Exercise intensity does not effect body composition change in untrained, moderately overfat women

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ABSTRACT

Objective To determine whether exercise intensity effects a change in body composition.

Design/Subjects Twelve untrained, moderately overfat, weight-stable women were randomly assigned to a high-intensity (80% \( V_{0,\text{max}} \)) or low-intensity (50% \( V_{0,\text{max}} \)) exercise group. Subjects trained four times per week for 12 weeks in monitored sessions, with a duration sufficient to expend 300 kcal. During this time, subjects were instructed to maintain their normal diet and activity patterns.

Outcome measures Pretesting and posttesting included measurement of height, weight, body fat (via hydrostatic weighing), seven skinfold sites, seven circumference sites, and \( V_{0,\text{max}} \).

Statistical analyses Results were analyzed using the Student's t test and paired samples t test.

Results Posttesting revealed no significant between-group differences for change in weight, percent body fat, fat mass, fat-free mass, sum of skinfold measurements, or sum of circumference measurements. Mean weight loss was 0.7 lb for the high-intensity group (\( P=.55 \)) and 3.3 lb for the low-intensity group (\( P=.03 \)). Hydrostatic data revealed that each group lost an identical amount of fat (5.0 lb), but the high-intensity group gained more than twice as much fat-free mass (4.3 vs. 1.8 lb). The greater increase in fat-free mass by the high-intensity group explains why the low-intensity group had a greater absolute weight loss.

Applications/conclusions This study suggests that fat loss is a function of energy expended rather than exercise intensity. Therefore, if fat loss is the goal and time is limited, persons should exercise safely at as high an intensity as tolerable to expend as much energy as possible during their allotted time. *J Am Diet Assoc.* 1995; 95:661-665.

Obesity, which is defined as excessively high body fat in relation to lean body mass, is a major health problem in the United States (1). Several studies (2) suggest that there has been a progressive increase in the ratio of weight to height during the past 100 years in industrial societies, and the trend is not slowing. The National Institutes of Health identifies one quarter to one third of the US population as overweight (3). As many as 40% of women and 24% of men are trying to lose weight at any given time (3).

Historically, obesity has been viewed as a result of poor eating habits. Recent evidence (4,5), however, indicates that inactivity may be more important than overeating as a cause for obesity. Recent studies (6-8) show that exercise is useful, if not critical, for long-term weight control.

Current exercise recommendations established by the American College of Sports Medicine call for low- to moderate-intensity regimens of greater frequency and duration (9). However, research supporting the intensity portion of the recommendation is lacking. It is not clear whether the intensity of the activity makes a difference, or if body composition change is simply related to the total energy expended.

Normally, at intensities exceeding 60% to 70% maximum oxygen consumption (\( V_{0,\text{max}} \)), there is a progressively greater dependence on carbohydrate as a fuel source (10,11). At 80% \( V_{0,\text{max}} \), carbohydrate provides 95% to 100% of the energy requirement. In contrast, exercise of long duration (90 to 240 minutes) at a lower intensity (50% to 60% \( V_{0,\text{max}} \)) uses proportionally less stored carbohydrate and increases reliance on lipids (12,13). This phenomenon is the basis for the recommendation that, for the greatest loss of body fat, exercise should be of lower intensity and longer duration (10,12). However, Wood (5), in a series of randomized controlled trials, found that sedentary men who began jogging lost body fat in proportion to total miles run. But Wood did not control intensity of exercise as a variable in these trials.

