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Effects of a 12-week-long program of vigorous-intensity physical activity on the body composition of 10-and 11-year-old children

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ABSTRACT

The purpose was to study the effects of a program of vigorous-intensity physical activity (PA) on the body composition of children. This investigation involved 108 school children from 10 to 11 years old (60 males 10.47 ± 0.50 yr, and 48 females 10.67 ± 0.48 yr). The variables measured were: body weight, fat-free mass (FFM), fat mass (FM), total body water (TBW), basal metabolic rate (BMR), body mass index (BMI), fat-free mass index (FFMI) and fat mass index (FMI). The design was experimental with two groups, experimental group EG (vigorous-intensity PA) and control group CG. Males of EG achieved higher improvements than CG in all the variables, apart from body weight, BMI and FFMI. Females of EG achieved more improvements than CG, especially in FFM(%), FM(kg), FM(%), FMI(kg/m²) and TBW(%). The program of vigorous-intensity PA used is effective in improving the body composition of 10-and 11-year-old children. **Key words:** BMI, FAT MASS, HEALTH, PHYSICAL EDUCATION, SCHOOL CHILDREN

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INTRODUCTION

Body composition (BC) can be understood as the division of body weight in different compartments that constitute the human body (Berral et al., 1991). Therefore, BC analysis allows to know the proportions of the various constituents parts of the human body (Moreno, 2000). According to Moreno (2000), the model traditionally used to evaluate BC is the model of two compartments, or bicompartamental, which posits that the human body is composed of a part of fat mass and another part of fat-free mass; or alternatively, fat mass and lean mass.

BC is closely related to people's health and measurement of BC allows the early detection of certain diseases (López et al., 2015a). As Cordova et al. (2013) noted, there is an increased prevalence of obesity during childhood, which can also lead to chronic diseases related to inactivity and obesity in adulthood. Currently childhood obesity is one of the major concerns regarding long-term health (Duncan et al., 2006).

Consequently, any action aimed at improving body composition in the population is justified, as it entails simultaneously improved health and reduction of the possibility of disease. Physical activity is proposed as the ideal means to improve physical fitness and body composition in children and adolescents, according to numerous studies (Borrego et al., 2015 a, b; López et al. 2013, 2015a; Ortega et al., 2013; Plonka et al. 2011). Physical activity can also be beneficial for the body composition of people with special needs, such as schoolchildren with ADHD (López et al. 2015b).

However, recent research indicates that schoolchildren are not doing enough physical activity during the day (Pérez et al., 2011), because nowadays in society the need to move and make any kind of physical effort is ever decreasing, and there are numerous behaviors that involve being seated for a long time throughout the day (Pate et al., 2011).

Overall, there is consensus on the need to increase levels of physical activity, since, according to different studies, regular physical exercise has a significant effect on weight loss due to important changes in circulation, hormonal status, the nervous system, the transport of substrates and the mobilization of lipids (Aguilar et al. 2014).

In this sense, Pienaar et al. (2013) concluded that the profile of body composition and physical fitness of children can improve with a multidisciplinary program that includes behavioral changes regarding physical activity and diet, although it should be in a continuous and controlled manner.

Likewise, high levels of physical activity, practiced regularly, can provide protection against obesity in children and adolescents (Herman et al., 2014). Besides, as shown in the study of Palencia et al. (2015), a higher number of minutes of vigorous physical activity is associated with indicators of lower adiposity and better physical fitness in schoolchildren aged 9 and 10, while less time is related to low cardiorespiratory physical fitness and an increased likelihood of being overweight and obese.

Nevertheless, it is necessary to take into account the intensity factor, since it is possible that a certain threshold of intensity may influence to a greater or lesser extent individual body composition (Abbott and Davies, 2004). Several studies have found significant relationships between physical activity (especially vigorous) and healthy body composition (Riddoch et al. 2009). In the same vein, Cho and Koh (2014) suggest that an aerobic exercise program coupled with dietary changes is effective for children who are overweight or obese and could have positive effects on body composition and healthy physical fitness.

Due to the direct relationship of body composition with an individual's state of health, more intervention programs are needed to improve people's body composition and, consequently, their health. The main objective of this research is to determine the effectiveness of a 12-week program of vigorous-intensity physical activity on the body composition of 10-and 11-year-old schoolchildren. The study assumes that the program of vigorous-intensity exercises reduces fat mass and improves other parameters of body composition in children.

