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EFFECT OF MICT AND HIIT ON CARDIOMETABOLIC RISK AND BODY COMPOSITION IN OBESE BOYS

EFEITO DE MICT E HIIT SOBRE O RISCO CARDIOMETABÓLICO E COMPOSIÇÃO CORPORAL DE MENINOS OBESOS

EFECTO DE MICT E HIIT SOBRE EL RIESGO CARDIOMETABÓLICO Y LA COMPOSICIÓN CORPORAL DE NIÑOS OBESOS

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ABSTRACT

Introduction: The prevalence of childhood obesity has increased and is associated with the development of several chronic diseases. Moderate-intensity continuous training is recommended as the main exercise method for treating obesity. However, in overweight and obese individuals, high-intensity interval training models have similar or greater fat reduction potential than moderate-intensity continuous training. Objective: This study aimed to compare the effects of 12 weeks of moderate-intensity continuous training and high-intensity interval training on cardiometabolic parameters, body composition, and cardiorespiratory fitness in obese adolescent boys. Methods: Fifty-six obese boys, aged 10-16 years old, were included. Anthropometric measurements, blood pressure, body composition, oxygen consumption, glucose, insulin, and the lipid profile were assessed. Participants were assigned to moderate-intensity continuous training (n=20), high-intensity interval training (n=20), and control (n=16) groups. The moderate-intensity continuous training sessions consisted of 90 minutes of cycling/walking exercises and the high-intensity interval training sessions consisted of 15 minutes of warm-up, 15-18 minutes of interval exercises, and 15 minutes of cool-down. Both were performed three times a week. A two-way mixed-model factorial analysis of variance (ANOVA) with repeated measures was used. Results: In the high-intensity interval training group, there was an increase in relative and absolute oxygen consumption and a reduction in diastolic blood pressure. However, in the moderate-intensity continuous training group, there were increases in relative oxygen consumption and high-density lipoproteins, as well as reductions in anthropometric measurements, fat mass, and triglycerides. Conclusion: Moderate-intensity continuous training may be a better protocol for the reduction of fat mass, anthropometric measurements, and improvement of the lipid profile, while high-intensity interval training may be more effective in improving blood pressure among obese boys. Both exercises improve cardiorespiratory fitness. **Level of evidence II; *Therapeutic studies - investigation of treatment results.***

Keywords: Exercise; High-intensity intermittent exercise; Body composition; Blood pressure; Adolescents.

RESUMO

Introdução: A prevalência da obesidade infantil tem aumentado e está associada ao desenvolvimento de diversas doenças crônicas. O treinamento contínuo de intensidade moderada é recomendado como o principal método de exercício para o tratamento da obesidade. No entanto, em indivíduos com sobrepeso e obesos, os modelos de treinamento intervalado de alta intensidade têm potencial para redução de gordura semelhante ou maior do que o treinamento contínuo de intensidade moderada. Objetivo: Este estudo teve como objetivo comparar o efeito de 12 semanas de treinamento contínuo de intensidade moderada e o treinamento intervalado de alta intensidade sobre parâmetros cardiometabólicos, composição corporal e aptidão cardiorrespiratória em adolescentes obesos do sexo masculino. Métodos: Foram incluídos 56 meninos obesos, com idades entre 10 e 16 anos. Foram avaliadas medidas antropométricas, pressão arterial, composição corporal, consumo de oxigênio, glicose, insulina e perfil lipídico. Os participantes foram designados a grupos de treinamento contínuo de intensidade moderada (n = 20), treinamento intervalado de alta intensidade (n = 20) e controle (n = 16). As sessões consistiram em 90 minutos de exercícios de ciclismo/caminhada e as sessões de treinamento intervalado de alta intensidade consistiram em 15 minutos de aquecimento, 15 a 18 minutos de exercícios intervalados e 15 minutos de relaxamento, ambos realizados três vezes por semana. Foi utilizada uma análise fatorial de variância (ANOVA) de modelo misto de duas vias com medidas repetidas. Resultados: No grupo treinamento intervalado de alta intensidade houve aumento do consumo relativo e absoluto de oxigênio e redução da pressão arterial diastólica. No entanto, o grupo de grupo de treinamento contínuo de intensidade moderada teve aumento do consumo relativo de oxigênio e lipoproteína de alta densidade, além de redução das medidas antropométricas, massa gorda e triglicerídeos. Conclusões: O treinamento contínuo de intensidade moderada pode ser um protocolo melhor para redução de massa gorda, medidas antropométricas e melhora do perfil lipídico, enquanto o treinamento intervalado de alta intensidade pode ser mais eficaz para melhorar a pressão arterial em meninos obesos. Ambos os exercícios melhoram a aptidão cardiorrespiratória. ***Nível de evidência II; Estudos terapêuticos – Investigação dos resultados do tratamento.***

