Rev Bras Cineantropom Hum

original article

DOI: http://dx.doi.org/10.5007/1980-0037.2016v18n3p268

# Comparison between two models of training with regard to resting energy expenditure and body composition in obese adolescents

## *Comparação entre dois modelos de treinamento sobre o gasto energético de repouso e a composição corporal de adolescentes com obesidade*

Bruno Affonso Parenti de Oliveira[1]
Fabrício Eduardo Rossi[2]
Camila Buonani[2]
Tiego Aparecido Diniz[2]
Paula Alves Monteiro[2]
Bárbara de Mello Antunes[2]
Rômulo Araújo Fernandes[2]
Ismael Forte Freitas Júnior[2]

**Abstract** – Different types of physical activity programs have been used with the purpose of improving body composition and increasing resting energy expenditure (REE) in obese adolescents. The aim of the present study was to compare the effects of two training models on REE and body composition in this population. The study included 20 obese male adolescents, who were randomly assigned to follow two training models: strength training (n=8, age=13,4±1.0) and functional training (n=12, age= 13.0±1.1). Body composition variables were estimated by dual-energy X-ray absorptiometry. REE was assessed by indirect calorimetry using the QUARK-PFT equipment (COSMED, Rome, Italy). The training protocol consisted of 30 minutes of aerobic training followed by 30 minutes of strength training (ST) or functional training (FT), both with a duration of 20 weeks. There were no significant differences between the two training models with regard to body composition (fat mass, FT= -7.6±5.5% vs. ST= -8.9±6.2%; p=0.620), (lean body mass, FT= 9.0±5.3% vs. ST= 6.8±6.7%; p=0.431) and to REE (FT= 19.6±15.3% vs. ST= 10.7±24.5%; p=0.331). Moreover, lean body mass (p=0.01) and fat mass (0.01) had an influence on REE. No differences were observed between the two training models, but both were effective in improving body composition and increasing REE in obese adolescents. Furthermore, the present study showed the importance of systematic physical training, since lean body mass and fat mass contributed to the increase in REE after the training period.

**Key words**: Adolescents; Body composition; Obesity; Training.

**Resumo** – *Diferentes tipos de programas de exercícios físicos têm sido utilizados na tentativa de melhorar a composição corporal e aumentar o gasto energético de repouso (GER) de adolescentes obesos. O objetivo foi comparar os efeitos de dois modelos de treinamento sobre o gasto energético de repouso e a composição corporal de adolescentes com obesidade. Participaram do estudo vinte adolescentes obesos do sexo masculino, foram divididos de forma aleatória em dois modelos de treinamento: treinamento contra resistência (n=8, idade=13,4±1,0) e treinamento funcional (n=12, idade= 13,0±1,1). As variáveis de composição corporal foram estimadas pela densitometria radiológica de dupla energia. O GER foi realizado por meio da calorimetria indireta usando o equipamento QUARK-PFT (COSMED, Roma, Itália). O protocolo de treinamento consistiu de 30 minutos de treino aeróbio seguidos de 30 minutos de treino contra resistência (TC) ou funcional (TF), ambos durante 20 semanas. Não houve diferenças significantes entre os dois modelos de treinamento na composição corporal (massa gorda, TF= -7,6±5,5% x TC= -8,9±6,2%; p=0,620), (massa corporal magra, TF= 9,0±5,3% x TC= 6,8±6,7%; p=0,431) e no GER (TF= 19,6±15,3% x TC= 10,7±24,5%; p=0,331). Além disso, a massa corporal magra (p=0,01) e massa gorda (p=0,01) influenciam o GER. Não há diferença entre os dois modelos de treinamento, porém ambos são eficazes na redução da composição corporal e aumento do GER de adolescentes obesos. Adicionalmente, foi verificada a importância do treinamento físico sistematizado, uma vez que a massa corporal magra e massa gorda contribuíram para o aumento do GER após o treinamento.*

**Palavras-chave**: *Adolescentes; Composição corporal; Obesidade; Treinamento.*

1 University of São Paulo. Department of Clinical Medicine. Ribeirão Preto, SP, Brazil.

2 São Paulo State University. Department of Physical Education. Presidente Prudente, SP, Brazil.

**Received**: 15 September 2015
**Accepted**: 27 April 2016

## INTRODUCTION

Obesity is affecting an increasing proportion of individuals worldwide[1]. According to the Brazilian Ministry of Health, 52.5% of the Brazilian population are overweight,17.9% of which are classified as obese[2], and there is a significant increase in the rates of obesity among the young[3], a concerning finding due to the association of obesity with cardiovascular diseases and early death[4].

