Fecha de recepción: 31 de marzo de 2024
Fecha de aceptación: 4 de junio de 2024

ARTÍCULO ORIGINAL
https://dx.doi.org/10.14482/sun.41.01.158.245

Comparing the Effects of Two Workout Protocols (HIIT vs. MICT) over Body Composition and Metabolic Markers on Early Adolescents with Obesity

Comparación de los efectos de dos protocolos de entrenamiento (HIIT vs. MICT) sobre la composición corporal y los marcadores metabólicos en adolescentes con obesidad

Cecilia Sepúlveda-Flores[1], Igor Cigarroa[2], Nicole Lasserre-Laso[3], Claudio Soto-Espíndola[4], Guillermo Leiva-Manzor[5]

[1] Directora, Escuela de Nutrición y Dietética, Facultad de Salud, Universidad Santo Tomás, Los Ángeles (Chile). ceciliasepulveda@santotomas.cl. https://orcid.org/0009-0009-9352-1967

[2] Director, Escuela de Kinesiología, Facultad de Ciencias de la Salud, Universidad Católica Silva Henríquez, La Florida (Chile). Correo electrónico: icigarroac@ucsh.cl. https://orcid.org/0000-0003-0418-8787.

[3] Académica en Nutrición y Dietética, Escuela de Nutrición y Dietética, Facultad de Salud, Universidad Santo Tomás, Los Ángeles (Chile). nlasserre@santotomas.cl. http://orcid.org/0000-0002-7217-5198

[4] Director, Escuela de Kinesiología, Facultad de Salud, Universidad Santo Tomás, Chile. Claudiosoto1@santotomas.cl. https://orcid.org/0000-0001-7245-9783

[5] Estudiante, Escuela de Nutrición y Dietética, Facultad de Salud, Universidad Santo Tomás, Los Ángeles (Chile). g.leival@icloud.com. https://orcid.org/0009-0003-8784-7844

Correspondencia: Igor Cigarroa. icigarroac@ucsh.cl

Cecilia Sepúlveda-Flores, Igor Cigarroa, Nicole Lasserre-Laso, Claudio Soto-Espíndola, Guillermo Leiva-Manzor

ABSTRACT

Introduction: Obesity in adolescents increases the risk of chronic diseases. Studies have shown that increasing physical activity improves metabolic health. However, there is a divergence regarding the effectiveness of different types of physical activity programs in adolescents.

Objective: To determine the effects of two physical activity programs on early adolescents with obesity, and to compare their benefits on body composition and metabolic markers.

Methodology: 35 adolescents diagnosed with obesity from a public school were selected and randomized in two groups. The HIIT group (n = 18) performed 1 min of intense exercise at 80-100 % of the maximum heart rate (HRmax) and rested 2 for a min, repeating this cycle 10 times; the MICT group (n = 17) performed 30 min of continuous exercise at 55-69% of HRmax. Both exercise programs were performed on a static bike, 3 times per week, for 12 weeks. All the participants had nutritional counseling weekly.

Results: We detected a statistically significant increase in the lean mass (p = 0.008 and p = 0.002) and a decrease in triglyceride levels (p = 0.080 and p <0.001), for the MICT and the HIIT groups, respectively.

Conclusion: Both exercise programs in conjunction with nutritional counseling, lead to a significant increase in lean mass and a decrease in triglyceride levels. MICT had a greater impact in decreasing fat mass, and both had a similar impact in reducing triglycerides levels.

Keywords: Obesity, adolescent health, exercise and physical activity, school health, health promotion.

RESUMEN

Introducción: La obesidad en adolescentes aumenta el riesgo de enfermedades crónicas. Estudios han demostrado que aumentar la actividad física mejora la salud metabólica. Sin embargo, existe divergencia sobre la efectividad de los distintos tipos de programas de actividad física en adolescentes.

Objetivo: Determinar los efectos de dos programas de actividad física en adolescentes con obesidad, y comparar sus beneficios sobre la composición corporal y los marcadores metabólicos.

Metodología: Se seleccionaron, de un colegio público, 35 adolescentes diagnosticados con obesidad. Los participantes se dividieron en dos grupos. El grupo HIIT (n = 18) realizó 1 min de ejercicio intenso al 80-100 % de la frecuencia cardiaca máxima (FC máx.) y descansó durante 2 min, repitiendo este ciclo 10 veces; el grupo MICT (n = 17) realizó 30 minutos de ejercicio continuo al 55-69 % de la FC máx. Ambos programas de ejercicio se realizaron en una bicicleta estática, 3 veces por semana, durante 12 semanas. Todos los participantes recibieron asesoramiento nutricional semanal.

Resultados: Se detectó un aumento estadísticamente significativo de la masa magra (p = 0.008 y p = 0.002) y una disminución de los niveles de triglicéridos (p = 0.080 y p <0.001), para los grupos MICT y HIIT, respectivamente.

Conclusión: Ambos programas de ejercicio, junto con el asesoramiento nutricional, produjeron un aumento significativo de la masa magra y un descenso de los niveles de triglicéridos. MICT tuvo un mayor impacto en la disminución de la masa grasa, y ambos programas de ejercicio tuvieron un impacto similar en la reducción de los niveles de triglicéridos.

Palabras clave: Obesidad, salud de los adolescentes, ejercicio y actividad física, salud escolar, promoción de la salud.

INTRODUCTION

Obesity is a disease evidenced by an excess of body weight, and when it occurs during early adolescence, it increases the risk of chronic non-communicable diseases such as metabolic syndrome, high blood pressure, dyslipidemia, fatty liver, type 2 diabetes, and cardiovascular diseases (1–3) biological and lifestyle factors on the risk of metabolic syndrome (MetS. Although obesity can have multiple causes in adolescents, the most frequent ones are low physical activity and bad eating habits (4–7)moderate and vigorous PA (MVPA.

Several studies in obese adolescents have shown that an increase in physical activity offers multiple benefits including a decrease in body fat, increase in muscle mass, decrease in triglycerides, increase in HDL cholesterol levels, and increase in insulin sensitivity (6,8–12)physical fitness, and cardiometabolic risk in adolescents participating in an interdisciplinary program focusing on the treatment of obesity. The final 12-week analyses involved 33 female adolescents who were split into two groups of concurrent training (CT. However, there is no consensus on what type of physical activity is more effective in adolescents, and having such information would be key to developing better physical education programs in schools.

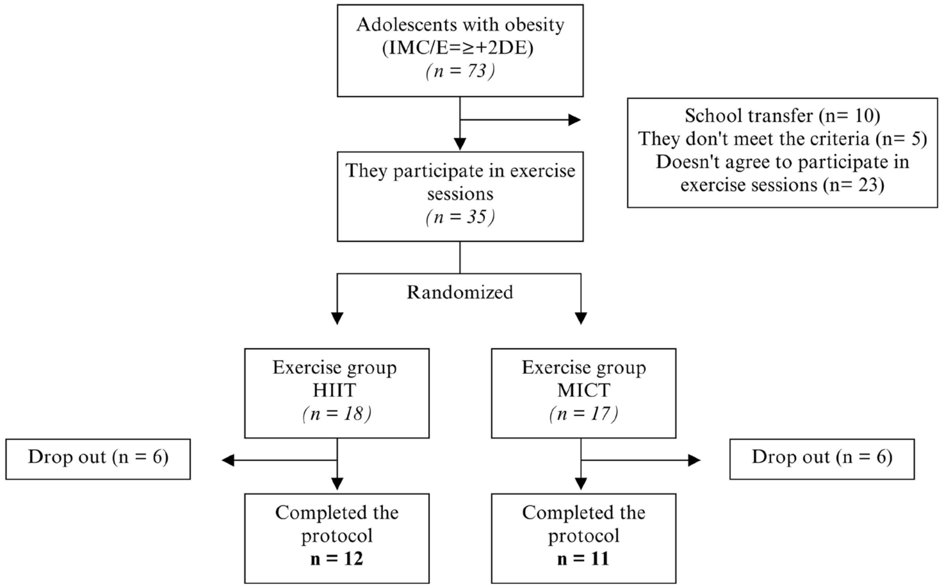
Both, the aerobic MICT and the anaerobic HIIT have shown positive effects over cardiovascular risk variables in adolescents (9,13–18). However, in the adult population with obesity, there is strong evidence supporting that HIIT has greater effects than MICT over cardiovascular risk factors (12,19,20). We aimed to determine whether HIIT or MICT, in conjunction with nutritional counseling, has a greater impact on anthropometric and metabolic variables in obese adolescents.

