EFFECTS OF EXERCISE INTERVENTION ON BLOOD LIPID LEVELS, GLYCOMETABOLISM, ADIPOCYTOKINE LEVELS, AND CARDIAC AUTONOMIC FUNCTION IN YOUNG FEMALES WITH HIDDEN OBESITY

KOJIRO ISHII1), MAKOTO AYABE1,2,3), TETSUKO OKABE1,4), TAKASHI IWATA1,5), KOHSAKU TAKAYAMA1) and TAICHI YAMAGUCHI1,6)

Abstract

We performed exercise intervention for 12 weeks in young females (22.3 ± 2.5 yrs; mean ± SD) with a %fat value of 30% or more (dual energy X-ray absorptiometry: DXA) despite a body mass index (BMI) of less than 25 kg/m², which indicates hidden obesity, and the following results were obtained.

The intensity of exercise was established as the double product break point calculated from heart rate and systolic blood pressure, and the subjects were instructed to exercise for 30 minutes or more for 3 or more times a week. Six weeks after exercise intervention, the BMI, body fat level, and plasma glucose level were lower than those before exercise intervention, and the %fat value was lower 12 weeks after intervention. Furthermore, cardiac autonomic function (CAF) was negatively correlated with changes in Total power and changes in fat (kg), suggesting that exercise-related improvement in CAF is involved in a decrease in %fat.


key word : obesity, exercise intervention, young female, cardiac autonomic function

I. INTRODUCTION

Recently, the desire to be thin in young females has become a social issue, and the National Nutrition Survey by the Ministry of Health, Labour and Welfare1) demonstrated that the number of females in their 20 s with a low body weight (BMI < 18.5) has doubled in the past 20 years.

On the other hand, obesity with a normal weight, i.e., “hidden obesity”, in which the body fat ratio is high even though the body mass index (BMI) is within the normal range, has drawn attention as a symbol of incorrect beliefs about the physique of young females2). The increase in the percentage of young females with a low body weight cannot be simply regarded as the slimming of young females. Our previous study with young female volunteers, in which the body composition (%Fat) was measured by dual energy X-ray absorptiometry (DXA), demonstrated that obesity, if judged based on BMI, would be underestimated in 30% of the subjects3).

Since lean body mass (LBM) is low in individuals with hidden obesity, exercise intervention should also be performed to improve the body composition without reducing the LBM. Individuals with hidden obesity may lead sedentary lifestyles because the LBM is low, and inactivity lowers the activity of the autonomic nervous system. Such activity has been reported to be reduced in obese individuals in particular, for example, the absence of enhancement of the sympathetic nervous system even by cold exposure4) or intake of capsaicin5). In this study, the effects of exercise on body composition, blood lipid levels, plasma glucose control indices, adipocytokine levels, and cardiac autonomic function (CAF) were examined in young obese females with a body weight

1)Laboratory of Human Performance and Fitness, Graduate School of Education, Hokkaido University
2)Laboratory of Exercise Physiology, Faculty of Health and Sports Science, Fukuoka University
3)Department of Exercise Physiology, School of Health and Sports Science, Fukuoka University
4)Department of Nutrition, School of Nursing and Nutrition, Tenshi College
5)Kushiro Red Cross Hospital
6)Department of Foods Distribution, Faculty of Dairy Science, Rakuno Gakuen University
within the normal range.

II. METHODS

II-A. Subjects

The subjects were 10 young females who had been judged as being obese despite a normal body weight (BMI < 25, 30% ≤ %Fat) by DXA in our previous study3), and gave consent to the present study and performing exercise (Age: 22.3 ± 2.6 yr., Height: 158.4 ± 4.2 cm, Weight: 53.2 ± 6.7 kg, BMI: 24.3 ± 1.1 kg·m⁻², %Fat: 32.2 ± 2.0%).

II-B. Exercise methods

The intensity of the double product break point (DPBP) of each subject was measured by ramp loading on a bicycle ergometer (CORIVAL 400, Lode, Groningen, Netherlands) using a DPBP measurement system (Kyokko Bussan, Tokyo, Japan). The subjects were instructed to exercise on a bicycle ergometer at the DPBP intensity for more than 30 min per exercise and more than 3 times per week. The exercise time was recorded by each subject in a monthly planner provided beforehand. The examination period was 12 weeks. In the sixth week, the DPBP was remeasured, and the load intensity was altered. Nutritional advice was given by a registered dietitian during the examination period.

II-C. Measurement parameters

The quantity of motion and the number of steps taken daily were measured using a pedometer with an accelerometer (Lifecorder, Suzuken, Nagoya, Japan).