MATERIALS AND METHODS

Participants

108 school children from 10 to 11 years old participated in the study (60 males: 10.47 ± 0.50 yr, height 1.47 ± 0.08 m, weight 43.18 ± 8.11 kg; and 48 females: 10.67 ± 0.48 yr, height 1.51 ± 0.08 m, weight 44.50 ± 9.46 kg). The children are in primary school and they have two hours of PE per week, but they do not practice any kind of sports outside the school. The research was approved by the Research Ethics Committee (No.03/02/2012) and all the students and their parents/legal guardians gave informed consent. The work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans.

Design

School children of four classes of primary education participated in the study ($n=108$). The composition of each class was mixed (boys and girls). Two classes carried out the physical activity program with exercises of vigorous intensity (Experimental Group EG, $n=48$) and the other two classes did not participated in the program of physical activity (Control Group CG, $n=60$). The program consisted of 3 sessions per week of vigorous-intensity physical activity and the duration of each lesson was 15 minutes (Table 1). The teachers of the school children were the same along the whole experiment and the lessons were conducted according to the predetermined program. The intensity of the effort in boys and girls of EG was established according to Borg scale (Borg, 1982). Due to the age of the subjects, four easy-to-understand options were developed about the perceived exertion during the physical education lessons. The options given were: 1-light, 2-somewhat hard, 3- hard, 4-very hard. After each lesson, the school children filled out the worksheet individually, indicating the intensity of the effort according to the established scale. The duration of the experiment was 12 weeks. Body composition was measured at the beginning and at the end of the experiment. PA lessons were carried out outdoors from January to April, with an average ambient temperature of 15°C , an average humidity level of 70% and an average atmospheric pressure of 1000 hPa.

PE program

Table 1. Description of the PE program

Duration of the PE program	EG	CG
12 weeks	Vigorous-intensity	No sessions
3 sessions / week	physical activity sessions	
15 min / session		

Experimental Group (EG)

The intensity of the activity of the experimental group was vigorous, always taking into account that the target group was composed of children, and in order to motivate them it was necessary to disguise the activities by means of games avoiding the analytical and traditional. To accomplish this, a set of games was developed to avoid monotony, which included the following: relay races, sprints, running, skipping rope and competitive sports and games.

All the games were set up in adapted spaces and with the necessary rules to achieve vigorous-intensity physical activity. In this manner vigorous intensity intervallic participation was achieved. If the intensity of the game seemed to decrease, a new incentive was quickly put into place, a small rule or modification or sometimes the researchers even took part in the game in order to maintain the intensity of the session.

Control Group (CG)

The children of the CG did not carry out the vigorous-intensity physical activity program.

Body Composition measurements

All participants were measured for selected body mass and body composition variables before and after the completion of the 12-week period. Measurements were performed in the morning, more than three hours after waking up and after last eating and drinking. Body mass and body composition were assessed with the bioelectrical impedance method (body's inherent resistance to an electrical current) using a Tanita BC 418-MA body composition analyzer (Tanita, Tokyo, Japan). All the recommendations for the analysis of bioelectrical impedance were followed. The device was plugged in and calibrated to account for the weight of clothing (0.2 kg). Afterwards, data regarding age, sex and body height of the subject were entered. Stadiometer HM - 250P Leicester (Marsden Scales, Rotherham, United Kingdom) was used to measure the height. Then, the subjects stood on the scale with their bare feet and hands on the marked places. The device analyzes body composition based on the differences of the ability to conduct electrical current by body tissues (different resistance) due to different water content. The variables measured were: body weight (kg), fat-free mass (FFM, kg and %), fat mass (FM, kg and %), total body water (TBW, kg and %), and basal metabolic rate (BMR, kcal). Additionally, the next indexes were calculated: body mass index (BMI, kg/m²), fat-free mass index (FFMI, kg/m²) and fat mass index (FMI, kg/m²).

Statistical analysis

Data analysis was performed using Statistical Package for Social Sciences 22 (SPSS-22) and STATISTICA-10 (data analysis software system). The Kolmogorov-Smirnov test was used to estimate the normality of the sample. A two-way repeated measures ANOVA was applied to analyze the between-group (CG and EG) and within-group (pre and post) effects. Moreover, the effect size (eta squared, η^2) for analysis of variance was calculated. Partial eta squared values of 0.01, 0.06 and 0.14 were interpreted as small, medium and large effect sizes, respectively (Richardson, 2011). When interaction effects were significant, post-hoc analyses using the HSD Tukey test were performed. Each time, $P < 0.05$ was considered as a significant difference.

RESULTS

Conforming to the answers of males and females about the intensity of the effort on each of the 36 sessions, it was observed that in the EG 80% of males and 90% of females classified the effort as very hard.

Table 2 shows that for males there was a 'time' interaction in all the variables, except BMI, so during the period of 12 weeks both groups achieved significant improvements in their body composition, but not in BMI.

