

Obese adolescents who gained/maintained or lost weight have similar results in body composition and cardiometabolic risk factors following a multidisciplinary intervention

By: Josiane Aparecida Alves Bianchini, Danilo Fernandes da Silva, Luzia Jaeger Hintze, Vanessa Drieli Seron Antonini, Carlos Andres Lopera, [Jessica McNeil](#), and Nelson Nardo Junior

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Abstract:

This study aimed to assess the impact of a multidisciplinary program of obesity treatment (MPOT) on adolescents who have maintained/gained weight or lost weight. Eighty-six adolescents aged 10–18 years were allocated in either the intervention group (IG; $n = 44$) or the control group (CG; $n = 42$). Each group was divided into two more groups: weight maintenance/gain and weight loss, as assessed after the intervention. The MPOT lasted 16 weeks and was conducted by a multidisciplinary team based on cognitive-behavioral therapy. We analyzed body composition and cardiometabolic parameters prior to and after the intervention. Adolescents from the IG who lost weight showed improvements in maximal oxygen uptake (23.54 ± 5.30 mL/kg/minute vs. 25.39 ± 5.63 mL/kg/minute), body fat percentage ($49.29 \pm 6.98\%$ vs. $46.75 \pm 8.56\%$), triglyceride levels (116.58 ± 46.50 mg/dL vs. 101.19 ± 43.08 mg/dL), diastolic blood pressure (75.81 ± 8.08 mmHg vs. 71.19 ± 6.34 mmHg), and the number of risk factors for metabolic syndrome (2.00 ± 1.06 vs. 1.58 ± 1.10). Adolescents from the IG who gained/maintained weight reported reduced body fat percentage ($48.81 \pm 5.04\%$ vs. $46.60 \pm 5.53\%$), systolic blood pressure (123.39 ± 14.58 mmHg vs. 115.83 ± 7.02 mmHg), diastolic blood pressure (74.83 ± 9.91 mmHg vs. 68.78 ± 5.95 mmHg), and number of risk factors for metabolic syndrome (from 1.67 ± 1.09 to 1.11 ± 0.68), and their lean mass (39.00 ± 7.20 kg vs. 41.85 ± 7.53 kg) and maximal oxygen uptake (23.74 ± 4.40 mL/kg/minute vs. 25.29 ± 5.17 mL/kg/minute) increased in a manner similar to those of adolescents who lost weight. Furthermore, we noted significant decreases in body mass index, body fat (kg), glycemia, and waist circumference in CG adolescents who lost weight, whereas those in the CG who maintained/gained weight had an increase in body mass index, hip circumference, body fat (kg), and lean mass. A 16-week MPOT promoted positive changes in body composition and cardiometabolic risk factors independently of weight changes.

Keywords: Adolescents | Intervention | Obesity | Weight gain | Weight loss

Article:

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Original article

Obese adolescents who gained/maintained or lost weight had similar body composition and cardiometabolic risk factors following a multidisciplinary intervention

Josiane Aparecida Alves Bianchini ^{a,*}, Danilo Fernandes da Silva ^a, Luzia Jaeger Hintze ^b,
Vanessa Drieli Seron Antonini ^a, Carlos Andres Lopera ^a, Jessica McNeil ^b, Nelson Nardo Junior ^a

^a *Multiprofessional Nucleus of Obesity Study, Department of Physical Education, State University of Maringá, Maringá, Parana, Brazil*

