

Effect of a 12-week weight management program on the clinical characteristics and dietary intake of the young obese and the contributing factors to the successful weight loss

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BACKGROUND/OBJECTIVES: The objectives were to investigate the effect of a 12-wk intervention with behavioral modification on clinical characteristics and dietary intakes of young and otherwise healthy obese and to identify factors for successful weight loss. The goal was to lose 0.5 kg per week by reducing 300-500 kcal/day and by increasing physical activities.

SUBJECTS AND METHODS: Forty four obese subjects (BMI > 25) and 19 normal weight subjects (BMI 18.5-23) finished the 12-week intervention. Obese subjects participated in 5 group educations and 6 individual counseling sessions. Normal weight subjects attended 6 individual counseling sessions for evaluations of dietary intake and exercise pattern. Anthropometric and clinical characteristics and 3-day dietary records were evaluated at baseline and week12.

RESULTS: Weight and serum triglyceride and free fatty acid concentrations in obese group decreased significantly with intervention. Intakes of energy, fat, and cholesterol decreased significantly in the obese. Active participation, realistic weight loss goal setting, and weight gain after high school graduation not during childhood were identified as key factors for successful weight loss.

CONCLUSIONS: The 12-week intervention with behavioral modification resulted in reduced energy and fat intakes and led to significant weight loss and improvements of clinical characteristics in the obese. The finding that those who became obese during childhood lost less weight indicates the importance of 'early' intervention.

Nutrition Research and Practice 2014;8(5):571-579; doi:10.4162/nrp.2014.8.5.571; pISSN 1976-1457 eISSN 2005-6168

Keywords: Obesity, weight loss, clinical parameters, dietary intake, behavioral modification

INTRODUCTION

Obesity has become a pandemic and leads to many health problems, such as metabolic syndrome; Korean young adults also face the challenges of obesity. According to the Korean National Health and Nutrition Examination Survey conducted in 2010 [1], the prevalence of obesity was 20.5% in those aged between 19 and 29 years and 31.0% among those in their 30s.

Nelson *et al.* [2] noted that young adults, particularly those aged between 18 and 25, were vulnerable to obesity due to dramatic lifestyle changes, such as living alone, reduced physical activity, and declines in overall diet quality. Obesity at a young age may lead to serious health problems with advancing age. Young people with a higher body mass index (BMI) have a significantly higher risk for coronary heart disease than their slender counterparts, and the risk for coronary heart disease increases by 3.3% for women and by 3.6% for men for every 1% increase in BMI above the desirable level [3]. In light of these statistics, weight control could be more vital in the earlier

stages of life for the prevention and management of metabolic syndrome [4].

Among the various weight management strategies, behavioral modification has been highlighted as a healthy and effective weight loss method because it can lead to overall changes in lifestyle. Milsom *et al.* [5] reported that 110 obese women aged 50 to 75 lost an average of 10.2% of initial weight through a 6-month lifestyle intervention using a 500-1,000 kcal deficit diet and individual counseling. After a 1-year lifestyle modification with a diet of 1,200-1,500 kcal per day and group education, a total of 55 middle-aged obese subjects had an average weight loss of 6.7 kg [6]. A 24-month intervention that provided group education and individual counseling sessions led to an average weight reduction of 5.1 kg in 138 middle-aged obese patients with at least one cardiovascular disease risk factor [7].

However, studies that have investigated the overall impact of behavioral modification on clinical characteristics and dietary intake among young obese subjects are relatively limited. It has been reported that subjects under 40 years of age and those

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science, ICT & Future Planning (grant number NRF-2009-0068320).

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Received: January 23, 2014, Revised: April 7, 2014, Accepted: April 7, 2014

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without obesity-related complications were more likely to drop out from weight loss interventions [8-11]. These results indicate that young obese subjects might be less motivated. Weight-loss interventions often result in a wide range of weight-loss achievements even within the same study group [10]. Therefore, understanding key factors that contribute to better compliance and successful weight loss would help develop strategies for more effective weight-loss interventions.

In this study, we investigated the effect of a 12-week weight management program with behavioral modification on the clinical characteristics and dietary intakes of young and otherwise healthy obese adults. The program included dietary and physical activity aspects, intensive group education, and individual counseling sessions for effective behavioral modification. We tried to identify the traits of those who lost more weight to identify the key factors leading to a successful weight loss.

SUBJECTS AND METHODS

Subjects

The study was conducted from September 2009 to June 2011. One hundred fifty-four subjects aged 19 to 45 years were screened using questionnaires, and 86 subjects were excluded from the study (Fig. 1). Subjects who were taking dietary supplements or medications known to affect serum lipid profiles were excluded from the study. Subjects with a high Beck Depression Inventory (BDI) score or any chronic disease, including endocrine, hepatic, renal, thyroid, or cardiac dysfunction, were also excluded from the study. Subjects who did not submit a 3-day dietary record at baseline were excluded from the study as well.

Forty-seven subjects with a BMI over 25 kg/m² were recruited into the obese group, and 21 subjects with a BMI between 18.5 and 23 kg/m² were recruited into the normal weight group. Of these, 63 subjects (44 obese and 19 normal weights) completed the study, and 59 subjects (40 obese and 19 normal weights) with complete dietary record data were included in the dietary intake analysis.

The protocol was approved by the Seoul National University Institutional Review Board (SNUIRB, IRB No. 0908/001-007), and written informed consent was obtained from all subjects.

