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ORIGINAL RESEARCH

Different consecutive training protocols to design an intervention program for overweight youth: a controlled study

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Objective: To find the optimal exercise program to be recommended in reducing adiposity and promoting long-term physical activity adherence in a sample of overweight adolescents.

Methods: Forty-five overweight adolescents were randomly divided into three exercise groups, to perform two phases of physical activity as follows: in the first phase, the first group performed a 16-week moderate-intensity resistance training (RT), the second group performed a 16-week high-intensity RT, and the third group performed a 16-week aerobic training (AT); in the second phase, all groups performed a 6-week AT. Anthropometric body composition and fitness measures were considered as outcome measures.

Results: After the second protocol, both RT groups showed a significant improvement in percentage of fat mass ($F_{2,76} = 5.843$; $p = 0.004$; $\eta^2 = 0.133$) and free fat mass ($F_{2,76} = 6.254$; $p = 0.003$; $\eta^2 = 0.141$), and in fitness tests ($p < 0.01$). The VO_2max values of the RT groups were significantly higher than those of the AT group ($F_{2,38} = 4.264$; $p = 0.021$; $\eta^2 = 0.183$). The rate of adherence to exercise was an average of 94% in both RT groups, whereas in the AT group, it was 83%. During the 12-week post-intervention follow-up, the number of participants who continued to perform physical activities was significantly higher in both the RT groups than in the AT group ($p < 0.05$).

Conclusion: The present study provides preliminary evidence that moderate-to-intense RT, followed by AT, can be an effective treatment for overweight adolescents, and the positive effects are maintained even after 12 weeks of follow-up.

Keywords: exercise, obesity, adolescents, adherence, resistance training

Introduction

In the last decades, resistance training (RT) has been recommended for children and adolescents which is to be applied with appropriate techniques and correctly supervised.[1] Indeed, the risks of injuries, due to the physical activity proposed to overweight adolescents, can be minimized by reducing training loads, using age-adequate equipment and ensuring adequate recovery between the training sessions.[2] Low-intensity RT programs do not guarantee an adequate training stimulus and could lead to difficulty in differentiating training adaptation from normal growth.[3] High-intensity progressive RT leads to reduction in adiposity and metabolic risk in normal-weight and overweight children,[4] increasing the muscle mass, which has been associated with improved insulin sensitivity.[5] Considering that continuity of physical activity is a necessary condition for long-term maintenance of weight loss, it is essential that the dose, mode and intensity should be appropriate and enjoyable to this target group.[6,7] Although overweight youth have traditionally been encouraged to participate in aerobic activities, the excess of

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body weight increases the risk of musculoskeletal injuries, decreasing self-confidence and enjoyment.[8] Aerobic exercise is usually avoided by overweight and obese adolescents to avoid being further ridiculed by their peers, whereas strength training provides an opportunity for them to experience success and feel good about their performance in which they often are better than their underweight peers.[9] Overweight adolescents show better adherence to RT, typically characterized by short period of loading exercises, with rest periods between sets and repetitions. An RT-conditioning program improves the socialization and mental discipline of participants who perceive fast self-improvement.[10] In fact, obesity is associated with low self-esteem, depressive mood and impairment in emotional well-being.[11,12] Consequently, the typology and methodology of training should respect the individual needs, goals and abilities in order to optimize gains, to prevent boredom and to promote exercise adherence.[13]

The aim of this study was to find the optimal exercise program to be recommended for overweight adolescents to reduce adiposity, improve free fat mass (FFM) and to promote long-term physical activity adherence in order to maintain the benefits of physical activity. It was hypothesized that both moderate- and high-intensity programs of RT may provide strength and metabolic benefits to this population and may positively prepare them to the successive phase of aerobic program (AP). Moreover, it was expected that the RT, promoting satisfaction with RT-related outcomes, could lead the participants to continue the following AP, important in terms of weight reduction.