^b *School of Human Kinetics, University of Ottawa, Ottawa, Ontario, Canada*

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Abstract

This study aimed to assess the impact of a multidisciplinary program of obesity treatment (MPOT) on adolescents who have maintained/gained weight or lost weight. Eighty-six adolescents aged 10–18 years were allocated in either the intervention group (IG; $n = 44$) or the control group (CG; $n = 42$). Each group was divided into two more groups: weight maintenance/gain and weight loss, as assessed after the intervention. The MPOT lasted 16 weeks and was conducted by a multidisciplinary team based on cognitive-behavioral therapy. We analyzed body composition and cardiometabolic parameters prior to and after the intervention. Adolescents from the IG who lost weight showed improvements in maximal oxygen uptake (23.54 ± 5.30 mL/kg/minute vs. 25.39 ± 5.63 mL/kg/minute), body fat percentage ($49.29 \pm 6.98\%$ vs. $46.75 \pm 8.56\%$), triglyceride levels (116.58 ± 46.50 mg/dL vs. 101.19 ± 43.08 mg/dL), diastolic blood pressure (75.81 ± 8.08 mmHg vs. 71.19 ± 6.34 mmHg), and the number of risk factors for metabolic syndrome (2.00 ± 1.06 vs. 1.58 ± 1.10). Adolescents from the IG who gained/maintained weight reported reduced body fat percentage ($48.81 \pm 5.04\%$ vs. $46.60 \pm 5.53\%$), systolic blood pressure (123.39 ± 14.58 mmHg vs. 115.83 ± 7.02 mmHg), diastolic blood pressure (74.83 ± 9.91 mmHg vs. 68.78 ± 5.95 mmHg), and number of risk factors for metabolic syndrome (from 1.67 ± 1.09 to 1.11 ± 0.68), and their lean mass (39.00 ± 7.20 kg vs. 41.85 ± 7.53 kg) and maximal oxygen uptake (23.74 ± 4.40 mL/kg/minute vs. 25.29 ± 5.17 mL/kg/minute) increased in a manner similar to those of adolescents who lost weight. Furthermore, we noted significant decreases in body mass index, body fat (kg), glycemia, and waist circumference in CG adolescents who lost weight, whereas those in the CG who maintained/gained weight had an increase in body mass index, hip circumference, body fat (kg), and lean mass. A 16-week MPOT promoted positive changes in body composition and cardiometabolic risk factors independently of weight changes.

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Keywords: Adolescents; Intervention; Obesity; Weight gain; Weight loss

Introduction

Excess weight in children and adolescents is a growing concern due to the elevated number of comorbidities [e.g., type 2 diabetes, hypertension, and metabolic syndrome (MS)],¹ which may develop at this time and may be present later in adulthood.² Thus, there is a need to develop

* Corresponding author. Multiprofessional Nucleus of Obesity Study, Department of Physical Education, State University of Maringá, Herculanô Ribeiro de Paiva Street, 948, Paris, Maringá, Parana 87083-380, Brazil.

E-mail address: josi_edf@hotmail.com (J.A.A. Bianchini).

intervention programs that encourage lifestyle changes in this population.³

Multidisciplinary interventions for obesity treatment in children and adolescents have presented improvements in anthropometric parameters, body composition, cardiorespiratory fitness, and cardiovascular risk factors such as MS and dyslipidemia.^{4–7} Nevertheless, studies that did not show any improvement in body weight are common.^{4,8,9} This may be in part explained by the increase in lean body mass coupled with the decrease in body fat mass observed following exercise interventions,^{4,10} or possibly due to natural growth and development that occur in adolescents.¹¹ Therefore, it may be suggested that weight loss should not be the only characteristic to be assessed following lifestyle interventions, because many other beneficial changes may occur. For instance, Masquio et al.¹² found that adolescents who had small reductions in body weight presented improvements in body mass index (BMI), fat mass, visceral fat, lean mass, and waist circumference (WC), whereas those who had small-to-moderate weight loss also presented reductions in insulin resistance and inflammatory markers following a 1-year multidisciplinary intervention. Wafa et al.⁸ and Hughes et al.⁹ noted weight gain in children aged 5–11 years following a 6-month lifestyle intervention. However, this weight gain was substantially less compared to the control group (CG), which received nutritional advice only⁷ or no intervention.⁸

According to the Canadian Obesity Network,¹³ the success in obesity treatment should be measured according to health benefits and well-being, instead of the amount of weight lost. However, to our knowledge, studies assessing the differential effects of a multidisciplinary program for obesity treatment (MPOT) in adolescents who gained or maintained weight after the intervention period, compared to those who lost weight, are scarce. Thus, the objective of the present study was to assess differences in body composition, glucose, insulin, lipid profile, and blood pressure in obese adolescents who gained/maintained or lost body weight following an MPOT. It was hypothesized that adolescents who took part in the MPOT would see improvements in body composition, and metabolic and hemodynamic parameters, irrespective of the amount of weight lost.

Methods

Participants

Adolescents and their families were recruited through media advertisements. Ninety-seven obese adolescents took part in this study. They were classified as obese according to the cutoff points laid out by Cole et al.¹⁴ and were invited to participate in the MPOT in 2011 and 2012 through media divulgation. Adolescents' age varied from 10 years to 18 years.

We used the following inclusion criterion: concordance of the adolescents and their parents/guardians in participating in the MPOT. The exclusion criteria were as follows: endocrine and metabolic diseases previously diagnosed and informed to

the pediatrician, long-term alcohol consumption, use of glucocorticoids and psychotropics that could affect appetite regulation, and <70% compliance in all multidisciplinary interventions.

