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Original

Effects on adolescents' lipid profile of a fitness-enhancing intervention in the school setting: the EDUFIT study

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Abstract

Objectives: **Observational studies have reported an association among physical activity, fitness and lipid profile in youth. The purpose of this study was to analyse the effect of a school-based intervention focused on increasing the number and intensity of Physical Education (PE) sessions a week, on adolescents' lipid profile.**

Methods: **A 4-month group-randomized controlled trial was conducted in 67 adolescents (12-14 years-old) from South-East Spain, 2007. Three school classes were randomly allocated into control group (CG), experimental group-1 (EG1) and experimental group-2 (EG2). The CG received the usual PE in Spain (2 sessions/week), the EG1 received 4 PE sessions/week, and the EG2 received 4 PE sessions/week of high intensity. The main study outcomes were fasting levels of total cholesterol, high-density lipoprotein cholesterol (HDLc), low-density lipoprotein cholesterol (LDLc) and triglycerides. All the analyses were adjusted for sex, sexual maturation, attendance and baseline value of the outcome studied.**

Results: **The intervention did not positively affect cardio-metabolic parameters except for LDLc, that was marginally yet significantly reduced in EG2 (-10.4 mg/dl), compared with the CG (+4.1 mg/dl) (p = 0.04); no differences were observed however for the LDLc/HDLc ratio. No significant effects were observed in EG1.**

Discussion: **Overall, a 4-month school-based physical activity intervention did not substantially influence lipid profile in adolescents. However, the results suggest that increasing both frequency and intensity of PE sessions had a modest effect on LDLc in youth. Future studies involving larger sample sizes and longer interventions should focus on the separate effects of volume and intensity of PE.**

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Key words: *Adolescent. Controlled trial. Fitness. Physical education. Lipid profile.*

EFECTOS DE UN PROGRAMA ESCOLAR ORIENTADO A LA MEJORA DE LA CONDICIÓN FÍSICA SOBRE EL PERFIL LIPÍDICO DE ADOLESCENTES: ESTUDIO EDUFIT

Resumen

Objetivos: **Los estudios observacionales han notificado una asociación entre la actividad física, la forma física y el perfil lipídico en la juventud. El propósito de este estudio fue analizar el efecto de una intervención basada en la escuela centrada en aumentar el número y la intensidad de las sesiones de educación física (EF) a lo largo de la semana, en el perfil lipídico de los adolescentes.**

Métodos: **Se realizó un estudio controlado de distribución aleatoria en 67 adolescentes (12-14 años) del sudeste de España, en 2007. Tres clases fueron distribuidas al azar a un grupo control (GC), un grupo experimental-1 (GE1) y un grupo experimental-2 (GE2). El GC recibió las sesiones habituales de EF en España (2 sesiones semanales), el GE1 recibió 4 sesiones de EF /semana y el GE2 recibió 4 sesiones de EF /semana de alta intensidad. Los criterios de valoración principales del estudio fueron las concentraciones en ayunas de colesterol toral, lipoproteínas de densidad elevada-colesterol (HDLc), lipoproteínas de densidad baja-colesterol (LDLc) y de triglicéridos. Se ajustaron todos los análisis para el sexo, maduración sexual, asistencia y valor basal de la variable estudiada.**

Resultados: **La intervención no afectó de forma positiva a los parámetros cardiovasculares a excepción de las LDLc que disminuyeron marginal aunque significativamente en el GE2 (-10,4 mg/dl), en comparación del GC (+4,1 mg/dl) (p = 0,04); sin embargo, no se observaron diferencias para el cociente LDLc/HDLc ratio. No se observaron efectos significativos en el GE1.**

Discusión: **De forma global, una intervención de actividad física basada en la escuela durante 4 meses no influyó de forma sustancial en el perfil lipídico de los adolescentes. Sin embargo, los resultados sugieren que el aumentar tanto la frecuencia como la intensidad de las sesiones de EF tiene un efecto modesto sobre las LDLc en los jóvenes. Los estudios futuros que impliquen una muestra mayor e intervenciones más duraderas deberían centrarse en los efectos separados del volumen e intensidad de la EF.**

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Palabras clave: *Adolescente. Ensayo controlado. Forma física. Educación física. Perfil lipídico.*

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Abbreviations

ANCOVA: One-way analysis covariance.
AVENA: Alimentación y Valoración del Estado Nutricional de los Adolescentes (Food and Assessment of Nutritional Status in Adolescents).
CG: Control group.
EDUFIT: EDUcation for FITness.
EG: Experimental group.
HDLc: High density lipoprotein cholesterol.
HELENA: Healthy Lifestyle in Europe by Nutrition in Adolescence.
LDLc: Low density lipoprotein cholesterol.
PE: Physical education.
TC: Total cholesterol.