METHODS

Participant Selection

The present study had a quasi-experimental design with a non-representative sample. Initially, we invited 73 obese adolescents from the public school "Escuela España" (Los Angeles, Chile) to participate in exercise sessions and counseling on healthy eating. Our exclusion criteria were the presence of metabolic disease or chronic disease (dyslipidemia, hypertension, diabetes, or other pathology) that would require specific medical treatment, pharmacological treatment, or that would guard against working out.

From the group of invited subjects, the ones that agreed to participate in the study, and met the inclusion criteria, were in total 35. This group of participants was randomly separated into 2 exercise groups: HIIT (n = 18) and MICT (n = 17), of which only 12 and 11 subjects completed the study, respectively (figure).



Note. Body mass index for a given age (BMI/E) +2 standard deviation (≥ + 2 SD) is referred to the growth patterns proposed by the WHO and adapted to the Chilean population (24). HIIT: high-intensity interval training, MICT: moderate-intensity continuous training.

Source: own elaboration.

Figure. Flow Scheme for the Participant Selection Process

This study was approved by the Ethics Committee of the Universidad Santo Tomás (Chile) (code:5-2016, December 2015). Prior to the beginning of the intervention, all participants signed an informed assent form, and their tutors signed an informed consent form.

Intervention and Workout Protocol

In both intervention groups, the training frequency was set to be 3 times per week over a period of 12 weeks (3 months) (8)but it is unknown whether a high-intensity interval training (HIIT. The participants were required to assist for a minimum of 28 sessions (80%) from a total of 36 sessions. Given the low initial attendance to the exercise sessions, it was necessary to extend the length of the intervention adding 2 extra months (8 weeks) to complete the study intervention.

Workshops on eating and healthy lifestyles: in addition to the physical activities, once a week (either before or after the workout) the participants attended workshops on nutritional counseling, conducted by specialized nutritionists, where they discussed the importance of consuming healthy foods (fruits, vegetables, dairy products, legumes, fish) and maintaining a healthy lifestyle. These teachings were delivered through active games and both group and individual methodologies. Each participant learned how to prepare a variety of healthy meals and snacks for their consumption. The contents covered in each workshop were sent to the parents or guardians of the adolescents through a personalized notebook.

High-intensity interval training (HIIT): in this group, the participants performed a cyclic workout on a static bike (Proteus Nitro V4, China) consisting of an active phase of 1 min, to peak at 80 to 100% of the maximum heart rate (HRmax), followed by a resting phase of 2 min. This cycle was repeated a total of 10 times to complete the session. The HR was measured with a heart rate monitor and pulsometer (Polar FT1, Finland) (21,22).

Continuous moderate-intensity exercise (MICT): in this group, participants performed a continuous active phase in the static bike for 30 min. to achieve a peak of 55 to 69% of the HRmax, without any resting phase. The bike and HR monitor were the same used with the HIIT group (22,23).

Sociodemographic Variables and Lifestyle

The sociodemographic data (age, sex, area of residence, educational level of the mother) were consulted with each tutor (mother, father, or close relative) and recorded in an entry form for the project. Data associated with the lifestyle, including food intake habits and physical activity, were collected using validated surveys (clinical test for assessing physical activity in children of Godard M. 2008 (24) and Eating Habits Questionnaire of Burrow A. 2008 (25)). A specific habit was considered as "good" when the survey score was higher than 7 points (10 to 7 points), "regular" between 6 to 4 points, and "bad" below 3 points (24,25).

Anthropometric Variables

The anthropometric evaluation was performed by trained professionals using standardized protocols (26). The body weight was measured on a digital balance (SECA 817, USA) with an accuracy of 100 g. For the measurement, each participant stood upright at the center of the balance in lightweight clothes and barefoot. The height was recorded with a height measurement instrument (SECA 217, USA) having an accuracy of 1 mm. Each participant stood upright over the platform with the knees stretched and the back, buttocks, and heels contacting the vertical portion of the instrument. The waist circumference (WC) was measured with a measuring tape made of non-distensible material (SECA Model 201, USA), by placing the midpoint between the costal flange and the iliac crest along the axillary mid-line. The nutritional status was classified according to the growth patterns for children and adolescents between 5 years 1 month and 19 years (WHO), based on the body mass index for the age: malnutrition (≤-2 SD), risk of malnutrition (between > -2 and ≤ -1 SD), normal (between> -1 and <+1 SD), overweight (between ≥ +1 and <+2 SD), obesity (≥ +2 SD) and severe obesity (≥ +3 SD) (27). To define abdominal obesity, a waist perimeter classification for the age was used: normal (<75%), risk of abdominal obesity (between 75 and 90%), and abdominal obesity (over 90) (27). The body composition was evaluated using a four-pole bodystat bioimpedance meter (QuadScan 4000) on the subjects before an 8-hour liquid and solid fast and at rest (without any intense exercise 12 hours before).

Determination of Metabolic Markers

Blood samples were obtained by venous puncture after 10 to 12 hours of fasting. Basal glycemia, total cholesterol (CT), HDL cholesterol (cHDL), LDL cholesterol (cLDL), VLDL cholesterol (cVLDL), and triglycerides (TG) were analyzed using the Ultra HDL enzymatic method (Abbott Diagnostics, USA) through absorbance measurement in an automated equipment ARCHITECT c4000 (Abbott, USA).

Insulin was determined by immuno-chemiluminescence using microparticles (Abbott Diagnostics, USA) in the ARCHITECT equipment. Systolic (PAS) and diastolic (PAS) blood pressure was measured by placing each patient in a supine position, after a 10-minute rest period, with a mercury sphygmomanometer (aneroid, ADC, 760) and a stethoscope (Littmann classic III). Three blood pressure measurements were made for each patient, by trained professionals, reporting the average value. For the lipid profile parameters, the cut-off point was the one for children over 10 years of age: CT <200 mg/dL, c-HDL ≥40 mg/dL, cLDL <130 mg/dL, and TG <130 mg/dL (28).

The results of all these biochemical tests were reviewed by a physician, who informed the tutors and participants in individual meetings held at the beginning of the intervention. All these measurements were evaluated two times, before the beginning of the physical exercise program and after its completion.

Statistical Analysis

The values obtained for the population studied were analyzed by calculating the average and standard deviation (SD) for continuous variables and as a percentage for categorical variables.

To determine the effect of the HIIT and MICT exercise program over the anthropometric variables and metabolic markers, a *t*-test for related samples was used, considering $p < 0.05$ as statistically significant.

To compare the exchange rates between HIIT and MICT exercise groups, the difference between pre-intervention and post-intervention values for each group was calculated using a t-test for independent samples, considering $p<0.05$ as statistically significant. For these tests, the effect size was estimated using *Cohen's d* model. Scores d <0.2 were considered as a *low effect*, between 0.2 and 0.8 as a *medium effect*, and d>0.8 as a *large effect* (29,30).

Given that with a low sample size we might not be able to detect a medium or large effect size as statistically significant, following Cohen's recommendation (1990), we calculated the statistical power (1-β) for each hypothesis test. In this regard, Cohen recommends that power values below 0.8 indicate the need to increase the sample size to detect statistically significant changes in the analyzed variables.