Before the start of exercise intervention and at the sixth and twelfth week of exercise intervention, the following were measured: body weight, BMI, body composition (body fat ratio, LBM) by DXA (QDR-2000, Hologic, Waltham, MA, USA), blood lipid levels (total cholesterol, HDL cholesterol, LDL cholesterol, neutral fat), plasma glucose control indices (fasting plasma glucose level, insulin level, HOMA-R), adipocytokine levels (leptin, adiponectin), and the intensity of exercise at the DPBP.

CAF was measured at rest with the subject in the sitting position, and the respiration rate was adjusted to 0.25 Hz (once every 4 sec) using an electronic metronome, before and after exercise intervention. CM5-induced electrocardiographic signals from the subject were amplified using a bioamplifier (AB-621G, Nihonkoden, Tokyo, Japan), sampled at 1 kHz using an A/D converter (PS-2032GP, TEAC, Tokyo, Japan), and input into a computer. The R-R interval was measured to within 1 ms from the electrocardiographic signals, and power spectra were determined by fast Fourier transformation (FFT). According to a previous study6~8), the spectra were quantified as the low-frequency (LF, 0.03~0.15 Hz) component, reflecting the activity of the sympathetic and parasympathetic nerves, and the high-frequency (HF, 0.15~0.5 Hz) component, reflecting the activity of the parasympathetic nerves. The total power (TP) between 0.03 Hz and 0.5 Hz was used as a parameter of the total activity of the autonomic nervous system.

II-D. Statistical Analysis

All data were expressed as the mean ± standard deviation. Statistical analysis of the exercise duration, the quantity of motion, and the number of steps taken daily were measured using the Lifecorder between the periods of the first to sixth week and the seventh to twelfth week, and CAF before and after exercise intervention was performed by the paired t-test. The differences in the body weight, BMI, body composition, blood lipid levels, plasma glucose control indices, adipocytokine levels, and the intensity of exercise at the DPBP between the time before exercise intervention, and the sixth and twelfth week of exercise intervention, were statistically analyzed by the Dunnett's test. The relationships among CAF, the body fat ratio, and the quantity of body fat before and after exercise intervention were examined by Pearson's correlation coefficient test. A value of p < 0.05 was regarded as significant.

III. RESULTS

Only 3 subjects could complete the exercise program for the 12 weeks of exercise intervention. There was no significant difference in the exercise dura-
tion between the exercise intervention periods of the first to sixth week and the seventh to twelfth week, but the exercise duration decreased in 6 of the 10 subjects.

The intensity of exercise at the DPBP was significantly higher at the sixth week of exercise intervention than before the start of exercise intervention, and the level was maintained thereafter. There was no significant difference in the intensity of exercise at the DPBP between the sixth and twelfth weeks of exercise intervention.

Table 1 shows the changes in the body weight, BMI, and body composition. Body weight and BMI were significantly lower at the sixth and twelfth weeks of exercise intervention than before exercise intervention, while the LBM remained unchanged. The body fat ratio was significantly lower at the twelfth week of exercise intervention than before exercise intervention.

There were no differences in the blood lipid and adipocytokine levels before and after exercise intervention. Among the plasma glucose control indices, there were no differences in the insulin level and HOMA-R before and after exercise intervention. The fasting plasma glucose level was significantly lower at the sixth week of exercise intervention than before exercise intervention, but was significantly higher at the twelfth week than at the sixth week, showing no significant difference between the time before exercise intervention and the twelfth week of exercise intervention (Table 1).

The CAF before and after exercise intervention could be analyzed in only 8 subjects because of data imperfection. There were no significant differences in any CAF parameters before and after exercise intervention. However, there were significant negative correlations between the change rates of TP and the quantity of body fat or the body fat ratio before and after exercise intervention (Fig. 1).

**IV. DISCUSSION**

Almost all studies on "hidden obesity", in which the body fat ratio is more than 30% even though the BMI is less than 25 kg/m², have been performed from the viewpoint of morphology, characteristics of physical intensity, and lifestyle. We reported that LDL cholesterol and blood leptin levels were higher, and the HDL cholesterol level was lower, in the subjects with hidden obesity than in the normal subjects (BMI < 25, 22% ≤ %Fat < 30%), and suggested that there were metabolic problems in the subjects with hidden obesity³. In the present study, to improve the metabolic function, exercise intervention was performed. However, except for the fasting plas-

Table 1. Changes in body weight, BMI, body composition, blood lipid levels, blood sugar control indices, and adipocytokine levels.

