Influences of Low Intensity Exercise on Body Composition, Food Intake and Aerobic Power of Sedentary Young Females

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Abstract. The present study was designed to investigate the influences of aerobic training on the body composition, aerobic power and food intake of sedentary young females in relation to the initial levels of these variables. Thirty one untrained college females (age=19.8 ± 0.2 yr, stature=154.4 ± 0.8 cm, body mass=53.3 ± 1.2 kg, mean ± SEM) participated in an exercise regimen consisting of 40% of maximum oxygen uptake (VO2max) for 30 minutes per day on a bicycle ergometer 5 times a week in a training period of 12 weeks. Food consumption was ad libitum but the content of daily food intake was recorded accurately throughout the whole training period and analyzed weekly. The average body mass index (BMI) and fat mass relative to body mass (%FM), estimated from the data of skinfold thickness, decreased significantly after the 12 wk training. There were significant negative correlations between the relative changes (%∆) and initial levels of both body mass (r= -0.447, p<0.05) and fat mass (r= -0.638, p<0.05), but the corresponding correlation for lean body mass (LBM) was not significant (r=0.186, p>0.05). While the energy intake during the training period did not differ significantly from that during the control period on the average, the %∆ value in energy intake between the two periods was negatively correlated to the energy intake during the control period (r= -0.604, p<0.05). In addition, there were low but significant negative correlations between both the initial levels of BMI and %FM and %∆ in energy intake; r= - 0.413 (p<0.05) for BMI and r= - 0.393 (p<0.05) for %FM. However, no significant correlations were found between %∆ in energy intake and those in body composition variables (r=0.116 to 0.237, p>0.05).

On the average VO2max relative to body mass (VO2max/BM) increased significantly, but VO2max relative to LBM (VO2max/LBM) did not. However, not only VO2max/BM but also VO2max/LBM was negatively correlated to the initial level; r= - 0.671 (p<0.05) for VO2max/BM and r= - 0.625 for VO2max/LBM. Thus, the present results indicate that whether the body composition, food intake and aerobic power of sedentary young females can be modified by the exercise regimen eliciting 40% of VO2max depends on their initial levels.


Keywords: aerobic training, energy balance, maximal oxygen uptake, health-related fitness

Introduction

The execution of regular exercise in daily life plays a role for maintaining health and fitness, and becomes the prevention and treatment of geriatric diseases. From the guideline of American College of Sports Medicine (ACSM, 1990a), it has been pointed out that the quantity and quality of exercise needed to attain health-related benefits may differ from what is recommended for fitness benefits. However, distinction between the levels of quantity and quality in physical activities for improving health and fitness in each other remains unclear. Among health benefits which can be introduced by regular exercise, one of the most important aspects will be the maintenance of body composition with good condition. Changes in body mass and composition are related to the energy expenditure of a program, and so the regimens with greater combination of frequency, duration, and/or intensity tend to show greater magnitude of change (Pollock, 1973). If the primary purpose of the training program is for weight loss, however, exercise regimens of greater frequency and duration of training and low to moderate intensity are recommended (ACSM, 1990a). In fact, Pollock et al. (1971) observed a significant reduction in the percentage of fat mass to body mass as a result of fast but less intense walking program. Considering potential hazards and compliance problems associated with high intensity activities (ACSM, 1990a), it is
reasonable to assume that, if substantial effects exist, exercise regimens at lower intensity will be useful for non-athletic population to make a habit of performing it in daily life and to improve safety in physical fitness related to health benefits, especially in a person with a lower fitness level.

As a general observation on the benefit of training, however, the extent of improvement in physical fitness with a given exercise regimen is directly related to its initial level (Pollock, 1973). The person with a low fitness level can achieve a significant training effect by a lower training stimulus as compared to persons with higher fitness levels. So far it is unclear about whether similar phenomenon can be applied to the changes in body composition following training. On the other hand, some researchers have reported that the adiposity may influence the balance between energy expenditure and intake during training period (Woo, 1985; Pi-Sunyer, 1987). The execution of exercise can induce the obese persons a negative balance between the energy expenditure and intake during training period in spite of no restriction in food consumption, but it is not true for normal weight subjects (Keim et al., 1990; Woo et al., 1982; Woo and Pi-Sunyer, 1985). Therefore, whether the physical fitness and/or body composition of non athletic population can be modified by lower to moderate intensity activities should be investigated in relation to their initial levels.