The 12-week weight management program

At baseline, all subjects received information about the aims and schedule of the study. The 12-week weight management program included 5 group education sessions and 6 individual counseling sessions (baseline and week 2, 4, 6, 10, and 12) to induce dietary and behavioral modification in the obese subjects. Subjects in the normal weight group attended 6 individual counseling sessions to evaluate their dietary intake and exercise patterns and were asked to keep their usual eating and exercise pattern to maintain body weight.

The topics of the group education sessions for the obese subjects were as follows: 1) planning for weight loss and how to write dietary records (baseline); 2) how to lose weight in a healthy way (week 2); 3) understanding the food exchange system and food labeling (week 4); 4) portion size control (week 6); and 5) strategies to maintain weight loss (week 12). During the individual counseling sessions, a registered dietitian evaluated 3-day dietary records and reinforced the incorporation of low-fat, low-sugar, low-salt, high-fiber, and low-energy diets. The obese subjects were also encouraged to exercise regularly and to modify undesirable eating behaviors, such as late-night snacking or binge eating.

The overall weight reduction goal was to lose about 0.5 kg per week by reducing calorie intake by 300-500 kcal per day from the estimated energy requirements and increasing physical activity. Mean recommended energy intakes for weight loss were 1,715 kcal/d for obese men and 1,390 kcal/d for obese women. A personalized goal was set for each obese subject following an individual interview with a registered dietitian at baseline. The food exchange system from the Korean Diabetic Association was used for meal planning. Recommended servings of each food group based on caloric goals and the amount of carbohydrate, protein, and fat were provided to each subject. On average, energy from carbohydrate, protein, and fat were 60%, 21% and 19%, respectively, in the individual plans. This recommendation was within the acceptable macronutrient distribution ranges (AMDR) for Koreans, in which carbohydrate comprises 55-70%, fat comprises 15-25%, and protein comprises 7-20% of the total calorie intake.

Anthropometric and blood pressure measurement

Body weight, waist and hip circumferences, and fat mass were measured using InBody 520 (Biospace, Korea). Standing height without shoes was measured using a stadiometer. BMI and waist-to-hip ratio (WHR) were calculated from the height and body weight and waist and hip circumferences, respectively. Blood pressure was measured using an automatic blood pressure monitor (Jawon Medical, Korea) after subjects rested for more than 10 minutes.

Biochemical analysis

Blood was collected in serum separator tubes (BD vacutainer® SST, Becton Dickinson, Franklin Lakes, NJ) after a 12-hour fast. The serum was separated by centrifugation and stored at -70°C until analysis. Blood glucose, total cholesterol, HDL cholesterol, and triglyceride concentrations were measured using Cobas Integra® 400 plus (Roche, Switzerland). LDL cholesterol was measured by elimination and an enzymatic assay (Green Cross

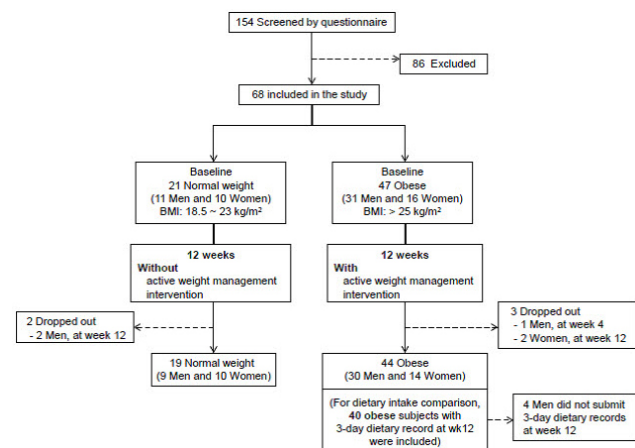


Fig. 1. Study design and subjects

Reference Lab, Korea). Nonesterified fatty acids (free fatty acids, FFA) in serum were measured using SICDIA NEFAZYME (Shinyang Chemical Co., Ltd., Korea). Serum leptin and high-molecular-weight-adiponectin (HMW-adiponectin) concentrations were determined using ELISA kits (Millipore, Billerica, MA) according to the manufacturer's instructions. The HMW-adiponectin was measured after the pretreatment of serum samples with digestion solution to remove hexameric and trimeric adiponectins.

Dietary Intake Assessment

All subjects were asked to provide 3-day dietary records (2 weekdays and 1 weekend day) at baseline, 2-, 4-, 6-, 10-, and 12-week time points. The intake and amount of food consumed was confirmed with individual interviews using pictures of the food in actual size. Analysis of nutrient intake was conducted using CAN-Pro 3.0, a nutritional analysis program developed by the Korean Nutrition Society. To evaluate changes in dietary intake, 3-day dietary records at baseline and week 12 were used. An average of the 3-day dietary intake was used as the daily intake of each subject.

Analysis of information from individual counseling

Information regarding exercise patterns, weight change history, family history of obesity and chronic diseases, goal weight, and weight control experiences of the subjects were collected through individual counseling. According to the weight change history, subjects who became obese after high school graduation were classified as having adult obesity.

Statistical analysis

Data were analyzed using SPSS software (version 19.0; SPSS Inc., Chicago, IL). Variables were examined for normality, and values that were not normally distributed were analyzed using non-parametric tests. Baseline characteristics, except dietary intake, were compared between the normal weight and obese groups using Student's *t*-test; baseline dietary intakes were tested using a 2-way ANOVA to evaluate the effects of sex and weight group.

To determine the effects of the 12-week program on anthropometric and clinical characteristics among obese subjects, subjects were divided into three subgroups based on the magnitude of weight loss: weight loss < 3 kg (< 50% of goal achievement), weight loss 3-6 kg (50-100%), and weight loss > 6 kg (> 100%).