RESULTS

The characteristics of the children belonging to the MICT and HIIT exercise groups are shown in Table 1. We observed a similar age (11.36 ± 1.21 and 11.58 ± 1.16) and a greater percentage of females (54.5% and 58.3%) in the MICT and HIIT groups, respectively. Most participants were urban residents and their mothers had complete secondary education but did not have a college education. Both groups shared similar anthropometric characteristics, however, the MICT group had a lower percentage of subjects classified with abdominal obesity compared to the HIIT group, where all the subjects presented this diagnostic. Regarding food intake habits, most subjects had "regular" habits. In the HIIT group no one had "bad" habits, while in the MICT, the 18.2% did have "bad" habits. Regarding physical activity, more than half of the subjects in the HIIT group presented "bad" habits before the intervention. In the HIIT group, only 8.3% presented "good" habits, in the MICT only 9.1% did.

Table 1. Characteristics of the Analyzed Groups

	MICT (n=11)	HIIT (n=12)
Male, %	45.5	41.7
Female, %	54.5	58.3
Age, years	11.36 ± 1.21	11.58 ± 1.16
Urban, %	90	100
Education level of the mother (%)		
Basic school education	27.3	16.7
Intermediate school education	72.7	83.3
University of technical education	0	0
Anthropometry and body composition		
Weight, kg	66.30 ± 13.72	69.16 ± 14.34
Height, cm	151.86 ± 8.69	153.85 ± 6.08
PC, cm	92.65 ± 9.55	96.79 ± 10.22
IMC, kg/m2	28.56 ± 3.86	28.95 ± 3.81
Abdominal obesity, %	90.9	100
Fat mass, %	36.67 ± 3.72	39.60 ± 3.09
Food intake habits		

Continúa...

Good (7-10)	9.1	8.3
Regular (6-4)	72.7	91.7
Bad (3-0)	18.2	0
Physical activity habits		
Good (7-10)	9.1	8.3
Regular (6-4)	45.4	25.0
Bad (3-0)	45.5	66.7

Note. Table 1 shows the characteristics of the groups analyzed. Depending on the type of exercise: continuous moderate-intensity (MICT) and high-intensity interval (HIIT). Values are expressed as average ± standard deviation, or percentages (%). PC: waist circumference, BMI: body mass index.
Source: own elaboration.

The changes obtained post-intervention are shown in Table 2. In both groups, we observed important changes in terms of body composition, with an increase in lean mass, and a reduction in triglycerides. No other significant differences were found among the anthropometric variables or in the metabolic markers.

Table 2. Analysis of Body Composition, Metabolic Markers, and Health Habits for the MICT and HIIT Groups

Variables	Pre-intervention		Post-intervention		p-value	p-value
	MICT	HIIT	MICT	HIIT	MICT	HIIT
Anthropometry and body composition						
BMI, kg/m2	28.56 ± 3.86	28.95 ± 3.81	29.09 ±3.81	29.00 ±4,28	0.269	0.905
Waist circumference, cm	92.65 ± 9.55	96.79 ± 10.22	91.54 ± 9.22	97.42 ± 11,37	0.440	0.583
Fat mass, %	36.67 ± 3.72	39.60 ± 3.09	35.95 ± 3.96	39.02 ± 3,00	0.244	0.516
Fat mass, kg	24.05 ± 5.09	27.71 ± 7.85	24.85 ± 5.22	27.84 ± 7,80	0.202	0.863
Lean mass, kg	41.79 ± 9.30	41.45 ± 6.75	44.03 ± 8.13	42.93 ± 8,26	0.008*	0.030*
Metabolic markers						
Fasting glycemia, mg/dl	87.18 ± 5.95	84.50 ± 5.93	87.40 ± 5.72	87.00 ± 6.83	0.350	0.237
Fasting insulin, mg/dl	15.85 ± 7.19	19.30 ± 5.97	15.14 ± 6.50	17.62 ± 4.13	0.697	0.385
HOMA-IR	3.44 ± 1.63	4.00 ± 1.14	3.27 ± 1.43	3.80 ± 1.04	0.706	0.564
Total cholesterol, mg/dl	166.0 ±21.52	171.17 ± 35.53	154.00 ±21.70	168.00 ±42.75	0.122	0.630
HDL, mg/dl	41.63 ± 13.65	45.00 ± 9.40	45.30 ±9.01	44.92 ± 5.55	0.181	0.972

Continúa...

LDL, mg/dl	96.27 ± 21.50	98.50 ± 22.44	87.90 ± 21.16	97.50 ± 31.88	0.317	0.857
vLDL, mg/dl	25.91 ± 17.91	27.67 ± 11.73	20.80 ± 15.27	25.58 ± 11.90	0.092	0.235
Triglycerides, mg/dl	129.18 ± 90.23	137.75 ± 58.61	102.80 ±76.25	127.50 ±59.96	0.002*	<0.001*
PAS, mmHG	107.10 ±11.63	106.67 ± 8.88	103.00 ±10.59	105.83 ± 9.00	0.151	0.339
PAD, mmHG	69.00 ± 9.62	70.42 ± 8.65	69.01 ± 9.94	69.58 ± 9.16	0.885	0.339
Health habits						
Food intake (score)	5,48 ± 1.26	5.63 ± 0.79	6.06 ± 1.15	5.87 ± 1.23	0.262	0.589
Physical activity (score)	3.73 ± 1.42	3.17 ± 1.90	4.18 ± 1.40	3.08 ± 1.56	0.534	0.886

Note. Data are shown as average ± standard deviation or percentages (%). To compare the results of the pre- and post-intervention variables, a student's t-test for related samples was used.
***:** statistical significance (p <0.05).
Source: own elaboration.

The rate of change for the anthropometric variables, body composition, and metabolic markers are shown in Table 3. We did not find differences between the groups for the variables studied, however, the MICT group exhibited a greater decrease in the waist circumference in comparison with the HIIT group. Also, we observed decreases in the total cholesterol CT having 8.13 mg less, LDL cholesterol having 5.9 mg less, triglycerides having 20.45 mg less, and systolic blood pressure having 3.27 mmHG less than the HIIT group. Additionally, the MICT group presented an increase in HDL cholesterol of 4.01 mg while the HIIT group showed a slight reduction instead.

Table 3. Comparison of the Change Rate between MICT and HIIT Groups

Variables	Difference (Δ)		Change (%)		p-value
	MICT	HIIT	MICT	HIIT	
Anthropometry and body composition ↑↓					
BMI, kg/m2	0.53 ±1.49	0.05 ± 1.42	↑1.8%	↑0.2%	0.483
Waist circumference, cm	-1.12 ± 4.61	0.62 ± 3.83	↓1.2%	↑0.6%	0.334
Fat mass, %	-0.72 ± 1.92	-0.57 ± 2.97	↓2,0%	↓1.5%	0.893
Fat mass, kg	0.80 ± 1.94	0.13 ± 2.61	↑3.2%	↑0.5%	0.498
Lean mass, kg	2.24 ± 2.47	1.47 ± 2.06	↑5.1%	↑3.4%	0.406
Metabolic markers					
Fasting glycemia, mg/dl	0.90 ± 2.88	2.50 ± 6.92	↑1.03%	↑2.9%	0.244
Fasting insulin, mg/dl	-0.66 ± 5.19	-1.69 ± 6.48	↓4.4%	↓9.6%	0.887

Continúa...

