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Strength training combined with high-intensity interval aerobic training in young adults' body composition

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Abstract
Introduction. Although health-enhancing effects of physical activity are well-reported, a high rate of physical inactivity worldwide is still observed. Additionally, the most effective method for weight control and/or weight loss is still unknown. In this sense, analyzing whether strength training could be useful when combined with high-intensity aerobic interval training to improve body composition is important to provide further knowledge of the effects of combined strength and aerobic training in young adults. Aim of Study. The purpose of the study was to compare the effects of high-intensity interval aerobic training (HIIT) with a combined strength training followed by HIIT (ST+HIIT) on body composition of young adults. Material and Methods. Eighteen college students (age 24.83 ± 6.60 years, body mass 70.05 ± 14.26 kg, height 1.72 ± 0.08 m) were subjected to two different training programs for 8 weeks: high-intensity interval aerobic training (n = 9), or strength training combined with high-intensity interval aerobic training in the same session (n = 9). Anthropometric variables were assessed. Results. After eight weeks significant differences were found in body fat mass (p = 0.01; ES = 1.11), waist circumference (p = 0.04; ES = 0.82) and hip circumference (p = 0.04; ES = 0.82) with a large effect size in the ST+HIIT group. A large decrease in fat-free mass was found in the HIIT group (p = 0.04; ES = 0.80). Conclusions. These findings suggest that strength training should be added to high-intensity interval aerobic training to improve body composition in adults by reducing body fat after 8 weeks. Performing HIIT seems to contribute to the loss of fat-free mass. These outcomes might be important for physical fitness professionals and researchers, providing further understanding of the dose-response effects of combined strength and aerobic training in young adults.

KEYWORDS: exercise, morphology, body fat, HIIT, health.

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Introduction

Although health-enhancing effects of physical activity are well-reported, a high rate of physical inactivity worldwide is still observed [14]. The current global exercise recommendations suggest a moderate-intensity physical activity (for a total of 150 to 300 minutes per week) or vigorous-intensity physical activity (for a total of 75 to 150 minutes per week) to produce substantial benefits in physical fitness and health [7]. Unfortunately, recent studies reported that most of the global population does not meet the suggested physical activity levels [14, 17], which results in overweight in around 38.5% of men and 39.2% of women [28]. In the last decade, most exercise programs aimed to provide weight loss, mainly body fat, through continuous moderate-intensity exercise (e.g. walking, running) [25, 27]. Nevertheless, some authors have recently reported that both high-intensity interval aerobic training and moderate-intensity continuous training produce positive adaptations in physical conditioning, weight loss and body composition

[2, 4]. Interestingly, some researchers provided evidence that high-intensity interval training seems to induce favorable metabolic adaptations similar to those induced by continuous exercise of lower intensity and longer duration in both healthy and clinical populations [1, 13]. However, the most effective method for weight control and/or weight loss has not yet been reported [27]. In this sense, alternative training programs are still being studied. Wewege et al. [27] reported that performing interval training in running produces better results in the body composition of young adults than cycling. Additionally, regardless of the training method used, evidence revealed greater exercise effectiveness when intensity levels are higher [9]. Moreover, Tjønna et al. [24] compared the effects of high-intensity interval aerobic training with those of moderate-intensity continuous aerobic training, reporting a significant decrease in total body mass, fat mass and visceral fat from high-intensity interval training, while continuous training induced no significant improvements. Nevertheless, difficulty in performing and maintaining high-intensity exercise for an extended period in the sedentary population was also shown [15]. It should be mentioned that high and/or moderate intensity training combined with strength training may be complementary training to prevent or reduce obesity [11]. Although strength training has been considered as a useful approach to fat mass loss [21], recent findings reported greater effectiveness in terms of body composition improvement when using aerobic training combined with strength training compared to aerobic exercise or strength training alone [3]. High-intensity interval training has increasingly emerged as an alternative for enhancing cardiorespiratory fitness, but also improving body composition by reducing body fat mass [11, 27]. However, most studies have focused on high-intensity interval training in trained or experienced young adults and measured only physical and physiological variables (e.g. maximal strength, endurance performance, oxygen kinetics, heart rate response, energy expenditure) [4, 12]. To the best of our knowledge, scarce studies have analyzed the combination of high-intensity interval training with strength training in overweight and young adults [18]. From this point of view, it is important to understand if the effects of strength training combined with high-intensity aerobic interval training could be beneficial to the body composition. Thus, the purpose of this study was to compare the effects of 8-week high-intensity interval aerobic training with a combined strength training followed by high-intensity interval aerobic training on the body composition of young adults. The established hypothesis was that combined high-intensity interval aerobic and strength training may induce body composition improvements through a potential increase in fat-free mass.

