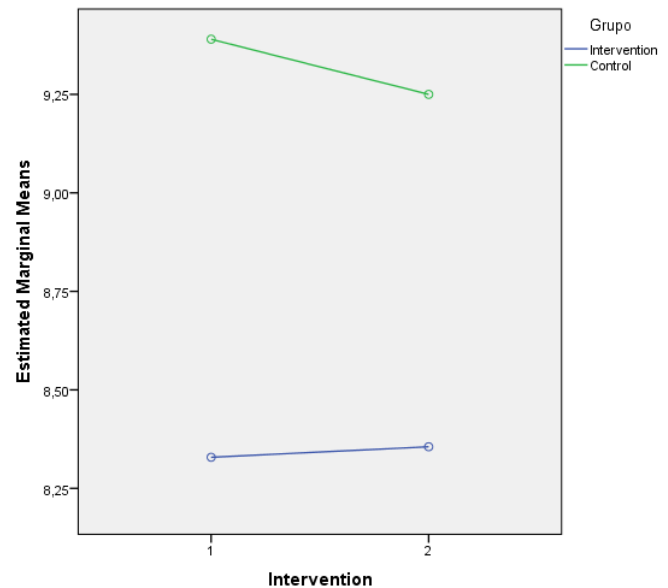
Table 2. Effect of a 6-months after-school physical activity program on physical fitness and academic performance.

	Post-test						
	PA group (n=18)			Control (n=10)		p-value e (g-t)	p-value (g-t) †
	$\bar{X} \pm SD$	Δ (pre-post)	Cohen's d	$\bar{X} \pm SD$	Δ (pre-post)		
Physical fitness							
BMI (kg/m²)	16,70±2,67	0.2	0,07	18,59±3,69	-0.03	0,407	0,662
Abdominal strength (rep/min)	32,94±10,63	5.72	1,11***	30,00±13,71	7.4	0,503	0,212
Flexibility (cm)	35,17±9,06	3.28	0,34*	35,50±11,00	-0.45	0,198	0,616
Aerobic capacity (m)	789,23±214,72	-27.19	0,16	771,42±178,92	12.85	0,147	0,191
Sprint (s)	4,50±0,69	-0.58	0,70**	4,73±0,68	-0.81	0,273	0,124
Agility (s)	8,21±1,11	-0.08	0,07	9,21±1,07	0.22	0,301	0,138
Lower Limb Power (cm)	141,44±33,98	21.58	0,64**	128,65±25,80	16.3	0,337	0,257
Upper Limb Power (cm)	202,74±70,88	5.52	0,09	184,40±31,22	-9.6	0,328	0,856
Academic performance							
Reading	46,44±26,09	17,92	0,69**	32,40±33,64	3,30	0,084	
Arithmetic	9,11±3,82	0.95	0,25*	8,90±3,72	3,00	0,600	
Writing	13,76±8,23	2,10	0,25*	9,10±10,75	-0,40	0,190	
Total score	69,05±35,13	21,00	0,58**	50,40±46,41	5.9	0,103	

PA: physical activity; n: sample number; $\bar{X} \pm SD$: mean and standard deviation; p-value: probability value; (g-t): group-time interaction BMI: body mass index; †: adjusted by maturity offset; *: small Cohen's d effect size; **: medium Cohen's d effect size; ***: large Cohen's d effect size.

The time-group interaction calculated from the GLM showed that the groups did not change significantly. For the specific physical fitness variables, the intervention's effect was still calculated as adjusted by the maturity offset. The results showed that maturation did not influence the results throughout the intervention. In addition to the results, we present graphs (see figure 2 and 3) of temporal change in each variable.