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Table 1
Preexercise means (± standard deviation) of physical characteristics for the high- and low-intensity exercise groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Exercise intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High (n=6)</td>
</tr>
<tr>
<td></td>
<td>Low (n=6)</td>
</tr>
<tr>
<td>Age (y)</td>
<td>30±5</td>
</tr>
<tr>
<td>Race</td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>2</td>
</tr>
<tr>
<td>White</td>
<td>4</td>
</tr>
<tr>
<td>Height (in)</td>
<td>66.50±1.75</td>
</tr>
<tr>
<td>Weight (lb)</td>
<td>150±13</td>
</tr>
<tr>
<td>Body mass index&lt;sup&gt;a&lt;/sup&gt;</td>
<td>23.8±2.3</td>
</tr>
<tr>
<td>% Body fat (hydrostatic)</td>
<td>31.1±3.8</td>
</tr>
<tr>
<td>V̇O&lt;sub&gt;2&lt;/sub&gt;max (mL x min&lt;sup&gt;−1&lt;/sup&gt;)</td>
<td>2,159±437</td>
</tr>
<tr>
<td>V̇O&lt;sub&gt;2&lt;/sub&gt;max (mL x kg&lt;sup&gt;−1&lt;/sup&gt; x min&lt;sup&gt;−1&lt;/sup&gt;)</td>
<td>31.5±3.8</td>
</tr>
</tbody>
</table>

<sup>a</sup>Significant (P<0.05) between-group difference determined by Student’s independent t-test.
<sup>b</sup>Calculated as kg/m<sup>2</sup>.

In 1980, Ballor (14) studied the effect of a 1,200 kcal/day diet combined with high- or low-intensity exercise, on body composition change. On the basis of the respiratory quotient, Ballor calculated that during high-intensity exercise (80% to 90% V̇O<sub>2</sub>max), 74.1% of the energy was derived from carbohydrate, compared with 33.4% during low-intensity exercise (40% to 50% V̇O<sub>2</sub>max). He postulated that because the low-intensity exercise group emphasized the use of fat as fuel, they would experience a greater change in body composition. However, posttesting revealed no significant difference between the body composition changes of the two groups (14). Explanations for the lack of significant between-group difference in body composition change include the fact that the frequency and duration of the exercise may not have been sufficient to elicit a change; that dietary habits may have changed as a result of the intensity of exercise; or that total energy expended, not exercise intensity, may be the most important factor for loss of body fat (14).

The findings of Tremblay et al (15) contradict those of Ballor. They studied 1,386 women and 1,257 men and found less subcutaneous fat in subjects who regularly practiced vigorous physical activities. This result persisted, even after statistical correction for energy expended during exercise. This indicates that the effect of exercise on body fat was not attributable to the energy cost of the activity, but rather to an effect on another component of energy balance. The investigators theorized that high-intensity exercise may decrease energy intake by increasing exercise-induced catecholamines (15). Catecholamine levels increase in direct response to the intensity of an exercise (4,16), and are thought to decrease appetite (17). Therefore, high-intensity exercise may cause a greater suppression of appetite, which would lead to lower stores of body fat.

In a later study, Tremblay et al (18) showed that diet composition is a major determinant of the magnitude of energy deficit produced by aerobic exercise. They investigated the effect of 60 minutes of exercise on energy balance under three dietary regimens: low fat, mixed, and high fat. Results showed that in the low-fat and mixed diet, postexercise energy intake did not compensate for energy expended during the exercise.

However, when a high-fat diet was eaten, intake was sufficient to fully compensate for the energy deficit resulting from exercise. However, because exercise intensity during this study was constant at 55% to 60% V̇O<sub>2</sub>max, it is not known if results would have been similar for exercise at a higher intensity.

During a 6-month period, Sweeney et al (19) evaluated the effect on body composition of severe energy restriction (60%) or moderate energy restriction (30%) coupled with exercise. They found that loss of body fat was greater for the group that was severely restricted than for the group that was moderately restricted; exercise had no significant effect. They further determined that although the group with severe energy restriction had a greater loss of fat-free mass, resting metabolic rate did not differ because of diet or exercise when expressed per unit of fat-free mass (19).

Unfortunately, because of conflicting studies and lack of published research, the impact of exercise intensity on body fat stores is still unclear. The purpose of this study was to determine whether exercise intensity affects a change in body composition.