Material and Methods

Evidence suggests that higher intensity levels of exercise can be an effective option to enhance cardiorespiratory fitness and to improve body composition by reducing body fat mass [5, 8]. This seems to be important in a world population which tends to be inactive and prone to develop diseases [14]. However, can the effects of strength training combined with high-intensity interval training be helpful to improve body composition? For this, a randomized controlled trial was developed to compare 8 weeks of high-intensity interval aerobic training (HIIT) and a combination of strength training plus interval aerobic training (ST+HIIT).

Participants

Eighteen college students (mean ± SD) age: 24.83 ± ± 6.60 years; body mass: 70.05 ± 14.26 kg; height: 1.72 ± 0.08 m, took part in this study and voluntarily provided their written informed consent. The subjects were randomly divided into two study groups, one of the groups performed high-intensity interval aerobic training (HIIT) and the other performed a combined strength and high-intensity interval aerobic training in the same session (ST+HIIT). Each individual was asked to report any previous illness, injury or any other physical issue that would hinder their performance and they were included in the study on condition they were healthy and injury-free. Criteria of exclusion from the study included evidence of any medical or orthopedic problem and a self-reported issue that would endanger their health. All the subjects gave their written informed consent before participation. For the entire sample participation in a minimum of 14 of the 16 sessions was required to be included in the analysis. The study was approved by the University of Beira Interior ethics committee (under project M7145, March 2016) and was conducted according to the Declaration of Helsinki.

Procedures

Before the experiments two weeks of familiarization to procedures was allowed to all the subjects. During these two weeks each subject was able to experiment with aerobic training intensities and strength training exercises. During that time the subjects were taught about the proper technique for each training exercise and any of their questions were properly answered to clear any doubts. Clear instructions concerning the

importance of adequate nutrition were also delivered.
All the subjects were evaluated before and after the implementation of each training program. To assess different variables, each subject went to the laboratory where the evaluations were performed on a specific day. No strenuous effort was permitted within 48 hours before any evaluation. These evaluations were applied in the week preceding the beginning of the training program and in the week after the end of the training program. Each subject remained in a resting position for 5 minutes before resting heart rate measurements. Then the resting heart rate was measured, followed by body composition and perimeters. Body mass, percentage of fat mass, fat-free mass and body water were measured using an electronic scale (Tanita Body Composition Analyzer BC-418, Illinois, USA). The measurements were taken based on standard procedures [20]. To complement the anthropometric evaluation, hip and waist circumferences were also assessed. To avoid typical errors in the measurement of these variables, each perimeter was measured 3 times and the mean value was considered for further analysis. The intraclass correlation coefficient of the values found exceeded 0.95 for hip circumference and 0.97 for waist circumference. The resting heart rate was monitored using a voltage meter (Tensoval Duo Control, Heidenheim, Germany) in a relaxed and seated position after resting for 5 minutes. Each subject was evaluated 3 times (intraclass correlation coefficient greater than 0.97) and the mean value was used to estimate the maximal heart rate (HRmax). To determine interval training intensities, Tanaka's equation [22] was used to obtain the estimated HRmax:

$$\text{HRmax} = 208 - (0.7 \times \text{age})$$

To determine the intensity of strength training, each subject in the ST+HIIT group was evaluated regarding maximal dynamic strength (1 maximum repetition, 1RM). For this purpose a progressive test was implemented until the maximal load was reached. Each subject started with an external load that was believed to be lifted only once at maximal effort. Following a 3-5 minute resting period another repetition was performed after adding some load. This was repeated until the maximum load was reached. No more than 5 attempts were allowed [6]. The determination of the 1RM load was made 1 week before the other assessments.
Both groups, HIIT and ST+HIIT, trained twice a week for 8 weeks. The HIIT group performed an aerobic interval treadmill training and the ST+HIIT group performed a strength training followed by the same aerobic training as the HIIT group. Each interval training session lasted for 25 minutes of running on a treadmill per session. Each workout was started with a slight warm-up (30% to 50% of estimated HRmax) for 5 minutes to prepare the body for physical exertion. Then the intensity increased to 75-95% estimated HRmax for 2 minutes, and then it dropped to 50% of the estimated HRmax for 2 minutes. These cycles of high and low intensities were performed until the 20 minutes of training were completed. It is important to point out that the higher intensities were progressively increased by 5% every two weeks, starting at 75% of estimated HRmax. Aerobic training was performed by the HIIT group as well as the ST+HIIT group – in the latter case it was 10 minutes after performing strength training. The strength training included 4 exercises in the following order: bench press, leg press, lat pull down and shoulder press. In the first week the load was settled as 50% of 1RM and then it was increased by 5% each week. Two minutes of rest were allowed between the sets and exercises. Then after 5 minutes of rest the same aerobic interval training was performed. The same researcher performed data collection, anthropometric assessments and training programs. No dropout occurred in the present study. There were no injuries resulting from the implementation of the training programs. A more detailed analysis of the strength training design can be found in Table 1.

Table 1. Strength training design

Weeks	Sets	Repetitions	Intensity
1	3	12	50% 1RM
2	3	12	55% 1RM
3	3	10	60% 1RM
4	3	10	65% 1RM
5	3	8	70% 1RM
6	3	8	75% 1RM
7	3	6	80% 1RM
8	3	6	85% 1RM

Note: RM – maximum repetition

Statistical analysis
Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) v.24.0® for Windows. Standard statistical procedures were selected for the calculation of means, standard deviations (SD) and 95%

confidence limits. The normality of all distributions was verified by the Shapiro–Wilks test and parametric statistical analysis was adopted. The independent t-test was used to identify the existence of differences between the groups in pre-training and post-training periods. To analyze the effect of training from pre- to post-training in each group the t-test for repeated measures was used. Changes from pre- to post-training were calculated (in %) and compared between the groups using paired t-test analysis. The level of significance of $p \leq 0.05$ was assumed for the rejection of the null hypothesis. The G*Power 3.0.10 program for Windows (University of Kiel, Germany) was used to calculate the magnitude of the effect (ES) between the pre- and post-training moments and to compare the groups at each moment. A value of 0.2 was considered small, 0.5 medium and 0.8 high [10].

Results

At the baseline there were no differences between the experimental groups regarding the age, body composition and anthropometric measures ($p < 0.05$; ES < 0.40). After the 8-week intervention period, body composition has significantly improved in the ST+HIIT group as shown in Table 2. Changes from pre- to post-training momentum reported statistically significant differences in anthropometric measures, specifically body fat, waist circumference and hip circumference with a large effect size in the ST+HIIT group. Even though there were no significant differences in fat-free mass, a small increase in the ST+HIIT group was found after the 8-week intervention period. The outcomes from the HIIT group only presented a significant decrease in the fat-free mass, with a large effect size. Although the HIIT group showed no significant differences in the other variables,

Table 2. Paired t-test analysis (Mean ± SD and confidence interval 95%)

