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Original

VARIABLES ANTROPOMÉTRICAS, CAPACIDAD AERÓBICA Y MUSCULAR: EFECTO DE UN PROGRAMA DE EJERCICIO FÍSICO APLICADO EN EL CONTEXTO ESCOLAR

ANTHROPOMETRIC MEASURES, AEROBIC AND MUSCULAR FITNESS: EFFECT OF AN EXERCISE PROGRAM APPLIED IN SCHOOL CONTEXT

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RESUMEN

El aumento de la obesidad infantil asociada a conductas sedentarias, potenciado por el uso de nuevas tecnologías y dietas deficientes, son generadores de niveles sin precedentes de sobrepeso y obesidad. La práctica de actividad física debe entenderse como una forma de prevención primaria y secundaria para reducir las enfermedades crónicas y muerte prematura. Este estudio tuvo como objetivo principal comprobar el efecto de un programa escolar de ejercicio físico sobre la composición corporal (IMC, % grasa corporal y circunferencia de cintura), capacidad aeróbica (VO_{2max}) y capacidad muscular (salto vertical, salto horizontal, flexiones de brazos, fuerza abdominal y flexibilidad). Siendo un estudio randomizado, se llevó a cabo el programa de ejercicio físico durante un período de tres meses, dos veces por semana, en sesiones de 60 minutos. Al principio de cada clase había una actividad lúdica deportiva para mejorar la capacidad aeróbica, seguido de actividades con el objetivo de desarrollar la fuerza (superior, media e inferior) y ejercicios de flexibilidad. El programa de ejercicios fue evaluado según los procedimientos de la plataforma FITEscuela (Ortega et al., 2011; Plowman, 2013; Welk, Laurson, Eisenmann & Cureton, 2011) y sus valores de referencia. Se obtuvieron resultados significativos en las variables de capacidad aeróbica (VO_{2max} , $p=.006$) e capacidad muscular (salto vertical, $p=.000$; salto horizontal, $p=.002$; fuerza abdominal, $p=.032$), así como en el nivel del porcentaje grasa corporal (%GC, $p=.017$).

Podemos concluir que el programa de ejercicios no tuvo el impacto esperado, en las variables de composición corporal (peso corporal y IMC), ni en las variables de fuerza (flexiones de brazos) y de flexibilidad. Con base en los resultados obtenidos podemos concluir que el programa tuvo influencia positiva en la disminución del %GC, en la mejoría de la capacidad aeróbica y muscular. Estos resultados reforzando la importancia de desarrollar estas intervenciones en contexto escolar y el impacto que pueden tener en la reducción de factores de riesgo cardiometabólico.

Palavra-Chave: Aptitud Física, Grasa Corporal, Actividad Física, Estudiantes, Centro Escolar

ABSTRACT

The increase in childhood obesity associated with sedentary behaviours, increased by the use of new technologies and a deficient diet, generates unparalleled levels of overweight and obesity. Therefore, the practice of physical activity should be understood as one of the forms of primary and secondary prevention for the reduction of chronic diseases and premature death. The main objective of this study was to evaluate the influence of a physical exercise program on body composition (body mass index (BMI), body fat (BF) and waist circumference (WC), aerobic fitness (VO_{2max}) and muscular fitness (vertical jump, horizontal jump, arm flexion, abdominal strength and flexibility). Being a randomized study, the exercise program was performed in a three-month period, twice a week, in 60-minute sessions. At the beginning of each class there was a playful sport activity to improve aerobic fitness, followed by a second activity with the goal to develop muscular fitness with strength (upper, middle and lower) and flexibility exercises. The physical exercise program was evaluated according to the procedures of the FITEscuela platform (Ortega et al., 2011; Plowman, 2013; Welk, Laurson, Eisenmann & Cureton, 2011) and their reference values. Significant results were obtained in the variables of the aerobic fitness (VO_{2max} , $p=.006$), muscular strength (vertical jump, $p=.000$; horizontal jump, $p=.002$), as well as the % BF level ($p=.017$). Regarding the variables of body composition, we can conclude that the exercise program did not have the expected impact on the BMI and WC, as well for the arm flexion and flexibility variables. Considering the results achieved, we conclude that the physical exercise program had a positive influence on the reduction of the % body fat, improvement of aerobic fitness and variables of muscular fitness (vertical jump, horizontal jump, abdominal strength), reinforcing the importance of developing this type of interventions and the impact they can take on reducing cardiometabolic risk factors.

