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EFFECTS OF HIGH INTENSITY INTERVAL TRAINING ON FAT MASS PARAMETERS IN ADOLESCENTS (*)

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ABSTRACT

Background: Childhood and adolescence are key to the development of chronic disease stages, the distribution of fat an important factor in this regard. The aim of the study was to evaluate the effects on fat parameters of a high intensity program developed in adolescents during physical education classes.

Methods: In 2013, 35 school-age children of Cáceres taken part in this study divided into two groups. The high-intensity group performed for 8 weeks, 4-6 sets of 20 seconds at maximal intensity with a ratio effort / recovery of 1: 3 to 1: 1. The other group, developed continuous aerobic exercise during the same time. It conducted an assessment of fat mass before and after the training program. Repeated measures ANOVA test was used to observe that there were no statistically significant differences.

Results: Continuous aerobic training group showed statistically significant differences in intra-group analysis in the percentage of fat mass trunk (Pre: 15.66 ± 4.16 vs Post: 16.95 ± 4.03; +1, 29%; p = 0.04) and the percentage of total fat (Pre: 21.58 ± 3.93 / Post: 22.34 ± 3.70; p = 0.05). Statistically significant differences were not found in the analysis between-groups in any of the studied variables.

Conclusions: The training program high intensity physical activity at school carried out during physical education classes did not improve fat mass parameters evaluated. However, maintaining these parameters could be a good result during the development of this stage, where an increase of these occurs.

Keywords: Adolescent, Obesity, Aerobic exercise, Body Fat Distribution, Physical activity, Students, Cholesterol, Insulin, Spain.

RESUMEN

Efecto de un protocolo de entrenamiento interválico de alta intensidad sobre masa grasa corporal en adolescentes

Fundamentos: La infancia y la adolescencia son etapas claves para el desarrollo de enfermedades crónicas, siendo la distribución de grasa un importante factor en este sentido. El objetivo del estudio fue evaluar los efectos sobre parámetros de grasa de un programa de alta intensidad desarrollado en adolescentes durante las clases de educación física.

Métodos: Durante el año 2013, 35 escolares cacereños participaron en el estudio divididos en dos grupos. El grupo de alta intensidad realizó durante 8 semanas de 4 a 6 series de *sprints* de 20 segundos a máxima intensidad con una relación esfuerzo/recuperación de 1:3 a 1:1. El otro grupo desarrolló ejercicio aeróbico continuo durante el mismo tiempo. Se llevó a cabo una evaluación de la masa grasa antes y tras el programa de entrenamiento. El test ANOVA de medidas repetidas se usó para analizar si existían diferencias estadísticamente significativas entre ambos grupos.

Resultados: El grupo de entrenamiento aeróbico continuo mostró diferencias estadísticamente significativas en el análisis intra-grupo en el porcentaje de masa grasa del tronco (Pre:15,66±4,16 *vs* Post:16,95±4,03; +1,29%; p=0,04) y el porcentaje de grasa total (Pre:21,58±3,93/ Post:22,34±3,70; p=0,05).

Conclusiones: El programa de entrenamiento de actividad física de alta intensidad en la escuela llevado a cabo durante las clases de Educación Física no mejoró los parámetros de masa grasa evaluados. Sin embargo, el mantenimiento de estos parámetros podría ser un buen resultado durante el desarrollo de esta etapa, donde se produce un incremento.

Palabras Clave: Obesidad, Ejercicio aeróbico, Adolescentes, distribución de la grasa corporal, Actividad física, Estudiantes, Colestero, Insulina.

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INTRODUCCIÓN

International guidelines about physical activities recommend that all children and young people should accumulate at least 60 minutes of moderate-intensity aerobic physical activity each day, or vigorous activity for a minimum of 20 minutes three days per week[1]. However, the majority of youth are widely regarded as far from meeting these recommendations[2]. Physical activity decreases by 65% during the adolescent years[3].

Adolescence is a key stage in the development of health behavior and, given the rising burden of chronic disease, it is essential to implement strategies to improve cardiometabolic health in youth[4]. Fat distribution appears to have a greater influence on cardiovascular risk factors that affect overall fat mass. Fat in the abdominal area is an important predictor of plasma triglycerides, LDL (light density lipoprotein) cholesterol and systolic blood pressure. Additionally, this tends to result in a decrease in central adiposity which reduces cardiovascular risk[5]. However, scientific evidence has not been found to conclude that fat distribution in other different areas of the abdominal region are associated with this disease.

