SHORT COMMUNICATION

Metabolic and Weight Loss Effects of Long-Term Dietary Intervention in Obese Patients: Four-Year Results

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Abstract

FLECHTNER-MORS, MARION, HERWIG H. DITSCHUNEIT, TIMOTHY D. JOHNSON, MARK A. SUCHARD, AND GUIDO ADLER. Metabolic and weight loss effects of long-term dietary intervention in obese patients: Four-year results. *Obes Res.* 2000;8:399–402.

Objective: To investigate the contribution of meal and snack replacements for long-term weight maintenance and risk factor reduction in obese patients.

Research Methods and Procedures: Prospective, randomized, two-arm, parallel intervention for 12 weeks followed by a prospective single-arm 4-year trial in a University Hospital clinic. One hundred patients, >18 years old and with a body mass index $>$ 25 and $\leq$ 40 kg/m^2, were prescribed a 1200 to 1500 kcal/d control diet (Group A) or an isoenergetic diet, including two meal and snack replacements (vitamin- and mineral-fortified shakes, soups, and bars) and one meal high in fruits and vegetables (Group B). Following a 3 months of weight loss, all patients were prescribed the same energy-restricted diet (1200 to 1500 kcal) with one meal and one snack replacement for an additional 4 years.

Results: All 100 patients were evaluated at 12 weeks. Mean percentage weight loss was 1.5 $\pm$ 0.4% and 7.8 $\pm$ 0.5% (mean $\pm$ SEM) for Groups A and B, respectively. At 12 weeks systolic blood pressure, plasma triacylglycerol, glucose, and insulin concentrations were significantly reduced in Group B, whereas no changes occurred in Group A. After 4 years, 75% of the patients were evaluated. Total mean weight loss was 3.2 $\pm$ 0.8% for Group A and 8.4 $\pm$ 0.8% (mean $\pm$ SEM) for Group B. Both groups showed significant improvement in blood glucose and insulin ($p < 0.001$), but only Group B showed significant improvement in triacylglycerol and systolic blood pressure compared to baseline values ($p < 0.001$).

Discussion: Providing a structured meal plan via vitamin- and mineral-fortified liquid meal replacements is a safe and effective dietary strategy for obese patients. Long-term maintenance of weight loss with meal replacements can improve certain biomarkers of disease risk.

Key words: dietary treatment, meal replacements, long-term weight loss, biomarkers for disease

Introduction

There is general concern that weight loss in obese patients is only transient, and therefore, future efforts at weight control should be aimed at prevention of weight gain. Recent reports, however, have demonstrated long-term successes in weight loss (1–3). These observations plus the documentation that a minimal weight loss (5% to 10% of initial body weight) can have profound health benefits (4) indicate a need for health professionals to utilize all effective methods to promote healthy weight loss in overweight or obese individuals.

The subject of the present study is the 4-year follow-up of patients who were originally instructed on the use of meal replacements for weight loss and weight maintenance (5). This report provides follow-up data of body weight and biomarkers of disease risk for 75% of the original patients who continued the meal replacement program as a means of reducing energy intake.

Materials and Methods

Patients were referred by their physicians to the University of Ulm Obesity Center because of past dissatisfaction with a standard energy-restricted diet plan for $\geq$3 months.

Submitted for publication October 18, 1999.
Accepted for publication in final form February 11, 2000.
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The study was carried out according to the principles of the Helsinki Declaration, and the Freiburg Ethics Committee International (Freiburg, Germany) approved the protocol. Individuals with a history of, or presence of, significant disease, endocrine disorders, psychiatric disorders, alcohol or drug abuse, or abnormal laboratory test results of clinical significance were excluded. In addition, women were excluded if they were lactating, pregnant, or wished to become pregnant.

One hundred patients agreed to participate in the study. They received no financial compensation other than free supplies of meal replacement products. The experimental design and results of the 2-year intervention have been previously reported (5). Patients were encouraged to maintain their usual level of physical activity and received monthly instruction in behavior modification by the dietitian. The study design consisted of a weight loss period (Phase I) of 3 months and a weight maintenance period (Phase II) of 48 months. Before study initiation, patients were randomly assigned to one of two groups (Group A or Group B). The initial demographics were not different between the study groups (5). Average age and body mass index of the 21 male and 79 female patients was 45.2 ± 10.1 years and 33.6 ± 3.6 kg/m^2, respectively.