To test for changes in anthropometric and clinical characteristics and dietary intakes before and after the program, the paired *t*-test or Wilcoxon's signed-rank test was used. To identify key factors for successful weight loss, the chi-square test was used for categorical variables and the Student's *t*-test was used for continuous variables of obese subgroups. Data are reported as the mean \pm standard error. Significance was set at $P < 0.05$.

RESULTS

Changes in anthropometric characteristics after 12-week program participation

The mean age of the normal weight group was 26.4 years, and that of the obese group was 30.5 years. Although we tried

Table 1. Comparison of anthropometric characteristics before and after 12-week program participation.

Characteristics	Normal weight (BMI 18.5-23 kg/m ²)		P value	Obese (BMI > 25 kg/m ²)		P value
	Before	After		Before	After	
Subjects	19			44		
Men [n (%)]	9 (47.4)			30 (68.2)		
Women [n (%)]	10 (52.6)			14 (31.8)		
Weight (kg)	60.1 \pm 1.8	60.1 \pm 1.9	NS	81.5 \pm 1.4*	78.9 \pm 1.3	< 0.001
Men	66.6 \pm 2.1	66.4 \pm 2.2	NS	84.7 \pm 1.2*	81.7 \pm 1.3	< 0.001
Women	54.3 \pm 1.3	54.2 \pm 1.4	NS	74.8 \pm 2.8*	72.6 \pm 2.7	0.014
BMI (kg/m ²)	21.5 \pm 0.3	21.5 \pm 0.3	NS	28.1 \pm 0.4*	27.1 \pm 0.4	< 0.001
Men	22.1 \pm 0.5	22.0 \pm 0.4	NS	28.0 \pm 0.4*	27.0 \pm 0.4	< 0.001
Women	21.0 \pm 0.3	21.0 \pm 0.3	NS	28.2 \pm 1.0*	27.4 \pm 0.9	0.009
Waist circumference (cm)	75.1 \pm 1.5	75.0 \pm 1.6	NS	92.4 \pm 1.1*	89.8 \pm 1.1	< 0.001
Men	77.1 \pm 1.7	76.9 \pm 1.8	NS	92.7 \pm 0.9*	90.0 \pm 0.9	< 0.001
Women	73.3 \pm 2.4	73.2 \pm 2.6	NS	91.7 \pm 2.9*	89.2 \pm 2.9	0.035
Hip circumference (cm)	92.0 \pm 2.3	91.6 \pm 2.4	NS	103.1 \pm 1.0*	101.2 \pm 0.9	< 0.001
Men	91.1 \pm 1.6	90.9 \pm 1.7	NS	102.2 \pm 0.7*	100.5 \pm 0.7	< 0.001
Women	92.7 \pm 4.3	92.2 \pm 4.3	NS	105.2 \pm 2.7*	102.8 \pm 2.5	0.012
WHR (Waist-to-hip ratio)	0.819 \pm 0.010	0.820 \pm 0.009	NS	0.895 \pm 0.006*	0.886 \pm 0.006	< 0.001
Men	0.846 \pm 0.008	0.846 \pm 0.007	NS	0.907 \pm 0.005*	0.896 \pm 0.005	< 0.001
Women	0.794 \pm 0.012	0.797 \pm 0.012	NS	0.871 \pm 0.012*	0.867 \pm 0.013	NS
Fat mass (kg)	14.1 \pm 0.8	14.0 \pm 0.8	NS	25.4 \pm 1.0*	23.0 \pm 1.0	< 0.001
Men	12.9 \pm 1.3	12.9 \pm 1.3	NS	24.0 \pm 0.9*	21.3 \pm 0.9	< 0.001
Women	15.3 \pm 0.7	15.0 \pm 0.8	NS	28.4 \pm 2.3*	26.6 \pm 2.2	0.011

Values are the mean \pm standard error. Variables were examined for normality, and values not normally distributed were analyzed using non-parametric tests. Significance was tested using a paired *t*-test or Wilcoxon's signed-rank test based on normality; significance of weight, BMI, hip circumference, and fat mass were determined using Wilcoxon's signed-rank test.

* Significant difference between the two weight groups at baseline ($P < 0.05$). NS: not significant ($P > 0.05$).

to match demographic characteristics other than BMI between the two groups, subjects in the obese group were older than those in the normal weight group. However, most of the normal weight and obese subjects were in their 20s. The heights of the obese and normal weight groups were similar for both men (174.2 ± 1.7 cm in obese vs. 174.0 ± 0.7 cm in normal weight) and women (160.7 ± 1.4 cm in obese vs. 162.3 ± 1.1 cm in normal weight). The weight and BMI of the obese group were significantly higher than those of the normal weight group as

subjects were assigned to the groups according to their BMI (Table 1). The waist circumference of the obese group was also significantly higher than that of the normal weight group.

Body weight, BMI, waist circumference, WHR, and body fat mass decreased significantly in the obese group after program participation. In the normal weight group, there was no significant change in weight, BMI, waist circumference, hip circumference, or fat mass during the 12-week period.

Table 2 Comparison of clinical characteristics before and after 12-week program participation.