Key words: Physical Fitness, Body Fat Mass, Physical Activity, Children, School



INTRODUCTION

In recent years, several studies have pointed to a direct link between sedentary behaviours and food considered to be less healthy, advocating as a solution the practice of physical activity (PA) and the implementation of healthier eating patterns (Brandstetter et al., 2012).

In fact, high levels of blood pressure, cholesterol, overweight and obesity, smoking, insufficient fruit and vegetable intake and physical inactivity are the main risk factors for the development of noncommunicable diseases, such as cardiovascular disease, diabetes and various types of cancer (Jolliffe & Janssen, 2007). These risk factors account for 60% of the 56 million annual deaths and 47% of diseases worldwide.

On the other hand, a balanced diet and physical activity influence, independently or jointly, health, although the practice of PA provides additional health benefits that are independent of nutrition and diet (Baptista et al., 2011).

There is no evidence that regular PA contributes to primary and secondary prevention of various chronic diseases and reduced risk of premature death. There is a linear relationship between the volume of PA and health and the more physically active people are fewer risks of disease they have. However, the greatest gains in health were observed in people who became progressively more active. Exercise programs should target all ages, since the risk of chronic illness begins in childhood and increases with age (Warburton, Nicol & Bredin, 2006).

In the study by Strong et al. (2005), it was reported that physical exercise intervention programs should have 60 minutes of moderate and vigorous physical activity (MVPA) so that there are benefits to the cardiorespiratory, musculoskeletal and metabolic factors.

The World Health Organization (WHO) recommends for the practice of PA that school-age children should accumulate 60 minutes of moderate-intensity PA daily and 20-30 minutes vigorously in activities such as running, jumping, climbing, descending and playful games - sports and collectives - leading to the improvement of strength and flexibility (WHO, 2010). Exercise programs should include games, activities, and exercises that prompt the cardiovascular system

and impact the skeleton to improve bone mineralization (WHO, 2010).

The recommendation of 60 minutes of moderate and vigorous daily physical activity is associated with 10000 to 14000 steps / day in pre-school and primary school children, 13,000 to 15,000 steps / day in boys and 11,000 to 12,000 steps / day in girls (Tudor-Locke et al., 2011).

In a recent study, Verloigne et al. (2012) concluded that a large number of children from different countries do not comply with the recommendations for PA, therefore the authors suggest that physical exercise and obesity prevention programs to be increasingly more widely publicized and used in order to promote healthy living habits.

The practice of activity should be initiated in childhood because, throughout this complex phase by the transformations inherent to growing, the patterns of behaviour that children assimilate can be decisive for a healthier future (ACSM, 2015; Boreham & Riddoch, 2001; Piéron, 1998).

It is during this period that children have the possibility to define a great part of their future, through the development of the attitudes inherent in the practice of PA. In this way, we should sensitize society to the importance of healthy living habits. However, we cannot avoid worrying when we witness an increasingly sedentary society, that is, with low levels of PA often associated with poor eating habits (Blair, 2009).

The results of the different studies suggest that improving motor proficiency at early ages has the potential to influence PA levels in later years and therefore implications on adiposity levels. Pleasure and success in participating in PA can promote and motivate for their practice. However, children with poor motor skills generally have a perception of their limited competence, which increasingly distances them from frequent PA. Because they know they are not as competent as their peers and do not want to show this inability they choose to refuse. Because they have a limited motor repertoire, they are less motivated to participate in physical activities that require high abilities. As these factors interact, a child with low motor competence will find PA less enjoyable than their partners with high motor competence (Lopes, 2010).



Schools are undoubtedly a unique place for the development of interventions that aim to promote PA, as no other institution has as direct and close contact with students and their families as schools (Brown et al., 2007, Corbin et al., 2014).

The aim of this study was to verify the effect of an exercise program on body composition, aerobic fitness and muscular fitness of children aged 10 to 13 years.

METHODS

Design

Experimental and longitudinal study, three months duration, with Control Group (CG) [n=49] non-participant in the exercise program and Experimental Group (EG) [n=21] participant in the exercise programme. Pre-post measurement was realized. Comparing pre - post outcomes measures of the CG and EG. The design details are described in the figure 1.

