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Does the Intensity of an Exercise Programme Modulate Body Composition Changes?

Abstract

Exercise training is a useful component of weight maintenance programmes. Although energy expenditure, not intensity or duration, seems to determine the amount of weight loss attributable to exercise, it is not clear whether changes in the components of body mass are also insensitive to these parameters. Thus, the aim of the present study was to compare the effect of two isoenergetic exercise training programmes, one of low and one of high intensity, on body composition. Fourteen healthy premenopausal untrained women were divided into two equivalent groups, which exercised on treadmill at 45 or 72 % of $\dot{V}O_{2max}$ four times a week for three months, spending 1548 kJ (370 kcal) per exercise session. No dietary intervention was applied. Body mass decreased significantly in both groups but more in the low-intensity than the high-intensity group (by mean ± SD, 3.3 ± 1.3 vs. 1.9 ± 0.9 kg, $p = 0.032$). The decrease in fat mass was significant in both groups (3.1 ± 1.2 vs. 2.4 ± 1.5 kg, respectively) but not significantly different between them. Fat-free mass did not change significantly in either group, although the difference between groups tended to be significant (decrease by 0.2 ± 0.7 kg in the low-intensity group vs. increase by 0.5 ± 0.6 kg in the high-intensity group, $p = 0.058$). In conclusion, exercise training at 45 % of $\dot{V}O_{2max}$ without dietary restriction produced a higher weight loss than at 72 % of $\dot{V}O_{2max}$, whereas the higher intensity tended to maintain fat-free mass, possibly, in part, through the smaller weight loss. Thus, both programmes may prove useful in eliciting favourable changes depending on which target (weight loss or maintenance of fat-free mass) is of higher priority.

Key words
Body weight · body fat · exercise training · weight loss

Introduction

The combination of dieting and exercise is considered to be the most effective behavioural approach for weight loss, and the maintenance of exercise may be one of the best predictors of long-term weight maintenance [9]. Endurance exercise seems to be the most useful kind of exercise in a weight management programme, as resistance exercise has not been shown to increase weight loss or attenuate the loss of fat-free mass typically accompanying weight loss, despite its clear advantages in increasing muscular strength and function [9].

Although the weight loss attributable to endurance exercise appears to be mainly dictated by total energy expenditure regardless of intensity or duration, it is not clear whether changes in the components of body mass are also insensitive to these parameters. The relevant literature is limited and heterogeneous in terms of sex, body fatness, intensities compared, and dietary intervention [1, 4, 7, 10, 11, 13]. There is also a study in which the two

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training protocols of different intensity compared, produced no change in body weight [14], thus limiting the possibilities to detect differences in body composition, and another study, in which adherence to the training programmes was too low to permit testing of the intensity hypothesis [8]. Finally, studies have investigated the influence of exercise intensity on body composition without having controlled for energy expenditure [2,3,6].

Therefore, the aim of the present study was to enrich the existing body of knowledge by comparing the effect of two isoenergetic exercise training programmes of different intensities on the body composition of healthy untrained women. We hypothesized that, in accordance with the majority of the relevant studies, intensity would not affect the changes in body composition.

Materials and Methods

Participants

Fourteen eumenorrheic women (menstrual cycle, 21 – 35 days), who responded to a public invitation, participated in the study. Subjects were normal-weight to overweight based on body mass index (ranging from 22 to 28 $kg \cdot m^{-2}$), were not suffering from any apparent illness, and were not taking any medication or dietary supplement. They had had experience with exercise training in the past but refrained from regular exercise (defined as at least three times a week, 30 min each time at 45% of $\dot{V}O_{2max}$) for at least one month before entering the study. Additionally, they had not dieted to lose weight and had had a stable weight for at least three months before entering the study. All participants were informed orally and in writing of the design and possible risks of the study and consented to participate. The study was designed and carried out according to the guidelines of the institutional Ethics Committee.