In the present study, anthropometric variables and VO$_2$max were measured for sedentary college females before and after a 12 wk aerobic training program with intensity corresponding to 40% of VO$_2$max. In addition, the energy intakes during control and training periods were recorded. From the viewpoint of the classification of intensity, the exercise at 40% of VO$_2$max performed in this study is prescribed as light exercise (ACSM, 1990a). The purpose of this study was to investigate the influences of light exercise on the body composition, food intake and aerobic power of young sedentary females in relation to the initial levels of these variables.

**Methods**

**Subjects**

Thirty one sedentary college females (age: 19.8 ± 0.2 yr, stature: 154.4 ± 0.8 cm, body mass: 53.3 ± 1.2 kg, mean ± SEM) volunteered to participate in the present study which went on for 14 weeks; the first two weeks were defined as the control period in which no extra exercise was loaded, and the next 12 weeks as the training period with a frequency of 5 times per week. All subjects had not participated in any organized program of regular physical exercise ( 30 min/day, 2 days/week) for at least 1 year prior to be tested. This study was approved by the Department of Molecular Life Science, Tokai University School of Medicine and complies with their requirements for human experimentation. The subjects were fully informed about the procedures to be utilized as well as the purpose of the study, and their written informed consent was obtained.

**Training**

Following flexibility and warm-up exercises, subjects performed on a cycle ergometer (Cateye ergociser EC-1500, Cateye Co., Japan) with intensity corresponding to 40% of VO$_2$max for 30 minutes per day. This exercise protocol elicited heart rate of 119.8 ± 2.9 beats/min per session, and expended 117.5 ± 3.1 kcal/session. The VO$_2$max of each subject during the exercise period was determined at the end of every 4 weeks, and accordingly, the exercise intensity was individually adjusted for the following 4 weeks.

**Dietary record**

Food consumption was ad libidum throughout the whole period of the study. Before this study began, however, we trained the subjects specially for one month, on how to record the content of food intake with accuracy. A direct measuring procedure was employed to record their intake of food quantitatively, using a kitchen scale to weigh the food. An eating-out manual was used to record the exact size, volume and amount of food taken. An equivalent amount of the food was then later weighed in the laboratory according to the size, volume and number recorded and the energy and nutrient intake calculated. Moreover, we analyzed the amount of protein, fat and carbohydrate intake. An accurate record of daily food intake was kept throughout the 14 days prior to the control period and 84 days of the training period and was analyzed weekly. The records of food intake were collected every week and then were processed by the Human Science Laboratory Nutrition Management System Nuts Ver. 2 soft ware. The means during the control period as well as during the training period were calculated separately. The value of food component as described in this guide was compatible with the ‘Standard Tables of Food Composition in Japan 4th revised edition’ (Resources Council, Science and Technology Agency, Japan 1982).

**Measurements**

Measurements for anthropometric variables and aerobic power were made before and after the 12 weeks of training.

**Anthropometric variables:** Anthropometric measurements included stature to the nearest 0.1 cm; body mass to the nearest 0.01 kg; skinfold thicknesses at the triceps and subscapular to the nearest 0.5 mm. Body mass index (BMI) was calculated as body mass divided by stature squared. The skinfold thicknesses of triceps and...
subscapular were measured with an Eiken caliper (Meikousya Co., Japan). The measurements were made on the right side of the body by the same investigator. The skinfold measurements were taken in duplicate. If the difference between two trials exceeded 1.0 mm, a third trial was performed and the closest two trials were averaged. The body density was estimated from the sum of the two skinfold measurements by the use of the equation of Nagamine and Suzuki (1964). The percentage of fat mass (FM) to body mass (BM), %FM, was calculated according to the equation of Brozek et al. (1963), and lean body mass (LBM) was estimated as the difference between BM and FM.

Aerobic power: Aerobic power (VO$_{2\max}$, defined here as the peak O$_2$ consumption during the test) was measured using a standard continuous progressive loading protocol performed on an electrically braked cycle ergometer (Iso-power ergometer 88006, Takeikiki Co., Japan). The intensity of exercise was 20 W during the first three minutes and 50 W during the next three minutes, and after seven minutes it was increased by 15 W every 1 min until volitional exhaustion. Electrocardiogram (RM-6000, Nihon Koden Co., Japan) monitoring and an open-circuit computerized gas analysis system (Respina IH26, NEC San-ei Co., Japan) provided a display of heart rate, expired flow, O$_2$ consumption, CO$_2$ production, and respiratory exchange ratio every 20 s during the test. The VO$_{2\max}$ was established when the following two criteria were met: 1) respiratory exchange ratio values were greater than 1.10; and 2) a plateau in oxygen uptake was achieved, as evidences by no more than an increase of 150 ml/min in oxygen uptake with an increase in work load (Taylor et al., 1955).

