Effects of Weight Loss Program with Diet and Exercise on Vital Age in Obese Middle-aged Women


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[Received January 15, 2003; accepted February 28, 2003]

The purpose of the present study was to examine the effectiveness of weight loss program in obese women by vital age, an index to comprehensively grasp health status. Subjects were 163 obese middle-aged women and were divided into two groups: Group D (n = 60) who followed a diet and Group DE (n = 103) who followed both a diet and exercise in a three-month weight loss program. Results before weight loss showed that vital age of obese middle-aged women was significantly higher than the chronological age, and in accordance with weight loss, vital age became significantly younger. In Group D, the significant difference between vital age and chronological age disappeared, and in Group DE, vital age became significantly lower than the chronological age. Differences between the two groups were observed in weight, BMI, body fat, abdominal girth, SBP, VO₂max and TG. This suggests that vital age in obese middle-aged women significantly became younger with weight loss by improving eating habits – an effect strengthened by exercise.

Keywords: weight loss, vital age, diet, exercise, obesity

[International Journal of Sport and Health Science Vol.1 (1) 89–94]

1. Introduction

Obesity in Japan is increasing by lack of exercise due to laborsaving devices and overeating. According to the Japan Society for the Study of Obesity (2000), obesity is defined as above 25 in BMI (body mass index: weight/height²). Obesity is closely related to coronary heart disease (CHD). Weight loss is mainly induced by diet and exercise. Because energy expenditure in general adult is low, exercise is usually combined with diet. According to a study reporting the margin of weight loss by diet alone and by combination of diet and exercise, weight loss of 0.7-3.0 kg is achieved by exercise [Nakata et al. (2002); Okura et al. (2002); Svendsen et al. (1993)]. However, it is not adequate to judge the effectiveness of weight loss programs by the margin of weight loss. The change of physical fitness, blood pressure, plasma lipids profiles, etc. should be included.

One of the indexes to evaluate factors related to health status and physical fitness is "biological vitality". Some calculation formulas to find the level of biological vitality have been proposed [Lee et al. (1993); Nakamura et al. (1998); Tanaka et al. (1990)]. Above all, Tanaka et al. (1990) defines "vital age" as "level of biological vitality" and constitutes it with behavioral physical fitness factors like cardiorespiratory endurance and CHD risk factors. This index has been used to examine the effect of exercise training with the elderly [Yamada et al. (2002)], hypertensives [Nho et al. (1996)], CHD patients [Shigematsu et al. (2000); Tanaka et al. (1992a)] and chronic obstructive pulmonary disease patients [Nakamura et al. (2002)]. It is also used to evaluate the effectiveness of weight loss program for obese women [Nakagaichi et al. (2001); Nakanihi et al. (1996)]. The preceding studies report that weight loss combining diet and exercise significantly improves vital age, but the effect of diet alone was not examined. Thus, it is not clear whether younger vital age is caused by diet or by combining
exercise.

We performed diet and exercise to obese middle-aged women and examined the effect of practicing exercise on vital age, the index to comprehensively grasp health status. We verified the hypothesis that diet alone contributes to lowering vital age and that combining exercise can further contribute to lowering vital age.

2. Method

2.1. Subjects

Subjects were 163 obese middle-aged women (average age: 46.9 ± 8.1 years) living in Ibaraki and Chiba prefectures collected by a local information magazine and divided into 60 subjects of Group D who followed diet alone and 103 subjects of Group DE who followed both diet and exercise. In dividing into the groups, while taking the willingness of subjects into consideration, care was taken that there was no difference in anthropometric characteristics between the groups. Those who have passed more than one year after last menstruation were defined as postmenopausal -- 16 (26.7%) in Group D and 30 (29.1%) in Group DE. Thus postmenopausal factors were similar. Before starting the study, we explained the purpose of this investigation and contents of the weight loss program to subjects. And, we confirmed that they were willing to participate in the measurement before and after weight loss and in the weight loss program continuously for three months, and obtained consents. Personal and anthropometric characteristics are shown in Table 1.