During Phase I, patients in Group A were prescribed personalized menus. The diet was composed of 1200 to 1500 kcal (19% to 20% of energy was as protein, 48% to 54% of energy as carbohydrate, and 25% to 34% of energy as fat). Three meals and two snacks were recommended. Group B was also prescribed similar self-selected diets, except two of three daily meals were replaced by diet shakes (Slim·Fast Foods Co., West Palm Beach, FL). The third meal consisted of 600 to 900 kcal with 30 to 45 g of protein. Each meal replacement contained 200 to 220 kcal, 14.0 to 17.0 g of protein, 27.0 to 33.5 g of carbohydrate, 5.0 to 6.6 g of fat, and 4.5 to 6.5 g of dietary fiber with vitamin and mineral fortification. Food exchange lists and food diaries were used to equalize energy and protein intake between groups.

During Phase II, patients received the same dietary instruction, i.e., to replace one meal and one snack with the energy-controlled meal and snack replacement. The energy content of the prescribed diets was the same for both groups.

At the end of the second year (month 27), 63 of the original 100 patients completed the study. By month 37, a total of 58 patients continued to keep their monthly appointments. Thirty-two of the 42 patients who had left the study were located. Twenty-two agreed to re-enter the weight control program between months 37 and 41.

At scheduled intervals, blood pressure, anthropometric and laboratory measurements, and side effects were recorded. Blood samples and analyses were as reported (5).

Weight loss over time was evaluated using generalized estimating equations (GEE) (6–8). Student's *t* test was used to make group comparisons of these measurements at each of the time points. To adjust for multiple comparisons, a test was considered significant if its *p* value was less than 0.01 as opposed to the traditional 0.05.

Results

Seventy-five percent (60 female and 15 male patients) of the original study population comprise the analyses in this report. Figure 1 represents the average percentage weight change for Groups A and B over time. There were no gender differences in percentage weight loss; hence, these data were combined for each of the original treatment groups.

During 4 years of weight maintenance, average weight loss of Group B was consistently greater than Group A ($p = 0.001$). Both groups showed a transient increase in body weight at month 41. A matched pairs analysis (matching for group, gender, and length of time a re-entrant subject was missing) found no significant body weight differences between the re-entry subjects and those who stayed in trial. Those subjects in Group A with regular visits lost an average of 3.2 ± 4.9%, whereas the transient drop-outs lost 3.0 ± 3.0%. In Group B, completers lost an average of 8.4 ± 5.0%, whereas transient drop-outs lost 8.5 ± 5.0%. The subjects also showed no increase in weight from the time of drop-out to the time of re-entry. An examination of individual patient records showed that those patients who had gained the most weight (>3 kg between months 39 and 41) coincided with their summer vacation and the time that they re-entered the study (month 41).

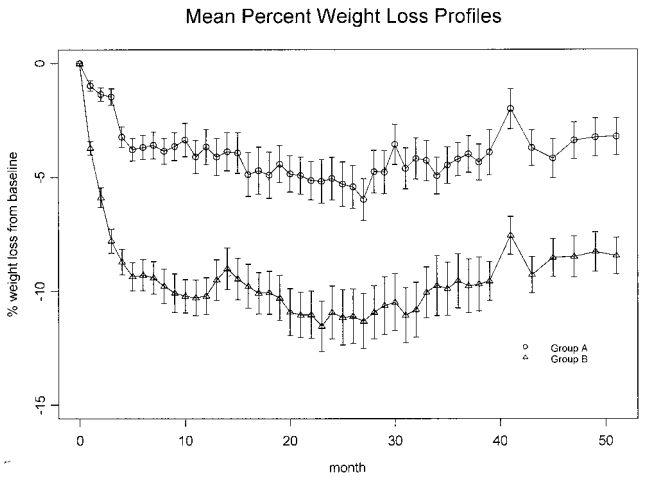

Figure 1. Mean (± SEM) percentage change from initial body weight in patients during 51 months of treatment with an energy-restricted diet (1200 to 1500 Kcal/d). Data were analyzed on an available case basis. Patients received either a conventional energy-restricted diet (control Group A, ○) or a diet with two meal and snack replacements (Group B, △) for 3 months. During the remaining 4 years, all patients received one meal and snack replacement daily.