Descritores: *Exercício físico; Exercício intermitente de alta intensidade; Composição corporal; Pressão arterial; Adolescentes.*

RESUMEN

Introducción: La prevalencia de la obesidad en la infancia ha aumentado y está asociada al desarrollo de diversas enfermedades crónicas. Se recomienda el entrenamiento continuo de intensidad moderada como principal método de ejercicio para tratar la obesidad. Sin embargo, los modelos de entrenamiento de intervalos de alta intensidad tienen un potencial similar o mayor que el entrenamiento continuo de intensidad moderada para reducir la grasa en personas con sobrepeso y obesidad. Objetivo: Este estudio tuvo como objetivo comparar el efecto de 12 semanas de entrenamiento continuo de intensidad moderada y de entrenamiento de intervalos de alta intensidad sobre parámetros cardiometabólicos, composición corporal y condición cardiorrespiratoria en adolescentes varones con obesidad. Métodos: Se incluyeron 56 niños obesos, de 10 a 16 años. Se evaluaron las medidas antropométricas, presión arterial, composición corporal, consumo de oxígeno, glucosa, insulina y perfil lipídico. Los participantes se dividieron en: grupos de entrenamiento continuo de intensidad moderada (n = 20), entrenamiento de intervalos de alta intensidad (n = 20) y grupo de control (n = 16). Las sesiones consistieron en 90 minutos de ejercicios de ciclismo / caminata y las sesiones de entrenamiento de intervalos de alta intensidad consistieron en 15 minutos de calentamiento, 15 a 18 minutos de ejercicio de intervalos y 15 minutos de relajación, ambos realizados tres veces por semana. Se utilizó un análisis de varianza de modelo mixto bidireccional (ANOVA) con medidas repetidas. Resultados: En el grupo de entrenamiento de intervalos de alta intensidad se produjo un aumento del consumo de oxígeno relativo y absoluto, así como la reducción de la presión arterial diastólica. Sin embargo, el grupo de entrenamiento continuo de intensidad moderada presentó un aumento del consumo relativo de oxígeno y lipoproteínas de alta densidad, además de promover una reducción en las medidas antropométricas, la masa grasa y los triglicéridos. Conclusiones: El entrenamiento continuo de intensidad moderada puede ser un mejor protocolo para reducir la masa grasa, las medidas antropométricas y mejorar el perfil lipídico, mientras que el entrenamiento de intervalos de alta intensidad puede ser más efectivo para mejorar la presión arterial en niños obesos. Ambos ejercicios mejoran la aptitud cardiorrespiratoria. ***Nivel de evidencia II; Estudios terapéuticos: investigación de los resultados del tratamiento.***

Descriptores: *Ejercicio físico; Ejercicio intermitente de alta intensidad; Composición corporal; Presión arterial; Adolescentes.*

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INTRODUCTION

The obesity prevalence in childhood has increased and is associated with the development of several chronic diseases at this life stage, including dyslipidemia, hypertension, type 2 diabetes, and cardiovascular diseases.[1,2] Thus, clinical follow-up and evaluation of early cardiometabolic risk are justified by children and adolescents lifestyle's changes, namely by increasing the sedentary behavior, especially in fun activities like videogames in male individuals, that may reduce the physical activities (PA) participation, fitness, as well as adopting unhealthy eating habits.[3,4] The combination of PA and nutritional guidance has been recommended as a preventive and therapeutic action in pediatric populations of obese and other comorbidities.[5,6]

Regular PA is the target of various health promotion, and it is at school that the opportunity is provided in weekly mandatory curricular activities. However, these activities only contemplate 120 minutes per week, which is insufficient for a healthy lifestyle. World Health Organization (WHO)[7] recommends at least 420 minutes in moderate to vigorous PA intensity per week, to reach a lifestyle considered healthy. Furthermore, adherence to exercises it is a difficult task, considering the technological evolution and the increased use of electronic devices.[8] Therefore, to achieve the goal of reducing fat mass (FM) and improving cardiometabolic indicators with regular PA, there is a need to break down many barriers, especially in boys. Thus, we emphasize the need to include new types of PA, which might provide greater participation, that are dynamic and bring challenges in its execution.