Statistics
Descriptive statistics included means ± SEM. The linear correlation coefficient (r) was calculated using the method of least squares. A paired, two-tailed Student’s t test was used to identify the significant difference in the descriptive data between before and after training. The probability level accepted for statistical significance was set at p<0.05.

Results
Comparison between before and after training in measurement variables
Table 1 shows descriptive data on anthropometric variables and aerobic power before and after training. On the average BM, BMI, skinfold thickness at triceps, %FM, and FM significantly decreased after training. The VO$_{2\max}$ and its relative value to LBM (VO$_{2\max}$/LBM) did not show significant change. However, VO$_{2\max}$ relative to BM (VO$_{2\max}$/BM) and exhaustion time increased significantly.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Descriptive data on body composition and aerobic power before and after training</th>
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<tbody>
<tr>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td>BM (kg)</td>
<td>53.3 ± 1.2</td>
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<tr>
<td>BMI (kg/m$^2$)</td>
<td>21.5 ± 0.4</td>
</tr>
<tr>
<td>Triceps (mm)</td>
<td>19.7 ± 1.0</td>
</tr>
<tr>
<td>Subscapular (mm)</td>
<td>17.0 ± 1.2</td>
</tr>
<tr>
<td>%FM (%)</td>
<td>25.0 ± 1.2</td>
</tr>
<tr>
<td>FM (kg)</td>
<td>13.6 ± 0.9</td>
</tr>
<tr>
<td>LBM (kg)</td>
<td>39.7 ± 0.6</td>
</tr>
<tr>
<td>VO$_{2\max}$ (ml/min)</td>
<td>1935.7 ± 59.5</td>
</tr>
<tr>
<td>VO$_{2\max}$/BM (ml/min · kg)</td>
<td>36.2 ± 1.1</td>
</tr>
<tr>
<td>VO$_{2\max}$/LBM (ml/min · kg)</td>
<td>48.8 ± 1.3</td>
</tr>
<tr>
<td>Exhaustion time (min)</td>
<td>17.1 ± 0.9</td>
</tr>
</tbody>
</table>

Mean ± SEM. BM, body mass; BMI, body mass index; %FM, relative fat mass; FM, fat mass; LBM, lean body mass; VO$_{2\max}$/BM, VO$_{2\max}$/LBM, VO$_{2\max}$ per unit of body mass; VO$_{2\max}$/LBM, VO$_{2\max}$ per unit of lean body mass; *, p<0.05.

<table>
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<tr>
<th>Table 2</th>
<th>Descriptive data on energy intake and its composition during control and training periods</th>
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</thead>
<tbody>
<tr>
<td>Control period</td>
<td>Training period</td>
</tr>
<tr>
<td>Energy (kcal)</td>
<td>1889.4 ± 44.9</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>65.6 ± 1.9</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>67.7 ± 2.4</td>
</tr>
<tr>
<td>Carbohydrate (g)</td>
<td>245.4 ± 6.2</td>
</tr>
</tbody>
</table>

Mean ± SEM.
Descriptive data on energy intake in each of the control and training periods are summarized in Table 2. There were no significant differences in energy intake and its composition between the two periods.

Relationship between initial level and relative change (%Δ) in each variable

Figure 1 shows relationships between initial and %Δ values in each of BM, FM and LBM. While there were significant negative correlations between initial and %Δ values for both BM (r = -0.447, p<0.05) and FM (r = -0.638, p<0.05), the corresponding relation for LBM was not significant (r=0.186, p>0.05). Again, the %Δ values in VO₂max, VO₂max/BM, and VO₂max/LBM were also negatively correlated to the initial levels; r = -0.601 (p<0.05) for VO₂max; r = -0.671 (p<0.05) for VO₂max/BM; and r = -0.625 (p<0.05) for VO₂max/LBM (Fig. 2). On the other hand, no significant correlation was found between initial level and %Δ in exhaustion time (r=0.063, p>0.05). The %Δ in energy intake between the control and training periods was negatively correlated to its control level (r = -0.604, p<0.05, Fig. 3). In addition, there were significant negative correlations between the initial levels of both BMI (r = -0.413, p<0.05) and %FM (r = -0.393, p<0.05) and %Δ in energy intake (Fig. 4).
Relationship between $\%\Delta$ values in different variables