As children and adolescents spend part of the day at school, a large percentage of the recommendations on physical activity could be carried out with interventions during physical education class (PE)[6,7]. The interventions of school-based physical activity shows

great efficiency in reducing obesity and increasing the physical condition of schoolchildren[8]. Most of these programs are capable of reducing the negative effects of a sedentary lifestyle with interventions of short duration[9].

Regarding physical activity in youth, it is spontaneous, which makes it high intensity and intermittent in nature[10]. Adolescents may find short bouts of high-intensity more appealing and easier to adhere to than traditionally recommended. So, current research not only aims at understanding new methods to achieve the health benefits of physical activity, but also at studying the benefits of higher intensities of activity[11].

High-intensity interval training (HIIT) is an economical and effective exercise protocol for reducing fat in overweight individuals[12], and therefore it could also be used as a preventive tool for this disease. Typically, the HIIT protocol consists in repeated brief sprinting exercise at an all-out intensity followed by low intensity exercise or rest. The duration of both the sprint and recovery periods varies from 6 seconds to 4 minutes. This type of exercise is a time-efficient strategy because it implies a markedly lower training volume to cause adaptations and health benefits –adiposity reduction and lean mass gain– than other traditional aerobic exercise programs[12]. This method has gained an increased scientific interest in recent times as far as early age is concerned, particularly childhood and adolescence[13-21].

An early study investigated the effects of HIIT on different cardiometabolic risk factors in adolescents. There were significant improvements in the body mass index (BMI) and body fat percentage. However, the authors found that statistically significant differences favouring the control group[13] .

Resaland, Anderssen[7] carried out a school-based intervention on physical activity of longer duration: exactly 2 years. During physical education classes, children increased from 15 to 55 minutes of high intensity training. The authors did not find statistically significant differences

between the groups in relation to the BMI and the waist-hip index (ICC). However, the body composition could only be altered positively even in those cases where the IMC did not change. At the end of the 3-months, in the follow-up the HIIT group showed significant improvements in BMI, VO2m, body fat percentage, mean arterial pressure and

high-density lipoprotein cholesterol. No significant differences were found between the two groups.

In a more recent study[17], BMI and insulin sensitivity showed significant improvements in both groups. However, there were significant differences between groups favoring the HIIT group.

Racil, Ben Ounis[20] investigated duration-matched interval bouts of moderate and high intensity. Both protocols were the same for all parameters except for the intensity of each exercise bout. The HIIT program provided greater benefits in LDL cholesterol, total cholesterol, insulin sensitivity, body fat percentage and BMI compared with the moderate-intensity program. Current research has established more promising improvements in some cardiometabolic risk factors using HIIT than in moderate intensity training in the adolescent age group. So, short bouts of high-intensity exercise could be an alternative approach to achieve the health benefits of physical activity in this cohort. Furthermore, aerobic fitness, insulin sensitivity, fasting plasma insulin and adiponectin were improved to a greater extent with HIIT than with moderate intensity training. Yet, it is inconclusive as to whether high-intensity training provides greater changes in BMI, body fat percentage, waist circumference, fasting plasma glucose and HDL than comparable moderate-intensity training in adolescents.

On the other hand, there is a large discrepancy in the total time spent in each exercise protocol [4]. Along these lines, a well-known review[12] has stated that more studies are needed to determine the optimal duration, frequency and recovery of this training method to produce significant improvements in cardiometabolic risk factors like body fat.

Thus, the purpose of this study was to evaluate the effects of a short training protocol performed during physical education lessons on fat mass parameters in adolescents.

METHODSS

During the 2012-2013 school year, thirty-five adolescents (19 boys, 16 girls) participated in the study. They were divided into two groups. One group performed three sessions/week of HIIT during 8 weeks, and the other group performed the same volume of continuous moderate aerobic exercise (CON). These volunteers were recruited from a local school.