Adolescents who were not available to partake in the intervention schedule (i.e., they were not able to participate in all scheduled interventions, showed interest in the program after it had already started, or their schedule did not match with the schedule of the MPOT) were invited to be part of the CG, and evaluated prior to and after the 16-week period. It is important to note that none of these participants presented any exclusion criteria and were thus eligible to take part in this study. This is a pragmatic trial designed to evaluate the effectiveness of interventions in real-life practice conditions. Despite the disadvantage of not randomizing participants in each group, as explanatory trials do (e.g., randomized controlled trials), pragmatic trials produce results that can be generalized and applied in routine practice settings.^{15,16}

Fifty of the 97 adolescents initially evaluated were allocated to the intervention group (IG) and 47 adolescents were assigned to the CG. However, six adolescents from the IG and five from the CG were excluded because they were unable to complete the intervention due to transportation issues, preference for other activities in the same period, or demotivation to continue in the MPOT, and/or they did not attend the last assessment session. Thus, 86 adolescents completed the protocol.

The MPOT lasted 16 weeks and was conducted twice a year. The main objective of the intervention team (i.e., physical educators, nutritionists, psychologists, and a pediatrician) was to aid in the establishment of eating and exercise behavior changes based on cognitive-behavioral therapy. The psychological and nutritional intervention was held weekly, including a 1-hour group meeting in each session. Physical educators gave one 1-hour lecture per week and helped adolescents in the IG take part in an exercise program three times per week, with each session lasting 1 hour. The pediatrician set up individual appointments with each family (parents and adolescents) to collect information that could help during treatment. The protocol of the MPOT has been described in more detail by Bianchini et al.⁴ The present study was approved by the local Ethics Committee (protocol 463/2009) and is in accordance with the guidelines of the Declaration of Helsinki.

Evaluation

During the week preceding the beginning of MPOT and the week following its completion, adolescents took part in a battery of assessments, which included body weight, stature, BMI, WC, and hip circumference (HC) measurements. Body weights of the participants, wearing light clothes and no shoes, were measured on a Welmy scale (Welmy, São Paulo, Brazil) to the nearest 0.05 kg. Height was measured with a wall stadiometer to the nearest 0.1 cm. BMI was calculated as the weight divided by height squared. WC and HC were measured with a WISO tape (WISO, Santa Catarina, Brazil) to the nearest 0.1 cm.

We also determined pubertal development according to Tanner stages.¹⁷ Adolescents identified themselves as being in stage 1 were classified as prepubertal, stages 2 and 3 as pubertal, and stages 4 and 5 as postpubertal.

Body composition was assessed by dual-energy X-ray absorptiometry (GE Healthcare Lunar enCORE, Denver, CO, USA). The participants were evaluated during the afternoon, while wearing light clothes and no metal objects. We computed relative and absolute body fat mass and absolute lean mass based on this assessment.

Blood examinations, blood pressure, and cardiorespiratory fitness

We determined blood glucose, insulin, total cholesterol and its fractions (high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, and very-low-density lipoprotein cholesterol), triglyceride (TG) levels, systolic and diastolic blood pressure (SBP and DBP), and maximal oxygen uptake ($\text{VO}_{2\text{max}}$) prior to and after the intervention.

Blood draws were conducted by specialists from an outpatient clinic during the morning following a 12-hour overnight fast (Laboclin, Bahia, Brazil). MS was diagnosed according to the International Diabetes Federation criteria.¹⁸ Five risk factors are used to evaluate MS: TG levels ≥ 150 mg/dL; fasting glucose ≥ 100 mg/dL or a previous diagnosis of type 2 diabetes; SBP ≥ 130 mmHg and/or DBP ≥ 85 mmHg; high-density lipoprotein cholesterol < 40 mg/dL in adolescents aged 10–16 years and boys > 16 years, and < 50 mg/dL in girls > 16 years; and WC above the 90th percentile according to gender and age.¹⁹ If, at least, three of these criteria are altered, including WC, MS is considered to be present.