Characteristics	Normal weight (BMI 18.5-23 kg/m ²)		P value	Obese (BMI >25 kg/m ²)		P value
	Before	After		Before	After	
Subjects	19			44		
Men [n (%)]	9 (47.4)			30 (68.2)		
Women [n (%)]	10 (52.6)			14 (31.8)		
Systolic blood pressure (mm Hg)	117.8 ± 2.8	118.4 ± 1.7	NS	130.3 ± 2.0*	127.7 ± 2.0	NS
Men	125.1 ± 3.5	123.4 ± 3.4	NS	132.2 ± 2.2	130.3 ± 2.3	NS
Women	112.0 ± 2.4	115.5 ± 2.5	NS	126.1 ± 3.8*	122.4 ± 3.6	NS
Diastolic blood pressure (mm Hg)	70.2 ± 2.5	68.3 ± 1.7	NS	78.1 ± 1.6*	75.5 ± 1.5	0.066
Men	73.0 ± 2.8	69.0 ± 2.0	NS	77.9 ± 1.6	75.6 ± 1.7	NS
Women	68.0 ± 3.3	68.5 ± 2.5	NS	78.6 ± 3.8 [#]	75.5 ± 3.3	NS
Total cholesterol (mg/dL)	168.2 ± 7.6	166.1 ± 5.6	NS	197.9 ± 4.8*	192.0 ± 5.1	NS
Men	160.3 ± 11.0	165.4 ± 9.2	NS	198.7 ± 6.7*	193.0 ± 6.8	NS
Women	175.4 ± 10.6	166.7 ± 7.2	NS	196.3 ± 5.1 [#]	189.7 ± 7.0	NS
LDL cholesterol (mg/dL)	93.1 ± 8.0	92.7 ± 5.9	NS	124.2 ± 4.2*	123.6 ± 4.7	NS
Men	85.9 ± 11.6	90.0 ± 8.7	NS	124.7 ± 5.7*	124.1 ± 6.3	NS
Women	99.5 ± 11.3	95.1 ± 8.4	NS	123.1 ± 5.7 [#]	122.6 ± 6.2	NS
HDL cholesterol (mg/dL)	62.7 ± 2.4	63.9 ± 3.1	NS	50.5 ± 1.9*	53.4 ± 1.6	0.061
Men	61.9 ± 3.6	64.1 ± 5.5	NS	48.2 ± 2.0*	54.1 ± 1.7	0.001
Women	63.3 ± 3.5	63.6 ± 3.7	NS	55.4 ± 3.9	51.9 ± 3.6	NS
Triglyceride (mg/dL)	82.7 ± 5.6	86.9 ± 6.9	NS	139.9 ± 15.3*	108.4 ± 6.5	0.012
Men	85.3 ± 6.4	95.4 ± 10.6	NS	155.0 ± 21.8 [#]	107.7 ± 8.7	0.008
Women	80.4 ± 9.2	78.0 ± 8.5	NS	107.6 ± 7.1*	109.9 ± 9.3	NS
Glucose (mg/dL)	92.1 ± 1.9	86.7 ± 1.4	0.004	95.9 ± 1.6	93.5 ± 1.5	NS
Men	94.3 ± 2.7	89.3 ± 1.9	NS	97.0 ± 2.0	93.2 ± 1.6	0.090
Women	90.0 ± 2.8	84.4 ± 1.9	0.030	93.6 ± 2.8*	94.3 ± 3.5	NS
Total:HDL cholesterol	2.77 ± 0.17	2.67 ± 0.13	NS	4.14 ± 0.18*	3.71 ± 0.13	0.024
Men	2.66 ± 0.25	2.68 ± 0.21	NS	4.33 ± 0.24	3.66 ± 0.16	0.003
Women	2.87 ± 0.25	2.70 ± 0.19	NS	3.74 ± 0.24*	3.82 ± 0.22	NS
LDL:HDL cholesterol	1.57 ± 0.16	1.53 ± 0.13	NS	2.62 ± 0.13*	2.40 ± 0.11	< 0.001
Men	1.46 ± 0.24	1.48 ± 0.18	NS	2.73 ± 0.17	2.37 ± 0.14	0.017
Women	1.66 ± 0.23	1.57 ± 0.17	NS	2.39 ± 0.20*	2.48 ± 0.18	NS
Serum free fatty acid (mEq/L)	198.2 ± 25.4	169.5 ± 20.5	NS	227.8 ± 15.7	187.6 ± 18.3	0.028
Men	167.3 ± 15.9	179.4 ± 28.9	NS	205.5 ± 18.6	197.3 ± 25.2	NS
Women	226.0 ± 45.5	160.6 ± 30.1	NS	273.9 ± 25.6	167.4 ± 21.0	0.005
Serum leptin (ng/mL)	4.08 ± 0.74	4.85 ± 0.85	0.022	7.74 ± 1.11*	6.61 ± 0.90	NS
Men	1.66 ± 0.42	2.19 ± 0.34	NS	4.94 ± 0.57*	3.60 ± 0.59	0.022
Women	6.26 ± 0.91	7.24 ± 1.14	NS	13.48 ± 2.65*	12.85 ± 1.43	NS
Serum adiponectin (µg/mL)	6.67 ± 1.41	9.47 ± 2.95	NS	9.04 ± 1.45	7.63 ± 0.93	NS
Men	6.78 ± 2.12	7.81 ± 2.64	NS	9.51 ± 2.01	7.56 ± 1.13	NS
Women	6.57 ± 2.00	10.95 ± 5.20	NS	8.04 ± 1.56	7.77 ± 1.67	NS

Values are the mean ± standard error. Variables were examined for normality, and values not normally distributed were analyzed using non-parametric tests. Significance was tested using a paired *t*-test or Wilcoxon's signed-rank test based on normality; significance of triglyceride, glucose, Total:HDL cholesterol, LDL:HDL cholesterol, serum leptin, and serum adiponectin were determined using Wilcoxon's signed-rank test, LDL:HDL cholesterol, ratio of LDL to HDL cholesterol; Total:HDL cholesterol, ratio of total to HDL cholesterol.