Moderate-intensity continuous training (MICT) has been recommended as the main exercise for treat obesity.[9,10] However, adherence to training is intermediate, which makes it difficult to achieve the goals in the medium and long term. Recent meta-analysis suggested that high-intensity interval training models (HIIT) have similar or greater potential than MICT to reduce fat in overweight and obese individuals, even it is performed with lower training volume.[10] There are few published studies that analyzed the effect of these two training methods along with nutritional guidance on different metabolic markers in obese boys. Thus, analyzing the effect of different training methods can provide additional information in the action towards the obesity prevention and control of body weight. Therefore, the aim of this study was to compare the effect of 12 weeks of exercises on MICT versus HIIT on cardiometabolic parameters, cardiorespiratory fitness, and body composition in obese boys.

METHODS

At the baseline, 62 boys were recruited and assigned to in three groups: 22 to MICT, 20 to HIIT and 20 to control group (CG). The final sample consisted of 56 obese boys, who completed the 12-week activities of MICT (n=20), HIIT (n=20) and CG (n=16). All subjects were submitted to medical evaluation with detailed history and physical examination. The Ethics committee of the Clinical Hospital in the Federal University of Paraná (protocol n. 2460.067/2011-03-UFPR) approved all the procedures of the study and registered with the Brazilian Registry of Clinical Trials (RBR-4v6h7b).

The inclusion criteria were: (a) being between 10 and 17 years-old; (b) be diagnosed with obesity; And (c) presentation of the informed consent form signed by the guardians. The adolescents were excluded when they presented: (d) diagnosis of diabetes; (e) use of medications that could interfere with blood pressure, glycemia, weight control or lipid metabolism; (f) use of drugs that influence appetite; and (g) orthopedic limitations.

Body mass (BM) was evaluated by platform model with resolution of 0,1kg. Height was measured by means of a stadiometer with resolution of 0,1 cm. The body mass Index (BMI) was converted into Z-score from the software WHO Anthro Plus®. Waist circumference was measured in centimeters by means of flexible non-extendable tape, with resolution of

0,1cm, and adjusted by height using waist to height ratio (WtHR). Body composition was determined by bioelectrical impedance (Biodynamics®), performed in the morning, after 12 hours of fasting. The fat-free mass (FFM), fat mass (FM) and percentage of FM (%FM) were calculated.[11]

Blood samples were collected after a period of at least 12 hours of fasting. Glucose, insulin, triglycerides (TAG), total cholesterol (TC), high-density lipoprotein (HDL-c) and low-density lipoprotein (LDL-c) were measured using automated standardized methods. Insulin sensitivity was measured by the quantitative index of insulin sensitivity verification (QUICKI). Blood pressure (BP) was measured in the right arm with Aneroid Sphygmomanometer with the appropriate size of the cuff for the circumference of the arm, with the adolescents in the seated position, after 10 minutes of rest[12].

Cardiorespiratory fitness was measured during treadmill stress test,[13] using a gas analyzer (Intel 486, DX2, 66 MHz). We obtained information on peak oxygen consumption (VO_{2peak}), respiratory exchange ratio (RER) and heart rate (HR) was monitored by means of a heart rate monitor (Polar-A1). To determine the VO_{2peak} maximum, at least two of the following criteria were observed: (a) exhaustion or inability to maintain the required speed; (b) RER>1.3; (c) Maximum HR (HRmax>190 bpm). The VO_{2peak} was expressed in absolute values (L/min) and relative to BM (ml/kg.min^{-1}).

The exercise program was performed with three weekly sessions over 12 weeks. The exercise sessions were carried-out in the afternoon on alternate days. Both exercise programs included warming up and cool down as well as ten minutes of stretching before and after training. The CG only participated in physical education classes. The Exercise Protocols are presented in Table 1.

Data analyses were performed with the statistical package SPSS (version 24.0). The results of quantitative variables were presented by means and standard deviations. Data normality verification was performed using the Shapiro-Wilk test. Differences between groups at baseline were verified by analysis of variance (ANOVA), using Bonferroni post-hoc for parametric variables and the Kruskal-Wallis test for non-parametric variables. The post intervention differences of each group and the time by group interactions were verified using the two-way mixed-model factorial ANOVA, and when differences were identified, post-hoc Bonferroni was used.