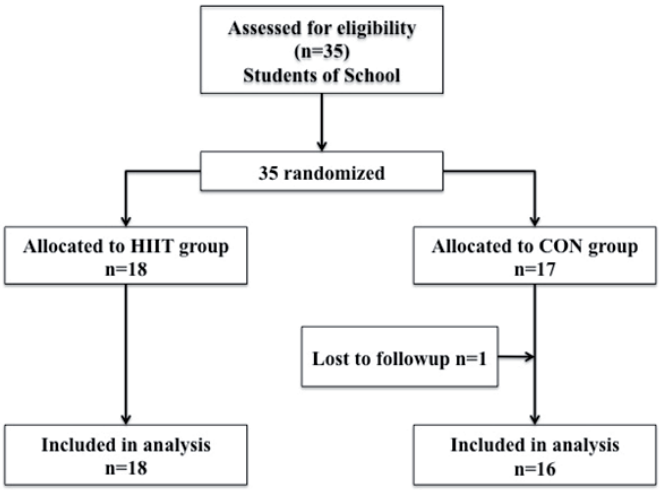
The study flow of participants is presented in figure 1. The Committee on Biomedical Ethics of the University of Extremadura gave approval for the study and all subjects provided a written informed consent from participants' parents or tutors. Inclusion criteria determined that participants should be adolescents, participate in at least 80% of sessions, and shouldn't change their dietary and physical activity habits.

As stated above, the study was carried out in a school during PE (Physical Education) lessons. The experimental protocol consisted of two weeks of testing before (Pre) and after (Post) an eight-week supervised specific training period (24 training sessions). Subjects were randomly assigned to one of the two treatment groups, one for high intensity interval training (HIIT, n=18; 5.88% with IMC>25) and the other for continuous moderate aerobic exercise (CON, n=17; 5.88% with IMC>25). They followed a familiarization session before pre-assessment, which consisted in a training session before evaluation.

Training included 3 sessions per week. Each training session had the same structure and duration for both groups (figure 2). However, the specific training that they performed was different.

After a general warm-up of approximately 10 minutes with a medley of varied exercises, the intervention took place. After the intervention, a practical opposition-cooperation team sport lesson took place which was programed by the teacher (handball and basketball).

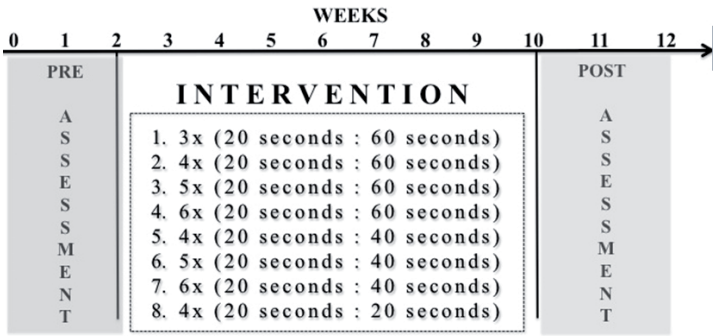
Figure 1
Flow of participants throughout the trial



During the training intervention, the HIIT group completed a 20-sec maximal-effort sprint within a 20 meter distance separated by cones. The 20-m sprint is a measure of anaerobic performance that has already been validated by previous studies[22]. Training progressed from three sets with 60 seconds of recovery to six sets with 20 seconds of recovery (Figure 2). The CON group performed the same continuous running time as the HIIT group at 65-75% of HRmax (maximum heart rate). Maximum heart rate was obtained through the Course Navette test with a heart rate monitor (Forerunner 210, Garmin, Schaffhausen, Switzerland). Also, intensity was controlled with a heart rate monitor. In each training session, the rating of perceived exertion[23] (scale of 0 to 10) was recorded immediately after training. A researcher supervised all exercise workouts during the PE lessons.

So that the results obtained after the training intervention were not conditioned by diet or exercise, participants were requested to not change their habits during the study.

Figure 2
Relationship work: recovery during 8-week intervention



However, these possible contaminant variables were controlled before and after the training intervention.

To detect possible interaction with other forms of physical activity, all participants were asked to complete the PAQ-C[24]. No significant difference was found between measurements.

An ad-hoc registration of 7 days was used for eating habits. Nutriber v 1.1.1.r5 software was used to calculate the amount of nutrients and total calories consumed by each subject on each day throughout the week. No significant differences were found between assessments.

Height was measured following standard procedures. Body mass index, body fat percentage, trunk fat percentage and leg fat mass percentage were analyzed by a bioelectrical impedance method using a standardized body composition analyzer (Tanita BC 418 MA, Tanita Corp, Tokyo, Japan).