Dyslipidemia was considered to be present in cases where one or more of the following variables were present: total cholesterol ≥ 170 mg/dL, high-density lipoprotein cholesterol < 45 mg/dL, low-density lipoprotein cholesterol ≥ 130 mg/dL, and TG levels ≥ 130 mg/dL. The cutoff points used were based on the recommendations laid out in the I Brazilian guidelines for the prevention of atherosclerosis in children and adolescents.²⁰

Insulin resistance and sensitivity were assessed by homeostasis model assessment insulin-resistance index (HOMA-IR) and quantitative insulin sensibility check index, respectively. HOMA-IR was calculated according to the following equation:

$$\left[\frac{\text{blood fasting glucose (milligrams per deciliter)} \times \text{blood insulin (in milliunits per liter)}}{405} \right]^{21} \quad (1)$$

Quantitative insulin sensibility check index was calculated using the following formula:

$$1 / (\log \text{ insulin} + \log \text{ blood glucose}). \quad (2)$$

Insulin resistance was considered when HOMA-IR values were ≥ 2.0 .²²

Blood pressure measurements were performed after 5–10 minutes of rest, using an automatic sphygmomanometer

(Microlife, Aargau, Switzerland). We used the right arm for all measurements, and all adolescents remained seated during each measurement.

$\text{VO}_{2\text{max}}$ was determined indirectly with the Leger 20-m multistage shuttle test.^{23,24} This is a maximal test initiated at a speed of 8.5 km/hour, which progresses in increments of 0.5 km/hour each minute until the adolescents reach their volitional exhaustion. Adolescents were guided by an audio signal and an operator who helped them pace themselves.

Statistical analyses

We used the Shapiro–Wilk test for normality. Data were presented as descriptive (means, standard deviation, and relative frequency) and inferential (comparison between moments and groups) statistics. Chi-square test was used to compare the prevalence of obesity, dyslipidemias, high blood pressure, insulin resistance, and MS between sexes for all the groups. Mixed repeated-measures analysis of covariance was used to compare both assessments moments (pre and post-intervention) in the weight gain/maintenance and weight loss group for both IG and CG. We used the Tanner stage as a covariate. Significance level was set at $p < 0.05$. Effect sizes were calculated to determine the magnitude of the intervention effect. Magnitudes of effect size were classified, according to Cohen,²⁵ as follows: ≤ 0.20 (trivial), between 0.21 and 0.50 (small), between 0.51 and 0.80 (moderate), and > 0.80 (large).

Results

From the 86 adolescents who completed the protocol, 44 adolescents (27 girls) were part of the IG and 42 adolescents (21 girls) formed the CG. Each group was then divided into two more groups: weight gain or maintenance (IG—18 adolescents; CG—26 adolescents) and weight loss (IG—26 adolescents; CG—16 adolescents).

The mean age of the IG adolescents at the beginning of the intervention who gained/maintained body weight and those who lost weight were 12.56 ± 0.92 years and 12.92 ± 2.00 years, respectively. In the CG, at the beginning of the intervention, adolescents who gained/maintained weight and those who lost weight were aged 13.65 ± 2.00 years and 13.28 ± 2.16 years, respectively. No differences in this variable were observed between the four groups ($p = 0.249$).

At baseline, 96.2% and 100% of the IG adolescents who lost weight and gained/maintained weight, respectively, were obese. The CG adolescents who lost weight and gained/maintained weight (87.5% and 84.6%, respectively) were obese. In IG adolescents, the prevalence of dyslipidemias was 80.8% in those who lost weight and 72.2% in those who gained/maintained weight. In the CG adolescents who lost weight and gained/maintained weight, the prevalence of dyslipidemias was 81.3% and 69.2%, respectively. As for high blood pressure, the prevalence at baseline was 24.5%, 27.8%, 37.5%, and 34.6% in IG adolescents who lost weight, IG adolescents who gained/maintained weight, CG adolescents who

lost weight, and CG adolescents who gained/maintained weight, respectively.

The prevalence of insulin resistance (according to HOMA-IR) was 88.5%, 83.3%, 93.8%, and 92.3% in IG adolescents who lost weight, IG adolescents who gained/maintained weight, CG adolescents who lost weight, and CG adolescents who gained/maintained weight, respectively. Finally, the frequency of adolescents with MS was 23.1%, 22.2%, 25.0%, and 19.2% in IG adolescents who lost weight, IG adolescents who gained/maintained weight, CG adolescents who lost weight, and CG adolescents who gained/maintained weight, respectively.

No sex differences were observed in body composition (absolute and relative body fat mass, and absolute lean mass) and in the prevalence of obesity, dyslipidemias, high blood pressure, insulin resistance, and MS ($p \geq 0.05$) among all the groups.

Anthropometric, cardiorespiratory fitness, and body composition parameters prior to and after 16 weeks of intervention, according to changes in body weight, are presented in Table 1.

Discussion

The objective of the present study was to assess potential differences in health parameters measured at baseline and following a 16-week MPOT intervention in adolescents, based on the weight gain/maintenance or weight loss following the program.