The effect size (ES) was calculated and adjusted to compare the magnitude of the effect compared to the CG. The ES was considered small (d=0.20), medium (d=0.50) and large (d=0.80). Clinical inference was conducted according to values lower than -0.80 as very harmful, between -0.79 and -0.40 harmful, between -0.39 and -020 possibly harmful, between -0.20 and 0.20 were considered trivial, between 0.20 and 0.39 possibly beneficial, between 0.40 and 0.79 beneficial and greater than 0.80 considered very beneficial.[14]

The sample power was calculated in the software G*Power (v. 3.1.9.2), using the ANOVA test of repeated measures, two measurements and three groups. Was attributed power of 0.80, α of 0.05 and ES of 0.5, and an estimated sample size of 45 participants.

RESULTS

The initial characteristics of the pre-intervention groups are presented in Table 2. The adherence to the training was 100% with HIIT, 91% with the MICT and 80% in the CG, and adolescents from the exercise groups participated in ≥85% of the sessions. The HIIT had higher averages of %FM, FM and SBP, lower averages of relative VO_{2peak} and energy expenditure (EE) during the sessions compared to the MICT (p<0.01). In addition, the MICT had higher glucose concentrations than the HIIT and CG (p<0.001). Furthermore, a higher proportion of high SBP was observed in the HIIT compared to the MICT (82.4% vs 17.6%; p<0.001), while we found similarity between MICT and HIIT for the proportions of high DBP (20.0% vs 25.0%; p=0.322).

Table 3 presents mean differences before and after intervention. Significant time by group interaction in BM, height, WC, WtHR, BMI, BMI-Z, FM, %FM, DBP, VO_{2peak}, HDL-c and TAG were observed (p<0.01).

Table 2. Characteristics of the pre-intervention sample.

	HIIT (n=20)	MICT (n=20)	CG (n=16)	p
Age (years)	12.84±1.87	12.79±1.56	12.58±1.76	0.901
Weight (kg)	83.78±21.92	74.99±14.14	80.88±20.14	0.329
Height (cm)	1.64±0.14	1.61±0.09	1.61±0.12	0.829
WC (cm)	102.88±11.66	97.15±8.91	101.36±10.99	0.105
WtHR (cm/m²)	0.63±0.03	0.60±0.05	0.63±0.04	0.067
BMI (kg/m²)	30.67±3.74	28.53±2.98	30.71±3.64	0.228
BMI-z	3.02±0.47	2.69±0.39	3.12±0.48	0.144
Fat mass (%)	43.82±6.68 [a]	35.78±4.93	41.18±6.87	0.000
Fat mass (kg)	36.95±12.03 [a]	26.98±7.33	36.35±11.24	0.009
FFM (kg)	46.82±13.02	48.00±8.83	51.06±12.80	0,655
SBP (mmHg)	124.53±12.96 [a]	107.30±13.62	113.85±12.71	0.000
DBP (mmHg)	71.68±6.93	67.10±10.65	68.85±7.03	0.251
VO_{2peak} (ml/kg.min)	33.71±3.28	38.22±5.07 [a]	35.52±3.67	0.012
VO_{2peak} (L/min)	2.28±1.33	2.69±0.64	2.80±1.27	0.242
EE (session)*	303.57±13.04	504.48±104.91 [a]	- ± -	0.000
Glucose (mgdl)	79.45±9.68	93.80±7.63 [ab]	83.46±9.17	0.000
Insulin (uUI/ml)	18.52±11.08	15.00±7.72	15.48±11.28	0.401
HOMA-IR#	3.67±2.43	3.45±1.67	3.21±2.46	0.774
QUICKI	0.32±0.03	0.33±0.02	0.33±0.02	0.996
TC (mg/dl)	164.35±40.73	149.75±28.61	149.77±39.46	0.395
HDL-c (mg/dl)	49.20±10.44	42.55±6.54	49.69±9.88	0.064
Triglycerides (mg/dl)	88.25±40.80	119.25±63.57	102.69±43.55	0.167

#=non-parametric test; *=t test of students; WC=waist circumference; WtHR=waist-to-height ratio; BMI=body mass index; FFM=fat-free mass; SBP=systolic blood pressure; DBP=diastolic blood pressure; VO_{2peak}=Peak oxygen consumption; EE=energy expenditure; HOMA-IR=homeostatic model assessment; QUICKI=Quantitative Insulin-sensitivity check index; TC=total cholesterol; HDL-c=high-density lipoprotein; TAG=triglyceride; Bold=p<0.05; a= MICT vs. HIIT p<0.05; b = MICT vs. CG p<0.05; c= HIIT vs. CG p<0.05;

Table 1. Protocols of interventions: High intensity interval Training (HIIT) and continuous training of moderate intensity (MICT).