SUBJECTS
We recruited subjects from the student body, staff, and faculty of Georgia State University, Atlanta. Eighteen candidates who were accepted into the study met the criteria for age (25 to 40 years), weight stability (less than a 5-lb fluctuation in the past 6 months), current diet (not on any type of special diet), training status (untrained, defined as exercising less than 30 minutes/day, 3 times per week), medications (not on any prescribed medication other than birth control pills), use of tobacco products (nonsmokers), and health (no current conditions for which exercise would be contraindicated). Table 1 describes the physical characteristics of the 12 subjects who successfully completed the study. Fourteen subjects were black and four were white. We did not attempt to control for the subject’s stage in menstrual cycle.

PROTOCOL
All subjects completed a prescreening questionnaire, a medical history questionnaire, and a human subject consent form. Subjects were randomly assigned to the high-intensity (n=9) or low-intensity (n=9) exercise group upon acceptance into the study. Persons in the high-intensity group exercised at 80% of their maximum aerobic capacities (V̇O<sub>2</sub>max), and those in the low-intensity group exercised at 50% of their V̇O<sub>2</sub>max. For 12 weeks, subjects exercised four times per week on a treadmill. Duration was adjusted to elicit an energy expenditure of 300 kcal per session. All exercise sessions were monitored.

Preexercise and postexercise data collection included the following: hydrostatic weighing, skinfold and circumference measures, V̇O<sub>2</sub>max, and dietary assessment. Body density was determined by hydrostatic weighing as described by Katz et al (20). Residual volume was measured by the oxygen dilution technique described by Wilmore et al (21). Body density was converted to relative percent fat using the equation of Lohman et al (22). The mean value of three repeat measurements on seven skinfold and seven circumference sites was calculated. Skinfold sites included the triceps, subscapular, chest, axilla, supraillium, abdomen, and thigh. Circumference sites measured were the wrist, chest, waist, abdomen, glutals, midthigh, and calf.

We administered a treadmill test using a protocol described by Davis et al (23). The treadmill test protocol consisted of 1-minute stages with incremental speed or grade increases. We determined an exercise prescription for the high- and low-
Table 2 Mean (± standard deviation) preexercise to postexercise changes for weight, percent body fat, fat mass, fat-free mass, sum of skinfolds, sum of circumferences, \( \text{VO}_2\max \), and body mass index for high- and low-intensity groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Exercise intensity</th>
<th>Difference between-group</th>
<th>P value *</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High (n=8)</td>
<td>Low (n=6)</td>
<td></td>
</tr>
<tr>
<td>Weight (lb)</td>
<td>-0.7 ± 2.6</td>
<td>-3.3 ± 2.5 *</td>
<td>.115</td>
</tr>
<tr>
<td>Body mass index</td>
<td>-0.1 ± 0.4</td>
<td>-0.6 ± 0.5 *</td>
<td>.078</td>
</tr>
<tr>
<td>% Body fat (hydrostatic)</td>
<td>-3.4 ± 4.1</td>
<td>-2.8 ± 5.1</td>
<td>.927</td>
</tr>
<tr>
<td>Sum of skinfolds (mm)</td>
<td>-16.1 ± 7.0 *</td>
<td>-15.8 ± 6.5 *</td>
<td>.947</td>
</tr>
<tr>
<td>Sum of circumferences (cm)</td>
<td>-7.0 ± 4.5 *</td>
<td>-11.4 ± 6.8 *</td>
<td>.223</td>
</tr>
<tr>
<td>Fat mass (lb)</td>
<td>-5.0 ± 5.8</td>
<td>-5.0 ± 5.8</td>
<td>.992</td>
</tr>
<tr>
<td>Fat-free mass (lb)</td>
<td>4.3 ± 4.0</td>
<td>4.0 ± 3.9</td>
<td>.417</td>
</tr>
<tr>
<td>( \text{VO}_2\max ) (ml x min (^{-1}))</td>
<td>209±359</td>
<td>234±278</td>
<td>.893</td>
</tr>
<tr>
<td>( \text{VO}_2\max ) (ml x kg (^{-1}) x min (^{-1}))</td>
<td>3.6±6.0</td>
<td>4.2±4.4</td>
<td>.831</td>
</tr>
</tbody>
</table>

*aDetermined using Student’s independent values t test. Significance set at P<.05, no differences were significant.