Introduction

Low levels of physical activity and physical fitness are considered powerful predictors of detrimental health outcomes, such as all-cause mortality, cardiovascular disease events and cancer events[1,2]. It is known that children and adolescents meeting recommended levels of physical activity (at least 60 minutes of moderate-to-vigorous intensity physical activity on a daily basis) have multiple health benefits[3]. In spite of this evidence, a significant number of young people do not accomplish this recommendation[4], as it was recently observed in Spanish[5] and European[6] adolescents. Governments, authorities and researchers suggest that adolescents' physical fitness must be improved to fight against cardiovascular disease in adulthood, and have identified increased physical fitness and activity in school as its primary aim to improve present and future youths' health[6-9]. Physical education (PE) is a mandatory part of the school curricula in most countries, including Spain. Daily PE is recommended by numerous entities to fight against the obesity epidemic and other cardiovascular disease risk factors[4,7,8].

Several studies have focused on promoting physical activity in schools to improve diverse health-outcomes, such as the Child-and-Adolescent-Trial-for Cardiovascular-Health (CATCH)[10], Cardiovascular-Health-in-Children (CHIC)[11], Middle-School-Physical- Activity-and-Nutrition (M-SPAN)[12], Sports-Play-and- Active-Recreation-for-Kids (SPARK)[13], FitKid Project[14], Activity-Bursts-in-the-Classroom (ABC)[15], Kinder-Sportstudie (KISS)[16], Healthy-study[17] and others school-based interventions[18-25]. Some comprehensive reviews have summarized many of these studies[4,26,27] and reported mixed results depending on the outcome studied.

The interventions mostly involved changes in PE, such as the classroom health curriculum, and in the food service program and included some family, community, and policy change components. Others focused on increasing the number of PE sessions a week[16,18,20]. However, there is a lack of information about the effects of increasing the intensity of the PE sessions on cardio-metabolic profile in young people. In the present school-based intervention study conducted on adolescents, we examined the effects on adolescents' lipid profile of: 1) increasing the number of PE a week (volume); 2) increasing the number and the intensity of the PE sessions (volume+intensity); and 3) increasing intensity for a given number of sessions (intensity).

Methods

Subjects

Participants were recruited from the EDUFIT (EDUcation for FITness) study. The complete methodology of the EDUFIT study has been described elsewhere[28]. This study is a group-randomized controlled trial (clinicaltrial.org NCT01098968). The intervention period lasted four months, from January to May (2007) and was developed in a high school from South-East Spain (Murcia). Data were collected before and after the intervention program. A total of 67 adolescents (70 invited), 43 boys and 24 girls (12-14 years, Tanner II-V), belonging to three different classes from same school, agreed to participate in this study, i.e. participation rate = 96%. The study flow is graphically represented in figure 1. The three classes were randomly assigned to control group (CG), experimental group-1 (EG1) and experimental group-2 (EG2).

No previous personal history of cardiovascular disease, no cognitive dysfunction, and to be able to actively participate in PE classes were the study inclusion criteria; all the participants met these criteria. No incentives for participating in the study were offered to the children.

A comprehensive verbal description of the nature and purpose of the study was given to the parents, school supervisors, and adolescents. Written consent to participate was requested from both parents and adolescents. This study was approved by the by the Review Committee for Research Involving Human Subjects of the University of Granada (Spain). The study protocol was performed in accordance with the ethical standards laid down in the 1961 Declaration of Helsinki (as revised in 2000).

Instruments

All measures were assessed during the 2007/2008 school year. Baseline data were collected during the month of January 2008 (before implementation of the EDUFIT program) and post-intervention data were collected in May 2008 (at the end of implementation of the program). The same research team members collected both baseline and post-intervention data.