Figure 5 indicates relationships between $\%\Delta$ values of BM and either FM or LBM. The $\%\Delta$ values in both FM and LBM were significantly correlated to that in BM; $r=0.906$ ($p<0.05$) for FM and $r=0.490$ ($p<0.05$) for LBM. However, there were no significant correlations between $\%\Delta$ in energy intake and those in BM ($r=0.227$, $p>0.05$), BMI ($r=0.237$, $p>0.05$), FM ($r=0.206$, $p>0.05$), and LBM ($r=0.116$, $p>0.05$). Similarly, the sum of energy expenditure introduced by training and $\Delta$ value in energy intake between control and training periods, $70.7 \pm 49.2$ kcal/day, was not significantly correlated to the changes in body mass and composition variables in both terms of absolute value ($r=0.087$ to 0.236, $p>0.05$) and relative value to the initial level ($r=0.040$ to 0.168, $p>0.05$). Moreover, there were no significant correlations between the $\%\Delta$ values of exhaustion time and either VO$_2$max/BM ($r=0.067$, $p>0.05$) or VO$_2$max/LBM ($r=0.070$, $p>0.05$).

Discussion

The training regimen used in the present study induced significant decreases in BM and BMI with reductions of $\%FM$ and FM on the average. These
changes in body composition variables agree with those which are recognized widely as a result of aerobic training (Wilmore, 1983), suggesting that the training at intensity eliciting 40% of VO2max can modify the body composition of sedentary young females by making a reduction in fat mass. Before accepting the present results on the changes in body composition, however, it must be noted that the adiposity of the subjects was estimated from the data of anthropometric measurements, and not determined by reference methods such as hydrostatic weighing or dual-energy x-ray absorptiometry. However, BMI can be an index of adiposity as an alternative to %FM determined by hydrostatic weighing method (ACSM, 1990b). Moreover, Broeder et al. (1997) have reported that %FM derived from the skinfold measurements agrees reasonably well with that determined by hydrostatic weighing with regard to tracking change following either endurance or strength training. Hence, we may say that similar changes would have been observed in body composition variables even if the other reference method such as hydrostatic weighing was used instead of anthropometric approach.

As shown in Figure 5, however, it is also true that there were the subjects who showed gains in BM with increasing both FM and LBM values after training. Changes in body mass and composition can be related to energy expenditure of a training program (Pollock, 1973). Therefore, it was expected that the relative changes in FM and LBM could be attributed to that in energy intake during the training period. In the present results, however, the relative changes in BM and body composition variables were not significantly correlated to that in energy between the control and training periods. On the other hand, it is interesting to note that the % in energy intake was negatively correlated to its control level in spite of no restriction in food intake. In addition to this point, there were low but significant negative correlations between both the initial BMI and %FM and ∆ in energy intake. These results suggest a possibility that, as an explainable reason for the individual variation in the relative changes in body composition variables, the influence of training on energy intake during daily life might differ between the subjects in accordance with the extent of adiposity.

The physiological backgrounds which result in the negative correlations between ∆ in energy intake and either energy intake in the control period or adiposity prior to training are unknown, but it might involve a homeostatic mechanism for regulating the appetite and/or adiposity of participants during the training period. From the review of Oscai (1973), exercise does not tend to suppress the appetite in male animals, although the appetite suppression effect appears to be related to the intensity of the exercise. On the other hand, studies using female animals have produced results which are not totally consistent with those for male animals (Wilmore, 1983). For example, Oscai et al. (1971) observed that, from the responses of both male and female rats to the same swimming program, exercise had no effect on the voluntary intake of food in the male animals, but the female animals showed significantly greater food intake than the sedentary female ones. Wilmore (1983), in his review of the research about the effect of exercise on appetite of humans through 1982, indicated that alterations in appetite with extended period of training were less clearly defined, although cross-sectional data have shown that the most active groups took higher daily caloric intake when compared to the least active groups. However, from the findings of prior studies concerning the influences of aerobic training at moderate intensity on energy balance, while females within normal body mass range show a hyperhagic response to compensate the increased energy expenditure, obese females with average %FM of 35 to 51% do not increase their energy intake as energy expenditure increases (Woo et al., 1982; Woo and Pi-Sunyer, 1985; Keim et al., 1990; Anderson et al., 1991). Moreover, Durrant et al. (1982) reported that, as an acute effect of short term aerobic exercise on energy balance, lean females overcompensated their increased expenditure by their increased intake. In the case of obese women, however, exercise can suppress hunger and appetite to a greater extent compared to lean ones (Durrant et al., 1982). In fact, Anderson et al. (1991) observed a significant decrease of energy intake in obese females as a result of the increased energy expenditure by execution of exercise. Without estimation of total energy output, of course, it is not possible to say in absolute term how exercise protocol used in this study influenced the regulation of energy intake. However, exercise at low to moderate intensity (or less than 60% VO2max) burns fats and carbohydrates for fuel in almost equal amount (Åstrand and Rodahl, 1986). In addition to this point, aerobic training increases fat utilization during submaximal exercise (Holloszy and Coyle, 1984). Thus, it is likely that since obese persons have excess energy stores, compensatory responses in energy intake to altered level may not begin to act until these are depleted by a certain degree (Woo and Pi-Sunyer, 1985). On the other hand, lean persons who have less fat store will need to compensate an increased energy expenditure by increasing energy intake. Taking these points into account together with the present result, it might be assumed that execution of light exercise in daily life can accommodate the energy intake of the participants to be their body mass and/or body composition scores within normal ranges. However, we have no information for supporting this assumption. Further investigation need to clear this point.