*bSignificant (P<.05) preexercise to postexercise within-group change determined by Student’s paired t test.

Intensity groups by regression analysis of the subject’s maximal oxygen uptake. Speed and grade were manipulated to elicit an 80% (high intensity) or 50% (low intensity) effort. Duration was determined by calculating the length of time each subject would need to exercise to expend approximately 300 kcal. We assessed the accuracy of the exercise prescription during weeks 2 and 6 of the study by analyzing expired gases after subjects had been exercising for at least 10 minutes. Adjustments were made to the prescription until analysis of expired gases indicated the speed and grade were sufficient to elicit the desired intensity.

A co-investigator analyzed the effect of exercise intensity on spontaneous dietary changes. Subjects were instructed to make no intentional changes to their current diets and activity patterns for the duration of the study. Dietary evaluation involved an initial self-recorded 4-day food record form with follow-up 4-day food and activity records at weeks 6 and 12. Subjects received instruction for the proper method of completing their diet and activity records. We analyzed diet for energy and composition using the US Department of Agriculture Nutrient Data Base for Standard Reference (Version 3, 1991, Noursecheck, Atlanta, Ga).

Data Analysis

We used the SPSS/PC+ (SPSS Inc; Chicago, Ill) software package for analysis of data. Descriptive statistics, including sample means, group means, standard deviations, and ranges, were calculated. Between-group mean differences were determined using the Student's independent values t test. A paired samples t test was used to determine preexercise to postexercise within-group change. A Pearson product-moment correlation coefficient was determined between all variables. Significance was established at P<.05.

RESULTS

Of the 18 participants, 12 completed the protocol as directed. Five participants dropped out during the first half of the study because of time constraints. The other participant completed the study but did not complete posttesting. All of the remaining 12 subjects completed 48 exercise sessions at their prescribed work rate. Posttesting took place within 3 days after subjects' last exercise session.

Student's t test comparison of means showed that there were no significant between-group differences for change in weight, percent body fat, sum of skinfold measures, sum of circumference measures, or \( \text{VO}_2\max \). Table 2 lists mean preexercise to postexercise changes for the high- and low-intensity groups.

Both the high- and low-intensity groups lost an identical amount of fat mass (5 lb), despite the fact that the low-intensity group lost 3.3 lb on the scale and the high-intensity group lost only 0.7 lb. This discrepancy can be explained by examining the change in fat-free mass (the high-intensity group gained 4.3 lb whereas the low-intensity group gained only 1.8 lb). For both groups the change in fat mass correlated negatively with the change in fat-free mass (average r=−.86). Change in fat mass and change in fat-free mass were negatively correlated (r=−.86).

Within-group preexercise to postexercise changes in sums of skinfolds and circumferences were significant (P<.05), but there were no significant between-group differences (Table 2). For the skinfolds, both groups had a similar (high=16.1 mm vs low=15.8 mm) decrease in the sum of seven skinfold measurements; site of loss did not differ between the groups (Figure 1). However, the sum of circumference measurements for the high-intensity group decreased 7.0 cm and for the low-intensity group 11.4 cm, a between-group difference of 4.4 cm (Figure 2). Most of the between-group difference can be accounted for by examining the change in the gluteal and waist measurements. The low-intensity group lost a total of 7.9 cm from the waist and gluteal sites, and the high-intensity group lost only 2.5 cm; a between-group difference of 5.4 cm.

Analysis of food and activity records indicated that there were no preexercise to postexercise changes in intake (macronutrient or micronutrient) or activity. Food intake was similar for both groups and averaged 1,830 kcal with 37% from fat, 48% from carbohydrate, and 15% from protein.