Th excessive accumulation of body fat may be mainly attributed to bad eating habits and sedentary lifestyle, resulting in a positive energy balance, which occurs when energy intake exceeds energy expenditure and leads to increased body fat[5]. Studies show that body composition variables have an important effect on energy metabolism[6] and that lean body mass (LBM) was the body compartment with the highest metabolic activity, explaining 73% of the variation in resting energy expenditure (REE) and 80% of the variation in overall energy expenditure[6]. In this context, it is extremely important to improve physical activity among obese adolescents, in order to increase REE and consequently reduce body fat[7].

Several types of exercise programs have been used to improve body composition and increase REE in obese adolescents. Concurrent training, a model that combines aerobic and strength exercises in the same training session, seems to be a very interesting strategy, since it has shown to be beneficial in reducing total and relative fat and increasing muscle mass in obese adolescents[8,9].

Conversely, functional training, another widely commercially available training model nowadays[10,11], consists of multiple-joint exercises that rely less on the use of equipment and stable bases, thus bringing the training program closer to daily life activities. However, few studies have investigated the effects of this training model on body composition and REE in obese adolescents.

Although strength and functional training are widely used and marketed by health professionals and gyms to enhance fat loss and increase energy expenditure, it is not clear in the literature which of these strategies is the most beneficial in terms of reducing total and trunk fat and increasing LBM and REE in obese adolescents. Therefore, the aim of the present study was to compare the effects of these two training models on REE and body composition in this population.

## METHODOLOGICAL PROCEDURES

This was a quasi-experimental study whose participants should meet the following inclusion criteria: (a) being classified as obese based on sex- and age- specific body mass index (BMI) cutoffs for obesity defined by Cole et al.[12] for the pediatric population; (b) being from 12 to 17 years of age at the time of assessment; (c) not having any clinical condition that made them unable to perform some of the exercises.

All precautions were taken to comply with ethical standards: the parents or legal guardians signed an informed consent form for adolescent's participation in the program, and the project was approved by the Research Ethics Committee at Universidade Estadual Paulista, campus de Presidente Prudente (protocol no. 07/2009).

Anthropometric measures, body composition, and REE of the adolescents were assessed before and after 20 weeks of training. Initial evaluations were performed a week before the beginning of the training program, and final evaluations occurred at the end of the intervention. Participants who missed three consecutive training sessions or missed four sessions during one month were excluded from the study.

The study included 20 obese male adolescents, eight of which participated in strength training (ST) and 12 in functional training (FT). Both groups underwent training sessions three times a week for 20 weeks, including an initial 4-week adaptation period. Each training session lasted for 60 minutes. Strength and functional training were combined with 30 minutes of aerobic training.

## Anthropometry and body composition

Body mass was measured using a digital scale (Filizola, São Paulo, Brazil) with maximum capacity of 180 kg and accuracy of 0.1 kg. Height was measured using a wall-mounted stadiometer (Sanny, São Paulo, Brazil), with accuracy of 0.1 cm and length of 2.20 m. Nutritional status was assessed based on BMI, according to the reference values provided by Cole et al.[12].

LBM, total fat mass (FM), trunk fat (TF) in kilograms, and body fat percentage (BF%) were estimated using a dual-energy X-ray absorptiometry (DXA) scanner version 4.7 (General Electric Healthcare, Lunar DPX-NT, UK). The DXA method estimates body composition by partitioning the body into three anatomic compartments: LBM, FM, and bone mineral content. The dose of radiation that the adolescents received was below 0.05 mrem, i.e., a dose 50 times lower than that used to perform an X-ray[13]. The DXA scan lasted for approximately 15 minutes and was performed with the participants resting in the supine position on the scanner table. All assessments were conducted at the same period of the day and by the same examiners.