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>6wks</th>
<th>12wks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight: kg</td>
<td>53.2±6.7</td>
<td>52.4±6.5*</td>
<td>51.7±6.1***</td>
</tr>
<tr>
<td>BMI: kg/m²</td>
<td>21.2±2.0</td>
<td>20.8±2.0*</td>
<td>20.6±1.8***</td>
</tr>
<tr>
<td>%Fat: %</td>
<td>32.2±2.0</td>
<td>31.1±1.9</td>
<td>30.5±2.2**</td>
</tr>
<tr>
<td>LBM: kg</td>
<td>35.4±4.2</td>
<td>35.4±3.8</td>
<td>35.4±3.7</td>
</tr>
<tr>
<td>T-cho: mg/dl</td>
<td>185.8 ± 26.4</td>
<td>182.1 ± 20.1</td>
<td>185.1 ± 17.0</td>
</tr>
<tr>
<td>HDL-cho: mg/dl</td>
<td>71.8 ± 8.1</td>
<td>73.4 ± 10.3</td>
<td>71.8 ± 12.8</td>
</tr>
<tr>
<td>LDL-cho: mg/dl</td>
<td>93.9 ± 201.9</td>
<td>96.1 ± 20.0</td>
<td>97.1 ± 16.2</td>
</tr>
<tr>
<td>TG: mg/dl</td>
<td>54.1 ± 18.9</td>
<td>46.6 ± 10.3</td>
<td>56.8 ± 19.2</td>
</tr>
<tr>
<td>FBS: mg/dl</td>
<td>81.8 ± 6.9</td>
<td>75.4 ± 11.3*</td>
<td>82.5 ± 6.1</td>
</tr>
<tr>
<td>IRI: microU/dl</td>
<td>9.90 ± 6.70</td>
<td>6.82 ± 3.59</td>
<td>7.83 ± 4.21</td>
</tr>
<tr>
<td>HOMA-R</td>
<td>2.06 ± 1.57</td>
<td>1.34 ± 0.85</td>
<td>1.62 ± 0.95</td>
</tr>
<tr>
<td>Leptin: microU/ml</td>
<td>8.23 ± 3.06</td>
<td>8.15 ± 2.96</td>
<td>7.73 ± 3.43</td>
</tr>
<tr>
<td>Adiponectin: microU/dl</td>
<td>8.87 ± 2.62</td>
<td>9.44 ± 2.88</td>
<td>8.51 ± 3.23</td>
</tr>
</tbody>
</table>

Mean± SD *: p<0.05, **: p<0.01, ***: p<0.001 vs. Before
ma glucose level, there were no differences in the blood lipid levels, plasma glucose control indices or adipokine levels between before and after exercise intervention. The blood parameter levels in the subjects were close to the normal ranges before exercise intervention, and this was probably the reason why large changes in the levels of these parameters did not occur.

In this study, it was most important that there was a correlation between the changes in CAF and body fat caused by exercise. Amano et al. performed exercise intervention in obese subjects by almost the same method as in our study, and reported that reduction of the body weight and the body fat ratio and enhancement of CAF were observed 12 weeks after the start of exercise intervention. Since the exercise intervention performed in our study was not under supervision, only 3 of the 10 subjects completed the instructed exercise program. Possibly because of this, enhancement of CAF was not observed in this study. However, there were significant correlations between the changes in CAF and the body fat ratio or the quantity of body fat, suggesting that the enhancement of autonomic nervous system activity affected the reduction of body fat, or conversely that the reduction of body fat enhanced autonomic nervous system activity. Moritani et al. reported that CAF was higher in long-distance runners than in healthy subjects. In the present study, increases in daily activities and improvement of the aerobic capacity due to exercise may have enhanced CAF.

These findings suggested that the effects of exercise intervention on the obese subjects were first observed as enhancement of autonomic nervous system activity and reduction of body fat, followed by improvement of metabolic functions. However, only a limited number of subjects completed the exercise program, and the exercise duration decreased in more than half of the subjects after the seventh week of exercise intervention. If all subjects had completed the instructed exercise program, the effects of the exercise intervention on the metabolic functions and CAF could have been significant even though the exercise intervention period was 12 weeks. Since voluntary exercise was considered important, the exercise intervention in our study was performed without supervision. It has been reported that an exercise habit was less often observed in subjects with hidden obesity than in healthy subjects. Therefore, it is necessary to develop exercise programs in which exercise can be performed and continued even without supervision.

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VI. REFERENCES