Regarding 'group x time' interaction, it is observed that changes in 8 variables of the EG differed from the CG. Therefore the males of the two groups improved after the period of 12 weeks, but the EG achieved clearly higher improvements in all the variables, apart from Body Weight, BMI and FFMI. Besides, in the EG there were significant pre to post changes at $p < 0.05$ in all the variables (with the exception of BMI), while in the CG there were significant pre to post changes at $p < 0.05$ only in 4 variables (Body Weight, FFM in kg, TBW in kg and BMR). With regard to mean differences, it is noteworthy that FM reduction in EG was -2.4%, while in CG it was only -0.7%. Further, effect size values suggested large practical significance in all the variables, with the highest effect size in FFM (kg) and TBW (kg) time interactions (0.754 and 0.746, respectively).

Table 3 shows that for females there was a 'time' interaction in all the variables, except BMI and FM (kg), so during the period of 12 weeks both groups achieved significant improvements in their body composition, but not in BMI and FM (kg). Regarding 'group x time' interaction, it is observed that changes in 5 variables of the EG differed from the CG. Therefore the females of the two groups improved after the period of 12 weeks, but the EG achieved more improvements, especially in FFM (%), FM (kg), FM (%), FMI (kg/m²) and TBW (%). Besides, in the EG there were significant pre to post changes at $p < 0.05$ in all the variables (with the exception of BMI), while in the CG there were significant pre to post changes at $p < 0.05$ only in 4 variables (Body Weight, FFM in kg, TBW in kg and BMR). With reference to mean differences, it is remarkable that FM reduction in EG was -1.9%, while in CG it was only -0.3%. Further, effect size values suggested large practical significance in all the variables, with the highest effect size in FFM (kg) and TBW (kg) time interactions (0.816 and 0.810, respectively).

Table 2. Results of the body composition measurements in males

	CG (n=38)			EG (n=22)			Differences	ES
	Pre	Post	M Dif.	Pre	Post	M Dif.		
Body Weight (kg)	41.0 ± 9.0	41.9 ± 8.1*	0.9	46.9 ± 7.0	48.0 ± 6.7*	1.1	time	0.643
BMI (kg/m²)	19.6 ± 2.7	19.5 ± 2.7	-0.1	20.2 ± 2.1	20.1 ± 2.3	-0.1	-	-
FFM (kg)	30.9 ± 4.8	31.9 ± 5.1*	1.0	35.4 ± 4.4	37.3 ± 4.7*	1.9	time	0.754
FFM (%)	76.0 ± 5.0	76.7 ± 5.3	0.7	75.8 ± 5.1	78.2 ± 5.2*	2.4	group x time	0.236
							time	0.453
							group x time	0.278
FFMI (kg/m²)	14.8 ± 1.4	14.9 ± 1.3	0.1	15.2 ± 1.0	15.6 ± 1.1*	0.4	time	0.321
FM (kg)	10.1 ± 3.8	10.0 ± 3.9	-0.1	11.5 ± 3.7	10.6 ± 3.4*	-0.9	time	0.240
							group x time	0.292
FM (%)	24.0 ± 5.0	23.3 ± 5.3	-0.7	24.2 ± 5.1	21.9 ± 5.2*	-2.4	time	0.453
FMI (kg/m²)	4.8 ± 1.6	4.7 ± 1.7	-0.1	5.0 ± 1.5	4.5 ± 1.5*	-0.5	group x time	0.278
							time	0.400
							group x time	0.265
TBW (kg)	22.6 ± 3.5	23.3 ± 3.7*	0.7	25.9 ± 3.2	27.3 ± 3.4*	1.4	time	0.746
							group x time	0.232

TBW (%)	55.7 ± 3.7	56.2 ± 3.9	0.5	55.5 ± 3.7	57.2 ± 3.8*	1.7	time	0.493
							group x time	0.302
BMR (kcal)	1383.2 ± 121.1	1402.8 ± 123.5*	19.6	1486.6 ± 114.3	1524.5 ± 121.6*	37.9	time	0.704
							group x time	0.172