The main finding of the present study is that the MPOT was able to improve significantly the BMI, BMI z score, HC, VO_{2max} , percentage and absolute body fat, TG levels, DBP, WC, and number of risk factors for MS in adolescents who lost weight. Conversely, IG adolescents who gained/maintained weight reported reduced relative and absolute body fat, SBP, DBP, WC, and number of risk factors for MS; their lean mass and VO_{2max} increased in a manner similar to those of adolescents who lost weight. Furthermore, we noted significant decreases in BMI, BMI z score, body fat (kg), glycemia, and WC in CG adolescents who lost weight, and increases in BMI, HC, body fat (kg), and lean mass in CG adolescents who gained/maintained weight.

Improvements in anthropometric, body composition, and cardiorespiratory fitness variables, as well as cardiovascular risk factors (e.g., type 2 diabetes, hypertension, and MS) following short-term lifestyle interventions in overweight and obese adolescents have been noted previously.^{4–7,26} However, studies that assessed the differential effects of an MPOT in adolescents who gained or maintained weight after the intervention period, compared to those who lost weight, are scarce.

For the results on body composition, IG adolescents who gained/maintained their body weight had improved lean mass but reduced absolute and relative body fat mass, which explains, in part, the overall lack of weight loss observed post-intervention. Covariance analysis showed that these improvements, except for absolute body fat, were not influenced by the Tanner pubertal stage. Thus, it is suggested that the

intervention utilized was mainly responsible for these improvements, although natural growth and development might also have played a role.¹¹

Certain studies recommend that weight maintenance or modest weight loss should be seen as a primary endpoint when assessing the effects of lifestyle interventions in pediatric populations.^{27–30} However, according to Wafa et al,⁸ Hughes et al,⁹ and Oude Luttikhuis et al,³¹ most pediatric patients cannot even maintain weight or achieve modest weight loss after short-term interventions. Wafa et al⁸ evaluated 34 children during a 6-month intervention, but only nine maintained or lost weight following this intervention.

Considering the necessity of creating goals for obesity control during intervention programs, Masquio et al¹² demonstrated that improvements in inflammatory state and insulin resistance were observed in adolescents (mean age 16.7 ± 1.6 years) who presented low-to-moderate weight loss (-7.64%) after 1 year of a multidisciplinary intervention. As weight loss increased (-12.10% to -19.39%), the adolescents also presented improvements in lipid profile, SBP, and DBP. However, it is important to point out that the adolescents assessed by Masquio et al¹² were in the postpubertal stage, so changes in body weight might have played a more important role in the control of risk factors related to obesity, which is also observed in adults.^{32,33}

Reinehr et al³⁴ verified the effects of a multidisciplinary program based on lifestyle modifications in obese adolescents (aged 9–13 years) and noted that those who lost weight also presented improvements in TG levels, SBP, DBP, insulin resistance, and high-sensitive C-reactive protein. However, no changes were observed in adolescents who gained or maintained body weight. Nevertheless, the authors observed that high-sensitive C-reactive protein showed a decreasing tendency in adolescents who gained or maintained weight [from 1.3 mg/L (0.9–3.3 mg/L) to 0.6 mg/L (0.4–4.7 mg/L)], indicating improvement in inflammatory state. This improvement was explained by the association between physical activity practice and lower high-sensitive C-reactive protein levels.^{34,35}

Ford et al³⁶ proposed a cutoff point based on the BMI z score in their study, which assessed 88 adolescents with a mean age of 12.4 years (range 9.1–17.4 years) during a 1-year multidisciplinary intervention focused on behavioral changes. These authors observed that a decrease of 0.25 in BMI z scores resulted in significant decreases in body fat, SBP, DBP, and TG levels. In addition, reductions of at least 0.5 in BMI z scores promoted even greater benefits in these variables. However, in the present study, IG adolescents who gained/maintained their body weight did not present improved BMI z scores, despite presenting improvements in other parameters.

In relation to changes in cardiovascular risk factors after a multidisciplinary intervention, we noted that adolescents who gained/maintained or lost weight showed improvements in DBP, WC, and the number of risk factors for MS. This last parameter presented a higher effect size for adolescents who gained/maintained weight (moderate), compared to those who lost weight (small). Moreover, those who lost weight during

Table 1
Anthropometric, cardiorespiratory fitness, and body composition parameters assessed before and after 16 weeks of MPOT according to changes in body weight (body weight loss and body weight gain/maintenance).