Methods

This was an intervention study with three parallel groups. The study protocol was divided into two phases: in the first (phase I), lasting 16 weeks, the first of the two RT groups performed a moderate-intensity RT and the second group a high-intensity RT, and the aerobic training (AT) group performed AP; in the second phase (phase II), lasting 6 weeks, all the three groups performed AP. At the end of the intervention, a 12-week post-intervention follow-up was made. Anthropometric measures, body composition and fitness parameters were assessed at baseline, after phase I and phase II and after follow-up period (Figure 1).

Forty-five overweight adolescents of both genders were enrolled in the study, but only 41 completed all phases of the study. The eligibility requirements were age ≥ 12 and ≤ 15 years, sedentary lifestyle, percentage of body fat ≥ 25% for male and ≥ 30% for female and body mass index (BMI) > 85th percentile, in comparison with the representative data of adolescents of the same age,[14,15] and a valid medical certificate. The exclusion criteria were: recent history of injury, presence of metabolic syndrome, cardiovascular diseases and low adherence to the training sessions (absences > 20%). The flowchart of the study is reported in Figure 2.

The Ethics Committee of University of Molise reviewed and approved this study. A written informed consent was obtained from all participants and their parents before the participants were recruited for the study, in accordance with the principles outlined in the Declaration of Helsinki. All data obtained for the study were anonymized.

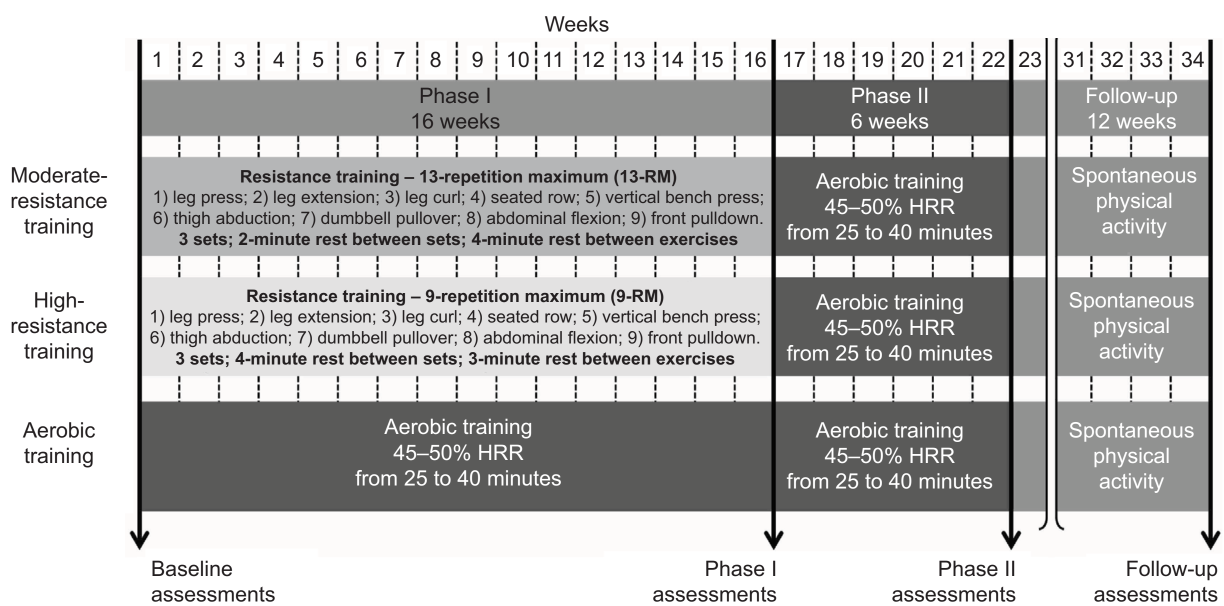

Figure 1 Study design.
Abbreviation: HRR, heart rate reserve.