HOMA-IR	-0.14 ± 1.12	-0.19 ± 1.12	↓4.3%	↓5.0%	0.620
Total cholesterol, mg/dl	-11.30 ± 20.94	-3.17 ± 22.11	↓7.3%	↓1.9%	0.389
HDL, mg/dl	4.01 ± 8.74	-0.08 ± 8.06	↑8.9%	↓0.2%	0.267
LDL, mg/dl	-6.90 ± 20.60	-1.00 ± 18.83	↓7.8%	1.0%	0.491
vLDL, mg/dl	-6.00 ± 10.08	-2.08 ± 5.74	↓28.8%	↓8.1%	0.266
Triglycerides, mg/dl	-30.70 ± 50.56	-10.25 ± 27.23	↓29.9%	↓8.0%	0.240
PAS, mmHG	-4.10 ± 8.25	-0.83 ± 2.89	↓4.0%	↓0.8%	0.259
PAD, mmHG	-0.10 ± 2.13	-0.83 ± 2.89	↓0.1%	↓1.2%	0.513
Health habits					
Food intake (score)	0.58 ± 1.59	0.24 ± 1.51	↑9.6%	↑4.1%	0.616
Physical activity (score)	0.45 ± 2.34	-0.08 ± 1.98	↑10.8%	↓2.6%	0.557

Note. Data are shown as average ± standard deviation. (Δ) = the difference between post-intervention and pre-intervention values. For the change (%), positive values indicate that there was an increase from the initial evaluation to the final, and negative values indicate that there was a decrease from the initial evaluation to the final. To compare the change rate, a student's t-test was used for independent samples. *: Statistical significance ($p < 0.05$).
Source: own elaboration.

The estimation of the effect size and the statistical power of the comparisons between aerobic and interval exercise, according to Cohen's model, are shown in Table 4.

Table 4. Estimation of the Effect Size and the Statistical Power for the Comparisons between MICT and HIIT Exercise Groups, according to Cohen's Model

Anthropometry and body composition - group MICT							
	MICT	*n*	Average ± S.D.	*t* (dof)	*p*-value	*d-Cohen*	Power
BMI (kg/m2)	Pre	11	28.56 ± 3.86	-1.17 (10)	0.269	0.353	0.186
	Post	11	29.09 ± 3.81				
Waist circumference (cm)	Pre	11	92.65 ± 9.55	0.804 (10)	0.440	0.242	0.113
	Post	11	91.54 ± 9.22				
Fat mass (%)	Pre	11	36.67 ± 3.72	1.239 (10)	0.244	0.374	0.202
	Post	11	35.95 ± 3.96				
Fat mass (kg)	Pre	11	24.05 ± 5.09	-1.365 (10)	0.202	0.411	0.235
	Post	11	24.85 ± 5.22				
Lean mass (kg)	Pre	11	41.79 ± 9.30	-3.302 (10)	0.008	0.996	0.844
	Post	11	44.03 ± 8.14				

Continúa...

Anthropometry and body composition - group HIIT							
	HIIT	*n*	Average ± S.D.	*t* (dof)	*p*-value	*d-Cohen*	Power
IMC (kg/m2)	Pre	12	28.95 ± 3.82	-0.122 (11)	0.905	0.035	0.051
	Post	12	29.00 ± 4.29				
Waist circumference (cm)	Pre	12	96.79 ± 10.22	-0.565 (11)	0.583	0.163	0.081
	Post	12	97.42 ± 11.37				
Fat mass (%)	Pre	12	39.60 ± 3.09	0.671 (11)	0.516	0.194	0.094
	Post	12	39.03 ± 3.00				
Fat mass (kg)	Pre	12	27.71 ± 7.85	-0.177 (11)	0.863	0.051	0.053
	Post	12	27.84 ± 7.80				
Lean mass (kg)	Pre	12	41.46 ± 6.75	-2.485 (11)	0.030	0.717	0.62
	Post	12	42.93 ± 8.26				
Metabolic markers - group MICT							
	MICT	*n*	Average ± S.D.	*t* (dof)	*p*-value	*d-Cohen*	Power
Fasting glycemia (mg/dl)	Pre	10	86.5 ± 5.8	-0.987 (9)	0.350	0.312	0.143
	Post	10	87.4 ± 5.72				
Fasting glycemia (mg/dl)	Pre	10	15.8 ±7.58	0.402 (9)	0.697	0.127	0.065
	Post	10	15.14 ± 6.50				
HOMA-IR	Pre	10	3.41 ± 1.71	0.389 (9)	0.706	0.123	0.064
	Post	10	3.27 ± 1.43				
Total cholesterol (mg/dl)	Pre	10	165.3 ± 22.55	1.706 (9)	0.122	0.539	0.332
	Post	10	154 ± 21.7				
HDL (mg/dl)	Pre	10	41.29 ± 14.34	-1.451 (9)	0.181	0.459	0.255
	Post	10	45.3 ± 9.01				
LDL (mg/dl)	Pre	10	94.8 ± 22.07	1.059 (9)	0.317	0.335	0.158
	Post	10	87.9 ± 21.16				
vLDL (mg/dl)	Pre	10	26.8 ± 18.62	1.883 (9)	0.092	0.595	0.391
	Post	10	20.8 ± 15.27				
Triglycerides (mg/dl)	Pre	10	133.5 ± 93.91	1.92 (9)	0.087	0.607	0.404
	Post	10	102.8 ± 76.25				
PAS (mmHG)	Pre	10	107.1 ± 11.63	1.571 (9)	0.151	0.497	0.29
	Post	10	103 ± 10.59				
PAD (mmHG)	Pre	10	69.1 ± 9.62	0.148 (9)	0.885	0.047	0.052
	Post	10	69 ± 9.94				
Metabolic markers - group HIIT							
	HIIT	*n*	Average ± S.D.	*t* (dof)	*p*-value	*d-Cohen*	Power
Fasting glycemia (mg/dl)	Pre	12	84.5 ± 5.93	-1.251 (11)	0.237	0.361	0.208
	Post	12	87 ± 6.84				
Fasting glycemia (mg/dl)	Pre	12	19.31 ± 5.98	0.904 (11)	0.385	0.261	0.131
	Post	12	17.62 ± 4.14				
HOMA-IR	Pre	12	4 ± 1.15	0.594 (11)	0.564	0.172	0.085
	Post	12	3.81 ± 1.04				

Continúa...

Total cholesterol (mg/dl)	Pre	12	171.17 ± 35.53	0.496 (11)	0.630	0.143	0.074
	Post	12	168 ± 42.75				
HDL (mg/dl)	Pre	12	45 ± 9.4	0.036 (11)	0.972	0.010	0.05
	Post	12	44.92 ± 5.55				
LDL (mg/dl)	Pre	12	98.5 ± 22.44	0.184 (11)	0.857	0.053	0.053
	Post	12	97.5 ± 31.88				
vLDL (mg/dl)	Pre	12	27.67 ± 11.73	1.256 (11)	0.235	0.363	0.21
	Post	12	25.58 ± 11.9				
Triglycerides (mg/dl)	Pre	12	137.75 ± 58.62	1.304 (11)	0.219	0.376	0.222
	Post	12	127.5 ± 59.96				
PAS (mmHG)	Pre	12	106.67 ± 8.88	1 (11)	0.339	0.289	0.15
	Post	12	105.83 ± 9.00				
PAD (mmHG)	Pre	12	70.42 ± 8.65	1 (11)	0.339	0.289	0.15
	Post	12	69.58 ± 9.16				
Health habits - group MICT							
	MICT	*n*	Average ± S.D.	*t* (dof)	*p*-value	*d-Cohen*	Power
Food intake (ptos)	Pre	11	5.48 ± 1.26	-1.188 (10)	0.262	0.358	0.19
	Post	11	6.05 ± 1.15				
Food intake (ptos)	Pre	11	3.73 ± 1.42	-0.644 (10)	0.534	0.194	0.09
	Post	11	4.18 ± 1.4				
Health habits - group HIIT							
	HIIT	*n*	Average ± S.D.	*t* (dof)	*p*-value	*d-Cohen*	Power
Food intake (ptos)	Pre	12	5.63 ± 0.79	-0.556 (11)	0.589	0.160	0.08
	Post	12	5.87 ± 1.23				
Food intake (ptos)	Pre	12	3.17 ± 1.90	0.146 (11)	0.886	0.042	0.052
	Post	12	3.08 ± 1.56				

Note. The data are presented as average and standard deviation (SD) for continuous variables and as a percentage for categorical variables. To determine the extent to which the HIIT and MICT exercise programs had an impact on the variation of the anthropometric variables and the pre-and post-intervention metabolic markers, a *t*-test for related samples was used, considering p <0.05 as significant. For these tests, the effect size was estimated according to Cohen's *d* model considering small effects those with scores d <0.2, medium effects with scores *d* between 0.2 and 0.8, and large effects in those with scores d> 0.8. dof: degrees of freedom.
Source: own elaboration.