From the guideline of ACSM (1990a), the minimal
training intensity threshold for improving VO_{2max} is work load eliciting 50% of VO_{2max}. In the present results on aerobic power, while VO_{2max} and VO_{2max/LBM} did not show significant changes, VO_{2max}/BM significantly increased after training. On the other hand, there were negative correlations between initial and ∆VO_{2max} values in VO_{2max} and VO_{2max}/BM as well as VO_{2max}/LBM (Fig. 2).

In the case of the subjects with lower aerobic power scores, therefore, not only VO_{2max}/BM but also VO_{2max} and VO_{2max}/LBM increased substantially. Gledhill and Eynon (1972) reported that, as a result of aerobic training eliciting 120 beats/min, more sedentary males with an average VO_{2max}/BM of 35 ml/kg·min prior to training improved their VO_{2max}/BM scores. Moreover, Edward (1974) has also indicated a similar phenomenon in sedentary young females as observed in the study of Gledhill and Eynon (1972). Edward (1974) observed that training at intensity of 125 beats/min for females with an average VO_{2max}/BM of 27 ml/kg·min induced significant increases in the time required to elicit a heart rate of 180 beats/min and VO_{2max}, and concluded that the work load associated with a heart rate of 125 beats/min should be considered as a greater than minimal or threshold stimulus for the initially very sedentary young females. The relationship observed in this study between initial and ∆VO_{2max} values in aerobic power agrees with the above mentioned findings, and suggests that training eliciting 40% of VO_{2max} can be a stimulus to improve aerobic power for sedentary young females whose fitness levels are about below 40 ml/kg·min and 50 ml/kg·min in terms of VO_{2max}/BM and VO_{2max}/LBM, respectively.

Further, exhaustion time significantly increased after training. However, the ∆ in exhaustion time was not significantly correlated to the initial level. In addition, no significant correlations were found between ∆VO_{2max} values of exhaustion time and aerobic power scores. Many researchers have reported that the execution of aerobic training for non-athletic population can improve endurance performances as well as aerobic power (Dowdy et al., 1985; Gettman et al., 1976; Milburn and Butts, 1983; Milesis et al., 1976; Shire et al., 1977). In most of the previous findings, however, the relative change in endurance performance, which is assessed by exhaustion time during the work rate-incremented exercise, is greater as compared to that in VO_{2max}. Moreover, Hickson et al. (1985) have found that, as a result of reduced training intensities, short- and long-term endurance performances are not reduced in parallel with the VO_{2max}. As major reasons for the large increase in the ability to perform prolonged strenuous exercise that occurs in response to endurance training, Holloszy and Coyle (1984) have suggested metabolic consequences of the adaptations of muscle to endurance exercises involving a slower utilization of muscle glycogen and blood glucose, a greater reliance on fat oxidation, and less lactate production during exercise of a given intensity. Considering these points, it seems that the increase in exhaustion time observed in the present study might be attributed to the adaptations of skeletal muscles in the lower extremities to the training stimulus. However, the full discussion on the subject lies outside the scope of this paper.

In summary, the present results indicate that whether the body composition and aerobic power of sedentary young females can be modified by exercise regimen eliciting 40% of VO_{2max} depend on their initial levels prior to training. In addition to this point, there is a possibility that aerobic training at low intensity can regulate the energy balance between intake and expenditure to be the body mass or body composition of the participants within a normal range.

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