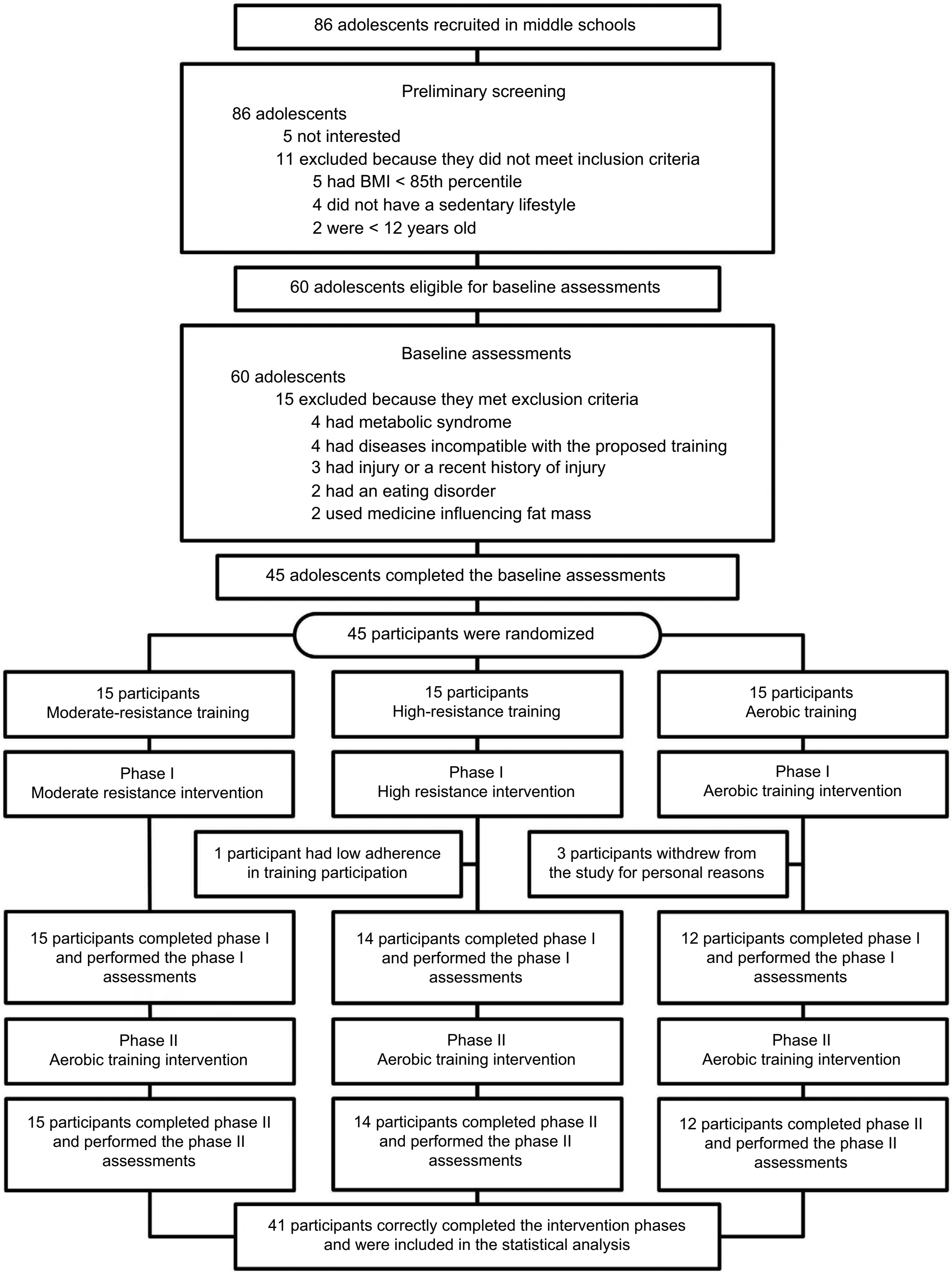

Figure 2 Flowchart of the intervention program.
Abbreviation: BMI, body mass index.

After the baseline assessment, the participants were randomly divided into three groups: moderate-resistance training (MRT), high-resistance training (HRT) and AT. They were randomized into groups of six, with two subjects randomly assigned to each group according to a sequence of computer-generated random numbers (SPSS version 20.0;

IBM, Armonk, NY, USA). This procedure was designed to obtain groups of equal sizes and to avoid selection bias.