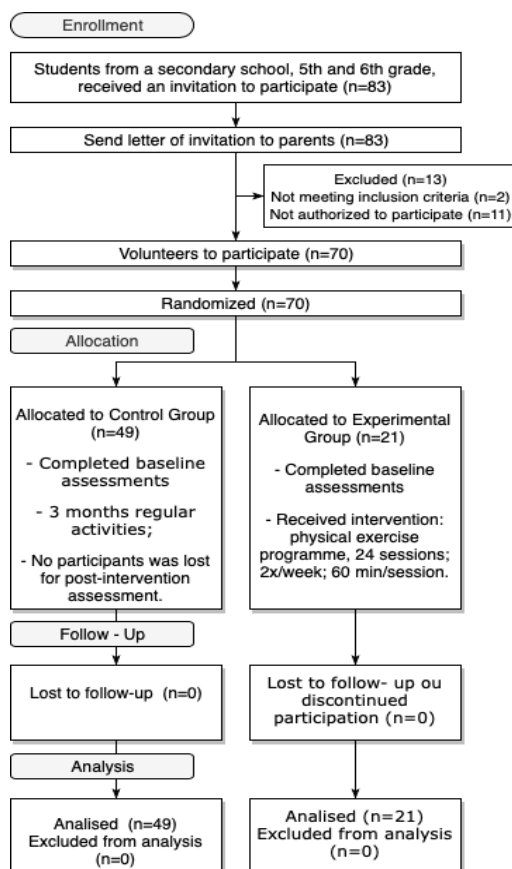


Figure 1. Flowchart of participants recruitment and trough programme implementation.

The study personnel involved in the recruitment process were not involved in screening, testing, or training procedures.

Participants

In the present study, 70 children (55.7% females) from one secondary school in Vidigueira (Portugal) took part in this study. Participants were 11.09 ± 2.06 years old (range=10-13 years). The structure used for group formation and intervention characteristics are shown in Figure 1.

Of all the participants, 42.85% belonged to the 5th grade and 57.14% belonged to the 6th grade. Prior to the start of the study was held a briefing session for students, parents, teachers and board of the school, where was explained the nature and objectives of the study, requiring the consent to parents and students. Only those students who received authorization from their parents participated in the study. Eligibility criteria included children aged 10 to 13, with no chronic disease.

Physical Exercise Programme

The EG went through a three-month standardized physical exercise program led by physical exercise specialists, with the support of the physical education teacher. The program consisted of 24 sessions of physical exercise in total and two training sessions per week, each training session lasted 60 minutes and had as its main objective to improve aerobic resistance, general strength, flexibility, coordination and balance. The sessions of this program had in the initial part ludic-sport activities with the objective of developing the cardiorespiratory capacity. These ludic-sport activities were composed by collective games, without the minimum material involved and, in some activities, we use music. The games, ensuring a maximum intensity of fun and involvement, were developed from the easiest to the most complex form. The main part was destined to the realization of a circuit of muscular strength (core, upper and lower limbs) and balance and general coordination that was weekly modified in order to be motivating to the participants. In the final part of the sessions was carried out exercises of flexibility and balance.



Anthropometrics, Body Composition and Physical Fitness Measurements

The anthropometrics, body composition and physical fitness measurements, were evaluated in a school context, and in a classroom situation (pavilion/gymnasium). All tests were supervised by the physical education teachers. A trained investigator performed all the measurements. FITEscola was the evaluation program used, complying with the reference values for anthropometrics, body composition and physical fitness (Welk et al., 2011). The anthropometric assessment included measuring height, weight and waist circumference (WC) and the calculation of body mass index (BMI). The height measurement was performed with a SECA® stationary stadiometer (SECA-214®, Hamburg, Germany) stadiometer, using national and international procedures. Thus, the participants were measured with minimal clothing and bare feet and turned from their backs to the marking of the stadiometer in an upright position, with the weight distributed on both feet, united heels and feet at 60 degrees, with the head placed in the Frankfort plane and with the arms extended beside the body (Rito, Breda & Carmo, 2010). In addition, an electronic scale was used to assess weight and body composition (percentage of fat mass) using a bipolar electric bioimpedance method (Tanita InnerScan Body Composition Monitor® model BC-418MA®, Segmental Body Composition Analyzer). The values were obtained with all the participants barefoot and with the least possible clothes, with the arms extended, completely still, fully supporting the soles of the feet and with the head upright. The bioelectrical impedance measurements were completed according to the device manufacturers' instructions, undertaken at least two hours after breakfast and required the participants to stand barefoot on metal electrodes. The evaluation of the waist circumference (WC) was obtained according to the methodology of Guide of Evaluation of Nutritional Status DGS-INSA (Rito et al., 2010). According to Cameron's method, the participants removed their clothing from the abdominal perimeter area and the measurement was performed with the plane of the tape perpendicular to the long axis of the body and parallel to the floor. The WC was measured at the level of the superior iliac crest. The BMI was calculated using the Quetelet equation, with weight and height [weight (kg)/height (m²)].