Variable	Body weight loss						Body weight gain or maintenance					
	Intervention group (n = 26)			Control group (n = 16)			Intervention group (n = 18)			Control group (n = 26)		
	Baseline	Post-16 wk	ES	Baseline	Post-16 wk	ES	Baseline	Post-16 wk	ES	Baseline	Post-16 wk	ES
Weight (kg)	85.01 ± 15.25	82.77 ± 14.70 ^a	-0.15 (trivial)	86.84 ± 21.46	85.43 ± 21.75 ^a	-0.06 (trivial)	79.92 ± 12.23	82.31 ± 12.28 ^a	0.20 (trivial)	83.30 ± 15.61	86.14 ± 16.17 ^a	0.09 (trivial)
Height (m)	1.60 ± 0.08	1.62 ± 0.08 ^a	0.25 (small)	1.64 ± 0.12	1.65 ± 0.12 ^a	0.08 (trivial)	1.62 ± 0.10	1.64 ± 0.09 ^a	0.21 (small)	1.64 ± 0.08	1.65 ± 0.08 ^a	0.13 (trivial)
BMI (kg/m ²)	33.03 ± 5.20	31.67 ± 5.41 ^a	-0.26 (small)	31.89 ± 4.75	30.96 ± 4.74 ^a	-0.20 (trivial)	30.37 ± 2.77	30.69 ± 3.20	0.11 (trivial)	30.95 ± 3.87	31.49 ± 4.11 ^a	0.14 (trivial)
BMI z score	4.03 ± 1.83	3.58 ± 1.85 ^a	-0.25 (small)	3.72 ± 1.36	3.37 ± 1.31 ^a	-0.26 (small)	3.53 ± 0.93	3.63 ± 1.07	0.11 (trivial)	3.36 ± 1.31	3.51 ± 1.38	0.11 (trivial)
HC (cm)	113.44 ± 10.24	110.39 ± 10.23 ^{a,b}	-0.30 (small)	110.76 ± 11.36	110.31 ± 11.20	-0.04 (trivial)	108.77 ± 7.69	107.89 ± 6.72	-0.11 (trivial)	108.90 ± 11.30	111.60 ± 9.77 ^a	0.26 (small)
VO _{2max} (mL/kg/min)	23.54 ± 5.30	25.39 ± 5.63 ^a	0.34 (small)	22.80 ± 2.39	24.03 ± 2.16	0.54 (moderate)	23.74 ± 4.40	25.29 ± 5.17 ^a	0.32 (small)	25.39 ± 4.58	24.77 ± 4.24	-0.14 (trivial)
Body fat (%)	49.29 ± 6.98	46.75 ± 8.56 ^a	-0.33 (small)	46.44 ± 4.66	45.47 ± 4.52	-0.21 (small)	48.81 ± 5.04	46.60 ± 5.53 ^a	-0.42 (small)	45.89 ± 6.97	46.00 ± 7.40	0.02 (trivial)
Body fat (kg)	40.33 ± 10.33	37.20 ± 10.74 ^a	-0.30 (small)	38.40 ± 9.28	37.06 ± 9.84 ^a	-0.14 (trivial)	37.36 ± 7.42	36.52 ± 7.24 ^{a,b}	-0.11 (trivial)	36.90 ± 9.79	38.21 ± 10.60 ^a	0.13 (trivial)
Lean mass (kg)	40.83 ± 7.65	41.48 ± 7.60	0.09 (trivial)	44.58 ± 12.66	44.58 ± 12.61	0.00 (trivial)	39.00 ± 7.20	41.85 ± 7.53 ^a	0.39 (small)	42.75 ± 8.10	44.02 ± 8.47 ^a	0.15 (trivial)

BMI = body mass index; ES = effect size; HC = hip circumference; MPOT = multidisciplinary program for obesity treatment; VO_{2max} = maximal oxygen uptake.

Metabolic parameters, blood pressure, and WC prior to and after 16 weeks of intervention, according to changes in body weight, are presented in Table 2.

^a Significant difference from the baseline within group.

^b Effect of covariate Tanner stage.

Table 2
Metabolic parameters, blood pressure, and WC before and after 16 weeks of MPOT according to changes in body weight (body weight loss and body weight gain or maintenance).