## Resting energy expenditure

REE was determined by measuring oxygen consumption and carbon dioxide production using the QUARK-PFT equipment (COSMED, Rome, Italy). The device was automatically calibrated with known gas concentrations (17% $O_2$ and 5% $CO_2$), according to manufacturer's specifications. The adolescents were instructed to fast for six hours and not to perform any physical activity on the day prior to the examination. Throughout the entire assessment period, the adolescents remained awake and lying in the supine position in a room at controlled room temperature from 21 to 24 °C and under low light and noiseless conditions. Oxygen consumption rate ($VO_2$) and carbon dioxide production rate ($VCO_2$) were measured for 30 minutes, but the first five minutes were discarded from analysis until individuals reached a stable state. REE was calculated using the Weir equation[14].

## Aerobic training

The intensity of aerobic training was determined by peak $VO_2$ and heart rate monitoring assessed by a continuous, progressive maximal stress test on a treadmill (ATL Inbrasport, Porto Alegre, Brazil) with maximum user weight of 180 kg, 0 to 26% slope, and maximum speed of 24 km/h. Aerobic training consisted of two stages with workload progressions every eight weeks: 1st to 8th week (65-75% peak $VO_2$) and 9th to 16th week (75-85% peak $VO_2$)[15], and a heart rate monitor (Polar® S810, Kempele, Finland) was used to ensure that heart rate remains within the intensity levels obtained in the maximal stress test .

## Strength training

After a four-week adaptation period focused on the execution of each movement to enable neuromuscular adaptation, the intensity of training was determined by the one-repetition maximum test (1RM) to predict 1RM load[16]. The training program included the following machines: 45° leg press, seated cable row, flat bench barbell press, hack squat, lat pull-down, leg curl with ankle weights, biceps curl, fly machine, overhead dumbbel triceps extension, leg extension, sit-up, lying trunk extension.

The strength training program consisted of eight phases with workload progressions every two weeks, namely: [phase one (1st and 2nd weeks, 2 sets of 25 repetitions, 45% 1RM); phase two (3rd and 4th weeks, 2 x 20 repetitions, 50% 1RM); phase three (5th and 6th weeks, 2x20 repetitions, 55% 1RM); phase four (7th and 8th weeks, 2 x 15 repetitions, 60% 1RM); phase five (9th and 10th weeks, 2 x 15 repetitions, 65% 1RM); phase six (11th and 12th weeks, 2 x 10 repetitions, 70% 1RM); phase seven (13th and 14th weeks, 2 x 10 repetitions, 75% 1RM); phase eight (15th and 16th weeks, 2 x 8 repetitions, 80% 1RM)][16].

## Functional training

Functional training consisted of static (isometric) and dynamic exercises using participants' own body weight and/or free weights and that simultaneously require different motor abilities (flexibility, strength, resistance, balance). The intensity of functional training was controlled using the Borg 6-20 rating of perceived exertion scale[17].

Functional training was performed in circuit and was also divided into eight phases, namely: phase one (1st and 2nd weeks, 2 sets of 10 repetitions); phase two (3rd and 4th weeks, 2 x 12 repetitions); phase three (5th and 6th weeks, 2 x 12 repetitions); phase four (7th and 8th weeks, 2 x15 repetitions); phase five (9th and 10th weeks, 1 x 20 repetitions); phase six (11th and 12th weeks, 1 x 20 repetitions); phase seven (13th and 14th weeks, 1 x 25 repetitions); phase eight (15th and 16th weeks, 1 x 25 repetitions)[16]. The progression of statistic exercises was controlled by the time of isometric contraction, with 30 seconds of sustained exercise and 30 seconds of rest. All training protocols were monitored by physical education professionals.

## Statistical analysis

The Shapiro–Wilk test was used to test the normality of data, and values were expressed as mean and standard deviation. The difference between interventions was investigated by relative delta and a t-test for independent samples was performed. Subsequently, the magnitude of the treatment effect was evaluated using the Cohen test[18,19]. The influence of LBM and FM on REE before and after the training program was examined by linear regression. All analyzes were performed using the SPSS software version 17.0. The significance level was set at $p<0.05$.