The Physical Fitness measurements (FITEscola, 2017) included six tests: shuttle test; sargent jump; horizontal jump; abdominal test, push up and sit and reach (right and left leg).

Cardiorespiratory fitness mirrors the overall capacity of the cardiovascular and respiratory systems and their ability to perform MVPA. The shuttle test was applied as a facilitator in the evaluation of Cardiorespiratory fitness since its protocol is easy to apply, with high assertiveness, and progressive effort levels adapted from the 20-meter run test (Leger & Lambert, 1982; Welk et al., 2011). Therefore, the cardiorespiratory fitness was calculated according to the calculation formula of VO_{2max}, as it appears in the FITEscola platform.

$$\text{VO}_{2\text{max}} \text{ (ml/kg/min)} = 41,76799 + (0,49261 * \text{lap}) - (0,00290 * \text{lap}^2) - (0,61613 * \text{BMI} + 0,34787 * \text{gender} * \text{age})$$

[Gender: girls:0 ; boys=1 ; BMI, kg/m² ; Age , years]

Figure 2. Calculation formula of VO_{2max}, as it appears in the FITEscola platform.

In the sargent test, a vertical jump applied to evaluate the explosive force, the participant should be able to reach the highest possible point with his fingertips. To do this, place a distance of 30 cm from the marking line of the jump, with the feet resting on the ground. The starting position is recorded and then the participant performs a squat and the jump in order to reach its highest point.

The horizontal jump test, assess the explosive force, were the participant should stand with the feet parallel and distant 10 to 20 cm, behind a demarcated line in the ground. The jump should be performed by flexing the knees and taking advantage of the arm swing.

The abdominal test, which has the objective of evaluating the abdominal strength. The participant should begin the test lying on his back on the mattress, with his head resting, his knees bent approximately 90 degrees, and feet resting on the mattress. The arms should be in extension, with the palms of the hand on the thighs and the fingers stretched, and the student's feet should not be safe. The student should flex the trunk, slowly and controlled, without raising the feet of the mattress. At the same time the hands should involve the knees.

The push up test consists of executing the greatest number of arm flexions (arm flexion movement and extension of the forearms) at a predefined rate. This



test aims to evaluate the resistance force of the upper limbs. The participant should begin the test with the body on a plank, with the elbow in extension, and with the feet slightly away, leaning on the tips of the feet. The hands should be placed under the shoulders and the width of these.

Sit and reach is to assess the flexibility of the lower limbs. The participant should sit on the floor, barefoot and facing the box, with one leg bent, with the sole planted on the floor, and the other in full extension, placing the foot against the box.

Statistical Procedures

The statistical treatment of the data was performed using software Statistical Package for the Social Sciences (IBM, SPSS® version 23.0). The descriptive statistics (mean and standard deviation) for each of the groups was evaluated using the Kolmogorov-Smirnov test with the Lilliefors correction. After this phase and to compare the groups at the different moments of evaluation, the non-parametric tests of Mann Whitney and Spearman were used, according to the Kolmogorov-Smirnov test result. In order to analyse the differences between the variables of the same group (pre-test and post-test) the Wilcoxon test was used. For all the analyses, a 95% confidence level was used ($p \leq 0.05$).

RESULTS

In order to achieve a greater rigor in the conclusions to be presented regarding the descriptive data at the time of the initial evaluation, we run a statistical analysis. The results are presented in the table 1.

Table 1. Results of anthropometric and body composition variables in the CG and EG at the initial evaluation.