For the MICT exercise, we found a large effect size for lean mass (kg), and average effect sizes were evidenced for the following variables: waist perimeter (cm), fat mass (kg) and fat mass (%), total cholesterol (mg/dl), HDL (mg/dl), LDL (mg/dl), vLDL (mg/dl), triglycerides (mg/dl), PAS (mmHG), and food intake (pts). The variables that showed small effect sizes were fasting insulin (mg/dl), HOMA-IR, PAD (mmHG), and physical activity (pts). It was not relevant to highlight the effect of glycemia during fasting (mg/dl), nor for the BMI (kg/m^2), which had an average effect size.

The HIIT exercise group exhibited average effect sizes for the following variables: fat mass (kg), fasting glycemia (mg/dl), fasting insulin (mg/dl), vLDL (mg/dl), triglycerides (mg/dl), PAS (mmHG), and PAD (mmHG). The variables that exhibited small effect sizes were BMI (kg/m^2), waist circumference (cm), fat mass (kg), fat mass (%), HOMA-IR, total cholesterol (mg/dl), HDL (mg/dl), LDL (mg/dl), food intake (pts), and physical activity (pts).

DISCUSSION

In the obese adolescents from our study samples, the average age was similar in both exercise groups, and the majority of adolescents lived in the urban area of the city, this fact influenced the levels of obesity observed (31,32).

Regarding the educational level of the participant's mothers, the majority had completed secondary education, a smaller percentage only attended primary education, and none of them had a university or technical degree. Several investigations have reported that a mother's lower educational level can be associated with the development of obesity in their children, and such association can be explained because of the mother's lack of knowledge in health and self-care that comes with having fewer education years (33,34).

Regarding the food intake habits (HI) that were evaluated qualitatively in our study through the frequency of consumption of foods containing fats and sugar (25), we found that the majority of the adolescents in both groups had regular HI, followed by bad HI. Both groups had good HI and the HI score was 5.58 ± 0.13 points. Concerning the survey of physical activity habits (HAF), which evaluated prolonged exposure to minimal energy expenditure exercises and lack of moderate and vigorous physical exercises, most adolescents from both groups had bad HAF, followed by those who had regular HAF. A small percentage of both groups had a good HAF score (3.73 ± 1.42 points). Burrows *et al* reported slightly lower HI and HAF scores for adolescents, than the ones found in our study (5.0 ± 1.2 and 3.4 ± 1.6, respectively) (24). Another study from Burrows reported that obese adolescents had HAF scores similar to our study (4 points in men and 3 points in women) (25). Fernandez *et al.*, using the same surveys as us, found a lower HI score in obese adolescents (4.46 ± 1.78) than the one obtained in our sample, and a higher HAF score (4.63 ± 1.78). Other studies have described HI and HAF in obese adolescents, but using different surveys, nonetheless, they all have found inadequate eating habits and low physical activity (35,36).

Adolescents from both groups had a metabolic profile characteristic of individuals with cardiovascular risk, as indicated by abdominal obesity, elevated triglycerides (28), and insulin resistance (37). Other Chilean and foreign studies conducted in obese children and adolescents have found a similar metabolic cardiac profile (1,1,28,38–43).

Regarding the overall results, we need to highlight the significant increase in lean mass (kg) for both MICT and HIIT groups, although the effect size was greater in adolescents who practiced MICT (d = 0.996). This finding is consistent with other studies that have reported that both types of exercise increase lean mass in adolescents (10,44).

For the triglycerides (TG), we found a significant decrease in both intervention groups. The effect size was average for both types of exercise (MICT $d = 0.607$ and HIIT $d = 0.376$). Most studies on obese adolescents have found similar results (6,48,49).

For the remaining variables analyzed, no significant changes were found, but there was a decreasing trend and an average size effect in waist circumference (Δ = -1.12; p = 0.444; d = 0.242) and fat mass (%) for the MICT group (Δ = -0.72; p = 0.244; d = 0.411), while for the HIIT group, the effect size was small (13). Most research on obese adolescents indicates that HIIT decreases body fat to a greater extent (14,17,45–47).

As for the metabolic variables, no significant differences were found in the MICT group, but there was a tendency to decrease an average effect size in some blood lipids such as CT (Δ = - 11.30; p = 0.122; d = 0.539), c-LDL (Δ = - 6.90; p = 0.317; d = 0.335), c- vLDL (Δ = -6.00; p = 0.092; d = 0.595). In the case of HIIT, only vLDL had a tendency to decrease and an average effect size (Δ = -2.08; p = 0.235; d = 0.363). Studies in obese adolescents have found that both types of exercise reduce these variables (48,49). There was no significant increase in c-HDL, similar to what has been shown in other studies on adolescents practicing HIIT (12,50,51). Fasting insulin did not show significant changes but tended to decrease and had a medium effect size with HIIT (Δ = -1.69; p = 0.385; d = 0.261) (16,45,48,49). It should also be noted that Bea *et al.* have reported that for the anthropometric variables, the positive effects are detectable between 16 and 24 weeks of intervention, and the metabolic effects may become detectable only after this period (16).

Regarding systolic and diastolic blood pressure (PAS and PAD), no significant changes were observed in either group, but for HIIT, both PAS and PAD showed a tendency to decrease and an average effect size (PAS: Δ = -0.83 ± 2.89; p = 0.339; d = 0.289; and PAD: Δ = -0.83 ± 2.89; p = 0.339; d = 0.289). While for MICT, only PAS had a tendency to decrease and an average effect size (Δ = -4.10 ± 8.25; p = 0.151; d = 0.497). Several studies have found changes in these variables for both types of exercise in adolescents (9,12,48,52,53).

Respecting the change of HI and HAF, although no significant changes were found, there was a tendency to improve HI in the MICT group with a medium effect size (Δ = 0.58 ± 1.59; p = 0.262; d = 0.358) while in the HIIT group, there was a small effect size. Regarding HAF, the effect size was small for both groups (54). A group of researchers found that the practice of physical exercise promotes better eating habits (55,56). It would be interesting in future research to also incorporate self-care online programs about healthy foods and exercise, either through web pages or mobile applications (57,58).

The results obtained could be explained by the small sample size due to the low adherence of the participants. The lack of motivation to maintain adherence to the exercise program and nutritional counseling sessions would probably be one of the causes.

The affective response may also be a predictor of adherence to an exercise program, explaining why several adolescents did not complete the intervention, especially in the HIIT group. It has been described that some HIIT protocols may perturb the metabolic homeostasis leading to a negative affective response. And some studies have even shown that exercises with high intensity, above the anaerobic threshold, produce psychological stress in individuals (59). The lack of adherence could also be influenced by the location of the intervention site. The exercise sessions in our study were carried out in an environment that was very familiar to the participants. For future research, it would be important to conduct outdoor exercise sessions and/or through active games in the school context, in mandatory physical education classes, or increasing the breaks between lectures (46,60). It would be also recommended for the schools to permanently incorporate workshops on healthy eating and take periodic measurements of the children's anthropometric indicators, by school nutritionists (11,61–63).