2.2. Measurement

We measured height, weight, BMI, body fat and the variables necessary for calculation of vital age (Tanaka et al., 1990): abdominal girth, systolic blood pressure (SBP), oxygen uptake and heart rate corresponding to lactate threshold (VO2LT and HRLT, respectively), total cholesterol (TC), low-density lipoprotein cholesterol (LDLC), triglycerides (TG), hematocrit (Hct), forced expiratory volume in 1.0 second (FEV1.0), stepping side-to-side and one leg balance with eyes closed.

For measurement of body fat, a bioimpedance meter (Bio impecmeter SS103, Sekisui Chemical Co., Osaka, Japan) was used and body density was estimated from measured electric resistance by the formula for obese middle-aged women of Tanaka et al. (1992b) and body fat was calculated by the formula of Brozek et al. (1963).

To measure VO2LT and HRLT, a graded exercise test using a cycling ergometer (818E, Monark, Stockholm, Sweden) was conducted by a multi-stage incremental load protocol by raising the friction load by 0.25 kp per minute. The pedal revolution was constant at 60 rpm. For analysis of expired gas parameters, metabolic measurement unit (Oxycon Alpha System, Mijnhardt Breda, The Netherlands) was used. To decide LT, about 1 ml blood was drawn from the antecubital vein of the arm each minute during the exercise test and the lactate concentration was analyzed by lactate analyzer (1500L, YSI Life Sciences, Yellow Springs, OH). When blood collection was difficult, LT was detected by rising point of VCO₂ to VO₂ (V-slope method). And, other expired gas parameters and cardiorespiratory endurance prediction formula of Okura & Tanaka (1999) were used suplementially.

Blood samples were collected in the morning after fasting of 12 hours or more. The concentrations of TC and TG were analyzed by enzymatic colorimetric method, high-density lipoprotein cholesterol (HDLGC) by modified enzymatic method, and LDLC by formula of Friedewald et al. (1972): LDLC = TC - (HDLGC + TG/5). Hct was analyzed by RBC cumulative pulse height detection.

Measurements of other items were done as in general. All items were measured before and after weight loss, and vital age was calculated by the formula in Table 2.

Table 1. Personal and anthropometric characteristics of the subjects at baseline.

<table>
<thead>
<tr>
<th></th>
<th>D (n = 60)</th>
<th>DE (n = 103)</th>
<th>t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>45.9 ± 8.2</td>
<td>47.5 ± 8.0</td>
<td>ns</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>155.8 ± 5.2</td>
<td>156.1 ± 5.3</td>
<td>ns</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>69.4 ± 8.2</td>
<td>69.5 ± 7.4</td>
<td>ns</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>28.6 ± 2.8</td>
<td>28.5 ± 2.6</td>
<td>ns</td>
</tr>
<tr>
<td>%fat (%)</td>
<td>35.1 ± 4.2</td>
<td>36.1 ± 5.1</td>
<td>ns</td>
</tr>
</tbody>
</table>

Values are presented as means ± standard deviations.
D = diet; DE = diet and exercise; BMI = body mass index; ns = not significant.

Table 2. The equation for the estimation of the vital age in Japanese women.

VA = 8.90VS + 0.33CA + 32.83

VS = -1.035 + 0.016X1 + 0.011X2 - 0.064X3 - 0.012X4 + 0.004X5 + 0.004X6 + 0.004X7 + 0.004X8 - 0.007X9 - 0.003X10 - 0.367X11

VA = vital age (yr); VS = vital score; CA = chronological age (yr); X1 = abdominal girth (cm); X2 = systolic blood pressure (mmHg); X3 = VO2LT (ml/kg/min); X4 = HRLT (beat/min); X5 = total cholesterol (mg/dl); X6 = low-density lipoprotein cholesterol (mg/dl); X7 = triglycerides (mg/dl); X8 = hematocrit (%); X9 = stepping side-to-side (n/20 s); X10 = one leg balance with eyes closed (s); X11 = forced expiratory volume in 1.0 second (l).
2.3. Diet and Energy Intake