During phase I, the MRT group performed the RT at isotonic machines with an intensity of 13-repetition maximum (13-RM), three sessions per week. The HRT performed the same exercises protocol with the same modality of MRT group, but with higher intensity (9-repetition maximum, 9-RM). The number of sets and repetitions was not modified during phase I, but the loads were modified in accordance with the strength improvement reached by the participants in order to assure an intensity of 9-RM and 13-RM. At baseline, the 9-RM and the 13-RM intensities, respectively used in HRT and MRT, were assessed during the familiarization sessions, and in the following weeks, the 9-RM and the 13-RM intensities were assessed every 3 weeks during the session of training. For the interpretation of the strength improvement, 1-RM was also indirectly estimated using the Brzycki submaximal method.[16] This indirect evaluation was used in order to ensure the safety of the participants.

The AT group performed AP, three sessions per week, at 45–50% of heart rate reserve, using cycle-ergometers and treadmills. The duration of each session was progressively increased from 25 minutes up to 40 minutes, adding 5 minutes every following session, with 10 minutes of warm-up and cool-down. During phase II, all the three groups performed AP with the same modalities of the AT group in phase I.

The physical activity was supervised by three professional personal trainers appointed for each group (the ratio of personal trainer and participants was at least 1:5) in order to assure the safety of the participants, the correct execution of the exercises and the adherence to the protocols. The heart rate was monitored using Polar Team 2 system (Polar Electro Oy, Kempele, Finland). All the participants performed two preliminary sessions to get familiarized with the correct use of isotonic machines and ergometers and to assess the RT loads (13-RM and 9-RM).

At the end of the intervention, the participants were exhorted to continue the physical activity, and after 12 weeks, they were reassessed (follow-up). A questionnaire was administered in order to investigate if they had an active daily life and continued their physical activity program. Based on the results of the questionnaire, the participants were classified into two categories: positive continuer (POS-CO) consisting of the participants who continued the physical activities, and negative continuer (NEG-CO) consisting of those who did did not continue the physical activity properly, after the end of the intervention. The follow-up assessment aimed to evaluate if the three groups had long-term benefits on anthropometric measures and body composition in comparison with their starting condition (baseline evaluation) and the condition achieved at the end of the intervention (phase II evaluation).

Anthropometric and body composition evaluation

Height, weight, BMI, waist circumference and waist–hip ratio were measured in order to evaluate macroscopic changes in the body measures. Internationally acceptable cut-off points for waist circumference were used in this study.[17] Body composition was assessed using skinfold measurements. The skinfolds were measured on the right side of the body and recorded to the nearest 0.1 mm. The measurements were taken in triplicate by the same investigator, and the average of the three measurements was used in the data analysis.

A skinfold caliper was used to measure biceps, triceps and subscapular and supra-iliac skinfolds. The measures obtained (in millimeters) were included in the Johnston et al[18] equation in order to obtain the body density of the participants. The body density was therefore used to calculate their percentage of fat mass (%FM) using the equation of Weststrate and Deurenberg,[19] specific for adolescent population. A study of Rodríguez et al[20] calculated that the predicted %FM assessed with this procedure has an absolute error of 5.92% in female and 3.90% in male subjects compared with the measurement obtained with the dual-energy X-ray absorptiometry. The FFM (in kilograms) of the participants was also calculated in order to evaluate modification in their lean body mass.

Physical assessment

Physical assessment was carried out using the specific tests of the Eurofit Test Battery for flexibility,[21] agility, resistance and balance, and the Queens College Step Test for aerobic fitness.[22] All the tests were performed between 9 and 12 am. The Queens College Step Test is used for estimating maximal oxygen uptake. The protocol consisted of stepping up and down on a platform of 41.3 cm, at a rate of 22 and 24 steps per minute (for females and males, respectively), for 3 minutes. The participants stopped the test after the third minute, and their heart rate was measured as beats per minute (bpm) after 20 seconds of recovery. The heart rate was assessed using a Polar A300 heart rate monitor, with H7 heart rate sensor. The estimation of maximum oxygen consumption (VO_2max) was made using one of the two following equations according to the gender: for males, VO_2max ($mL\cdot kg^{-1}\cdot min^{-1}$) = 111.33 – (0.42 × bpm); for females, VO_2max ($mL\cdot kg^{-1}\cdot min^{-1}$) = 65.81 – (0.1847 × bpm).[23] The Sit and Reach Test was performed to measure the flexibility of the lower back and hamstring muscles.[24] The Abdominal Curl Test, an endurance strength test for abdominal muscles, was used to record the total number of curl-ups performed by each participant in 60 seconds.[25] The Flamingo Balance Test assessed the ability to balance on a single-leg-standing position. The total number of times of loss of balance in 60 seconds was recorded.[26] The Shuttle Test assessed anaerobic power, speed and agility. The total time taken to consecutively run 10 times the distance of 5 m between two markers was recorded.[24]