* Significant difference between the two weight groups at baseline ($P < 0.05$). NS: not significant ($P > 0.05$).

[#] A tendency towards a difference between the two weight groups at baseline ($P < 0.1$).

Changes in clinical characteristics after 12-week program participation

A comparison of clinical characteristics before and after the 12-week program is shown in Table 2. The obese group had significantly higher total cholesterol, LDL cholesterol, and triglyceride concentrations and systolic and diastolic blood pressures than those of the normal weight group at baseline. HDL cholesterol concentration was significantly lower in the obese subjects than the normal weight subjects at baseline. There was no significant difference in fasting blood glucose between the two groups.

After 12 weeks, significant decreases in serum triglyceride and free fatty acid (FFA) concentrations were observed in the obese group. Diastolic blood pressure tended to decrease ($P = 0.066$), and HDL cholesterol tended to increase ($P = 0.061$) in the obese group.

There was no significant change in LDL cholesterol in either the normal weight or obese groups at the 12-week time point. However, the large weight loss group (> 6 kg loss) showed a significant decrease in LDL cholesterol (from 128.3 ± 5.2 to 108.2 ± 10.6 mg/dL, $P = 0.029$). Similarly, while the change in blood glucose concentration was not significant in the obese group, a significant decrease in blood glucose concentration was

observed in the large weight loss group (from 103.5 ± 6.6 to 90.0 ± 4.5 mg/dL, $P = 0.027$).

Obese subjects had significantly higher baseline serum leptin compared with normal weight subjects, and significant decreases in serum leptin concentrations in the intermediate (from 6.45 ± 0.94 to 4.76 ± 1.03 ng/mL, $P = 0.017$) and large weight loss groups (from 8.16 ± 3.43 to 4.45 ± 2.22 ng/mL, $P = 0.046$) were observed after program participation. Serum leptin concentrations in the normal weight group increased significantly despite no significant weight change in the normal weight group. Serum high-molecular-weight (HMW)-adiponectin concentrations at baseline were not different between the two groups and did not change with weight loss.

Comparison of dietary intakes before and after 12-week program participation

Energy, macronutrients, and cholesterol intakes were estimated by 3-day dietary records (Table 3). There was a significant decrease in dietary intakes of energy, fat, and cholesterol in the obese group after program participation. A significant decrease in percent energy from fat and a tendency towards decreased animal fat intake ($P = 0.069$) in the obese group were also observed. The decline in cholesterol intake was significant

Table 3. Comparison of energy, macronutrient, and cholesterol intakes estimated by 3-day diet records before and after 12-week program participation.

	Normal weight (BMI 18.5-23 kg/m ²)		P value	Obese (BMI 25 kg/m ²)		P value
	Before	After		Before	After	
Subjects	19			40		
Men [n (%)]	9 (47.4)			26 (65.0)		
Women [n (%)]	10 (52.6)			14 (35.0)		
Energy (kcal)	1,855.3 ± 100.5	1,739.4 ± 128.0	NS	2,175.4 ± 115.7*	1,904.8 ± 77.7	0.031
Men	1,957.0 ± 186.1	1,961.8 ± 193.7	NS	2,342.9 ± 147.1	2,051.6 ± 99.4	0.088
Women	1,763.7 ± 93.1	1,539.2 ± 151.1	NS	1,864.5 ± 161.0	1,632.1 ± 87.3	NS
Protein (g)	77.4 ± 4.7	63.0 ± 4.6	0.024	92.6 ± 5.6 [#]	83.0 ± 5.6	NS
Men	80.0 ± 7.9	69.8 ± 5.8	NS	99.1 ± 7.2	91.7 ± 7.8	NS
Women	75.1 ± 5.8	56.9 ± 6.7	0.059	80.7 ± 8.0	66.8 ± 4.4	NS
% of energy	16.9 ± 0.8	14.7 ± 0.7	0.047	17.1 ± 0.4	17.8 ± 1.3	NS
Animal protein (g)	45.4 ± 3.9	32.9 ± 3.8	NS	56.7 ± 4.2 [#]	47.5 ± 4.7	NS
Fat (g)	62.4 ± 4.8	58.7 ± 6.6	NS	77.5 ± 5.1*	60.6 ± 3.5	0.007
Men	69.4 ± 8.8	67.2 ± 8.3	NS	82.6 ± 6.5	64.4 ± 4.5	0.030
Women	56.1 ± 4.2	50.9 ± 9.9	NS	67.9 ± 7.9	53.6 ± 5.5	NS
% of energy	29.9 ± 1.2	28.9 ± 1.6	NS	31.7 ± 1.0	28.4 ± 1.1	0.027
Animal fat (g)	34.4 ± 4.1	32.1 ± 5.1	NS	41.6 ± 3.7	32.6 ± 2.5	0.069
Carbohydrate (g)	238.2 ± 15.1	236.5 ± 15.1	NS	268.8 ± 13.6	245.4 ± 11.6	NS
Men	244.4 ± 27.2	264.7 ± 25.2	NS	287.8 ± 17.7	264.1 ± 15.8	NS
Women	232.6 ± 16.2	211.1 ± 14.2	NS	233.5 ± 17.7	210.9 ± 10.7	NS
% of energy	51.6 ± 1.9	55.8 ± 1.9	0.045	50.0 ± 0.9	51.9 ± 1.4	NS
Fiber (g)	15.2 ± 1.2	15.5 ± 1.1	NS	17.9 ± 1.0	17.8 ± 0.9	NS
Men	14.2 ± 2.0	15.3 ± 1.9	NS	18.1 ± 1.3	17.8 ± 1.1	NS
Women	16.1 ± 1.6	15.7 ± 1.3	NS	17.6 ± 1.5	17.8 ± 1.8	NS
Cholesterol (mg)	388.0 ± 38.2	317.7 ± 44.7	NS	433.1 ± 30.2	290.7 ± 22.0	0.001
Men	391.2 ± 53.0	331.0 ± 59.9	NS	440.0 ± 36.3	320.6 ± 28.9	0.017
Women	385.2 ± 57.4	305.7 ± 68.5	NS	420.3 ± 55.5	235.2 ± 28.2	0.018