	Weeks 1-4	Weeks 5-8	Weeks 9-12	Week volume
HIIT - 3x per week	Sets: 2	Sets: 2	Sets: 2	45-54 minutes HIIT and 90 minutes of warm-up and cold-down
	Bouts: 8 per set	Bouts: 8 per set	Bouts: 8 per set	
	Bout duration: 30s	Bout duration: 30s	Bout duration: 30s	
	Recovery: 60s	Recovery: 45s	Recovery: 30s	
	Intensity: 100% MAS	Intensity: 100% MAS	Intensity: 100% MAS	
	R= 4 minutes	R= 4 minutes	R= 4 minutes	
MICT 3x per week	45min indoor cycling	45min indoor cycling	45min indoor cycling	270 minutes
	45min outdoor walking/runing	45min outdoor walking/runing	45min outdoor walking/runing	
	35-55% FCreserve	45-65% FCreserve	55-75% FCreserve	

HIIT= high-intensity interval training; MICT= moderate-intensity continuous training; MAS= maximum aerobic speed; R= rest between sets.

Table 3. Physical, physiological and blood variables (mean ± SD) before (pre) and after (post) interventions.

	MICT (n=20)			HIIT (n=20)			CG (n=16)			Time by Group		GC *vs.* MICT		GC *vs.* HIIT		MICT *vs.* HIIT	
	Δ mean change	SD	*P*	Δ mean change	SD	*p*	Δ mean change	SD	*P*	F	P	d	CI	d	CI	d	CI
Weight (kg)	-2.225	14.15	0.000	1.075	15.63	0.205	0.218	14.21	0.122	11.139	0.000	0.14	T	-0.04	T	-0.18	T
Height (cm)	0.022	0.09	0.000	0.011	0.09	0.000	0.025	0.08	0.018	6.595	0.002	0.03	T	0.11	T	0.09	T
WC (cm)	-4.230	9.08	0.000	-0.515	8.50	0.585	1.444	7.76	0.053	11.986	0.000	0.56	B	0.17	T	-0.35	PB
WtHR (cm/m)	-0.034	0.04	0.000	-0.008	0.02	0.246	0.008	0.02	0.308	13.834	0.000	0.95	VB	0.41	B	-0.61	B
BMI (kg/m²)	-1.565	3.06	0.000	-0.035	2.64	0.858	0.069	2.50	0.861	14.882	0.000	0.49	B	0.03	T	-0.45	B
BMI-z	-0.313	0.41	0.000	0.005	0.33	0.880	-0.118	0.34	0.889	22.283	0.000	0.43	B	-0.25	PH	-0.71	B
Fat mass (%)	-3.207	5.13	0.001	-1.066	4.42	0.442	2.189	6.59	0.098	6.187	0.004	0.72	B	0.41	B	-0.37	PB
Fat mass (kg)	-2.993	7.40	0.002	-0.316	8.55	0.830	2.493	7.95	0.074	5.976	0.003	0.58	B	0.24	PB	-0.27	PB
FFM (kg)	0.768	8.615	0.136	1.391	9.073	0.192	-1.336	9.552	0.192	1.053	0.234	0.19	T	0.21	PB	0.06	T
SBP (mmHg)	-3.700	14.39	0.219	-0.325	9.74	0.673	2.458	9.65	0.190	1.726	0.190	0.44	B	0.20	PB	-0.24	PB
DBP (mmHg)	-0.800	11.85	0.744	-5.675	4.22	0.002	0.271	4.40	0.236	4.950	0.012	0.11	T	0.97	VB	0.52	B
VO_{2peak} (ml/kg.min)	3.452	4.94	0.000	3.214	2.17	0.000	-0.226	2.49	0.745	5.795	0.006	0.86	VB	1.04	VB	0.06	T
VO_{2peak} (L/min)	0.146	0.68	0.016	0.251	1.00	0.000	0.034	0.93	0.788	5.118	0.010	0.11	T	0.16	T	-0.09	T
Glucose (mg/dl)	-0.050	8.70	0.973	3.150	5.45	0.167	0.872	5.20	0.285	1.305	0.282	0.11	T	-0.30	PP	-0.39	PB
Insulin (uUI/ml)	0.196	7.97	0.842	-1.175	7.10	0.420	-0.881	7.31	0.479	0.422	0.659	-0.12	T	0.03	T	0.15	T
HOMA-IR	0.061	1.68	0.813	-0.142	1.52	0.688	-0.081	1.56	0.786	0.140	0.870	-0.07	T	0.03	T	0.11	T
QUICKI	-0.002	0.02	0.626	-0.001	0.01	0.843	0.003	0.01	0.503	0.317	0.730	0.22	PB	0.17	T	-0.04	T
TC (mg/dl)	-3.750	26.40	0.297	-8.950	27.61	0.055	-2.769	25.93	0.316	0.538	0.588	0.03	T	0.16	T	0.16	T
HDL-c (mg/dl)	5.600	6.98	0.002	-3.050	7.40	0.164	-3.542	7.34	0.438	6.656	0.003	1.03	VB	0.05	T	-0.97	VB
TAG (mg/dl)	-38.600	52.18	0.000	9.650	28.35	0.065	5.474	28.52	0.759	7.498	0.002	0.95	VB	-0.10	T	-1.04	VB