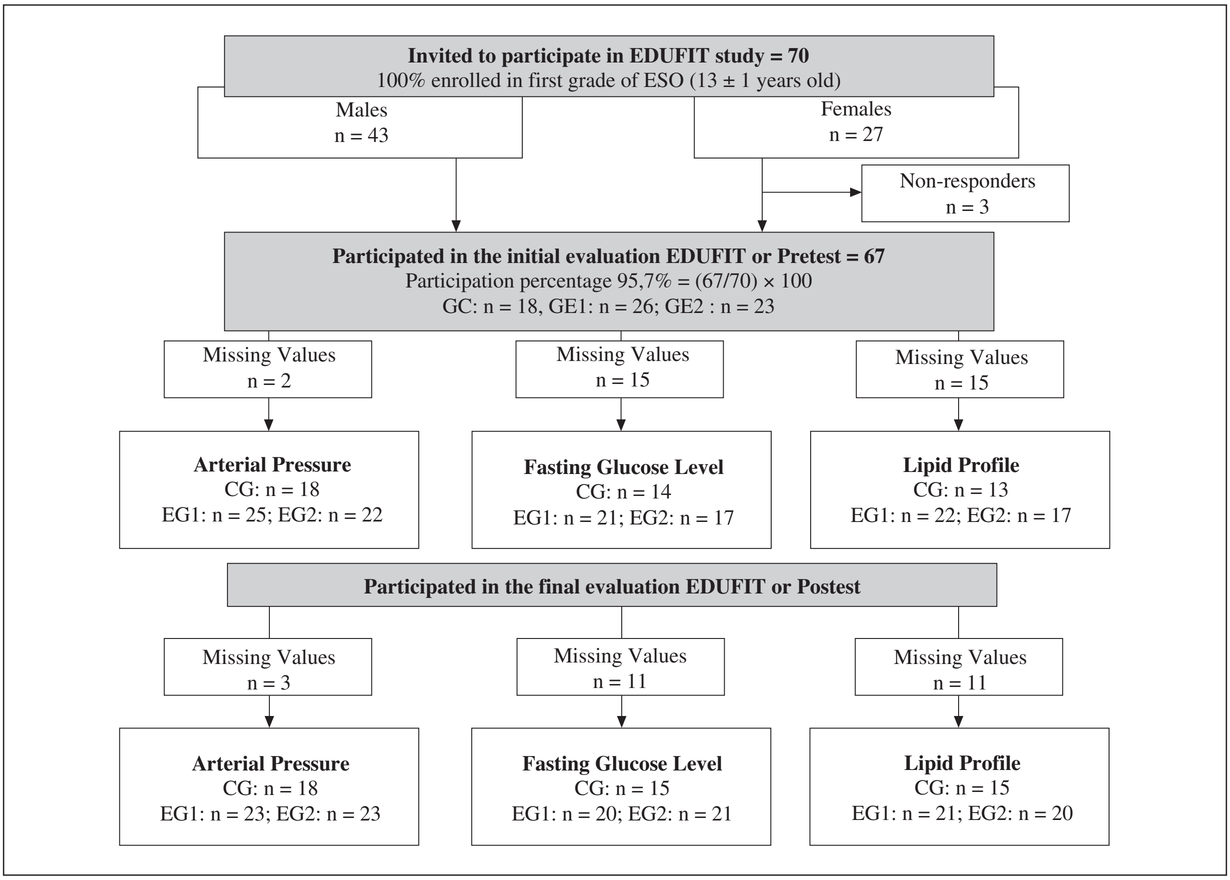

Fig. 1.—Study flow. EDUFIT: Education for Fitness; PE: Physical Education.