# RESULTS

In the present sample, the FT group had a mean BMI of 30.0±3.8 g/cm$^2$ and a BF% of 45.0±4.8%, and the ST group had a mean BMI of 31.8±6.6 g/cm$^2$ and BF% of 43.0±5.7%, showing no statistical differences. Table 1 shows mean and standard deviation values for body composition and REE in the pre-intervention period. No statistical difference was observed between the training models at the beginning of the study.

**Table 1.** Comparison of two training models with regard to anthropometric variables, body composition, and REE in obese adolescents before intervention

| | FT (n=12) | ST (n=8) | p |
|---|---|---|---|
| Age (years) | 13.0±1.1 | 13.4±1.0 | 0.456 |
| Height (cm) | 159.2±10.0 | 165.1±12.0 | 0.097 |
| Weight (kg) | 73.4±16.0 | 81.7±36.0 | 0.105 |
| FM (kg) | 35.2±8.9 | 32.0±23.9 | 0.700 |
| %BF | 45.0±4.8 | 43.0±5.6 | 0.398 |
| TF (kg) | 15.8±4.4 | 14.7±10.0 | 0.700 |
| LBM (kg) | 39.8±9.0 | 47.5±7.4 | 0.063 |
| REE (kcal) | 24.3±3.0 | 24.0±14.9 | 0.643 |

FT: functional training, ST: strength training, FM: fat mass, %BF: body fat percentage, TF: trunk fat, LBM: lean body mass, REE: resting energy expenditure.

**Table 2.** Relative delta for comparison between functional and strength training in obese adolescents.

| | FT (n=12) | ST (n=8) | p | Cohen's d effect size |
|---|---|---|---|---|
| Weight (kg) | 0.88±4.0 | 0.10±4.0 | 0.677 | 0.19* |
| FM (kg) | -7.6±5.5 | -8.9±6.2 | 0.620 | 0.22** |
| %BF | -7.9±4.4 | -9.2±5.5 | 0.590 | 0.26** |
| TF (kg) | -5.6±9.0 | -9.9±8.7 | 0.295 | 0.48** |
| LBM (kg) | 9.0±5.3 | 6.8±6.7 | 0.431 | 0.36** |
| REE (kcal) | 19.6±15.3 | 10.7±24.5 | 0.331 | 0.44** |

FT: functional training, ST: strength training, FM: fat mass, %BF: body fat percentage, TF: trunk fat, LBM: lean body mass, REE: resting energy expenditure. * = trivial effect size; ** = small effect size.

Table 2 shows the relative differences in the variables studied after 20 weeks of intervention in the FT and ST groups, as well as between-group differences. There was no statistically significant difference between the two training models, either in body composition variables or REE. Moreover, as an additional analysis, the magnitude of treatment effect was measured by Cohen's *d*[18] and revealed that all variables had a small effect size[19].

Table 3 shows the contribution of body composition variables to REE. In the pre-training period, LBM explained 20.1% of the variation in REE (p=0.01), and after 20 weeks of training both LBM ($r^2$:0.354; p=0.01) and FM ($r^2$=0.465; p=0.01) have a significant influence on REE.

**Table 3.** Influence of body composition on resting energy expenditure in obese adolescents subjected to physical training

| | Independent variables | $r^2$ | r | p |
|---|---|---|---|---|
| Before training (n=20) | LBM (kg) | 0,201 | 2,126 | 0.04* |
| | FM (kg) | 0,083 | 1,281 | 0.21 |
| After training (n=20) | LBM (kg) | 0,354 | 3,141 | 0.01* |
| | FM (kg) | 0,465 | 3,958 | 0.01* |

LBM: lean body mass, FM: fat mass, r2: coefficient of determination, * p<0.05.

## DISCUSSION

When comparing strength and functional training, there was no significant difference in REE and body composition among obese adolescents undertaking the different training protocols. However, body composition variables modulated REE, especially after the training period.