SD=standard deviation; WC=waist circumference; WtHR=waist-to-height ratio; BMI=body mass index; FFM=fat-free mass; SBP=systolic blood pressure; DBP=diastolic blood pressure; VO_{2peak}=Peak oxygen consumption; EE=energy expenditure; HOMA-IR=homeostatic model assessment; QUICKI=Quantitative Insulin-sensitivity check index; TC=total cholesterol; HDL-c=high-density lipoprotein; TAG=triglycerides; Bold=p<0.05; CI= clinical inference; T= trivial; PB=possibly beneficial ; B= beneficial; VB= Very beneficial; PH=possibly harmful.

HIIT showed significant increase in VO_{2peak} compared to CG, as well as reduction of DBP, compared to MICT and CG (p<0.01). HIIT significantly reduced the proportion of high SBP and high DBP in comparison with MICT (-15.7% vs + 15.7% and -25.0% vs +5.0%). The MICT showed a significant increase in VO_{2peak} compared to CG and HDL-c compared to HIIT, as well as a reduction in BM, WC, WtHR, BMI-Z, FM, %FM and TAG compared to HIIT and CG (p<0.01). Regarding the CG, only an increase in height was observed (p=0.018).

HIIT had a large effect size to reduce DBP (d=0.98) and increase of the relative VO_{2peak} (d=1.05) than the CG, suggesting a beneficial effect. Whereas the MICT compared to the CG showed large effect size for reduction of the WtHR (d=0.94) and TAG (d=0.93), as well as increase in relative VO_{2peak} (d=0.84) and HDL-c (d=1.06), which suggested beneficial. The comparison between both training modes indicated a possible beneficial effect for reduction of %FM (d=0.37), TAG (d=1.04) and a very beneficial effect for increased HDL-c (d=0.97) in favor of the MICT, while a higher beneficial effect for reduction of DBP (d=0.52) in favor of HIIT.