– *Blood pressure*. Systolic and diastolic blood pressures were measured with a manual oscillometric device aneroid (Riester), appropriate to children's ages. The adolescent was sit quietly for 6 minutes, with his or her back supported, feet on the floor, left arm supported, and cubital fossa at heart level. The measurements were done at the left arm, keeping the arm tended at the time of measurement. Measurements were made between 10 and 16 minutes with 2 minutes of interval between each measurement until the change in systolic blood pressure was less than 5 mmHg between both measures and the next. We recorded the average of the last three measurements as a valid measurement of systolic and diastolic blood pressure.
The mean arterial pressure, defined as the average arterial pressure during a single cardiac cycle, was calculated using the following equation: diastolic blood pressure + [0.333 × (systolic blood pressure – diastolic blood pressure)][29].
– *Blood measurements*. Blood samples were collected at the antecubital vein between 8:00 and 9:00 AM, after an overnight fast. Serum concentrations of glucose, total cholesterol (TC), high-density lipoprotein cholesterol (HDLc), low-density lipoprotein cholesterol (LDLc) and triglycerides were measured on the clinical chemistry system with enzymatic methods. The serum sample was processed in a LX-20PRO Beckman Coulter of IZASA®. The methodology used was direct: glucose (hexokinase), cholesterol (cholesterol esterase with quinine), triglycerides (lipase glycerol kinase) and HDL (direct method with elimination of other particles and cholesterol esterase reaction). We calculated the LDLc/HDLc ratio.
– *Health-related fitness*. We assessed cardiorespiratory fitness with the 20-m shuttle run test, as previously described[28,30]. Muscular fitness was assessed by the standing long jump test and speed-agility by the 4×10-m shuttle run test. All the tests were performed twice, and the best score was retained, except the 20-m shuttle run test, which was performed only once. These tests have been proved to be valid and reliable in young people[31-34]. A detailed description of the protocols used for fitness testing were previously published[9,30].
– *Anthropometry*. Height and weight were measured by standardized procedures. Weight was measured in underwear and without shoes with an electronic scale (Type SECA 861) to the nearest 0.1 kg, and height was measured barefoot in the Frankfort

- horizontal plane with a telescopic height measuring instrument (Type SECA 225) to the nearest 0.1 cm. Body mass index was calculated as body weight in kg divided by the square of height in meters.
- *Sexual maturation*. Stages of pubertal development were assessed following the methodology described by Tanner and Whitehouse[35] as was done in a national multicenter study[36]. Five stages were recognized for each of the following characteristics: genital development and pubic hair in males, and breast development and pubic hair in females.

Procedures

The intervention was implemented by PE teachers assigned by the school, who did not participate in the pre-intervention or post-intervention assessments. Details of the intervention have been described elsewhere[28]. A summarized scheme of the intervention is presented in figure 2. In short, adolescents in the CG received the usual PE sessions according to the National Education Program in Spain, i.e. 55 min sessions twice a week. This duration includes the time for teachers to organize the session, and for the children to change clothes, have shower and come/go from/to the classrooms. Adolescents in the EG1 had four PE sessions a week, with the same aims, contents and pedagogical strategies than the sessions in the CG. Adolescents in the EG2 received four PE sessions a week of high intensity. The PE sessions for the EG2 had the same aims and contents than those for CG and EG1. A team of expert PE teachers helped to design the pedagogical strategies to increase session's intensity of EG2. Polar-610 heart rate monitors were used to measure the intensity of the sessions in randomly selected students (n = 38) from the three groups during 15 sessions, also randomly selected. Mean and maximum heart rate were significantly higher in the EG2 (mean = 147 and max. = 193 bpm) compared with CG (mean = 116 and max. = 174 bpm) and EG1 (mean = 129 and max. = 177 bpm), confirming that PE sessions for the EG2 were more intense than for the other two groups, as previously reported[30].

Data analysis

Data are presented as means and standard errors. Analyses were performed with the PASW (Predictive Analytics SoftWare, formerly SPSS) Statistics Command Syntax Reference software version 18.0 for Windows and the level of significance was set to 0.05.

The intervention's effects on cardio-metabolic profile were studied by one-way analysis covariance (ANCOVA), including group as fixed factor (GC, GE1 or GE2), pre-post intervention change as the dependent variable and sex, maturity development (Tanner) baseline values of the dependent variable and attendance rate as covariates. Pairwise comparisons were made (post-hoc) with Bonferroni correction.

Results

Baseline characteristics of the adolescents studied are shown in table I. Adolescents from the CG were