Maximal oxygen uptake

Each participant was subjected to an incremental maximal test on a motor-driven treadmill, aimed at eliciting exhaustion within 7 – 11 min. Subjects reported to the laboratory 3 h after having consumed a light meal and after having abstained from vigourous exercise for three days. They warmed up for 6 – 8 min, beginning at 4 $km \cdot h^{-1}$ and finishing at 6 $km \cdot h^{-1}$, and then started the test at 7 $km \cdot h^{-1}$ for 2 min. Speed was increased by 2 $km \cdot h^{-1}$ every 2 min until volitional exhaustion. The treadmill remained horizontal during all steps. Ventilatory and gas exchange responses were measured continuously with an automated open-circuit system (TrueMax 2400, Parvo Medics, Sandy, UT, USA). Heart rate was monitored continuously by a Polar Accurex monitor (Kempele, Finland). Criteria for achievement of $\dot{V}O_{2max}$ were plateauing of oxygen uptake in spite of an increase in speed, a respiratory exchange ratio above 1.14, and a heart rate value at least equal to the age-predicted value (220 – age).

Body composition

Body composition was assessed between the 2nd and 12th day of the menstrual cycle, after a day of abstinence from vigourous exercise and at least 3 h after a meal. Body mass was measured to the nearest 0.1 kg by an electronic balance (Seca, Hamburg, Germany). Height was measured to the nearest 0.1 cm by a stadiometer incorporated in the balance. Body density was measured by hydrostatic weighing and was converted to percent body fat through the equation of Siri [12]. The VacuMed (Ventura, CA, USA) system equipped with the HydroWT2 software was used for the body composition analysis.

Exercise parameters

Based on the results of the baseline measurements, the participants were divided into two equal groups ($n = 7$) of similar age, body mass, percent body fat, and $\dot{V}O_{2max}$. Each group was then randomly assigned to a low-intensity or high-intensity exercise training programme. For each member of the former group, we calculated the treadmill speed corresponding to 45% of her $\dot{V}O_{2max}$ ($l \cdot min^{-1}$) and the duration necessary to produce an energy expenditure of 1548 kJ (370 kcal), based on an equivalence of 21 kJ to 1 l of O_2. For each member of the latter group, we calculated the treadmill speed corresponding to 72% of her $\dot{V}O_{2max}$ and the duration necessary to produce the same energy expenditure. The choice of speed and duration was verified by subjecting two members of each group to an exercise session while analyzing expired air.

Training

Each participant performed a supervised exercise session having the intensity and duration described above four times a week (on average) for three months, thus completing 50 sessions. We instructed the participants not to modify their dietary or activity habits during this period and repeated this instruction at regular intervals. Apart from this, we did not apply any dietary intervention in order not to affect a possible influence of exercise intensity on appetite. Within 1 – 3 d after completion of the training programme we reassessed the body composition of each participant as described above.

Nutrition

To evaluate the participants' nutrition, we asked them to keep a three-day food record in the middle of the study. Dietary records were analyzed in Microsoft® Access by the use of a food database created in our laboratory on the basis of published data [5].

Statistics

Results are reported as the mean ± SD. The distribution of all dependent variables was examined by the Kolmogorov-Smirnov test and was found not to differ significantly from normal. Significant differences with respect to exercise intensity and time were detected by two-way ANOVA with repeated measures on time. Pairwise comparisons were performed through simple main effect analysis. Baseline values and changes in body composition with exercise training in the two groups were compared by two-tailed Student's *t*-test for independent samples. The level of statistical significance was set at $\alpha = 0.05$ for all tests. The SPSS (version 10.0) was used for all analyses. Finally, to determine the meaningfulness of the effect of intensity on body composition changes, effect sizes were calculated as the difference between means divided by the pooled SD.