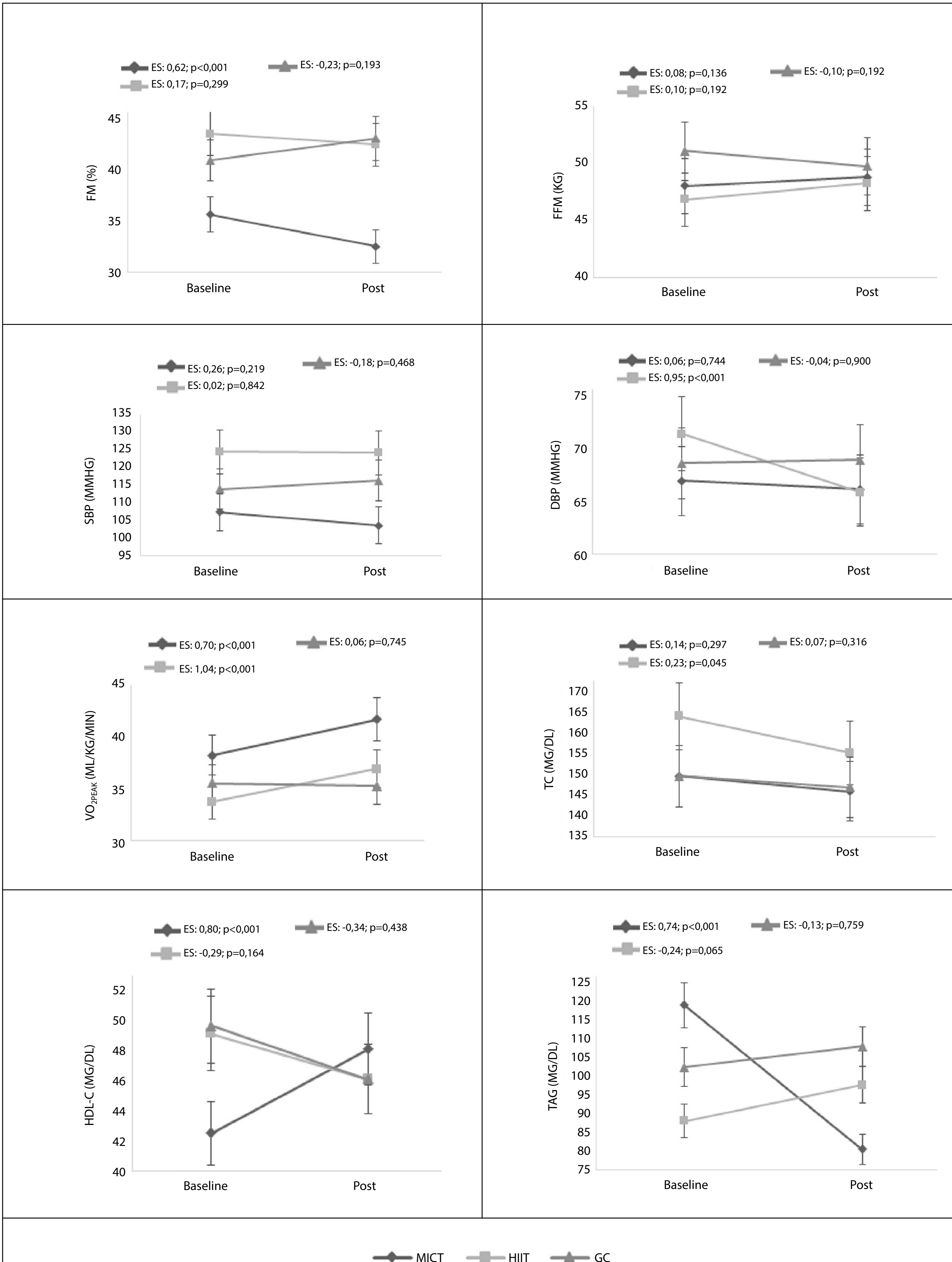
Figure 1 shows the effect size data at the baseline and post intervention for the MICT, HIIT and CG individually. It was identified a beneficial MICT effect to reduce the %FM, TAG, as well to increase VO_{2peak} and HDL-C. There was a very beneficial effect for reduction of DBP and increase of VO_{2peak} and possibly beneficial for reduction of TC in HIIT. While CG had a potentially harmful effect to increase %FM and reduction of HDL-c.

DISCUSSION

This study aimed to compare two modalities of training on anthropometric indicators, body composition, cardiometabolic markers and cardiorespiratory fitness in obese boys. The main findings indicate higher effects in HIIT were found compared to MICT to promote improvements in DBP. However, the volume of HIIT was not sufficient to reduce the FM or improve cardiometabolic biomarkers, which was achieved by MICT. Therefore, based on our data it could be stressed that the higher volume of the MICT was an important factor in reducing FM and improving the lipid profile in obese boys. Thus, investigating recommendations of volume, type and intensity of PA are necessary to optimize EE, fat oxidation and improve physical capacities during weight reduction programs.[15]

In the initial phase, the HIIT presented higher %FM, however the effect of exercise on the significant reduction of anthropometric measurements and FM occurred significantly only in the MICT and with a very beneficial effect size, probably due to the higher volume of training and EE per session. Other studies comparing these two modalities show controversial results,[6,16,17] however, this is one of the few studies that examine the high volume MICT. Luo et al.[18] found similar and significant improvement in body composition and metabolic risk factors following a high volume MICT in both boys and girls. The total volume of training can be a determinant factor in interventions that seek to reduce FM in obese individuals, thus 54 minutes per week of HIIT with 90 minutes of light activities for warm-up and cold-down were not effective for weight reduction in obese boys in our study. This hypothesis is also confirmed in another study with obese adults, in which the authors identified that HIIT with higher volume (150 min/week) was better than the MICT with equivalent volume and low volume HIIT (60 min/week) for the reduction of FM.[19] Thus, the practice of exercise with greater volume and intensity can lead to temporary suppression of the appetite, which assists the regulation of the energetic balance and contributes to the caloric deficit,[20] main component for reducing BM.[21] However, the dose response of exercise in reducing body fat is not yet well established.