Variable	Body weight loss						Body weight gain or maintenance					
	Intervention group (n = 26)			Control group (n = 16)			Intervention group (n = 18)			Control group (n = 26)		
	Baseline	Post-16 wk	ES	Baseline	Post-16 wk	ES	Baseline	Post-16 wk	ES	Baseline	Post-16 wk	ES
Glycemia (mg/dL)	86.58 ± 9.37	89.08 ± 9.67	0.26 (small)	87.56 ± 8.47	83.06 ± 7.55 ^a	−0.56 (moderate)	88.78 ± 5.29	85.61 ± 5.99	−0.56 (moderate)	88.50 ± 6.95	86.00 ± 7.35	−0.35 (small)
Insulin (mg/dL)	20.30 ± 7.97	17.97 ± 9.76 ^b	−0.26 (small)	16.93 ± 6.13	16.64 ± 6.71	−0.05 (trivial)	17.49 ± 8.42	18.57 ± 12.90	0.10 (trivial)	20.45 ± 9.95	23.94 ± 14.18	0.29 (small)
HOMA-IR	4.42 ± 1.95	4.02 ± 2.33 ^b	−0.19 (trivial)	3.69 ± 1.50	3.47 ± 1.52	−0.15 (trivial)	3.88 ± 2.02	3.92 ± 2.73	0.02 (trivial)	4.47 ± 2.23	5.21 ± 3.51	0.26 (small)
QUICKI	0.315 ± 0.028	0.320 ± 0.028	0.18 (trivial)	0.320 ± 0.020	0.323 ± 0.023	0.14 (trivial)	0.319 ± 0.022	0.320 ± 0.022	0.05 (trivial)	0.313 ± 0.021	0.307 ± 0.019	−0.30 (small)
TC (mg/dL)	156.81 ± 23.83	151.08 ± 24.93	−0.24 (small)	161.63 ± 28.95	159.31 ± 32.11	−0.08 (trivial)	164.94 ± 32.02	160.72 ± 30.14	−0.14 (trivial)	166.04 ± 28.93	164.04 ± 32.25	−0.07 (trivial)
TG (mg/dL)	116.58 ± 46.50	101.19 ± 43.08 ^a	−0.34 (small)	104.13 ± 37.90	102.50 ± 33.60	−0.05 (trivial)	108.90 ± 42.89	116.33 ± 77.33	0.12 (trivial)	115.50 ± 54.85	128.73 ± 58.01	0.23 (small)
LDL-c (mg/dL)	88.21 ± 24.62	86.79 ± 24.60	−0.06 (trivial)	96.55 ± 23.34	96.19 ± 24.24	−0.02 (trivial)	92.61 ± 21.40	87.68 ± 22.47	−0.22 (trivial)	96.87 ± 21.61	90.92 ± 31.48	−0.22 (small)
HDL-c (mg/dL)	45.35 ± 9.03	44.27 ± 7.89	−0.13 (trivial)	45.06 ± 8.72	42.63 ± 6.34	−0.32 (small)	50.33 ± 10.13	49.72 ± 10.95	−0.06 (trivial)	46.08 ± 11.73	44.92 ± 9.89	−0.11 (trivial)
VLDL-c (mg/dL)	23.06 ± 9.29	20.69 ± 8.65	−0.26 (small)	18.33 ± 8.56	20.50 ± 6.72	0.28 (small)	21.78 ± 8.59	23.27 ± 15.55	0.12 (trivial)	23.10 ± 10.97	25.75 ± 11.61	0.23 (small)
SBP (mm/Hg)	122.58 ± 17.42	121.23 ± 9.22	−0.10 (trivial)	129.00 ± 13.68	125.94 ± 11.42	−0.24 (small)	123.39 ± 14.58	115.83 ± 7.02 ^a	−0.07 (trivial)	124.38 ± 12.71	126.69 ± 13.19	0.18 (trivial)
DBP (mm/Hg)	75.81 ± 8.08	71.19 ± 6.34 ^a	−0.64 (moderate)	76.31 ± 15.66	75.06 ± 11.05	−0.09 (trivial)	74.83 ± 9.91	68.78 ± 5.95 ^a	−0.76 (moderate)	72.73 ± 7.50	73.96 ± 10.21	0.14 (trivial)
WC (cm)	92.77 ± 10.13	89.97 ± 10.78 ^{a,b}	−0.27 (small)	92.58 ± 9.62	89.41 ± 9.76 ^a	−0.33 (small)	90.11 ± 6.79	88.11 ± 5.92 ^a	−0.31 (small)	91.91 ± 10.16	92.16 ± 8.96	0.03 (trivial)
Risk factors Dyslip (n)	1.27 ± 0.87	1.08 ± 0.98	−0.21 (small)	1.13 ± 0.89	1.44 ± 0.89	0.35 (small)	1.11 ± 0.90	1.06 ± 0.87	0.06 (trivial)	1.23 ± 1.14	1.42 ± 0.95	0.18 (trivial)
Risk factors MS (n)	2.00 ± 1.06	1.58 ± 1.10 ^a	−0.39 (small)	1.81 ± 1.17	1.88 ± 0.81	0.07 (trivial)	1.67 ± 1.09	1.11 ± 0.68 ^a	−0.63 (moderate)	1.69 ± 1.19	1.92 ± 1.20	0.19 (trivial)