Other parameters such as waist-hip ratio and maximal oxygen uptake (VO_2max) were measured to characterize the sample. Waist-hip ratio was measured with an anthropometric tape. With the subject standing erect and feet together, a horizontal measurement was taken at the maximal circumference of the buttocks to measure the hip circumference. In the same position, a horizontal measurement was taken above the umbilicus and below the xiphoid process to measure the waist circumference[25]. VO_2max was assessed through the indirect Course Navette test. Subjects had to run for twenty meters from one line to another to the rhythm of a tape. This rhythm increased every minute. Subjects began the test at a speed of eight kilometers per hour. After the first minute, it was increased to nine kilometers per hour. From then on, the speed was increased every minute by 0.5 kilometers per hour. The test ended when they could not keep up the rhythm[26]. VO_2max was calculated using the predictive equation described by Leger, Mercier et al[27].

Data are presented as mean ± SD. Standard statistical methods were used for the calculation of the mean and standard deviations. In addition, before the analysis the Shapiro-Wilks test for the normality of distribution and Levene's test for homogeneity of variance were calculated for all variables. ANOVA was used for repeated measures to compare responses in each variable across the two time points.

When a global difference over time was determined, the Bonferroni post hoc analysis was used to identify where changes occurred. The $p<0.05$ criterion was followed for establishing statistical significance.

RESULTADOS

The subjects' characteristics and differences are shown in Table 1. Both groups had similar general baseline characteristics, as proposing a different training protocol for each group formed a part of the project.

Differences between groups in terms of rating of perceived exertion (RPE) and the heart rate percentages during the treatment are included in Table 2. RPE was 3.66±1.07 for the HIIT group while that of the CON group was 2.13±1.65. Work percentages in terms of heart rate percentages was 89.93±4.38 in the HIIT group and 72.92±7.25 in the CON group. Regarding the heart rate observed in each group, the data were different between the HIIT group (192.05±8.96) and the CON group (166.85±19.89).

Training effects on total fat mass, trunk fat mass and left and right leg fat mass are shown in Table 3. The percentage of trunk fat mass in the CON group was significantly higher after 8 weeks of training (PRE: 15.66±4.16 vs. POST: 16.95±4.03; +1.29%). Also found were statistically significant differences in the CON group in total fat mass percentage (PRE: 21.58±3.93 vs POST: 22.34±3.70; +0.76%).

Table 1
Characteristics of subjects at baseline in the HIIT group and the CON group

	High-intensity interval training n=18	Moderate-intensity continuous training n = 16	p
Age, years	11.06 ± 0.24	11.29 ± 0.47	0.06
HRmax, bpm	202.08 ± 8.66	189.21 ± 35.35	0.21
BMI, kg/m^2	18.43 ± 2.83	20.06 ± 3.32	0.13
WHR, kg/m^2	0.84 ± 0.05	0.84 ± 0.06	0.97
VO2max, ml·min·kg	46.10 ± 5.66	45.55 ± 6.55	0.80

IHRmax: heart rate maximum, BMI: body mass index, WHR: waist-hip ratio, VO_2max: maximal oxygen uptake
Values are mean ± standard deviation

Table 2
Intensity of program parameters

	Entrenamiento interválico de alta intensidad n = 18	Entrenamiento aeróbico de moderada intensidad n=16	p
RPE, Borg scale	3.66 ± 1.07	2.13 ± 1.65	0.03
Average HR, rpm	181.35 ± 9.33	152.03 ± 17.61	< 0.01
Maximal HR, rpm	192.05 ± 8.96	166.85 ± 19.89	< 0.01
Percentage HR, %	89.93 ± 4.38	72.92 ± 7.25	< 0.01

RPE: rate of perceived exertion, HR mean: heart rate mean, HR max: maximum heart rate, HR: heart rate.
Values are mean ± standard deviation

Table 3
Effect of 8 weeks of the program on fat mass parameters

	Variable	Preintervention	Postintervention	p (within-group comparison)	Effect size *d*
Fat mass (%)	HIIT (n=18)	24.26 ± 5.74	24.99 ± 5.31	0.06	0.13
	CON (n=16)	21.58 ± 3.93	22.34 ± 3.70	0.05	0.20
Trunk fat mass (%)	HIIT (n=18)	18.37 ± 6.57	19.50 ± 5.80	0.06	0.18
	CON (n=16)	15.66 ± 4.16	16.95 ± 4.03	0.04	0.32
Right leg fat mass (%)	HIIT (n=18)	30.52 ± 4.73	30.48 ± 4.90	0.90	0.01
	CON (n=16)	27.90 ± 4.69	27.64 ± 4.55	0.40	0.06
Left leg fat mass (%)	HIIT (n=18)	30.76 ± 5.00	30.62 ± 5.00	0.56	0.03
	CON (n=16)	28.18 ± 4.34	28.13 ± 4.20	0.87	0.01

Values are mean ± standard deviation. d effect size.