Results

Baseline characteristics of the two groups are presented in Table **1**. There were no significant differences between the groups. It is

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Table **1** Baseline characteristics of the participants

Parameter	*Low-intensity group (n = 7)*	*High-intensity group (n = 7)*
Age (yr)	31 ± 9	30 ± 9
Body mass (kg)	68.7 ± 8.7	64.1 ± 6.3
Height (m)	1.66 ± 0.06	1.61 ± 0.06
Body mass index ($kg \cdot m^{-2}$)	24.8 ± 2.3	24.6 ± 1.7
Body fat (%)	33.2 ± 4.6	33.0 ± 3.3
$\dot{V}O_{2max}$ ($l \cdot min^{-1}$)	2.31 ± 0.33	2.34 ± 0.34
$\dot{V}O_{2max}$ ($ml \cdot kg^{-1} \cdot min^{-1}$)	34.0 ± 5.6	36.6 ± 3.8

Table **2** Body composition of the participants at the onset and end of a three-month training programme at different exercise intensities but equal energy expenditure

Parameter	*Low-intensity group*		*High-intensity group*	
	Onset	*End*	*Onset*	*End*
Body mass (kg)	68.7 ± 8.7	65.4 ± 8.9*	64.1 ± 6.3	62.2 ± 5.9*
Body fat (%)	33.2 ± 4.6	30.1 ± 5.6*	33.0 ± 3.3	30.2 ± 2.9*
Fat mass (kg)	23.0 ± 5.7	20.0 ± 5.9*	21.1 ± 2.9	18.8 ± 2.3*
Fat-free mass (kg)	45.7 ± 4.2	45.4 ± 4.6	42.9 ± 4.7	43.4 ± 4.7

* Significantly different from onset ($p \leq 0.001$)

notable that, although the participants met the body mass index criterion for non-obesity, their percentage body fat was quite high, ranging from 26.5 to 39.2 and averaging values that characterize obese individuals.

The low-intensity group exercised at 6.7 ± 0.3 $km \cdot h^{-1}$ for 62 ± 5 min per session, whereas the high-intensity group exercised at 9.1 ± 0.8 $km \cdot h^{-1}$ for 43 ± 6 min per session. Both protocols were well tolerated by the subjects, had equal participation, and no adverse events were observed or reported. Food intake was similar in the two groups and averaged 8453 kJ (2020 kcal) daily, derived from carbohydrates by 50%, lipids by 33%, and proteins by 17%.

Body composition data at the onset and end of the study are presented in Table **2**. Body mass decreased in all participants; the decrease was significant in the whole sample and in each group ($p \leq 0.001$). Additionally, there was a significant interaction of intensity and time because the decrease in the low-intensity group was higher than in the high-intensity group ($p = 0.032$).

Percentage body fat and fat mass decreased in all participants; the decrease was significant in the whole sample and in each group ($p \leq 0.001$). There were no significant differences between groups with respect to these two parameters.

Finally, fat-free mass decreased in most (five) of the members of the low-intensity group and increased in most (six) of the members of the high-intensity group. The interaction of intensity and time was borderline significant ($p = 0.058$), as was the increase in the high-intensity group ($p = 0.070$).

The Fig. **1** summarizes the body composition changes observed. The effect size of intensity was 1.30 on body mass change, 0.53 on fat mass change, and 1.12 on fat-free mass change.

Discussion

We have examined whether exercise intensity modulates the body composition changes elicited by a three-month training programme in healthy untrained women. Body composition changes are often overlooked in weight management programmes, body mass being the outcome measure receiving the prime interest. However, fat mass reduction rather than body mass reduction, along with maintenance of fat-free mass should be the actual targets of such programmes. Exercise training is indispensable to this end but the most effective exercise prescription is still debatable. As mentioned in the Introduction, endurance exercise is preferred to resistance exercise but the optimal intensity and duration of it, especially with regard to body composition changes, not just body mass changes, is yet to be determined. The present study aimed at contributing to the elucidation of this issue.