DBP = diastolic blood pressure; Dyslip = dyslipidemias; ES = effect size; HDL-c = high-density lipoprotein cholesterol; HOMA-IR = homeostasis model assessment insulin-resistance index; LDL-c = low-density lipoprotein cholesterol; MPOT = multidisciplinary program for obesity treatment; MS = metabolic syndrome; QUICKI = quantitative insulin sensibility check index; SBP = systolic blood pressure; TC = total cholesterol; TG = triglyceride; VLDL-c = very-low-density lipoprotein cholesterol; WC = waist circumference.

^a Significant difference from the baseline within group.

^b Effect of covariate Tanner stage.

the intervention had improved TG levels and those who gained/maintained weight had decreased SBP. These results seem to be associated with the regular practice of exercise, which improves blood pressure and lipid profiles,³⁷ considering that CG adolescents, even those who lost weight, did not have improvements in these same variables. Although we did not assess eating habits, we presume that cognitive-behavioral therapy contributed to changes in eating habits as well.³⁸ Furthermore, our exercise intervention combines aerobic and resistance training, which was shown to be even more efficient than only aerobic exercise in reducing risk factors for MS.¹⁰

One factor that can be associated with the improvements in cardiovascular risk factors is the increase in cardiorespiratory fitness. Nassiss et al.³⁹ reinforced that adolescents who presented better levels of cardiorespiratory fitness also presented lower cardiovascular risk, independently of BMI. These positive changes in cardiorespiratory fitness are particularly important in IG adolescents who gained/maintained body weight, because it is expected that relative VO_{2max} decreases as weight increases. In the present study, however, cardiorespiratory fitness was improved in the adolescents of the IG group, despite increases or no change in body weight. The practice of exercise and physical activity, especially activities involving greater muscle groups (e.g., jogging, playing basketball) may have contributed to this decrease in body fat, increase in lean mass, and improvement in cardiorespiratory fitness.

These results show the importance of participating in a multidisciplinary intervention for obese adolescents, reinforcing that these adolescents can achieve positive results for their health irrespective of their success in short-term weight loss. Freedhoff and Sharma⁴⁰ developed a practical guide to obesity management, which discusses the importance of achieving quality-of-life or health-based goals that can be reached within a reasonable time span. For example, the goal for one adult can be to walk a few blocks to work, whereas for another it can be to reduce the need for blood pressure medication. According to the authors, these objectives can be achieved through improvement in physical fitness⁴⁰ alone, independently of changes in body weight. Freedhoff and Sharma⁴⁰ stated that success in treatment approaches should be measured on the basis of the achievement of these goals, instead of the amount of weight lost.

These ideas and practices should also be applied to adolescents, especially because adolescents are experiencing natural growth and development,¹¹ which naturally increases their height, weight, and BMI¹⁴. Improvements noted in the present study (e.g., cardiorespiratory fitness, body composition, blood pressure, and metabolic parameters) are mainly associated with the practice of physical activity combined with nutritional- and psychological-based intervention programs, and are independent of the changes in body weight. Exercise, especially the combination of aerobic and resistance-based exercises, leads to an improvement in resting energy expenditure and help improve lipid oxidation.⁴¹ Although we did not measure the resting metabolic rate, adolescents had an increase in lean body mass, which is the primary determinant of

changes in the resting energy expenditure.⁴² Moreover, as previously mentioned, the improvements in VO_{2max} may also be associated with the positive changes in health parameters assessed in the present study.

Thus, it seems necessary to consider other success criteria during intervention programs to treat obese adolescents that take into account not only body weight, but also body composition, cardiorespiratory fitness, and hemodynamic and metabolic parameters.³¹

In summary, the present study demonstrated that a 16-week MPOT promoted positive changes in body composition, hemodynamic parameters, cardiorespiratory fitness, and risk factors for MS in adolescents who lost weight or gained/maintained weight. Although some studies propose that success in a short-term intervention is based on changes in body weight and BMI measurements, we suggest the need for future short-term programs to also consider changes in body composition, cardiorespiratory fitness, and hemodynamic and metabolic parameters, as these are crucial markers of important health modifications.

Conflicts of interest

The authors declare no conflicts of interest.

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