Variables	Group	Pre-training	Post-training	p-value	ES
BM	HIIT	66.97 ± 17.46 (53.55, 80.38)	66.16 ± 16.49 (53.48, 78.83)	0.18	0.49
	ST+HIIT	73.13 ± 10.30 (65.21, 81.05)	72.22 ± 9.78 (64.70, 79.74)	0.13	0.56
BMI	HIIT	22.55 ± 4.40 (19.17, 25.92)	22.33 ± 4.23 (19.08, 25.58)	0.26	0.40
	ST+HIIT	24.18 ± 2.20 (22.49, 25.88)	23.88 ± 1.92 (22.40, 25.36)	0.16	0.52
FM%	HIIT	21.90 ± 8.16 (15.63, 28.17)	22.69 ± 8.96 (15.80, 29.58)	0.21	0.45
	ST+HIIT	24.08 ± 8.97 (17.18, 30.97)	22.80 ± 9.21 (15.72, 29.88)	0.03*	0.90
FM	HIIT	15.04 ± 8.12 (8.80, 21.29)	15.38 ± 8.54 (8.82, 21.95)	0.40	0.29
	ST+HIIT	17.44 ± 6.06 (12.79, 22.10)	16.29 ± 6.00 (11.68, 20.90)	0.01*	1.11
FFM	HIIT	51.64 ± 12.44 (42.08, 61.21)	50.51 ± 11.56 (41.63, 59.40)	0.04*	0.80
	ST+HIIT	55.72 ± 11.13 (47.17, 64.28)	55.93 ± 11.06 (47.43, 64.44)	0.72	0.12
BW	HIIT	39.27 ± 9.75 (31.77, 46.76)	38.53 ± 9.22 (31.44, 45.62)	0.07	0.69
	ST+HIIT	40.80 ± 8.14 (34.54, 47.74)	40.96 ± 8.10 (34.73, 47.18)	0.72	0.12
VF	HIIT	2.67 ± 2.87 (0.46, 4.87)	2.56 ± 2.92 (0.31, 4.80)	0.35	0.33
	ST+HIIT	3.44 ± 1.81 (2.05, 4.84)	3.00 ± 1.22 (2.06, 3.94)	0.10	0.61
WC	HIIT	77.39 ± 13.83 (66.76, 88.02)	76.11 ± 11.08 (67.59, 84.63)	0.31	0.36
	ST+HIIT	83.28 ± 8.51 (76.74, 89.82)	81.39 ±7.19 (75.86, 86.92)	0.04*	0.82
HP	HIIT	100.33 ± 9.11 (93.33, 107.34)	97.78 ± 7.05 (92.36, 103.20)	0.12	0.58
	ST+HIIT	102.72 ± 6.41 (97.79, 107.65)	100.33 ± 5.22 (96.32, 104.35)	0.04*	0.82

Note: BM (kg) – body mass; BMI (kg/m^2) – body mass index; FM% (kg) – fat mass in percentage; FM (kg) – fat mass; FFM (kg) – fat-free mass; BW (kg) – body water; VF (units) – visceral fat; WC (cm) – waist circumference; HP (cm) – hip circumference. Pre-corresponding to the baseline values, post- corresponding to the values after 8-weeks of training. ST+HIIT – combined strength and high-intensity interval aerobic training; HIIT – high-intensity interval aerobic training
* p-value < 0.05

it was possible to verify a decrease in the values of hip circumference, waist circumference and body mass (Table 2).

When comparing the changes obtained with the training programs between the groups, significant differences were found in fat mass, with a considerable loss in the ST+HIIT group (Figure 1). Despite no statistically significant differences recorded in the other variables, a moderate effect size between the groups in terms of visceral fat (decreased for ST+HIIT) and a large effect in terms of body water and fat-free mass (decreased for HIIT) were observed.