a) BMI**b) Abdominal strength**

c) Flexibility**d) Aerobic capacity****e) Sprint****f) Agility**

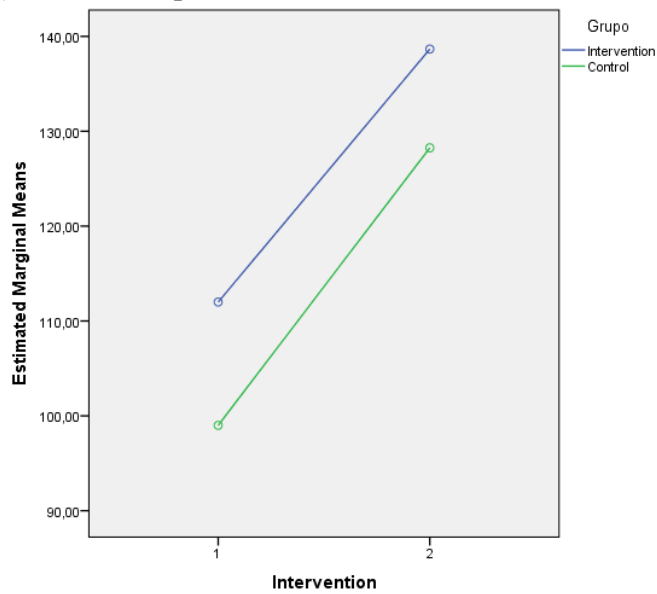
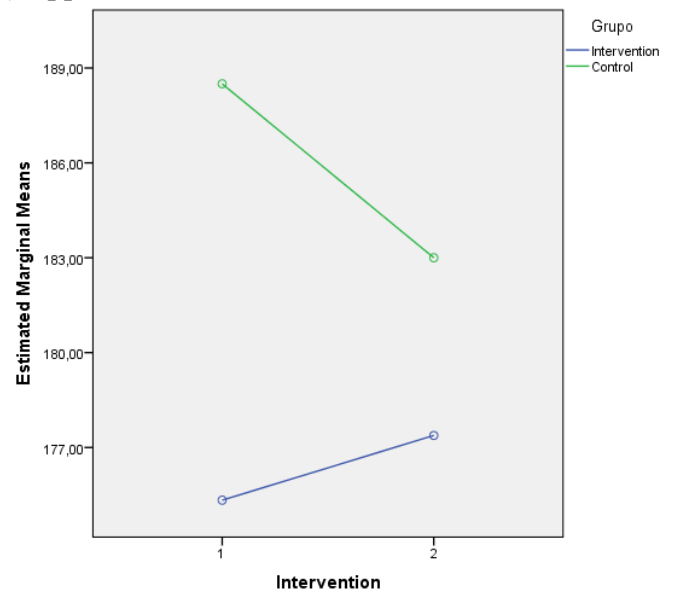
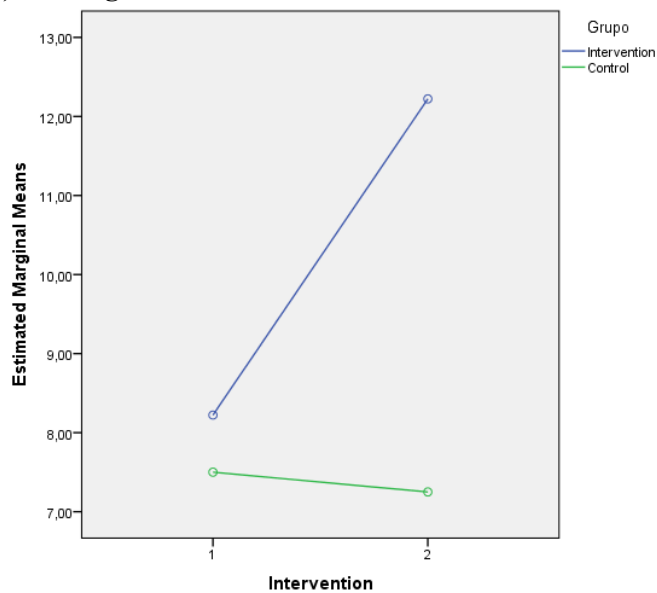
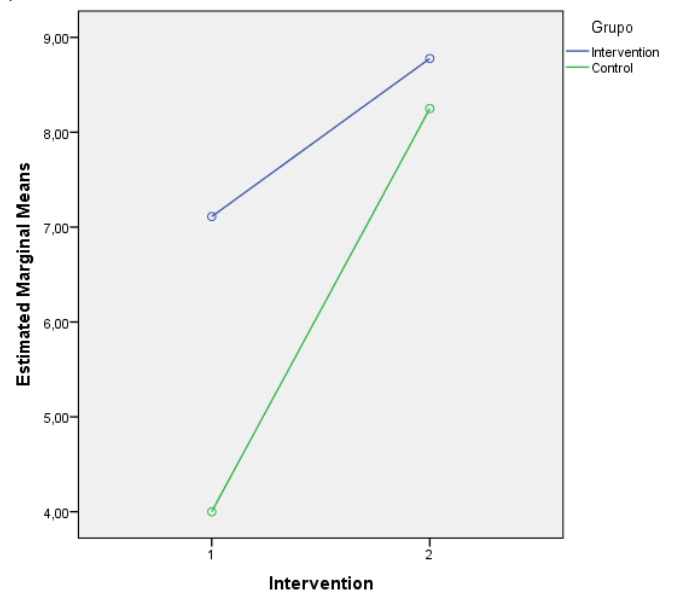
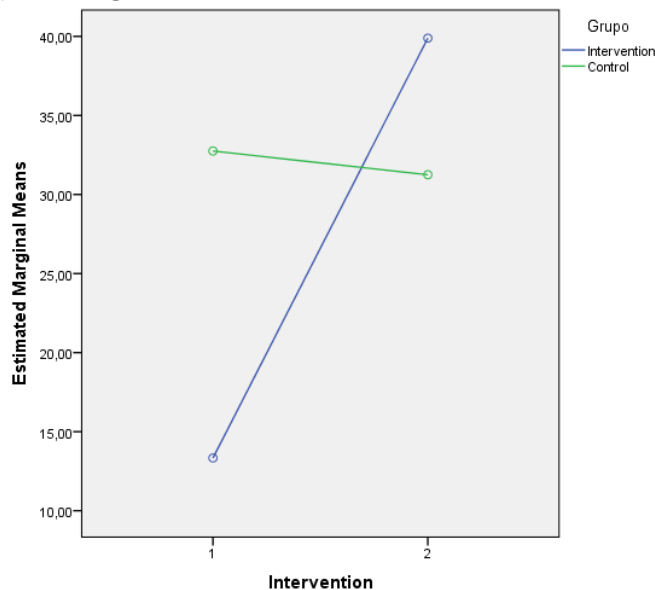
g) Lower limb power**h) Upper Limb Power**