Regarding the participation of parents and family, although they were very actively involved at the beginning of the intervention, it would have been necessary to include and engage them during the extension of the intervention, to educate them as well, and to reinforce the change of HI and HAF in their children. Studies have shown that the positive reinforcement exerted by the family over the children, in terms of healthy eating and incorporating more exercise, can be very successful. Additionally, if the parents maintain adequate body weight and reduce food portions, the effects of weight control achieved would be even more favorable for the children (54,64, 65–67).

According to Prochaska, supporting behavioral techniques in the process of change would allow to the detection of the psychological development stage of the adolescents (pre-contemplation, contemplation, preparation for action or action) and support them with emotional coaching to acquire valuable techniques such as self-assessment, self-motivation, self-regulation, short-term goals, and support to prevent relapses (68).

Within the strengths of our study, we employed validated and standardized documents and protocols used in laboratories, and we were able to answer, to some extent, the questions presented at the beginning of the project.

Today, the greatest challenge is how to implement a good multi-disciplinary program in schools, focusing on the prevention and treatment of obesity in adolescents and their co-morbidities. The most successful interventions are those implemented within school programs and that have continuity over time, which implies a challenge for most schools, especially for public ones.

CONCLUSION

We found that for obese adolescents, both MICT and HIIT exercise programs, along with nutritional counseling, lead to a significant increase in lean mass (kg) and a significant decrease in triglycerides. The size of the effect of decreasing fat mass (kg) was larger in the MICT group than in the HIIT, and for the TG, the effect size was average in both groups.

Although no significant changes were found in the other variables analyzed, we must highlight that for the MICT group, medium effect sizes were found for: a decrease in waist circumference, fat mass percentage, CT, c-LDL, c-vLDL, PAS, PAD, and improvement of HI. In the HIIT group, a medium effect size was observed for: the decrease of vLDL, fasting insulin, and PAS.

The current challenge is to implement physical exercise sessions through active games and outdoor jogging in the mandatory physical education classes, as well as increasing the length of study breaks at school, incorporating healthy eating counseling sessions conducted by school nutritionists and emotional coaching supported by the school psychologists. It is also necessary to involve and engage the families and the school communities in the change of behavior.

Acknowledgments: We want to acknowledge all the staff from the public school “Escuela España” (Los Ángeles, Chile), the adolescents and their tutors to participated in this project, the university students of the Universidad Santo Tomás who contribute to this project and specially in memory of Jaime Tito Aedo for his great support on the analysis of the investigation.

Ethical statement: The study was approved by the Ethics Committee of the Universidad Santo Tomás (Chile) (code:5-2016, December 2015) and conducted by the guidelines of the Declaration of Helsinki. Informed consent was obtained from all subjects involved in the study.

Disclaimer: None of the authors declare any conflicts of interest.

Funding: The present research has not received specific support from public sector agencies, commercial sector, or nonprofit entities.

REFERENCES

1. Burrows R, Correa-Burrows P, Reyes M, Blanco E, Albala C, Gahagan S. High cardiometabolic risk in healthy Chilean adolescents: associations with anthropometric, biological and lifestyle factors. Public Health Nutr. febrero de 2016;19(3):486-93.

2. Kim Y. Effects of Exercise Training Alone on Depot-Specific Body Fat Stores in Youth: Review of Recent Literature. Pediatr Exerc Sci. 1 de febrero de 2018;30(1):58-68.

3. García AG, Urbina Treviño MV, Villalpando Sánchez DC, Aguilar CA. Diagnostic accuracy of triglyceride/glucose and triglyceride/HDL index as predictors for insulin resistance in children with and without obesity. Diabetes Metab Syndr Clin Res Rev. julio de 2019;13(4):2329-34.

4. Telford RD, Telford RM, Martin MK, Welvaert M. Drivers of adolescent adiposity: Evidence from the Australian LOOK study. J Sci Med Sport [Internet]. agosto de 2019 [citado 30 de agosto de 2019]; Disponible en: https://linkinghub.elsevier.com/retrieve/pii/S1440244019301951

5. Herter-Aeberli I, Osuna E, Sarnovská Z, Zimmermann MB. Significant Decrease in Childhood Obesity and Waist Circumference over 15 Years in Switzerland: A Repeated Cross-Sectional Study. Nutrients. 15 de agosto de 2019;11(8):1922.

6. Branco BHM, Valladares D, de Oliveira FM, Carvalho IZ, Marques DC, Coelho AA, et al. Effects of the Order of Physical Exercises on Body Composition, Physical Fitness, and Cardiometabolic Risk in Adolescents Participating in an Interdisciplinary Program Focusing on the Treatment of Obesity. Front Physiol [Internet]. 6 de agosto de 2019 [citado 31 de agosto de 2019];10. Disponible en: https://www.frontiersin.org/article/10.3389/fphys.2019.01013/full

7. Venetsanou F, Kambas A, Gourgoulis V, Yannakoulia M. Physical activity in preschool children: Trends over time and associations with body mass index and screen time. Ann Hum Biol. 26 de agosto de 2019;1-25.

8. Liu J-X, Zhu L, Deng J-M. The effects of high-intensity interval training versus moderate-intensity continuous training on fat loss and cardiometabolic health in pediatric obesity: A protocol of systematic review and meta-analysis. Medicine (Baltimore). marzo de 2019;98(10):e14751.

9. Lee S, Kim Y. Effects of Exercise Alone on Insulin Sensitivity and Glucose Tolerance in Obese Youth. Diabetes Metab J. 2013;37(4):225.

10. Stoner L, Rowlands D, Morrison A, Credeur D, Hamlin M, Gaffney K, et al. Efficacy of Exercise Intervention for Weight Loss in Overweight and Obese Adolescents: Meta-Analysis and Implications. Sports Med. noviembre de 2016;46(11):1737-51.

11. Espinoza-Silva M, Latorre-Román PÁ, Párraga-Montilla J, Caamaño-Navarrete F, Jerez-Mayorga D, Delgado-Floody P. Respuesta en escolares con obesidad al ejercicio intervalado de alta intensidad aplicado en el contexto escolar. Endocrinol Diabetes Nutr [Internet]. agosto de 2019 [citado 31 de agosto de 2019]; Disponible en: https://linkinghub.elsevier.com/retrieve/pii/S253001641930148X

12. Plavsic L, Knezevic OM, Sovtic A, Minic P, Vukovic R, Mazibrada I, et al. Effects of high-intensity interval training and nutrition advice on cardiometabolic markers and aerobic fitness in adolescent girls with obesity. Appl Physiol Nutr Metab [Internet]. 6 de agosto de 2019 [citado 31 de agosto de 2019]; Disponible en: http://www.nrcresearchpress.com/doi/10.1139/apnm-2019-0137

13. Sigal RJ, Alberga AS, Goldfield GS, Prud'homme D, Hadjiyannakis S, Gougeon R, et al. Effects of Aerobic Training, Resistance Training, or Both on Percentage Body Fat and Cardiometabolic Risk Markers in Obese Adolescents: The Healthy Eating Aerobic and Resistance Training in Youth Randomized Clinical Trial. JAMA Pediatr. 1 de noviembre de 2014;168(11):1006.

14. Costigan SA, Eather N, Plotnikoff RC, Taaffe DR, Lubans DR. High-intensity interval training for improving health-related fitness in adolescents: a systematic review and meta-analysis. Br J Sports Med. octubre de 2015;49(19):1253-61.

15. Ventura AK. Does Breastfeeding Shape Food Preferences Links to Obesity. Ann Nutr Metab. 2017;70(Suppl. 3):8-15.

16. Bea JW, Blew RM, Howe C, Hetherington-Rauth M, Going SB. Resistance Training Effects on Metabolic Function Among Youth: A Systematic Review. Pediatr Exerc Sci. agosto de 2017; 29(3):297-315.