*Significant pre to post changes at $p < 0.05$

Table 3. Results of the body composition measurements in females

	CG (n=22)			EG (n=26)			Differences	ES
	Pre	Post	M Dif.	Pre	Post	M Dif.		
Body Weight (kg)	44.1 ± 11.0	45.6 ± 11.2*	1.5	44.8 ± 8.1	45.8 ± 8.4*	1.0	time	0.739
BMI (kg/m²)	19.1 ± 3.7	19.2 ± 3.9	0.1	19.5 ± 2.9	19.3 ± 2.9	-0.2	-	-
FFM (kg)	32.7 ± 6.5	34.0 ± 6.8*	1.3	33.0 ± 4.8	34.5 ± 4.9*	1.5	time	0.816
FFM (%)	75.0 ± 4.6	75.3 ± 4.6		74.0 ± 4.5	75.9 ± 4.7*		time	0.585
			0.3			1.9	group x time	0.357
FFMI (kg/m²)	14.2 ± 2.0	14.3 ± 2.1	0.1	14.3 ± 1.4	14.5 ± 1.4*	0.2	time	0.360
FM (kg)	11.4 ± 5.0	11.6 ± 5.0	0.2	11.9 ± 3.9	11.3 ± 4.1*	-0.6	group x time	0.252
FM (%)	25.0 ± 4.6	24.7 ± 4.6		26.0 ± 4.5	24.1 ± 4.7*		time	0.585
			-0.3			-1.9	group x time	0.357
FMI (kg/m²)	4.9 ± 1.9	4.9 ± 1.9		5.2 ± 1.6	4.8 ± 1.6*		time	0.373
			0.0			-0.4	group x time	0.292
TBW (kg)	24.0 ± 4.8	24.9 ± 5.0*	0.9	24.1 ± 3.5	25.3 ± 3.6*	1.2	time	0.810
TBW (%)	54.9 ± 3.4	55.1 ± 3.4		54.2 ± 3.3	55.6 ± 3.4*		time	0.565
			0.2			1.4	group x time	0.354
BMR (kcal)	1282.6 ± 169.2	1308.8 ± 178.7*	26.2	1294.9 ± 127.9	1324.6 ± 136.7*	29.7	time	0.729

*Significant pre to post changes at $p < 0.05$

DISCUSSION

The results of our research indicated that in the males of EG there were significant pre to post changes at $p < 0.05$ in all the variables (with the exception of BMI), while in CG there were significant pre to post changes at $p < 0.05$ in only 4 variables (Body Weight, FFM in kg, TBW in kg and BMR). In the case of girls, in EG there were significant pre to post changes at $p < 0.05$ in all the variables (with the exception of BMI), while in the CG there were significant pre to post changes at $p < 0.05$ in only 4 variables (Body Weight, FFM in kg, TBW in kg and BMR).

Piennar et al. (2013) studied the effect of a physical activity, diet, and behavior modification intervention of 13 weeks, three times per week for 60 minutes on the body composition of 37 overweight and obese children with a mean age of 11 years (20 subjects in the intervention group and 17 in the control group). They studied the variables body weight, BMI and FM %. In Piennar et al. study, body weight increased significantly in CG (2.25 kg) and decreased significantly in EG (-2.82 kg); in the present study body weight increased significantly in males and females of both groups. In the study of Piennar et al., BMI increased significantly in CG (0.6) and decreased significantly in EG (-1.9); in this study BMI practically did not change. In Piennar et al. study, FM increased in CG (3.8%) and decreased in EG (-4.34%); in the present study males and females of both groups reduced FM %, but reduction was significant only in EG.

Similarly, Aguilar et al. (2014), in their systematic review on physical activity programs to reduce excess weight and obesity in children and adolescents, indicated that several studies found links between physical activity and improvements in fat-free mass and BMI. Likewise, López et al. (2015) implemented a program of physical activity of 12 weeks (2 hours per week) in a sample of 12 male schoolchildren with ADHD, with an average age of 9.38 years old. The physical activity lessons were specially prepared for ADHD children. The authors found an increase in the body weight (0.6 kg), like in the present research, where males and females of both groups increased their body weight too. The sample of López et al. saw a slight reduction in BMI (-0.21), but this difference was not significant; similarly in the present study BMI practically did not change in any group. López et al. found a no significant reduction of FM (-0.28%), while in the present study males (-2.4%) and females (-1.9%) of EG significantly reduced this variable.

In the same vein, Cordova et al. (2013) studied a sample of 137 children aged 11 to 13 and found that the children who were more physically active had lower BMI and fat mass percentage, results consistent with the present study. Nevertheless, Arriscado et al. (2015) analyzed a sample of 329 schoolchildren (aged 11 and 12 years) and found no significant relation between physical activity and body composition, unlike in the present study.