Figure 2. Physical fitness changes from a 6-months after-school physical activity program.
Blue line: PA intervention group and Green line: Control group.

a) Writing**b) Arithmetic**

c) Reading



d) Total score

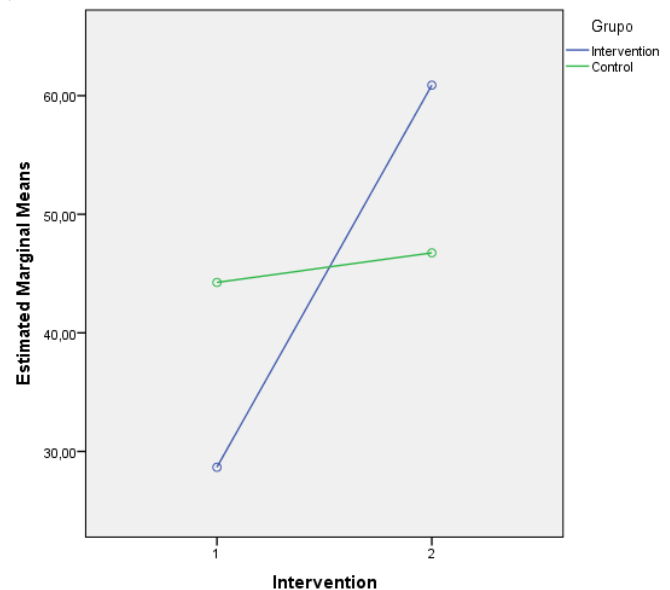


Figure 3. Academic performance changes from a 6-months after-school physical activity program. Blue line: PA intervention group and Green line: Control group.

Discussion

Our study aimed to describe a successful experience promoting school physical activity in the context of social vulnerability. Following the WHO recommendations, we provide daily physical activity for six months, five times a week, in the counter shift of a school. Our activities also included muscle and bone-strengthening exercises three times a week. Children exposed to this program showed improvements in physical fitness (just in abdominal strength, sprint, and lower limb power) and academic performance. However, the gains were in different magnitudes, middle-large for fitness and small-middle for academic performance.

Regarding physical fitness, a systematic review has shown that meeting daily physical activity recommendations can provide gains in general physical fitness²². Our results did not indicate that time changes interacted with somatic maturation, allowing us to assume that the changes occurred due to the intervention. However, our results differed from those presented by Morrow et al.²³ (similar proposal), as only abdominal strength, flexibility, sprint, and muscle power had positive effects. Furthermore, aerobic capacity worsened at the end of the intervention.