Statistical analysis

Analysis of variance (ANOVA) was performed to assess the homogeneity of the three groups in terms of age, gender, BMI, weight, %FM and FFM, measured at baseline. Repeated-measures ANOVA was performed to assess significant differences in the anthropometric measures, body composition and fitness parameters scores, among the three different time point evaluations (within factor named time: pre vs. intermediate vs. post evaluation), among the three groups (between factor named groups: MRT vs. HRT vs. AT) and for the interaction time × groups. The dependent variables analyzed are shown in Table 1. Bonferroni post hoc test was used to assess mean differences where a significant F was observed. The alpha test level for statistical significance

Table 1 Results obtained by the three groups in the pre, intermediate and post assessments

		MRT	HRT	AT
		Means (SD)	**Means (SD)**	**Means (SD)**
Anthropometric measures				
Weight (kg)	Pre	69.18 (18.72)	68.51 (13.15)	68.32 (14.05)
	Intermediate	70.04 (16.70)	70.47 (11.37)	68.50 (13.62)
	Post	71.25 (15.46)	72.24 (11.39)	70.00 (11.42)
Height (m)	Pre	1.57 (0.09)[a]	1.56 (0.08)[a]	1.59 (0.07)
	Intermediate	1.59 (0.10)	1.58 (0.07)[a]	1.60 (0.07)
	Post	1.61 (0.07)[b]	1.60 (0.05)[b,c]	1.62 (0.06)
BMI (kg·m^{-2})	Pre	27.81 (5.41)	27.48 (3.59)	26.93 (3.92)
	Intermediate	27.54 (4.23)	28.58 (4.67)	27.57 (4.39)
	Post	26.96 (3.85)	27.84 (1.48)	26.45 (3.44)
Waist circumference (cm)	Pre	84.20 (9.67)	88.21 (9.61)	88.54 (10.89)
	Intermediate	83.35 (8.97)	83.75 (9.1)	88.38 (10.85)
	Post	83.23 (7.97)	83.64 (6.39)	85.40 (11.97)
WHR	Pre	0.81 (0.05)	0.88 (0.09)	0.89 (0.07)
	Intermediate	0.84 (0.10)	0.86 (0.08)	0.89 (0.07)
	Post	0.84 (0.09)	0.87 (0.09)	0.87 (0.12)
Body composition				
%FM	Pre	34.07 (6.70)[a,c]	33.33 (7.29)[a,c]	32.92 (6.42)
	Intermediate	31.11 (5.00)[b]	30.92 (6.04)[b]	33.50 (6.23)
	Post	29.41 (3.52)[b]	30.28 (3.39)[b]	32.56 (5.41)
FFM (kg)	Pre	46.80 (10.05)	45.31 (8.55)[a]	45.78 (10.59)
	Intermediate	45.77 (11.81)[a]	48.40 (8.01)	46.45 (10.6)
	Post	49.92 (8.16)[c]	49.83 (5.87)[b]	48.66 (8.61)
Physical fitness test				
Flamingo Balance Test (seconds)	Pre	7.83 (2.98)[a,c]	7.50 (2.71)[a,c]	7.25 (2.77)
	Intermediate	3.23 (3.19)[b,*]	3.30 (2.45)[b,*]	8.08 (2.78)[a]
	Post	2.36 (2.98)[b,*]	3.00 (2.42)[b,*]	5.70 (2.63)[c]
Shuttle Test (seconds)	Pre	25.36 (2.49)[a]	25.05 (2.53)[a]	26.17 (1.66)
	Intermediate	24.06 (3.46)*	23.10 (1.46)*	27.41 (2.54)[a]
	Post	22.44 (2.57)[b,*]	22.43 (1.00)[b,*]	24.9 (1.08)[c]
Abdominal Curl Test (repetitions in 60 seconds)	Pre	18.88 (4.9)[a]	19.79 (8.86)[a]	19.33 (5.26)
	Intermediate	19.85 (2.95)[a]	20.00 (2.51)[a]	19.83 (5.75)
	Post	23.45 (3.59)[b,c]	25.86 (2.89)[b,c]	21.80 (5.09)
Sit and Reach Test (cm)	Pre	12.92 (5.91)	10.86 (4.31)	12.00 (4.66)
	Intermediate	15.60 (5.34)	14.57 (3.29)	12.33 (3.95)
	Post	16.14 (6.10)	14.79 (2.87)	12.65 (3.54)
VO_2max (mL O_2·kg^{-1}·min^{-1})	Pre	31.40 (3.63)[a]	30.21 (3.02)[a]	31.50 (2.15)
	Intermediate	32.47 (3.43)	31.36 (3.39)	31.53 (1.98)
	Post	34.23 (3.20)[b,*]	33.36 (3.27)[b,*]	32.52 (2.54)[b]