Four obese men did not submit 3-day diet records at week 12.

Values are the mean ± standard error. Variables were examined for normality, and values not normally distributed were analyzed using non-parametric tests. Significance was tested using a paired *t*-test or Wilcoxon's signed-rank test based on normality. Significance of protein intake and percent calories from protein were determined using Wilcoxon's signed-rank test.

* Significant difference between the two weight groups at baseline ($P < 0.05$).

[#] A tendency towards a difference between the two weight groups at baseline ($P < 0.1$), NS: not significant ($P > 0.05$).

Table 4. Comparison of vitamin and mineral intakes estimated by 3-day diet records before and after 12-week program participation.

	Normal weight (BMI 18.5-23 kg/m ²)		P value ³	Obese (BMI >25 kg/m ²)		P value
	Before	After		Before	After	
Subjects	19			40		
Men [n (%)]	9 (47.4)			26 (65.0)		
Women [n (%)]	10 (52.6)			14 (35.0)		
Vitamin A (µg RE)	679.8 ± 69.0	743.5 ± 111.0	NS	864.0 ± 95.0	784.3 ± 84.9	NS
Men	664.3 ± 137.7	873.4 ± 162.3	NS	834.3 ± 132.9	841.5 ± 125.2	NS
Women	693.8 ± 53.6	626.6 ± 150.0	NS	919.2 ± 117.9 [#]	677.9 ± 66.5	0.048
Vitamin B ₁ (mg)	1.21 ± 0.13	1.14 ± 0.10	NS	1.45 ± 0.10	1.29 ± 0.08	0.090
Men	1.35 ± 0.27	1.19 ± 0.14	NS	1.60 ± 0.13	1.40 ± 0.09	NS
Women	1.07 ± 0.08	1.09 ± 0.15	NS	1.17 ± 0.13	1.10 ± 0.11	NS
Vitamin B ₂ (mg)	1.06 ± 0.06	1.00 ± 0.09	NS	1.36 ± 0.08*	1.17 ± 0.07	0.032
Men	1.03 ± 0.13	1.12 ± 0.11	NS	1.44 ± 0.11 [#]	1.26 ± 0.10	NS
Women	1.09 ± 0.05	0.89 ± 0.13	NS	1.21 ± 0.10	1.00 ± 0.07	0.091
Vitamin B ₆ (mg)	1.85 ± 0.12	1.75 ± 0.12	NS	2.46 ± 0.16*	2.54 ± 0.41	NS
Men	2.02 ± 0.21	1.75 ± 0.17	NS	2.49 ± 0.16	2.32 ± 0.17	NS
Women	1.71 ± 0.11	1.74 ± 0.18	NS	2.40 ± 0.38	2.93 ± 1.14	NS
Niacin (mg)	16.4 ± 1.1	14.3 ± 1.1	0.078	20.5 ± 1.4*	20.6 ± 1.9	NS
Men	18.9 ± 1.7	16.1 ± 0.7	NS	22.9 ± 1.9	50.7 ± 0.9	NS
Women	14.2 ± 0.9	12.7 ± 1.9	NS	16.2 ± 1.3	16.4 ± 1.3	NS
Vitamin C (mg)	70.8 ± 8.5	67.7 ± 7.5	NS	74.4 ± 5.2	89.2 ± 8.1	0.071
Men	66.6 ± 15.6	68.6 ± 9.6	NS	74.6 ± 6.7	86.4 ± 9.1	NS
Women	74.5 ± 8.7	67.0 ± 11.9	NS	74.0 ± 8.6	94.5 ± 16.4	NS
Folate (mg)	195.2 ± 17.2	195.6 ± 14.8	NS	238.0 ± 17.2	237.9 ± 18.9	NS
Men	166.9 ± 24.9	213.5 ± 25.9	NS	242.4 ± 23.1 [#]	243.6 ± 26.6	NS
Women	220.7 ± 21.9	179.5 ± 15.3	NS	229.9 ± 25.0	227.3 ± 22.8	NS
Vitamin E (mg)	16.0 ± 1.6	15.7 ± 1.7	NS	18.9 ± 1.3	15.4 ± 1.0	0.005
Men	15.9 ± 2.3	17.7 ± 3.3	NS	20.8 ± 1.8	16.5 ± 1.4	0.010
Women	16.1 ± 2.3	13.9 ± 1.4	NS	15.3 ± 1.0	15.5 ± 1.1	NS
Calcium (mg)	499.6 ± 42.6	460.9 ± 44.5	NS	609.5 ± 55.2	550.3 ± 36.3	NS
Men	413.3 ± 62.6	497.2 ± 63.2	NS	645.8 ± 78.1	592.8 ± 50.6	NS
Women	577.2 ± 48.5	428.3 ± 63.7	0.048	542.1 ± 61.9	471.2 ± 38.1	NS
Phosphorus (mg)	954.6 ± 58.6	859.8 ± 65.3	NS	1,172.7 ± 67.3*	1,013.8 ± 49.5	0.037
Men	947.7 ± 102.6	927.8 ± 83.3	NS	1,240.9 ± 89.0	1,076.9 ± 66.5	NS
Women	960.9 ± 68.0	798.6 ± 98.7	NS	1,046.1 ± 93.0	896.5 ± 59.9	NS
Iron (mg)	15.0 ± 1.9	12.2 ± 1.1	NS	16.4 ± 1.2	14.2 ± 1.2	0.078
Men	14.9 ± 3.4	11.5 ± 1.0	NS	17.3 ± 1.6	15.2 ± 1.7	NS
Women	15.1 ± 2.2	12.9 ± 1.8	NS	14.7 ± 1.8	12.4 ± 1.2	NS
Zinc (mg)	10.1 ± 1.6	7.5 ± 0.6	NS	10.8 ± 0.7	9.0 ± 0.5	0.010
Men	9.4 ± 1.0	8.1 ± 0.9	NS	11.7 ± 0.9	9.8 ± 0.7	0.036
Women	10.7 ± 2.9	7.0 ± 0.8	NS	9.0 ± 0.7	7.7 ± 0.5	NS
Sodium (mg)	3,360.7 ± 250.4	3,103.1 ± 270.5	NS	4,371.5 ± 239.6*	3,747.5 ± 213.8	0.027
Men	3,494.9 ± 384.5	3,598.2 ± 307.0	NS	4,718.3 ± 316.7*	3,946.0 ± 263.4	0.034
Women	3,239.8 ± 341.5	2,657.6 ± 395.0	NS	3,727.5 ± 291.2	3,379.0 ± 358.0	NS
Potassium (mg)	2,193.9 ± 123.2	2,063.5 ± 171.9	NS	2,594.1 ± 124.9 [#]	2,492.1 ± 114.7	NS
Men	2,068.9 ± 218.7	2,230.4 ± 291.0	NS	2,756.8 ± 168.5 [#]	2,524.9 ± 144.8	NS
Women	2,306.4 ± 128.0	1,913.4 ± 198.2	0.020	2,292.0 ± 146.6	2,431.1 ± 193.6	NS