An important result highlighted is the decrease in aerobic capacity. Initially, we hypothesized that this variable could undergo moderate to high-magnitude changes, but the results were the opposite. Recently, a study addressed the dose-response of physical activity at different intensities on aerobic fitness. Burden et al.¹² investigated 339 adolescents, and the results indicated that 20 minutes of vigorous physical activity daily was associated with aerobic fitness increases. As in our results, Burden et al.¹² demonstrate that moderate daily physical activities do not affect aerobic fitness. Strengthening our results, a recent school intervention study showed that positive effects on aerobic capacity are possible through high-intensity games²⁴, which questions the WHO recommendation itself (and recommendations based on it), suggesting that future recommendations focus only on vigorous physical

activity. Furthermore, the lack of objective control of the intensity of activities may have been the main limitation for the results not to have been positive.

These results are, in a way, consistent with the proposed physical training (performed three times a week) followed by the recommendations of resistance exercise prescription for children at school¹⁶. These recommendations indicate that the initial training period should emphasize the acquisition of strength in the core, followed by progressive work on strengthening the limbs. In our case, the emphasis was on plyometrics due to the material resources available. These results align with some evidence demonstrating that muscle training in children tends to show results from the core to the extremities during the first few months²⁵. Furthermore, it is consistent that improvements in power and sprint occur simultaneously, as Mello et al.²⁶ demonstrated that these variables depend on each other, both in children and adolescents.

Our intervention proposed a considerable increase in the weekly volume of physical activity, being in accordance with the national recommendations for the promotion of physical activity at school²⁷. Furthermore, the use of the school environment as an intervention space (e.g., playground, recess, before and after time to school) is a recommended strategy for increasing autonomous physical activity practice²⁸. Our results indicated that the use of the school environment, in addition to increasing the weekly physical activity volume, presented benefits for physical fitness (in our protocol, specifically abdominal strength, sprint, and lower limb power) and academic performance, demonstrating the importance of physical activity beyond the biological components.

Regarding academic performance, our results are consistent with current evidence. Garcia-Hermoso et al.³¹, in a meta-analysis, highlighted that improving the quality (e.g., inserting an exercise program and/or inserting small games into the curriculum) of physical education, similar to our proposed, can result in slight increases in students' cognition. The same authors also showed a positive effect on academic performance, especially on math-related skills.

In addition, other reviews^{32,33} have shown that interventions in different school-related contexts (e.g., outside the school physical education class) can positively affect academic performance. Contreras-Orsorio et al.³³ demonstrated that sports activities (e.g., small games), present in our proposal, positively impact children's cognition. Furthermore, the authors suggest that organized sports (at school, sports clubs, etc.) may be better for developing executive functions than simply increasing the physical activity time. Another example is the review by Liu et al.³⁴, who demonstrated that regular physical exercise (e.g., circuits, physical training, strength training) has chronic beneficial effects on executive functions, which are fundamental for academic performance.

Although our results, in a specific context of social vulnerability, were consistent with what the current literature reports, our study has some limitations that must be considered. When analyzing the results of the generalized linear regression analyses, we took into account that the test power was very low, so we chose to consider the effect size more relevant; this strategy may be questionable. We did not include the nutritional control of both groups, a strategy that could have been carried out and could explain some results. Regarding the intervention, we did not assess exercise and physical activity intensity, so we no had absolutely sure that all children were in the moderate-vigorous intensity during the intervention. Although we have a control group, the non-randomization of the groups and the non-blinding of the intervention providers can lead to a bias in the results.

Conclusion

The results collectively showed that after six months of meeting WHO physical activity recommendations, socioeconomically vulnerable children had improvements in physical fitness and

academic performance. Significant enhancements occur in abdominal strength, flexibility, sprint and lower limb power. With regard to academic performance, we noticed improvements in all components. This evidence supports that interventions and public policies aimed at schools with a high level of vulnerability should include the regular practice of physical activity.

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Author Contributions

Marcio Morche y Júlio Mello participated in all the processes of project organization and data analysis, in addition to draft the manuscript. Augusto Pedretti participated in data analysis and draft the manuscript, in addition to reviewing and approving the final version.

Conflict of interest

Ninguno de los autores presenta conflicto de interés.



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