Notes: [a]Significant p-value in the comparison vs. post score. [b]Significant p-value in the comparison vs. pre score. [c]Significant p-value in the comparison vs. intermediate score. *Significant p-value in the comparison vs. AT.

Abbreviations: MRT, moderate-resistance training; HRT, high-resistance training; AT, aerobic training; SD, standard deviation; BMI, body mass index; WHR, waist–hip ratio; %FM, percentage of fat mass; FFM, free fat mass.

was set at 0.05. Effect size was calculated as η^2. For all the statistical analyses, the SPSS statistical software package was used (version 20.0; IBM).

For the analysis of the follow-up data, the number of POS-CO and NEG-CO of each group was calculated, and a chi-squared 3 × 2 (three groups × two categories) was performed to find significant differences among the three groups in physical activities participation after the end of the intervention (chi-squared 2 × 2 was instead used for paired comparisons among the groups). The variations (Δs) between the follow-up scores and the phase I and phase II evaluation scores were calculated. The Δ was calculated for each group (MRT, HRT and AT) and for each category (POS-CO and NEG-CO) for the following four variables: weight, BMI, %FM and FFM. This analysis aimed to assess the long-term modification of the three-group participants in comparison with their starting condition (baseline evaluation) and the condition at the end of the intervention (phase II evaluation), depending on whether they continued to perform physical activity.

The alpha test level for statistical significance was set at 0.05.

Results

The sample characteristics are shown in Table 2.

The repeated-measures ANOVA showed significant differences among the time for height ($F_{2,76} = 21.836$; $p < 0.001$; $\eta^2 = 0.365$), %FM ($F_{2,76} = 5.843$; $p = 0.004$; $\eta^2 = 0.133$), FFM ($F_{2,76} = 6.254$; $p = 0.003$; $\eta^2 = 0.141$), Flamingo Balance Test ($F_{2,76} = 32.597$; $p < 0.001$; $\eta^2 = 0.462$), Sit and Reach Test ($F_{2,76} = 9.678$; $p < 0.001$; $\eta^2 = 0.203$), Shuttle Test ($F_{2,76} = 7.988$; $p = 0.001$; $\eta^2 = 0.174$), Abdominal Curl Test ($F_{2,76} = 8.477$; $p < 0.001$; $\eta^2 = 0.182$), and VO_2max ($F_{2,76} = 32.692$; $p < 0.001$; $\eta^2 = 0.462$). Significant differences among the groups were found for Flamingo Balance Test ($F_{2,38} = 72.555$; $p = 0.013$; $\eta^2 = 0.205$), Shuttle Test ($F_{2,38} = 11.637$; $p < 0.001$; $\eta^2 = 0.380$), and VO_2max ($F_{2,38} = 4.264$; $p = 0.021$; $\eta^2 = 0.183$). Finally, significant differences in the interaction time × group were found for %FM ($F_{4,76} = 3.333$; $p = 0.014$; $\eta^2 = 0.149$) and Flamingo Balance Test ($F_{4,76} = 8.331$; $p < 0.001$; $\eta^2 = 0.304$). The scores obtained by each group at baseline, phase I and phase II assessments and post hoc statistical analysis results are reported in Table 1.