Four obese men did not submit 3-day diet records at week 12.

Values are the mean ± standard error. Variables were examined for normality, and values not normally distributed were analyzed using non-parametric tests. Significance was tested using a paired *t*-test or Wilcoxon's signed-rank test based on normality. Significance of intakes of vitamin A, vitamin B₆, folate, iron, and zinc were determined using Wilcoxon's signed-rank test.

* Significant difference between the two weight groups at baseline ($P < 0.05$).

[#] A tendency towards a difference between the two weight groups at baseline ($P < 0.1$). NS: not significant ($P > 0.05$).

in all obese subgroups (data not shown). Carbohydrate and protein intakes of the obese group did not change significantly with program participation.

Dietary vitamin and mineral intakes assessed by 3-day dietary records are presented in Table 4. At baseline, obese subjects consumed significantly higher amounts of vitamin B₂, B₆, niacin,

phosphorus, and sodium than did normal weight subjects.

Significant decreases in phosphorus and sodium intakes were observed in the obese group after program participation. The obese group showed a tendency of increased vitamin C intake ($P=0.071$) after program participation. While vitamin B₂, vitamin E, and zinc intakes decreased significantly in the obese group after the 12-week program, the intake levels still met Dietary Reference Intakes for Koreans (KDRIs; data not shown).

Comparison of obese subgroups divided according to weight loss magnitude

To identify factors for successful weight loss, we compared the characteristics of obese subgroups. Because all subjects in the large weight loss group (> 6 kg loss; > 100% of goal achievement) became obese in adulthood, participated in every individual counseling session, and submitted all 3-day dietary records, a statistical analysis between the large and small weight loss group was impossible for these values. Therefore, we compared the small weight loss group (< 3 kg loss; < 50% of goal achievement) with the intermediate and large weight loss groups combined (≥ 3 kg loss).

Subjects in the intermediate and large weight loss group were more diligent in submitting 3-day dietary records than those in the small weight loss group (4.9 / 5.0 vs. 4.3 / 5.0, respectively, $P=0.008$; average of actual number of submissions/ number of submissions requested). In addition, those in the intermediate and large weight loss group tended to attend individual counseling more often than those in the small weight loss group (4.9 / 5.0 vs. 4.7 / 5.0, respectively, $P=0.074$).

The proportion of subjects who became obese after graduating high school was significantly higher in the intermediate and large weight loss group than that in the small weight loss group (93.7% vs. 46.4%, respectively, $P=0.003$).

DISCUSSION

In this study, we examined the effect of a 12-week weight management program with group education and individual counseling sessions on clinical characteristics and dietary intakes in young obese but otherwise healthy adults; most of the subjects were in their 20s. Obese subjects lost an average of 2.7 kg (i.e., 3.3% of body weight), and BMI, waist and hip circumferences, WHR, and fat mass decreased after program participation. While the magnitude of weight loss seemed somewhat modest compared to the goal (> 6 kg loss), it was similar to what has been reported in previous studies [6,13]. In addition, 36% of obese subjects lost more than 3 kg (average loss of 5.5 kg and 6.6% of initial body weight).