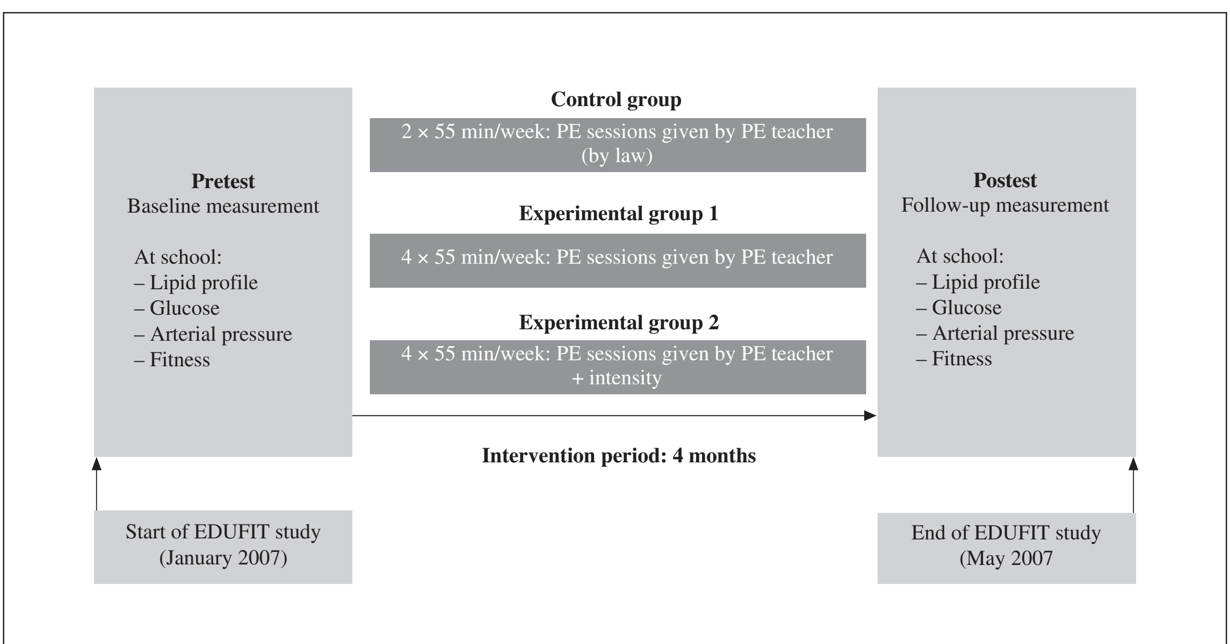

Fig. 2.—Content and timetable of the intervention. EDUFIT: Education for Fitness; PE: Physical Education.

Table I
Baseline characteristics of the participants

	Participants (n = 67)		*CG (n = 18)*		*EG1 (n = 26)*		*EG2 (n = 23)*		*p*
Age (years)	13.0	(0.1)	13.8	(0.1)	12.9	(0.1)	12.7	(0.1)	0.001
Tanner (%): Stages I/II/III/IV/V								0.21	
I	0		0		0		0		
II	16.4		0		23.1		21.7		
III	23.9		33.3		19.2		21.7		
IV	47.8		44.4		53.8		43.5		
V	11.9		22.2		3.8		13.0		
Weight (kg)	54.8	(1.7)	59.3	(3.7)	54.6	(3.1)	51.6	(1.9)	0.22
Height (cm)	156.5	(0.9)	157.5	(1.4)	156.4	(1.6)	156.0	(1.5)	0.80
Body mass index (kg/m²)	22.3	(0.6)	23.8	(1.4)	22.2	(1.1)	21.1	(0.6)	0.24

Data are means and (standard errors), unless otherwise stated. CG, control group (2 sessions Physical Education / week); EG1, experimental group-1 (4 sessions / week); EG2, experimental group-2 (4 session / week + high intensity). One-way (group) analysis of the variance. Differences in sexual maturation between groups were analysed using Chi-square test.