Both groups followed the same diet. To maintain good nutrition while controlling energy intake, we instructed subjects to use MicroDiet (Sunny Health, Nagano, Japan) whose prominent effect is recognized as a weight loss aid [Kagoshima et al. (1993); Tanaka et al. (1999)]. The energy of one meal is 169-173 kcal and because it is possible to intake protein, carbohydrates, fat, various amino acids, vitamins, minerals and others well balanced, the meal mostly satisfies the recommended dietary allowances for the Japanese [Ministry of Health and Welfare, (1999)]. The frequency of intake was 1-2 meals each day and we instructed subjects to take the other meals with good balance of nutrition, controlled to 400-600 kcal per meal. We had subjects record the content of each meal and submit the record when participating in each class. Based on the food records, we estimated the amount of energy intake, and a nutritionist instructed them concerning eating habits, etc.

We estimated energy intake per day from a three-day meal record. It was $1875 \pm 433$ kcal/d ($n = 29$) for Group D and $1937 \pm 346$ kcal/d ($n = 53$) for Group DE before the class, and $1013 \pm 196$ kcal/d for Group D and $1019 \pm 198$ kcal/d for Group DE during the class.

2.4. Exercise and Energy Expenditure

We performed to Group DE a supervised exercise program of three times a week, or a combined program of supervised exercise program once a week and exercise practice at one’s home. The content of the supervised exercise program was centered on bench-stepping exercise [Hayakawa et al. (1996, 2000)] and programmed aerobic/anaerobic/accommodating circuit exercise (PACE) [Tanaka (1998)], whose details were reported elsewhere [Nakata et al. (2002); Okura et al. (2002)]. The supervised exercise of once a week was walking, taking into consideration that practicing can be easy even at home, and we instructed subjects to exercise around home as daily as possible on days without class. The energy expenditure by exercise was estimated to be about 1000 kcal per week from oxygen uptake or heart rate during exercise [Okura et al. (2002, 2003)].

The energy expenditure per day was estimated from weekly activity, using a pedometer with an accelerometer (Lifecoder, Suzuken, Nagoya, Japan). We had subjects wear pedometers all day except when bathing and sleeping. The daily energy expenditure was calculated as the sum of basal metabolism and physical activity amount, based on gender, age, height and weight input to the device. The calculation formula of the basal metabolism is as follows.

\[
\text{Basal metabolism (kcal/d) = 1969 reference value of basal metabolism (kcal/m}^2\text{h)} \times \text{Body surface area (m}^2\text{)} \times 24 \text{ (h)}
\]

\[
\text{Body surface area (m}^2\text{) = Weight (kg) } \times \text{Height (cm)} \times 88.83/10000
\]

The reference value of basal metabolism is 34.3 for the ages of 20 to 29, 33.2 for 30 to 39, 32.5 for 40 to 49 and 32.0 for 50 to 59 (Ministry of Health and Welfare, 1994). The daily energy expenditure before the class was $1927 \pm 196$ kcal/d ($n = 51$) for Group D and $1966 \pm 199$ kcal/d ($n = 67$) for Group DE, and it was $1857 \pm 207$ kcal/d for Group D and $1954 \pm 199$ kcal/d for Group DE during the class. The decrease of energy expenditure in Group D corresponds to the decrease of basal metabolism, and the decrease of basal metabolism was compensated for by increase of physical activity in Group DE.

2.5. Statistical Processing

The measurement value of each item is shown in average ± standard deviation. For comparison of each item between the groups, a two-way analysis of variance (time x intervention) was used.
Comparison between chronological age and vital age at each test. Significant difference between chronological age and vital age.

For comparison between the groups before weight loss, an unpaired t-test was applied, and for comparison of change within each group and comparison of chronological age and vital age before and after weight loss, paired t-tests were applied. For all statistical analyses, SPSS 11.0J was used and the statistical level of significance was set at 5%.

3. Results

The results of measurement before and after weight loss are shown in Tables 1 and 3. There were no significant differences in age, height, weight, BMI and body fat between Groups D and DE before weight loss. Among the other measurement items, difference between groups was observed only in FEV1.0. Vital age before weight loss was significantly higher than the chronological age (Group D: +5.6 ± 4.1 years; Group DE: +5.5 ± 5.9 years).