	CG (n=49)	EG (n=21)	Value of U	p
	Mean (SD)	Mean (SD)		
BMI	19.8±12.14	19.5±4.75	481.500	.672
% BF	21.5±4.54	22.6±9.34	464.500	.522
WC	74.2±9.72	71.3±14.64	506.000	.913

BMI: body mass index; %BF: body fat; WC: waist circumference

According to the results we can conclude that there are no significant differences between the CG and EG for any of the anthropometric and body composition variables.

Table 2. Descriptive results of the variables of aerobic and muscular fitness in the initial evaluation.

	CG (n=49)	EG (n=21)	Value of U	p
	Mean (SD)	Mean (SD)		
VO _{2max}	37.82±6.66	39.62±6.67	444.500	.370
Vertical Jump	17.00±5.27	18.87±5.67	417.500	.212
Horizontal Jump	125.28±22.2	106.40±55.4	460.500	.489
Abdominal Push-Up	25.57±16.59	31.55±18.21	423.000	.241
Sit & Reach Right	4.80±4.81	10±6.91	265.000	.001
Sit & Reach Left	23.19±4.19	21.65±5.11	458.000	.467
Sit & Reach Left	22.80±4.79	21.16±5.28	497.000	.822

In order to compare the variables of physical fitness of the CG and the EG in the initial assessment (baseline), the difference between the two groups was statistically significant for push up ($U=265.000$; $p=.001$), presenting the elements of the best control group (10.0/4.80). From this analysis, we can also observe that no significant differences were observed between groups for the remaining variables.

Table 3. Results of anthropometric and body composition variables in the CG and EG in the final evaluation.

	CG (n=49)	EG (n=21)	Value of U	p
	Mean (SD)	Mean (SD)		
BMI	19.96± 4.60	19.89±4.49	510,00	.954
% BF	20.66±9.02	21.11±8.40	481,500	.672
WC	73.08±12.11	74.17±13.24	489,000	.744

BMI: body mass index; %BF: body fat; WC: waist circumference

According to the results (table 3) we can verify that there are no significant differences between the CG and the EG regarding the BMI ($U=510.00$, $p=.954$), %BF ($U=481.500$, $p=.672$) and WC ($U=489.000$, $p=.744$) at the end of the exercise program.

Table 4. Comparison of the variables of aerobic and muscular fitness in the final evaluation.

	CG (n=49)	EG (n=21)	Value of U	p
	Mean (SD)	Mean (SD)		
VO _{2max}	39.27±6.15	40.80±7.18	450.000	.408
Sargent Jump	23.42±6.62	21.79±7.78	432.000	.289
Horizontal Jump	136.95±28.47	136.22±28.6	494.500	.798
Abdominal Push-Up	31.90±14.32	30.77±18.51	467.500	.547
Sit & Reach Right	6.66±4.62	10.85±5.16	286.000	.003
Sit & Reach Left	22.61±5.13	21.02±5.02	432.000	.289
Sit & Reach Left	22.28±4.83	21.04±5.27	457.000	.464



According to table 4, we can say that between the CG and the EG there are statistically significant differences in push up ($U=286.000$; $p=.003$), which does not happen for the remaining variables of aerobic and muscular fitness.

Table 5. Comparison of anthropometric and body composition variables of the EG in the initial and final evaluation.

	Experimental Group (n=21)		Dif.	p
	Pre	Post		
	Mean (SD)	Mean (SD)		
BMI	19.50±4.75	19.89±4.49	0.39	.007
% BF	22.56±9.34	21.11±8.40	-1.45	.017
WC	71.32±14.64	74.17±13.24	2.85	.001

BMI: body mass index; %BF: body fat; WC: waist circumference

According to the values found, we can affirm that there are very significant differences between the initial evaluation and the final evaluation in the EG for all the variables related to the body composition, namely BMI ($p = .007$), %BF ($p = .017$) and WC ($p=.001$).

Regarding %BF, and according to the average values found, there was a decrease (-1.45%), which is in line with our initial expectations. Regarding BMI and WC, the results indicate an increase in values, which seems to be a contradiction in relation to the previous one, mainly in relation to WC (+2.85 cm).

Table 6. Comparison of the EG variables of aerobic and muscular fitness in the initial and final evaluation.