Table II
Effects of the intervention on cardio-metabolic profile

	n	*Pre*		*n*	*Post*		*n*	*Difference (Post-Pre)**	
Mean arterial pressure (mm Hg) †									
CG	18	82.1	2.1	18	75.2	1.4	18	-5.8	1.2
EG1	25	79.2	1.4	23	75.4	1.4	22	-4.6	1.1
EG2	22	77.3	1.4	23	74.7	1.5	22	-2.9	1.1
p (groups)		0.130		0.933		0.248			
Glucose (mg/dl)									
CG	14	76.1	2.6	15	77.2	2.2	14	-6.0	3.0
EG1	21	81.5	2.2	20	81.0	1.6	17	0.6	2.6
EG2	17	84.8	2.2	21	80.3	2.6	16	-0.1	2.5
p (groups)		0.48		0.476		0.248			
Triglycerides (mg/dl)									
CG	13	63.5	3.6	15	77.9	12.0	13	14.9	12.0
EG1	22	65.4	5.8	21	75.9	10.5	18	7.8	10.4
EG2	17	60.1	8.0	20	68.1	5.4	16	5.6	10.2
p (groups)		0.831		0.737		0.834			
Total Cholesterol (mg/dl)									
CG	13	132.3[a]	6.3	15	134.2	6.0	13	-1.5	7.3
EG1	22	140.0	6.3	21	146.5	5.4	18	4.8	6.2
EG2	17	157.2[a]	6.4	20	138.0	6.3	16	-9.5	6.3
p (groups)		0.038		0.333		0.300			
HDL cholesterol (mg/dl)									
CG	13	40.2	4.1	15	37.4	3.1	13	-6.8	3.3
EG1	22	45.5	3.5	21	44.0	3.2	18	1.9	2.8
EG2	17	48.2	3.4	20	39.7	2.5	16	-5.4	2.7
p (groups)		0.361		0.289		0.114			
LDL cholesterol (mg/dl)									
CG	13	79.5[b]	4.8	15	81.2	5.8	13	4.1[b]	4.7
EG1	22	83.0	4.8	21	87.5	4.2	18	2.8	4.0
EG2	17	97.2[b]	4.7	20	84.6	5.2	16	-10.4[b]	4.1
P (groups)		0.040		0.686		0.041			
LDLc/HDLc (mg/dl)									
CG	13	2.3	0.3	15	2.4	0.2	13	0.3	0.2
EG1	22	2.1	0.2	21	2.2	0.2	18	-0.1	0.1
EG2	17	2.2	0.2	20	2.2	0.2	16	0.0	0.1
p (groups)		0.802		0.838		0.365			

Data are means and standard errors, unless otherwise stated. CG, control group (2 sessions Physical Education / week); EG1, experimental group-1 (4 sessions / week); EG2, experimental group-2 (4 sessions / week + high intensity).
One-way analysis of co-variance (dependent variable = post-pre differences, fixed factor = group). Pairwise comparisons were performed using Bonferroni adjustment. Common superscripts ([a] in vertical direction) indicate significant differences between groups ($p < 0.05$) or ([b] in vertical direction) borderline differences between groups ($p < 0.1$), respectively.
* Descriptive values for the differences and p values are adjusted by sex, sexual maturation, attendance and the corresponding baseline values of the outcome. Analyses were done only on subjects that had valid data at both assessment points. † This is an average score computed from systolic and diastolic blood pressure.

older than those from the EG1 and EG2 (p = 0.001), yet no differences were observed in sexual maturation status (p = 0.21). No significant differences in weight, height or body mass index were observed among the study groups. Seventy two percent of the participants attended 75% or more of the sessions.

Table II shows the baseline, follow-up and change (post-pre) values for cardio-metabolic profile (blood pressure, glucose level and lipid profile) after adjustment for sex, sexual maturation and attendance.

Most of study variables did not differ among the study groups at baseline, except for TC and LDLc that were lower in the CG compared with the EG2 (p = 0.05 and p = 0.07, respectively). Consequently, all the models were further adjusted for baseline levels of the outcome studied (table II). After the intervention, we did not find any significant difference in the three studied groups on the lipid variables studied, except for LDLc (table II) that was marginally, yet significantly, reduced in the EG2 compared to CG (p = 0.04); no differences were observed for the LDLc/HDLc ratio though. No significant effects were observed in EG1 for any parameter studied. Additional adjustment for changes in body mass index did not alter the results (data not shown).

Partial correlation analyses adjusted for sex, sexual maturation and attendance did not show any associations between changes on fitness and metabolic-lipid profile (data not shown). Overall, the results did not differ when age was used in the models instead of sexual maturation status.

Discussion

The results of the present study suggest that increasing the frequency plus intensity of PE sessions a week during four months does not seem to be enough stimuli for improving of the overall lipid profile in adolescents. Despite our results showed a significant reduction in LDLc in the group that increased both frequency and intensity of PE sessions (EG2), compared with the group receiving usual PE (CG), no differences were observed in the LDLc/HDLc ratio, indicating that the intervention did not have a clear beneficial effect on lipid profile. These results should be taken as preliminary. The lack of significant effects could be due to the small sample size and consequent small statistical power, as well as the short time duration of the intervention.