From baseline to 16 weeks (phase I), the rate of adherence to exercise program was an average of 94% (each participant performed at least 40 sessions of the expected 48, with an average of 45 sessions performed) in both MRT and HRT groups with no significant differences between groups, whereas in the AT group, it was 83%. From the 16th to the 22nd week (phase II), the rate of adherence was > 98% for the two groups (at least 16 sessions performed of the expected 18), and in the AT group, it was 78%.

The results of the chi-squared test showed significant differences among the three groups relative to participation in physical activity after the end of the intervention (chi^2 value = 6.73; $p = 0.035$). The comparison in pair showed that MRT (chi^2 value = 4.64; $p = 0.031$) and HRT (chi^2 value = 5.57; $p = 0.018$) groups had a significantly high number of subjects who continued the physical activity in comparison with the AT group. The %Δ of the follow-up scores compared with baseline and phase II assessment scores are reported in Table 3.

Discussion

This study proposed a new combination of training protocols for overweight adolescents, designed with a first phase of RT (MRT or HRT) that prepares the subjects to the successive second phase of AP, and compared it to AP performed in both the first and the second phase.

AP is the traditional intervention program to shift the balance between the intake and expenditure of energy, decreasing waist circumferences and consequently abdominal fat accumulation, which is associated with a great risk of developing overweight pathologies.[27] AP represents the widely used type of physical training for correction of excessive body mass by increasing the energy expenditure.[28] The problem is that this kind of training does not have a great sustainability for overweight subjects,[8] given the higher physical and physiological demands, and does not provide the best chance

Table 2 Sample description

Group	Age (years)	Weight (kg)	Height (m)	BMI (kg·m^{-2})	Fat mass (%)
MRT	12.73 ± 0.70	69.18 ± 18.72	1.57 ± 0.09	27.81 ± 5.41	34.07 ± 6.70
HRT	12.21 ± 0.43	68.51 ± 13.15	1.56 ± 0.08	27.48 ± 3.59	33.33 ± 7.29
AT	12.67 ± 0.65	68.32 ± 14.05	1.59 ± 0.07	26.93 ± 3.92	32.92 ± 6.42
Total	12.54 ± 0.64	68.59 ± 15.45	1.57 ± 0.08	27.25 ± 4.51	33.48 ± 6.67

Note: The three groups were homogeneous at baseline.
Abbreviations: BMI, body mass index; MRT, moderate-resistance training; HRT, high-resistance training; AT, aerobic training.

Table 3 Differences between follow-up scores compared to pre and post scores

Group	**MRT**		**HRT**		**AT**	
Category	**POS-CON**	**NEG-CON**	**POS-CON**	**NEG-CON**	**POS-CON**	**NEG-CON**
Numerosity	10	5	10	4	3	9
Significance	Chi² = 4.64; p = 0.031*		Chi² = 5.57; p = 0.018*			
Comparison with the pre assessments						
Weight (kg)	–5.4	+3.1	–6,0	+2.9	–2.4	+3.1
BMI (kg·m⁻²)	–2.6	+2.8	–1.9	+1.1	–1.3	+1.6
%FM	–4.8	+1.8	–5.4	+2.2	–2.3	+0.5
FFM (kg)	+4.7	–0.8	+5.1	–1.7	+1.2	–0.6
Comparison with the post assessments						
Weight (kg)	–5.2	+1.9	–6.3	+1.7	–2,9	+2.2
BMI (kg·m⁻²)	–1.5	+3.3	–1.7	+2.6	–1.1	+2.1
%FM	–0.7	+6.3	–2.7	+5.6	–2.2	+2.2
FFM (kg)	+1.9	–3.2	+1.1	–4.4	+0.4	–3.3

Notes: POS-CON (positive continuer): participants who continued to perform physical activities after the end of the study; NEG-CON (negative continuer): participants who did not continue to perform physical activities after the end of the study. *Statistically significant in comparison with AT.