With regard to body composition, both FT and ST were effective in reducing FM, %BF, and TF and in increasing LBM, which is in line with findings from a study by Cayres et al.20 with 49 obese adolescents. In their study, adolescents engaged in functional training showed a reduction in relative delta of -5.4 for FM and an increase of 4.1 for LBM, and those engaged in strength training showed a reduction in FM of -10,8 and an increase in LBM of 5.0. Cobayashi et al.[21] describe excess body fat as an independent risk factor for the development of cardiovascular diseases[22]. In this sense, strategies aimed at preventing and reversing this condition are extremely important, especially if implemented at an early stage. According to Almeida et al.[10] the regular practice of physical exercise by obese children and adolescents, in addition to improving body composition, may lead to increased energy demand and thus becomes essential in body weight control.

An investigation developed by Lee et al.[24] found that three months of resistance and aerobic training performed in isolation were effective in reducing total and central adiposity and promoted an increase in LBM among obese male adolescents, corroborating data from the present study. Conversely, Deforche et al.[25] observed that severely obese adolescents who followed a 10-month program combining diet (1,400 to 1,600 kcal/day) and continuous aerobic exercise exhibited reduced FM and LBM.

Additionally, the authors suggested the inclusion of resistance training in order to maintain or increase LBM. In this context, a study by Davis et al.[26] revealed that obese adolescents subjected to a combination of strength and aerobic training associated with nutrition education for 16 weeks showed reduced FM and increased LBM.

In a meta-analysis of studies with severely obese adolescents of both genders (12 to 16 years of age; BMI= 33.9 kg/m$^2$; BF%= 41.5%), LeMura and Maziekas[27] found that the combination of strength and aerobic training promoted the most significant changes in body composition, especially with the performance of low-intensity, long-duration exercise. This agrees with findings from our study, which developed a training protocol that give priority to lower intensity and long duration, a strategy that showed to be beneficial to improve both body composition and REE.

Lazzer et al.[28] investigated the effects of nine-month program that associated aerobic and strength training with diet on body composition and REE in adolescents and observed a reduction of 16.9 kg in total body mass, 15.2 kg in FM, and 1.8 kg in LBM ($p<0.05$). However, this program was not effective in preventing significant reductions in REE even after adjustment for LBM, in contrast to our study, which, in addition to finding a reduction in body fat variables, also observed an increase in LBM and REE in the two training models.

Physical exercise increases daily energy expenditure (DEE) during its performance and after its completion[6]. At the same time, strength training promotes an increase in LBM, which is considered the main factor responsible for the increase in REE, as observed in our study, which found that LBM influenced resting metabolic rate before and after training. According to Trevisan and Burini[29], for each kilogram of LBM gained an increase of around 50 kcal/day in DEE occurs. Conversely, Rodrigues et al.[30] demonstrated that REE is influenced by FM, a finding that is line with the results of the present research for the post-training period ($r^2$: 0.465, $p=0.01$).

Although this is a longitudinal study comparing two different models of intervention, the lack of a control group for comparison with functional training and strength groups should be construed as a limitation of our research.

It is worth emphasizing that no similar studies have been found in the literature comparing these two training models and their effects on REE and body composition in obese adolescents, as we did in this study. Additionally, a search in the specialized literature revealed few studies on functional training, which again demonstrates the importance of and the need for the present investigation.

## CONCLUSION

We concluded that no difference was found between functional training and strength training in the parameters analyzed, but both were effective in improving body composition profile and in increasing resting energy expenditure in obese adolescents. Furthermore, the present study showed the importance of systematic physical training, since LBM and FM contributed to the increase in REE after the intervention period.


## Acknowledgements

The authors would like to thank Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) for the funding received (process no. 2011/07683-0).


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**CORRESPONDING AUTHOR**

Bruno Affonso Parenti de Oliveira
Universidade de São Paulo,
Faculdade de Medicina de Ribeirão Preto,
Departamento de Clínica Médica
Avenida dos Bandeirantes, 3900.
CEP: 14049-900 Ribeirão Preto, SP. Brasil.
E-mail: bruno_parenti@usp.br