Significant improvement in lipid profiles of the obese group, a decrease in triglyceride and FFA, was observed despite a modest weight loss. A significant decrease in serum glucose was observed only in the large weight loss group (> 6 kg loss). These results are consistent with previous studies. Lang *et al.* [12] reported that a 3.2% reduction in body weight through an 8-week program with exercise and nutrition education did not lead to a reduction in serum fasting glucose concentrations despite observed improvements in blood lipid profiles. Dansinger *et al.* [13] showed that a 2-month calorie restriction

resulted in 3.5 kg of weight loss and a reduction in cardiac risk factors but no change in glucose concentrations. It seems that lipid profiles are more sensitive to modest weight loss than blood glucose concentration.

Leptin and adiponectin are adipose tissue-specific proteins, and obese people are reported to have higher leptin and lower adiponectin concentrations [14,15]. In the present study, serum leptin in the obese group decreased significantly in both intermediate (5.0% weight loss) and large weight loss groups (9.1% weight loss). This is consistent with the finding that at least 5% weight loss is required to decrease leptin concentrations in obese people [15,16]. On the contrary, serum HMW-adiponectin concentration at baseline was not different between the obese and normal groups, which is inconsistent with findings from other studies [12,15]. However, the finding by Kuo *et al.* [17] that there was no significant correlation between plasma adiponectin and BMI in a healthy population is consistent with the results observed in this study. No change in serum HMW-adiponectin concentration following weight loss might indicate that adiponectin is less responsive than leptin to a moderate weight reduction. Elisabet *et al.* [18] also reported that 10-week hypoenergetic (-600 kcal/day) diets in obese but otherwise healthy subjects led to a significant reduction in leptin secretion but no significant change in adiponectin concentration with 7.5% weight loss.

It seems that a significant reduction in energy and fat intakes contributed to weight loss in the obese group in this study. In addition, a significantly positive correlation between changes in percent calories from animal fat and BMI was observed in the obese group ($r=0.325$, $P=0.041$), which is consistent with the results from the study by Alison *et al.* [19]. The percent of calories from animal fat showed a positive association with weight gain in 41,518 women in the Nurses' Health study. Obese subjects appeared to reduce animal based food intake during weight management program participation because significant decreases in cholesterol and sodium were observed. This may be the effect of nutrition education: in a study conducted by Dansinger *et al.* [13], obese subjects who were asked to maintain a restricted caloric intake (1,200-1,600 kcal) and received group education reduced intake by an average of 244 kcal per day and reduced intakes of carbohydrate, total and saturated fat, and cholesterol. Considering the positive association between fat intake and blood lipid profile, including triglyceride and cholesterol levels, the improvements in lipid profiles could be attributed to reduced fat intake, which was the main dietetic strategy in the 12-week education program. Decreased phosphorus intake might be explained by the reduced intake of processed foods and animal protein by the obese subjects, given that processed foods and animal protein usually contain high quantities of phosphorus. In addition, a significant decrease in sodium intake and a tendency towards increased vitamin C intake were observed in the obese subjects. Therefore, the 12-week program with nutrition education and personalized nutrition guidance in this study appeared to help obese subjects incorporate healthier eating patterns, as evidenced by reduced sodium and phosphorus intake and increased vitamin C intake.

Subjects who lost more than 6 kg participated more actively

in the program than subjects who lost less than 3 kg. Higher attendance at individual counseling sessions and more diligent submission of dietary records have been reported to result in more successful weight loss and better clinical outcomes [20]. Given that participation can mediate the relationship between autonomous motivation and weight loss [21], those who lost more weight may have been more motivated. Significantly more frequent submission of dietary records in those who lost more weight was observed ($P = 0.008$), and attendance at the scheduled individual counseling sessions tended to be higher ($P = 0.074$). In light of these results, the submission of 3-day dietary records seemed to be a more sensitive indicator of autonomous motivation than attendance because keeping a dietary record likely plays a role in self-monitoring [22], the centerpiece of behavioral modification for weight loss, by helping with self-assessment and providing evaluative information [23-25].

The age of obesity onset has been reported as a predictor of dropout [9] rather than as a key factor for successful weight loss. However, we identified the age subjects became obese as a key factor for successful weight loss; in this study, those who became obese after high school graduation achieved more successful weight loss compared with those who were obese during childhood despite no difference in the family history of being overweight. This result may be because those who have been obese since childhood are more likely to have deeply rooted behavioral factors related to weight gain, such as specific dietary patterns. In a study by Dunn *et al.* [26], of young adults in the highest or lowest intake quintiles for 13 nutrients at baseline, over 60% of the subjects remained in the same or adjacent quintiles after 7 years, which indicates that people tend to maintain their dietary habits.

There are some limitations to this study. The mean age of the obese group was significantly higher than that of the normal weight group, although we tried to match for factors other than BMI between the two groups. Additionally, the extrapolation of our results to a more heterogeneous population might be limited because the subjects included in our study were highly educated and comprised a fairly homogenous population.

In conclusion, the 12-week weight management program led to significant improvements in anthropometric and clinical characteristics, which seemed to be due to significant decreases in energy and fat intakes. Although obese subjects in this study were young and otherwise healthy, moderate weight loss resulted in beneficial effects on metabolic risk factors such as high triglyceride and FFA concentrations.

ACKNOWLEDGMENT

We thank Min Soo Kim for analysis of the FFA.

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