	Experimental Group (n=21)		Dif.	p
	Pre	Post		
	Mean (SD)	Mean (SD)		
VO_{2max}	37.82±6.66	39.27±6.15	1.45(0.51)	.006
Sargent Jump	17.00±5.27	23.42±6.62	6.42(1.35)	.000
Horizontal Jump	125.28±22.26	136.95±28.47	11.67(6.21)	.002
Abdominal Push-Up	25.57±16.59	31.90±14.32	6.33(2.27)	.032
Sit & Reach Right	4.80±4.81	6.66±4.62	1.86(0.19)	.097
Sit & Reach Right	23.19±4.19	22.61±5.13	-0.58(0.94)	.438
Sit & Reach Left	22.80±4.79	22.28±4.83	-0.52(0.04)	.394

We can say that the variables of VO_{2max} ($p=.006$), sargent jump ($p=.000$), horizontal jump ($p=.002$) and abdominal ($p=.032$), present statistically significant differences between the initial and final evaluations. An improvement worthy of acknowledging in the results obtained in the second moment of evaluation. Regarding push up, and although there were no statistically significant overall differences, the mean

values also indicate an improvement in this competence.

DISCUSSION

Our study aimed to contribute to the knowledge of the influence of an exercise program, in a scholar context, on anthropometric and body composition and physical fitness variables, developed with students between 10 and 13 years of age.

From the results presented, the exercise program seems to have contributed to a decrease in the %BF, the same did not occur with WC and BMI. Thus, we can say that the first objective of improving all variables related to body composition has not been proven. The same was true in the MOVI-2 study, which had an eight-month intervention, with two 90-minute lessons per week and a 150-minute Saturday morning class, which revealed that there was success in decreasing %BF and levels related to metabolic factors in the female gender. It was also possible to verify that there was no change in the prevalence of overweight, obesity and BMI (Martinez-Vizcaino et al., 2014). Based on the results presented, the exercise program promoted a significant increase in aerobic and muscular fitness in the intervention group. So, we can say that goal two has been reached. The results verified are supported by the scientific community which suggests that PA is positively related to the increase in aerobic fitness in children and young people, influencing cardiovascular and metabolic health, increasing physical fitness and reducing the %BF, which in turn eliminates processes leading to cardiovascular disease and diabetes (Lee et al., 2010). According to the physiology of the exercise, and based on the concept of the training load, it is possible, through resistance training, to provide increases in VO_{2max} from 5% to 15%. According to the literature, there seems to be unanimity in assuming that the frequency of three to four days per week, with a duration of 30 to 60 minutes per session, for one to three months, has been associated with these improvements in physical fitness (USDHHS, 2008). In the FITkids study by Khan et al. (2014), who had a nine-month intervention with five classes per week of 70 minutes of moderate to vigorous physical activity, the intervention group presented a reduction of %BF both for overweight, obese and normoponderal participants. Our study also showed an improvement in %BF. In the study developed by Thivel et al. (2011),



an exercise programme (with an increase in an extra class of physical education) that lasted six months applied to children, some of them obese, who used the shuttle test as a means of evaluating VO₂max and aiming to increase the cardiorespiratory fitness, obtained results in everything similar to ours. The authors reported an improvement in VO₂max, although no significant differences between the control and experimental groups were verified.

Similarly, the investigation by Sacchetti et al. (2013) concluded that a two years intervention with two more classes of 50 minutes per week improved the test (running test and long jump) in the experimental group, but without significant differences for BMI, therefore this study is also in line with ours.

Also, in this regard, the JuvenTUM study by Siegrist, Lammel, Haller, Christle and Halle (2013) is in line with ours, since it found a slight increase in cardiorespiratory evaluation in relation to control group. It is recalled that this study lasted for one year with two weekly lessons of 45 minutes.

CONCLUSIONS

Throughout the present study, the effects of an exercise program on body composition and aerobic and muscular fitness were investigated by collecting and analysing data using the reference values of the FITescola platform (Laurson, Eisenmann & Welk, 2011; Leger & Lambert, 1982; Ortega et al., 2011). It can be concluded that in general, positive results were obtained in the variables of aerobic and muscular fitness and that the expected effects for BMI and WC were not verified. However, %BF presented significant results. Also, regarding the variables of aerobic and muscular fitness, there were significant statistical differences between the moment of the initial and final evaluation. Our study reveals that 120 minutes of exercise, implemented in a school context through a supervised session, reduces the %BF, increase the cardiorespiratory fitness as also certain components of muscular fitness. We can conclude that the WHO guidelines regarding the intensity, frequency and volume of regular PA for the implementation of an exercise program have contributed decisively to a part of the success of the program.

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