17. Collins H, Fawkner S, Booth JN, Duncan A. The effect of resistance training interventions on weight status in youth: a meta-analysis. Sports Med - Open [Internet]. diciembre de 2018 [citado 31 de agosto de 2019];4(1). Disponible en: https://sportsmedicine-open.springeropen.com/articles/10.1186/s40798-018-0154-z

18. Broadney MM, Belcher BR, Berrigan DA, Brychta RJ, Tigner IL, Shareef F, et al. Effects of Interrupting Sedentary Behavior With Short Bouts of Moderate Physical Activity on Glucose Tolerance in Children With Overweight and Obesity: A Randomized Crossover Trial. Diabetes Care. octubre de 2018;41(10):2220-8.

19. Wewege M, van den Berg R, Ward RE, Keech A. The effects of high-intensity interval training vs. moderate-intensity continuous training on body composition in overweight and obese adults: a systematic review and meta-analysis: Exercise for improving body composition. Obes Rev. junio de 2017;18(6):635-46.

20. Roy M, Williams SM, Brown RC, Meredith-Jones KA, Osborne H, Jospe M, et al. High-Intensity Interval Training in the Real World: Outcomes from a 12-Month Intervention in Overweight Adults. Med Sci Sports Exerc. septiembre de 2018;50(9):1818-26.

21. Keating SE, Johnson NA, Mielke GI, Coombes JS. A systematic review and meta-analysis of interval training versus moderate-intensity continuous training on body adiposity: Exercise for body fat reduction. Obes Rev. agosto de 2017;18(8):943-64.

22. Hannan A, Hing W, Simas V, Climstein M, Coombes J, Jayasinghe R, et al. High-intensity interval training versus moderate-intensity continuous training within cardiac rehabilitation: a systematic review and meta-analysis. Open Access J Sports Med. enero de 2018;Volume 9:1-17.

23. Norton K, Norton L, Sadgrove D. Position statement on physical activity and exercise intensity terminology. J Sci Med Sport. septiembre de 2010;13(5):496-502.

24. Burrows A R, Díaz B E, Sciaraffia M V, Gattas Z V, Montoya C A, Lera M L. Hábitos de ingesta y actividad física en escolares, según tipo de establecimiento al que asisten. Rev Médica Chile [Internet]. enero de 2008 [citado 30 de agosto de 2019];136(1). Disponible en: http://www.scielo.cl/scielo.php?script=sci_arttext&pid=S0034-98872008000100007&lng=en&nrm=iso&tlng=en

25. Godard M C, Rodríguez N M del P, Díaz N, Lera M L, Salazar R G, Burrows A R. Valor de un test clínico para evaluar actividad física en niños. Rev Médica Chile [Internet]. septiembre de 2008 [citado 30 de agosto de 2019];136(9). Disponible en: http://www.scielo.cl/scielo.php?script=sci_arttext&pid=S0034-98872008000900010&lng=en&nrm=iso&tlng=en

26. Stewart A, Marfell-Jones M, Olds T, De Ridder H, International Society for Advancement of Kinanthropometry issuing body. International standards for anthropometric assessment [Internet]. 2011 edition. Lower Hutt, New Zealand : International Society for the Advancement of Kinanthropometry; 2011 [citado 30 de agosto de 2019]. Disponible en: https://trove.nla.gov.au/work/26414250

27. Ministerio de Salud de Chile. Patrones de Crecimiento para la evaluación nutricional de niños, niñas y adolescentes desde el nacimiento hasta los 19 años de edad [Internet]. 2018 [citado 30 de agosto de 2019]. Disponible en: http://www.bibliotecaminsal.cl/wp/wp-content/uploads/2018/07/2018.06.14-PAC_Interior-con-lineas-de-corte-14-juliov3.pdf

28. Barja Yáñez S. DISLIPIDEMIAS EN ESCOLARES CHILENOS: PREVALENCIA Y FACTORES ASOCIADOS. Nutr Hosp. 1 de mayo de 2015;(5):2079-87.

29. Cohen J. Statistical power analysis for the behavioral sciences. 2. ed., reprint. New York, NY: Psychology Press; 2009. 567 p.

30. Cohen J. Things I Have Learned (So Far). Am Psychol. 1990;9.

31. Delisle Nyström C, Barnes JD, Blanchette S, Faulkner G, Leduc G, Riazi NA, et al. Relationships between area-level socioeconomic status and urbanization with active transportation, independent mobility, outdoor time, and physical activity among Canadian children. BMC Public Health [Internet]. diciembre de 2019 [citado 19 de diciembre de 2019];19(1). Disponible en: https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-019-7420-y

32. Najera H, Nandy S, Carrillo-Larco RM, Miranda JJ. Within-country migration and obesity dynamics: analysis of 94,783 women from the Peruvian demographic and health surveys. BMC Public Health [Internet]. diciembre de 2019 [citado 19 de diciembre de 2019];19(1). Disponible en: https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-019-6586-7

33. Wallby T, Lagerberg D, Magnusson M. Relationship Between Breastfeeding and Early Childhood Obesity: Results of a Prospective Longitudinal Study from Birth to 4 Years. Breastfeed Med. enero de 2017;12(1):48-53.

34. Poulsen PH, Biering K, Winding TN, Nohr EA, Petersen LV, Ulijaszek SJ, et al. How does psychosocial stress affect the relationship between socioeconomic disadvantage and overweight and obesity? Examining Hemmingsson's model with data from a Danish longitudinal study. BMC Public Health [Internet]. diciembre de 2019 [citado 19 de diciembre de 2019];19(1). Disponible en: https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-019-7699-8

35. Calderón García A, Marrodán Serrano MD, Villarino Marín A, Martínez Álvarez JR. Valoración de la condición nutricional, y de hábitos y preferencias alimentarias en una población infanto-juvenil (7 a 16 años) de la comunidad de madrid. Nutr Hosp [Internet]. 2018 [citado 19 de diciembre de 2019]; Disponible en: https://www.nutricionhospitalaria.org/articles/02244/show

36. Lyngdoh M, Akoijam BS, Singh KS. Diet, Physical Activity, and Screen Time among School Students in Manipur. :8.

37. Burrows A R, Leiva B L, Burgueño A M, Maggi M A, Giadrosic R V, Díaz B E, et al. Sensibilidad insulínica en niños de 6 a 15 años: asociación con estado nutricional y pubertad. Rev Médica Chile [Internet]. noviembre de 2006 [citado 19 de diciembre de 2019];134(11). Disponible en: http://www.scielo.cl/scielo.php?script=sci_arttext&pid=S0034-98872006001100009&lng=en&nrm=iso&tlng=en

38. Burrows A R, Burgueño A M, Leiva B L, Ceballos S X, Guillier O I, Gattas Z V, et al. Perfil metabólico de riesgo cardiovascular en niños y adolescentes obesos con menor sensibilidad insulínica. Rev Médica Chile [Internet]. julio de 2005 [citado 19 de diciembre de 2019];133(7). Disponible en: http://www.scielo.cl/scielo.php?script=sci_arttext&pid=S0034-98872005000700007&lng=en&nrm=iso&tlng=en

39. Bustos P, Saez K, Gleisner A, Ulloa N, Calvo C, Asenjo S. Metabolic syndrome in obese adolescents. Pediatr Diabetes. febrero de 2010;11(1):55-60.

40. Eyzaguirre F, Silva R, Román R, Palacio A, Cosentino M, Vega V, et al. Prevalencia de síndrome metabólico en niños y adolescentes que consultan por obesidad. Rev Médica Chile. junio de 2011;139(6):732-8.

41. Friend A, Craig L, Turner S. The Prevalence of Metabolic Syndrome in Children: A Systematic Review of the Literature. Metab Syndr Relat Disord. abril de 2013;11(2):71-80.