Several school-based interventions have evaluated the effect of increasing the activity dose in PE on cardio-metabolic profile in adolescents[16,17,22,23,25,37]. Previous school-based intervention studies observed mixed effects on cardio-metabolic parameters, depending on the outcomes studied. Rosenbaum et al.[23] studied the effects of a 4-month school-based intervention based on health, nutrition and exercise classes plus an anaerobic exercise program. While no effect was observed on lipid profile, the intervention was beneficial on insulin sensitive and inflammatory markers. Benson et al.[37] did not find significant differences on cardio-metabolic factors (HDLc, LDLc, TC, triglycerides, TC/HDL, insulin, glucose, homeostasis assessment model 2-insulin resistance) between the intervention and control group, after a 8-week high-intensity progressive resistance program (twice a week). Similar findings were observed by Walther et al.[25] . They showed who concluded that despite dedicating 45 additional minutes of daily physical activity and a monthly lesson about healthy lifestyle, trough one school year (intervention class vs control class), children's lipid profile (TC, HDLc, LDLc) was not improved. In contrast, they found significant differences on concentration of circulating endothelial progenitor cells in the intervention group. Another multicomponent school-based program (Healthy study)[17] did not result in greater decreases on glucose level after 3-year intervention, but it reduced fasting insulin levels. Kriemler et al.[16] observed that increasing the frequency of PE a week (from 2 days a week to daily) had a positive effect on HDLc and triglycerides, but not on systolic-diastolic blood pressure and glucose level, after one school-year of intervention (KISS study). This study also reported a positive effect on cardiorespiratory fitness, which concur with our results on fitness, previously published[30]. Another school-based study (CHIC study)[11], consisting on 8-week exercise program and 8-week of classes on nutrition and smoking, observed marginal reductions in TC and improved the fitness level of those students who received the intervention.

Treviño and co-workers[24] conducted an intervention program lasting 8 months and consisting on a class of PE focused on health, a family program, a school cafeteria program, and an after-school health club in 1,221 fourth-grade Mexican-American children. The authors observed a significant reduction in glucose level in the intervention group. These results are not in agreement with our results or with other previous studies in overweight[22] or non-overweight[16,17,23,37] children. Among the studies that included blood pressure as outcome in young people[11,16,25], none observed positive effects, in line with our findings. In fact, most of the studies were conducted in predominantly healthy children with normal levels of blood pressure, in whom blood pressure is not expected to be reduced, probably not even desirable. Exercise might be more effective in children and adolescents with increased metabolic risk factors such as overweight or at risk for high blood pressure, as previously shown in adult population[38].

Limitations

A major limitation of the present study is its small sample size, which make this study to be considered a pilot study. Due to this small sample size and consequent small power, we cannot analyse boys and girls separately, which is a limitation of the study. As most of the school-based intervention studies, we randomized groups instead of individuals what in addition to small sample size used in our study increase the risk that the study groups were not identical at baseline. This was the case in our study and some baseline differences in lipid profile were observed among groups. Nevertheless, we controlled all the analyses for baseline values of the outcome studied, which mathematically balanced possible baseline differences, reducing the error inherent to group-randomized controlled trials. Another limitation of this study is the lack of information on insulin, which is more sensitive to physical activity than glucose levels. Likewise, we do not have any measurement of cholesterol in lipoprotein subfractions. This is a limitation, since it has been suggested that exercise can have a different effect on small vs. large particles of HDLc and LDLc[39].

Most of school-based studies are multicomponent interventions (e.g. parents programs, nutrition, and increase physical activity during/after school time). We chose to test a simpler and more practical model that focused the intervention on changes in the school curricular. An important contribution of EDUFIT program to previous studies is the specific and combined analysis of volume and intensity with effects on cardio-metabolic profile in three different groups in a single school-based study.

Health implications

There are a number of public health implications stemming from this paper. Nowadays, children have fewer opportunities to be active in a safe and independent manner, especially in large cities of developing countries that are rapidly urbanizing. Factors that decrease energy expenditure, such as the declining time for PE in schools, may play an important role in the prevalence of obesity among children. Because students spend large amounts of time in school, there is a great potential for increasing their level of physical activity through school-based interventions[4].

Conclusions

Overall, the program did not substantially influence lipid profile of the adolescents. However, our results suggest that increasing both frequency and intensity of PE sessions had a modest effect on LDLc in youth. Future studies involving larger sample sizes and longer interventions should focus on the separate effects of volume and intensity of PE.

Acknowledgments

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