The average weight loss of all participants (2.6 kg) was in good agreement with the energy deficit caused by exercise (50 sessions · 1548 kJ/session = 77404 kJ, or 18 500 kcal, assuming an energy equivalent of 7700 kcal/kg of tissue). Nevertheless, since energy intake was not measured prior to training, it cannot be excluded that the observed weight loss was due to the fact that subjects reduced energy intake along with participation in the

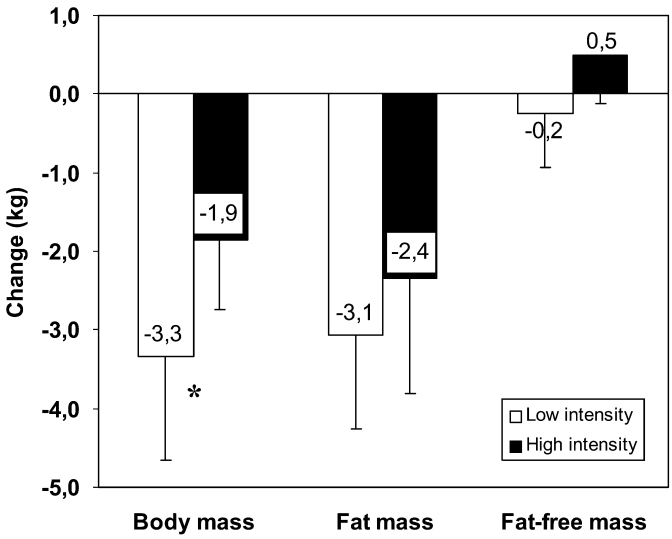

Fig. **1** Changes in body composition parameters during the study. Fat-free mass was calculated as body mass minus fat mass. * Significant difference between groups ($p = 0.032$).

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training programmes. The weight loss of the low-intensity group was significantly higher than that of the high-intensity group (by 1.4 kg), with a large effect size. This may be due to different effects of the two intensities on the dietary and physical activity habits of the participants. For example, high-intensity exercise might more effectively stimulate appetite and/or encourage relaxation after exercise periods.

Half of the difference between groups was due to a difference in fat mass loss and half to a difference in fat-free mass change, the latter being borderline significant and with a large effect size. The difference in fat-free mass change between the training protocols either suggests that high-intensity endurance exercise elicits some degree of muscle hypertrophy in untrained women or simply reflects the fact that it was less effective in reducing body weight or is due to a combination of the two. A significant attenuation of fat-free mass loss with high- compared to low-intensity endurance training (– 1.5 vs. – 2.5 kg) in a weight loss programme involving dietary restriction has been reported [11] and has been attributed (on a hypothetical basis) to an increased secretion of growth hormone and a recruitment of fast-twitch muscle fibers (which are prone to hypertrophy) with high-intensity exercise. Additionally, Grediagin et al. [7] observed a considerably (although not significantly) higher increase in fat-free mass with isoenergetic high- compared to low-intensity endurance training (4.2 vs. 1.8 kg) without dietary restriction.

Contrary to the evidence for an effect of intensity on fat-free mass change presented above, the other relevant papers [1,4,10,13] show no effect. Additionally, all papers (including ours) show no effect of intensity on fat mass change. In terms of total body mass change, all other studies show no effect of intensity, although the study most similar to ours in terms of sample, training protocols, and (no) dietary intervention [7] has found that only the low-intensity programme produced a significant weight loss.

In conclusion, with the reservation of the small sample size, our results indicate that exercise training of women at 45% of $\dot{V}O_{2max}$ without dietary restriction produced a higher weight loss than at 72% of $\dot{V}O_{2max}$, whereas the higher intensity tended to maintain fat-free mass, possibly, in part, through the smaller weight loss. Thus, both programmes may prove useful in eliciting favourable changes depending on which target (weight loss or maintenance of fat-free mass) is of higher priority.

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