42. Mahbuba S, Mohsin F, Rahat F, Nahar J, Begum T, Nahar N. Descriptive epidemiology of metabolic syndrome among obese adolescent population. Diabetes Metab Syndr Clin Res Rev. mayo de 2018;12(3):369-74.

43. Sapunar J, Aguilar-Farías N, Navarro J, Araneda G, Chandia-Poblete D, Manríquez V, et al. Alta prevalencia de trastornos nutricionales por exceso, resistencia insulínica y síndrome metabólico en escolares de la comuna de Carahue, Región de la Araucanía. Rev Médica Chile. septiembre de 2018;146(9):978-86.

44. Boutcher SH. High-Intensity Intermittent Exercise and Fat Loss. J Obes. 2011;2011:1-10.

45. Thivel D, Masurier J, Baquet G, Timmons BW, Pereira B, Berthoin S, et al. High-intensity interval training in overweight and obese children and adolescents: systematic review and meta-analysis. J Sports Med Phys Fitness [Internet]. enero de 2019 [citado 31 de agosto de 2019];59(2). Disponible en: https://www.minervamedica.it/index2.php?show=R40Y2019N02A0310

46. Delgado-Floody P, Espinoza-Silva M, García-Pinillos F, Latorre-Román P. Effects of 28 weeks of high-intensity interval training during physical education classes on cardiometabolic risk factors in Chilean schoolchildren: a pilot trial. Eur J Pediatr. julio de 2018;177(7):1019-27.

47. Seo Y-G, Lim H, Kim Y, Ju Y-S, Lee H-J, Jang H, et al. The Effect of a Multidisciplinary Lifestyle Intervention on Obesity Status, Body Composition, Physical Fitness, and Cardiometabolic Risk Markers in Children and Adolescents with Obesity. Nutrients. 10 de enero de 2019;11(1):137.

48. Nascimento H, Alves AI, Medeiros AF, Coimbra S, Catarino C, Bronze-da-Rocha E, et al. Impact of a School-Based Intervention Protocol—ACORDA Project—On Adipokines in an Overweight and Obese Pediatric Population. Pediatr Exerc Sci. agosto de 2016;28(3):407-16.

49. Bond B, Weston K, Williams C, Barker A. Perspectives on high-intensity interval exercise for health promotion in children and adolescents. Open Access J Sports Med. noviembre de 2017;Volume 8:243-65.

50. Eddolls WTB, McNarry MA, Stratton G, Winn CON, Mackintosh KA. High-Intensity Interval Training Interventions in Children and Adolescents: A Systematic Review. Sports Med. noviembre de 2017;47(11):2363-74.

51. Martin-Smith R, Buchan DS, Baker JS, Macdonald MJ, Sculthorpe NF, Easton C, et al. Sprint Interval Training and the School Curriculum: Benefits Upon Cardiorespiratory Fitness, Physical Activity Profiles, and Cardiometabolic Risk Profiles of Healthy Adolescents. Pediatr Exerc Sci. 1 de agosto de 2019;31(3):296-305.

52. Elnaggar RK, Elshazly FA, Abdelbasset WK, Ahmed AS. Cardiovascular risk profile, oxygen uptake, and perceived exertion rate in children with obesity: the interactive effect of exercise intensity and duration. Diabetes Metab Syndr Obes Targets Ther. abril de 2019;Volume 12:527-36.

53. García-Hermoso A, Cerrillo-Urbina AJ, Herrera-Valenzuela T, Cristi-Montero C, Saavedra JM, Martínez-Vizcaíno V. Is high-intensity interval training more effective on improving cardiometabolic risk and aerobic capacity than other forms of exercise in overweight and obese youth? A meta-analysis: High-intensity interval training in overweight youth. Obes Rev. junio de 2016;17(6):531-40.

54. Khammassi M, Miguet M, O'Malley G, Fillon A, Masurier J, Damaso AR, et al. Health-related quality of life and perceived health status of adolescents with obesity are improved by a 10-month multidisciplinary intervention. Physiol Behav. octubre de 2019;210:112549.

55. Manz K, Mensink GBM, Finger JD, Haftenberger M, Brettschneider A-K, Lage Barbosa C, et al. Associations between Physical Activity and Food Intake among Children and Adolescents: Results of KiGGS Wave 2. Nutrients. 11 de mayo de 2019;11(5):1060.

56. Fillon A, Mathieu ME, Masurier J, Roche J, Miguet M, Khammassi M, et al. Effect of exercise-meal timing on energy intake, appetite and food reward in adolescents with obesity: The TIMEX study. Appetite. marzo de 2020;146:104506.

57. Nitsch M, Adamcik T, Kuso S, Zeiler M, Waldherr K. Usability and Engagement Evaluation of an Unguided Online Program for Promoting a Healthy Lifestyle and Reducing the Risk for Eating Disorders and Obesity in the School Setting. Nutrients. 27 de marzo de 2019;11(4):713.

58. Alcântara CM de, Silva ANS, Pinheiro PN da C, Queiroz MVO. Digital technologies for promotion of healthy eating habits in teenagers. Rev Bras Enferm. abril de 2019;72(2):513-20.

59. Oliveira Sediyama CM. Lifestyle and vitamin D dosage in women with breast cancer. Nutr Hosp [Internet]. 20 de septiembre de 2016 [citado 29 de noviembre de 2018];33(5). Disponible en: http://revista.nutricionhospitalaria.net/index.php/nh/article/view/584

60. Dias KA, Ingul CB, Tjønna AE, Keating SE, Gomersall SR, Follestad T, et al. Effect of High-Intensity Interval Training on Fitness, Fat Mass and Cardiometabolic Biomarkers in Children with Obesity: A Randomised Controlled Trial. Sports Med. marzo de 2018;48(3):733-46.

61. Fabián Vásquez ED Lydia Lera, Jorge Meza, Isabel Salas, Pamela Rojas, Eduardo Atalah y,-. Impacto del ejercicio de fuerza muscular en la prevención secundaria. Nutr Hosp. 1 de marzo de 2013;(2):347-56.

62. Rosario Oliva Rodríguez MTR Begoña Gil Barcenilla, Guadalupe Longo Abril, ,. Impacto de una intervención educativa breve a escolares sobre. Nutr Hosp. 1 de septiembre de 2013;(5):1567-73.

63. Sgambato MR, Cunha DB, Souza BSN, Henriques VT, Rodrigues RRM, Rêgo ALV, et al. Effectiveness of school–home intervention for adolescent obesity prevention: parallel school randomised study. Br J Nutr. 14 de noviembre de 2019;122(9):1073-80.

64. Rotman SA, Fowler LA, Ray MK, Stein RI, Hayes JF, Kolko RP, et al. Family Encouragement of Healthy Eating Predicts Child Dietary Intake and Weight Loss in Family-Based Behavioral Weight-Loss Treatment. Child Obes [Internet]. 12 de diciembre de 2019 [citado 19 de diciembre de 2019]; Disponible en: https://www.liebertpub.com/doi/10.1089/chi.2019.0119

65. Derks IPM, Bolhuis K, Sijbrands EJG, Gaillard R, Hillegers MHJ, Jansen PW. Predictors and patterns of eating behaviors across childhood: Results from The Generation R study. Appetite. octubre de 2019;141:104295.

66. Stromberg SE, Wheeler PB, Chardon ML, Janicke DM. Parent perceptions of restrictive feeding on the relationship between youth BMI z-score and weight control behavior use in African American youth: A mediational study. Eat Behav. abril de 2019;33:67-72.

67. Shahsanai A, Bahreynian M, Kelishadi R. Perceived barriers to healthy lifestyle from the parental perspective of overweight and obese students. :11.

68. Jaimovich P S, Campos S C, Campos S MS, Moore B J, Pawloski R L, Gaffney F K. Estado Nutricional y Conductas Asociadas a la Nutrición en Escolares. Rev Chil Pediatría. diciembre de 2010; 81(6):515-22.