As a result of our three-month weight loss program, the weight significantly decreased by 7.7 ± 3.1 kg in Group D and by 9.4 ± 2.8 kg in Group DE. In accordance with weight loss, all items except FEV1.0 changed significantly in Group D, and in also Group DE, all items except FEV1.0 and HR1.7 changed significantly. These changes contributed to lowering vital age, except the change of HR1.7 in Group D. As a result, vital age became significantly younger: the significant difference from the chronological age disappeared in Group D and vital age became significantly younger than the chronological age in Group DE (Fig. 1).

Two-way analyses of variance showed that changes in weight, BMI and body fat have significant interactions and that the effect of weight loss was greater in Group DE than in Group D. For vital age, a similar result was shown, and among the constituting variables of the vital age equation, significant interactions were observed in abdominal girth, SBP, VO2max and TG.

4. Discussion

The purpose of the present study was to evaluate the effectiveness of weight loss program, not only by margin of weight loss and some measurement items but also by using an index that can grasp health status more comprehensively. Criterion of the indexes is mostly chronological age, as represented by biological age. Nakamura et al. (1988) proposed the effectiveness of principal component analysis, which can be free from weakness of multiple regression model conventionally used in many cases. Vital age is the index to evaluate "level of biological vitality" which Tanaka et al. (1990) made using the principal component analysis in accordance with this proposal. While the generally used explanatory variables of the biological age are the results of physiological examination result in rest hours, this index, vital age, is characterized by involving oxygen uptake, heart rate and behavioral physical fitness factors, so it can be used as a more comprehensive index. Therefore, we used vital age as the index to evaluate the effectiveness of weight loss program.

Vital age calculated from the measurement result before weight loss was significantly higher than chronological age in both groups, and vital age of the obese was higher, as preceding studies reported [Nakamura et al. (2001); Nakanishi et al. (1996)]. While the difference between the chronological age and vital age was more than 10 years by the report by Nakanishi et al. (1996), it was about 5 years in the present study and the report by Nakagaichi et al. (2001). Taking into consideration that subjects of the report by this study and Nakagaichi et al. (2001) were around 28 in BMI and that subjects of the report by Nakanishi et al. were around 25 in BMI, it is not necessarily said that as the level of obesity increases, vital age becomes older. Thus, it can be said that the result of vital age is not influenced by a single factor like fatness, but it comprehensively grasps the health status of subjects.

The result of the present study was satisfactory in improving not only weight and body fat but also many blood items and physical fitness items. These results are not limited in this study but correspond to the preceding studies we have reported [Nakagaichi et al. (2001); Nakanishi et al. (1996); Tanaka et al. (1999)]. The change of each variable constituting the vital age equation contributed to the direction in making vital age younger except the change of HR1.7 in Group D. As a result, the significant difference between vital age and chronological age disappeared in Group D, and
vital age became significantly younger than the chronological age in Group DE (Fig.1). Because a prominent effect was observed even in Group D not combining exercise, it was suggested that vital age deteriorating in the obese women became younger by weight loss in accordance with improvement of the eating habit. Combining exercise with diet contributed to the further effect obtained by diet alone.

From the group comparison, items suggested to be effective by combining exercise with diet were weight, BMI, body fat, abdominal girth, SBP, VO₂\textsubscript{2lit} and TG beside vital age (Table 3). Among these, there were no items changed not by diet alone but by combining exercise, indicating the effect of exercise strongly. The fact that VO₂\textsubscript{2lit} improved even in Group D, which did not exercise, may be due to the improvement of cardiorespiratory endurance by decreased load on the body with reduced weight. This result is interesting in reconfirming the effect of diet. Aerobic exercise practiced in Group DE contributed to further decrease in weight and body fat, but did not affect agility and balance. Although the study is limited to the result of exercise combined with relatively severe diet, the exercise program performed in the present study is not sufficient and should be examined further.

From the above, the hypothesis of the present study, that vital age of obese women becomes younger even by diet alone and that vital age becomes further younger by combining exercise, was supported.

References:

International Journal of Sport and Health Science
Vol.1 No.1, March 2003
93
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