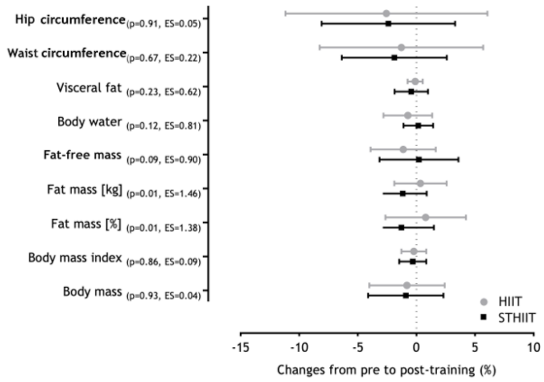

Figure 1. Changes from pre- to post-training

Discussion

The purpose of the study was to compare the effects of high-intensity interval aerobic training (HIIT) with strength training followed by HIIT (ST+HIIT) in the body composition of young adults. A significant improvement of body composition was reported in the combined strength and high-intensity interval aerobic training group after 8 weeks of intervention. These results corroborate the hypothesis that combined strength training and aerobic high-intensity interval training induces body composition improvements. Despite the changes in body fat mass, the fat-free mass did not change in the ST+HIIT subjects. This fact might be explained by the short duration of the training protocol (8 weeks) that could not be enough to elicit significant improvement in lean mass. Nevertheless, this period of intervention in ST+HIIT was sufficient to significantly improve other anthropometric variables, specifically hip and waist circumferences. These findings are consistent with previous studies [12, 19], where the authors observed no significant changes in lean mass after a 6- or 4-week intervention period of high-intensity interval training, respectively [12, 19]. Curiously, a significant decrease in fat-free mass was shown after the HIIT intervention. These results could be explained either by a possible demotivation associated with HIIT, negatively influencing the quality of the workout, or by the non-existence of an adequate stimulus for enhancing fat-free mass, such as the phenomenon of muscle hypertrophy [5]. High-intensity interval training has emerged as an efficient alternative to conventional training methods due to its effects on different variables and populations [8, 23]. It is considered as an interesting time-efficient method to the improvement in physical conditioning, weight loss and body composition [2, 4]. Remarkably, the present study reported significant improvements in fat mass (–6.6%), waist circumference (–2.3%) and hip circumference (–2.4%) in the ST+HIIT group after the 8-week intervention. To support our findings a recent meta-analysis showed that a short-term intervention of high-intensity exercise training can improve body fat (~2 kg) and waist circumference (~3 cm) in adults [27]. The limited time available is stated to be an obstacle for many adults to practice physical activity [26], thus an intense exercise method with less demand for time may provide an appropriate strategy to produce modest improvements in the body composition. Interestingly, the absence of a significant difference in visceral fat was reported in both experimental groups. In contrast, a meta-analysis [25] examining the effects of exercise and caloric restriction on visceral adipose tissue loss found that exercise is related to a 6.1% decrease in visceral fat, regardless of a lack of a reduction in body weight. In the meta-analysis 84% of the studies applied a long-term intervention (≥12 weeks). A possible mechanism underlying these distinct effects on visceral effects could also be related to the duration of the intervention period, which in our study was a short-term intervention. In order to provide a possible answer to the question of the study, according to the obtained results the strength component seems to be a boost for the high-intensity interval aerobic training, assisting to improve the body composition in young adults after the 8-week intervention. This important fact could be an update to previous evidence. Kessler et al. [16] in their systematic review study concluded that a short-term HIIT protocol (≤10 weeks) was slightly useful in providing significant modifications in anthropometric variables. Moreover, combining strength and high-intensity interval aerobic training seems to be more effective than high-intensity aerobic training alone to achieve body fat loss and perimeters improving body composition in young adults. Our data provide interestingly dose-response effects of exercise-related with body composition. Notwithstanding the interesting findings revealed in our study, some limitations should be acknowledged: (i) the number of subjects was relatively low, where adding more participants could have provided more statistical differences in body composition parameters; (ii) our study is a two-group pre-test and post-test design without a control group, which may limit the generalizability of our results; (iii) the absence of subcutaneous adiposity fold measures and also nutrition parameters; (iv) the non-existence of a group without any training intervention, which could facilitate a comparison of experimental groups with a control group. For future investigations a large and prospective study could be interesting to establish the best HIIT protocols for decreasing visceral fat (i.e. another component of body composition), or even to introduce physical fitness parameters to measure in both training programs.

Conclusions

Our data suggest that an 8-week program of combined strength and high-intensity interval aerobic training (ST+HIIT) significantly improved the body composition of young adults when properly supervised. Differences in body fat (percentage and absolute values), waist and hip circumferences were found in ST+HIIT, while a significant decrease in fat-free mass of HIIT was reported. Specifically, the outcomes of the present study provided information concerning the effects of combined strength and high-intensity interval aerobic training with favorable changes in the body composition of young adults.

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Conflict of Interests

The authors declare no conflict of interest.

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