Plonka et al. (2011) studied 59 girls aged between 9 and 16 years (average 12.55 ± 1.67 yr), divided in two groups: 29 physically active (PA) girls (regular swimming training on average 6.93 ± 4.98 month/year, 5 ± 1.86 days/week and 2.20 ± 1.07 hours/day) and 30 physically inactive (PI) girls (physically active on average for 6.94 ± 4.15 month/year, 1.69 ± 1.09 days/week and 1.11 ± 0.46 hours/day). In the study the BMI of PA girls (18.19 ± 2.29) was significantly lower than the BMI of PI girls (20.57 ± 4.33); in the present study the BMI was very similar in CG and EG and practically did not change. FM of PA girls ($18.39 \pm 7.02\%$) was also significantly lower than in PI girls ($22.97 \pm 9.72\%$); similarly, in the present research the girls of EG had significant improvements in this variable. Regarding FM (kg), Plonka's et al. (2011) PA girls had lower values (9.22 ± 4.97 kg) than PI girls (12.34 ± 7.62 kg), although this difference was not significant; in the present study, girls of CG slightly increased their fat (kg) and the girls of EG slightly reduced their fat (kg). Finally, the FFM of Plonka's et al. PA girls was higher (37.86 ± 5.60 kg) than PI girls (36.1 ± 7.43 kg); in this study EG increased FFM (kg) more than CG.

Abbott and Davies (2004) studied the level of habitual physical activity and physical activity intensity and their relationship to body composition in 47 5- to 10.5-year-old (mean age 8.4 ± 0.9 yr) children, obtaining that vigorous activity and hard activity were significantly correlated to body fat percentage ($r = -0.44$, $p = 0.004$ and $r = -0.39$, $p = 0.014$), but not BMI. In addition these authors found that moderate intensity activity was not correlated with measures of body composition. The results of Abbott & Davies (2004) are similar to those of the present study.

Cho and Koh (2014) studied the effects of aerobic exercise on the body composition of 28 obese male children in elementary school. The children were divided into two groups: exercise group (n=14) and control group (n=14). The exercise group received dietary behavior education and performed an aerobic exercise program during 12 weeks and, after the program, the exercise group showed a significantly reduced BMI. However, in the present study significant improvements were not found in BMI. Perhaps the most important factor for reducing BMI in children is their daily diet, and physical exercise only contributes to this process.

Collings et al. (2015) examined the associations between sedentary time and adiposity in 504 adolescents (42% boys) from schools in Cambridgeshire, UK, with a mean age 15.0 ± 0.3 years. They found that sedentary time was not associated with change in adiposity in either gender and concluded that sedentary time may not determine changes in adiposity from mid-to late adolescence. These results differ from the present study, where an improvement in the body composition of the schoolchildren was observed when physical activity increased.

However, De Moraes et al. (2015) examined the associations between physical activity and body composition in 485 Brazilian children and found that both moderate-to-vigorous and vigorous physical activity was negatively associated with body composition (BMI and body fat percentage) variables. Duncan et al. (2006) also found a link between physical activity and body fat in 1115 children from New Zealand (536 boys, 579 girls) aged 5-12 years, like has been observed in the present paper.

In the study by López et al. (2013), the authors implemented a physical activity program to 36 schoolchildren (20 males and 16 females), aged 3 to 5. The program consisted of intense physical activity three days per week, 15 minutes per day, for 12 weeks. These authors found practically no change in BMI (0.222), like in the present study. The sample of López et al. (2013) significantly reduced FM (-1.68%), like in the EG of the present research. Regarding FFM %, they found a no significant increase, just 0.36%, while in the present research the increase in EG was significant (2.4% for males and 1.9% for females).

Palencia et al. (2015) analyzed the relationship between daily minutes of vigorous physical activity and adiposity in 179 schoolchildren (97 girls) 9 to 10 years old. They found that vigorous physical activity is associated with lower adiposity. Specifically, they found that more than 14.5 daily minutes of vigorous physical activity was associated with lower adiposity indicators (the probability of excess weight and obesity increased 1.8 times if they had fewer minutes). In the present study, the results fall in line, as EG achieved higher improvements in body composition than CG.

Finally, it is important to note some considerations. In this study BMI practically did not change; perhaps one of the reasons could be that the children were in growing process. However, FM decreased and FFM increased in both males and females, an aspect that could be related to the increase in BMR, and that could be a future line of research.

CONCLUSIONS

The 12-week PE program of vigorous-intensity physical activity used in this research has shown its effectiveness to improve the body composition of 10-and 11-year-old children, being effective in both males and females. Therefore, the implementation of this program in schools is highly recommended.

In addition, in further studies it would be advisable to carry out other intervention programs through physical activity, with larger samples and of a longer duration. It is also recommended to use different types of physical

activity, always taking into account the intensity factor. Thus, there will be more resources available to improve body composition of schoolchildren through physical activity and the effectiveness of these resources will be known.

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