In this study, 12 weeks of HIIT induced a significant reduction in DBP levels, demonstrating superiority to the MICT. It is noteworthy that both presented similar proportions of high DBP at the beginning of the intervention, and all adolescents in the HIIT reduced the DBP to adequate levels, while there was an increase in the proportion of high DBP in the MICT. Exercise intensity is proposed as a main determinant of BP reduction following exercise training. A rigorous "working interval" is the drive to promote training adaptations following HIIT protocols[22] and was the central difference between exercise programs in this study. Previous meta-analysis suggests that HIIT generate significant reductions only in SBP in overweight and obese youth, but not in DBP.[23] Mariano



ES=effect size; FM=fat mass; FFM=fat-free mass; SBP=systolic blood pressure; DBP=diastolic blood pressure; VO_{2peak}=Peak oxygen consumption; TC=total cholesterol; HDL=high-density lipoprotein; TAG=triglycerides.

Figure 1. Graphs of the effect at baseline and post the exercises interventions and control group.

et al.[24] suggest that the changes in SBP and DBP is type of exercise and sex dependent, indicate greater reduction in SBP after MICT session in women and a slightly reduction of DBP in men, whereas in men there was a greater reduction in DBP following interval resistance training. Besides the present study, only one published research analyzes the effect of exercise program in obese boys and found similar results.[25] Therefore, our findings support the type of exercise dependent response in DBP, suggesting to HIIT protocol could be the main factor to regulate DBP in obese boys.

In both training groups of the present study, a significant improvement in cardiorespiratory fitness was observed. A study examining different exercise interventions, also showed a significant improvement in VO_{2peak} regardless of exercise type in children.[26] VO_{2peak} is the main indicator of cardiorespiratory fitness and an important cardiometabolic health marker, associated with a decrease in the risk of morbidity and mortality in the general population.[27] Although both training groups significantly increased VO_{2peak}, our data reinforce the hypothesis that HIIT is an efficient exercise methodology for this parameter, even with low volume.[28]

Regarding cardiometabolic markers, this investigation showed that the HIIT was not superior to the MICT, although the training method suggested significant improvements in the lipid profile in other studies,[16,29] as well as improvements after the HIIT intervention were more effective when compared to the MICT.[16,17] In fact, our findings suggest that 12 weeks of MICT may be more effective to promote significant reductions in triglycerides and increase in long-term HDL-c, particularly when compared only with the nutritional orientation. However, no training method promoted alterations in relation to blood glucose and insulin resistance, nevertheless the MICT demonstrated a potentially beneficial clinical effect in the increase of insulin sensitivity in relation to the CG, a result that adds to the effects of the lipid profile. However, further studies are needed to define the most appropriate combinations to maximize cardiometabolic benefits, since the MICT showed beneficial clinical effect on cardiorespiratory fitness and HIIT very beneficial, which is directly associated with the best health profile in children and adolescents.[4]

This study presents some limitations that should be highlighted. Firstly, the training EE between the modalities was not equivalent. Moreover, there was no control over the nutritional variables during the intervention, however, all groups received the same nutritional orientations. For future studies, it is suggested that combined training methods be explored between these modalities, with volume control or caloric equivalence of the exercises. Our findings suggest distinct benefits between the two modalities, thus, the combination between these can be a tool to promote greater results in a program of obesity treatment and comorbidities in adolescents, providing greater dynamics of physical activities, which can increase student's adherence to the exercise. Studies on the combined training demonstrate that it is possible to promote the different benefits of both protocols in comparison to the isolated version.[9,30]

CONCLUSION

In conclusion, the MICT was the most effective protocol for the reduction of FM, anthropometric measurements, and improvement of the lipid profile, while HIIT was superior to reduce DBP in obese boys. In this study, it is important to highlight that the dropouts were less than 10% in the HIIT and MICT, which demonstrate excellent adherence of adolescents to the proposed exercises. Finally, we highlight the importance of physical activity recommendations with adequate volume for adolescents, in order to promote greater adherence to obesity treatment intervention and contribute to better effects of weight control programs.

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