DISCUSIÓN

After 24 sessions of training in two different types of workout, total fat mass and trunk fat mass in the CON group was significantly higher after training. Although fat parameters did not improve, the HIIT group did not increase the amount of both the total and trunk fat mass in the same overall time that it took the CON group to obtain their less than desired results.

As different protocols were established for each group, the baseline characteristics were similar.

After 8 weeks of training in the two different types of workout, the total fat mass and trunk fat mass in the CON group were significantly higher after training.

A recent study showed that the amount of abdominal fat could be independent of the level of physical activity in early ages close to adolescence [26]. In the same way, it is well known that during early stages of puberty, an increase in fat occurs in both genders (28). Therefore, achieving these values in our research may be considered a breakthrough in this field. Indeed, as already stated, though not improving fat parameters, in the same overall time that it took the CON group to

obtain their less than satisfactory results, the HIIT group did not increase the amount of the total fat mass and trunk fat.

In summary, some previous studies obtained improvements in body composition after applying an HIIT program in healthy adolescents[13,17, 20, 21]. However, while these results seem contrary to those in the present study, our HIIT group managed to maintain total and trunk fat mass but not decrease these values.

In an early study, subjects completed 3 sets of 2 bouts of 10-s at 100-120% maximal aerobic speed with 10-s rests between bouts and 3-min rests between sets during 10 weeks [13]. There was a significant decrease in fat mass percentage, but no significant differences in comparison with the control group. After high intensity training 3 times per week during 3-months, significant improvements were obtained in the fat mass percentage and other body composition parameters[21]. Likewise, in a study with children who performed an HIIT program for 12 weeks (3-6 sets of 60 seconds at 100% HRmax with a recovery of 3 minutes at 50% HRmax) BMI was improved. However, no significant differences ($p = 0.680$) were found in the fat mass percentages at the end of the training[17

Racil, Ben Ounis[20] applied two different protocols during 12 weeks: the HIIT group performed two sets of six bouts of 30-s at 100% maximal aerobic speed with 30-s active recovery at 50% peak velocity. The moderate-intensity program followed the same structure, but the running bouts were performed at 70% peak velocity. Significant improvements were found in BMI and aerobic fitness. Also, the HIIT program provided greater benefits in low-density lipoprotein cholesterol (LDL), total cholesterol, insulin sensitivity, body fat percentage and BMI compared with the moderate-intensity program.

So far, no significant decrease in fat mass percentage has been found in studies in which a seven week HIIT program was used[14-16, 18]. In the three studies by Buchan et al,[14-16] improvements were observed in aerobic fitness and other physical parameters after 7 weeks of training. Subjects performed 4-6 sprints of 20 meters during 30 seconds with 30 seconds recovery. However, BMI, waist-hip ratio or body fat percentage did not show improvements with the same protocol. Gamelin et al[18] used HIIT in adolescents during 7 weeks (3 days per week). After increasing workout intensity and decreasing recovery time throughout the program, they observed improvements of VO2max without any change in anthropometric parameters. The fact that there was no change observed in leg fat mass is consistent with a previous study which developed a high intensity training for the obese and did not find any improvements in this parameter[29].

Some recommendations by researchers included a longer-duration intervention of 7 weeks[30]. However, an 8 week trial used in this study was not enough to find significant reductions in healthy adolescents. It may be possible that the duration of the program was not long enough to provoke metabolic changes as seen in other HIIT studies with adolescents. Consequently, interventions in adolescents with a duration longer than 8 weeks would be needed in order to check if significant changes in anthropometric parameters are also caused with high intensity protocols.

Sexual maturation can have great effects on metabolic outcomes. Taking into account the hormonal implications of puberty on metabolism is of vital importance for the validity of the results[4]. Probably not controlling sexual maturation has been a limiting factor for finding results closer to other studies previously cited.

In conclusion, after a short training protocol of high intensity interval training incorporated into physical education lessons during 8 weeks, neither program improved body fat mass parameters in adolescents. Although no significant changes in total and trunk fat mass

after HIIT were observed, changes obtained in the present study could be seen as a good result during this developmental stage where a large increase in this parameter occurs. Therefore during physical education lessons, HIIT could be more useful than continuous aerobic training to avoid total and trunk fat mass gains in adolescents.

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