DISCUSSION

Estimated weight loss, on the basis of total energy expenditure as a result of the exercise, was 4.1 lb (12 weeks×4 sessions/week×300 kcal/session=14,400 kcal). Actual weight loss for the high-intensity group was 0.7 lb; the low-intensity group lost 3.3 lb (P=.115). This greater weight loss by the low-intensity group may incorrectly lead some persons to believe the change in body composition had also been greater. However, weight alone is not a good indicator of body composition change. Evaluation of weight alone does not reveal the change in fat or fat-free mass. As expected, both groups gained fat-free mass as
a result of the exercise. However, the high-intensity group gained 2.5 lb more fat-free mass than the low-intensity group. This difference could be attributed to the fact that the high-intensity group, as a result of exercising at a higher intensity, had a greater increase in the muscle and/or glycogen stores. Therefore, even though both groups lost an identical 5 lb of fat mass, the low-intensity group showed a greater loss on the scale.

For both groups, the negative correlation between fat mass and fat-free mass indicates that, even as fat is lost, it is possible to gain fat-free mass. If the increase in fat-free mass is attributable to muscle hypertrophy rather than increased glycogen stores or other nonmuscle components of fat-free mass, resting metabolic rate may increase, which would be beneficial for long-term weight control.

It is important to know the components of weight loss. Therefore, the best indicator of body composition change is one that predicts change in fat mass and fat-free mass. From a practical standpoint, most people want to know how much fat they lost and, perhaps more importantly, where they lost fat. In
this study hydrostatic weighing was used to predict body composition because it is considered the gold standard. However, hydrostatic weighing is not practical in most settings. A more practical and user-friendly method of assessing body composition uses anthropometric measures. Most validation studies indicate that the change in percent body fat determined by anthropometric measures correlates well with the change predicted by hydrostatic weighing (24). In reality, the use of skinfold and circumference measures may actually be of greater use to the clinician because, not only do they predict body composition change, but they may also give an indication of where that change took place.

In this study there was no difference between the high- and low-intensity groups for either the total loss, or site of loss, for skinfold measurements (Figure 1). These findings are consistent with the fact that both groups lost the same amount of fat mass. However, analysis of circumference measure data shows that, overall, the low-intensity group experienced a 38% greater loss of circumference measures (11.4 cm) than the high-intensity group (7.0 cm). This finding is consistent with the fact that the high-intensity group gained more fat-free mass than the low-intensity group. The major differences in circumference occurred at the gluteals. The high-intensity group had a 5.1 cm loss from the gluteals, whereas the high-intensity group lost only 1.6 cm. For the waist, the low-intensity group lost 2.8 cm; the high-intensity group lost 0.9 cm. This difference may be explained by the greater increase in fat-free mass in the high-intensity group. This fat-free mass may have been in the form of gluteal and abdominal/back muscle or gluteal and abdominal/back intramuscular glycogen stores. An increase in either would offset the change in circumference because of fat loss.

In a practical sense, if low-intensity exercise causes a greater decrease in gluteal and waist measurements, it may be more motivating for a person to exercise at that intensity. Too often people start an exercise program and get discouraged when they do not see results from their exercise. If exercisers get positive feedback by having their clothes fit more loosely or by seeing a change on the scale, they may be more likely to adhere to their exercise regimen.

APPLICATION

Because this study suggests that loss of fat mass is related more to total energy expended than to exercise intensity, people should exercise at the intensity that best fits their needs. When prescribing exercise, several factors should be considered. The fact that low-intensity exercise may cause a greater change in total weight, gluteal circumference, and waist circumference may be an important incentive for continued participation in an exercise program. However, if the greater increase in fat-free mass experienced by people who exercise at a high intensity is associated with an increase in muscle mass, resting metabolic rate would increase, which may improve the long-term prognosis for weight control.

Another important variable to consider when prescribing exercise is the person’s desires. Knowing that total energy expenditure is the most important factor for body composition change will allow each person to tailor an exercise program to his or her particular desires, abilities, and time constraints. Clinicians should work with clients to construct a realistic exercise program. If body composition change is the goal, and time is limited, persons should be encouraged to work safely at as high an intensity as possible for their allotted time. Conversely, if time is not a factor, as for some retirees, people should be encouraged to work for a longer duration at a lower intensity. This would reduce the risk of injury and keep the person busy, decreasing time available for unhealthful snacking and other undesirable habits.

References