Abbreviations: MRT, moderate-resistance training; HRT, high-resistance training; AT, aerobic training; BMI, body mass index; %FM, percentage of fat mass; FFM, free fat mass.

to compete with slimmer peers. Moreover, overweight teenagers, performing prolonged periods of aerobic exercise in which most overweight teens "fail", perceived themselves to be under constant scrutiny from their peers and ridiculed by them.[29] Conversely, RT is an exercise modality in which overweight adolescents can excel relatively to their peers, given their larger FFM.[30] Since this kind of training is enjoyable and satisfying, it can influence the adoption of active behaviors,[26] considering that physical inactivity is strongly related to adolescent obesity.[31] In the first part of this study, we tried to establish a dose–response relationship comparing moderate- vs. high-intensity RT protocols, and consequently to assess the most effective RT intensity. Our results showed the same effect of both RT protocols on body composition and fitness parameters. Preview studies showed that high-intensity progressive training decreases adiposity and improves the related metabolic outcomes, more than low- and moderate-intensity trainings. In the present study, the differences in intensity between the two RT protocols were not very relevant (9-RM vs. 13-RM) because more vigorous intensity would have not been suitable for this population. After phase II, the participants of both RT groups showed significant improvements in body composition (%FM and FFM) and in physical fitness tests (Flamingo Balance Test, Shuttle Test and VO_2max), compared to baseline and AT groups, with no differences between them (Table 1). AT group showed a significant improvement only in the Flamingo Balance Test, Shuttle Test and VO_2max after phase II. The significant improvements in FFM and related skills, such as balance and speed (assessed by Flamingo Balance Test and Shuttle Test, respectively), after phase II, confirmed the utility of performing RT before AP. The nonsignificant changes in anthropometric measures may be due to the intervention without a dietary control. However, dietary restriction has been shown to cause FFM loss that could negatively counteract the RT gains.[32,33] Moreover, dietary intervention in addition to physical activity protocol would have been a confounding variable in the present study.[27,34,35] Previous findings indicated that the combined training (RT plus AP) was the best choice for obese and overweight adolescent physical activity treatment.[27] However, the combination of the two activities may be heavy, too long and unpleasant, accelerating the risk of incurring a decrease in enjoyment and endangering the lifelong commitment to physical activity necessary to prevent weight regain.[7] Overweight participants, choosing activities as RT which promote vigorous exertion and physical changes, may improve their self-confidence and self-efficacy in carrying out the successive AP protocol. The level of satisfaction of adolescents with the intervention program was assessed by the adherence to the physical activity programs and by the number of dropped-out subjects. The dropped-out subjects in this study were all girls, and it is well known that overweight females are more acutely sensitive to any implied criticism relating to their body, bodily performance or social practices. Nevertheless, it has to be remarked that almost all the dropped-out subjects belonged to the AT group.[36]

The adherence of the two experimental groups was significantly higher than that of AT, and more participants in the experimental groups passed from the first phase to the second phase. Participants in MRT and HRT groups, in fact, showed significantly more adherence and compliance in the following AP than those in AT. The subjects who discontinued physical activity after all the three intervention protocols showed a weight increase especially in terms of %FM and loss of FFM. Those who carried on the physical activity after the intervention continued to lose weight, maintaining the FFM level achieved.

Therefore, this program of training may prepare participants to be more available to continue the AP and to assume a more active lifestyle as it was demonstrated by follow-up results.

Conclusion

RT followed by AP can be an effective treatment option for obese youth. This is the first study that proposes an intervention based on different exercise protocols in sequence for overweight population. Overweight adolescents, who want to maximize the effect of the physical activity, should prepare themselves through RT before performing AP exercises, which assures them safe physical and health benefits.[37,38]

The positive effect of the programs proposed in this study was the global maintenance of training effects after intervention,[39] motivating the adolescents to adopt an active lifestyle.[11] MRT or HRT performed before AP, in fact, increased long-term exercise adherence, compared to AP alone.[8] These findings represent an advancement in the theory-based physical activity intervention for overweight adolescents.

Disclosure

The authors report no conflicts of interest in this work.

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