Table 1. Anthropometric and biochemical measurements at baseline, 2 and 4 years after treatment

Measurements*	Baseline ($n = 100$)	3 months ($n = 100$)	27 months ($n = 63$)	51 months ($n = 75$)
Body weight (kg)†‡				
Group A	92.7 ± 10.8§	91.4 ± 11.6	85.0 ± 11.8¶	88.6 ± 11.0¶
Group B	92.6 ± 13.7	85.5 ± 13.4¶	82.2 ± 13.4¶	83.1 ± 13.3¶
SBP (mm Hg)**				
Group A	140 ± 14	141 ± 16	138 ± 13	139 ± 15
Group B	139 ± 15	130 ± 13¶	124 ± 12¶	126 ± 13¶
DBP (mm Hg)**				
Group A	83 ± 6	82 ± 5	80 ± 6	80 ± 7
Group B	82 ± 6	80 ± 5	78 ± 5¶	78 ± 6
Triacylglycerol (mM)†**				
Group A	2.13 ± 1.34	2.15 ± 1.50	1.77 ± 0.62	1.44 ± 0.42
Group B	2.23 ± 1.24	1.75 ± 1.09¶	1.40 ± 0.49¶	1.29 ± 0.32¶
Cholesterol (mM)†				
Group A	6.01 ± 0.94	5.84 ± 1.00	5.69 ± 0.60	5.58 ± 0.52
Group B	5.83 ± 1.01	5.79 ± 0.89	5.35 ± 0.95	5.37 ± 0.45
HDL-cholesterol (mM)†				
Group A	1.27 ± 0.41	1.24 ± 0.31	1.18 ± 0.17	1.21 ± 0.12
Group B	1.31 ± 0.41	1.30 ± 0.44	1.39 ± 0.77	1.26 ± 0.16
Blood glucose (mM)				
Group A	5.05 ± 0.85	5.07 ± 0.79	4.52 ± 0.42¶	4.40 ± 0.34¶
Group B	4.97 ± 0.87	4.58 ± 0.74	4.40 ± 0.39¶	4.37 ± 0.32¶
Insulin (pM)				
Group A	134.6 ± 50.4	139.1 ± 63.2	98.8 ± 30.0¶	92.6 ± 17.1¶
Group B	132.0 ± 53.1	84.9 ± 30.4¶	81.8 ± 30.2¶	82.5 ± 22.4¶

* SBP, systolic blood pressure; DBP, diastolic blood pressure.
† GEE gender effect; $p < 0.01$.
‡ GEE quadratic time effect; $p < 0.01$.
§ Values are means ± SD.
¶ Significantly different from baseline; $p < 0.01$ (paired t test).
** GEE treatment effect; $p < 0.01$.

Gender, group, time, and time squared plus interactions were fit with the GEE model. No interactions were significant. At 4 years, both groups exhibited a significant weight reduction from their baseline weight. There was a significant group effect in which Group B had a greater percentage change from baseline for all time points. This significance was due to the difference in the initial weight loss observed at the completion of the first 3 months.

At the completion of the study, 14 patients had lost more than 10% body weight, 28 patients lost 5% to 10%, and 25 patients lost 0% to 5% body weight compared to baseline. Eight of the 75 patients had gained an average of 2.4 ± 1.8 kg compared to their baseline weight; all were in Group A.

Table 1 summarizes the changes in other study parameters during the 4 years. Expressed as kilograms of weight loss, there were gender differences (males lost more weight than females) that were not present when weight loss was based on a percentage of initial body weight. With minimal weight loss at 2 and 4 years, glucose and insulin were significantly reduced over time in Groups A and B (paired t test, $p < 0.01$). Group B showed significant reductions in systolic blood pressure and triacylglycerol when compared to baseline (paired t test, $p < 0.01$). GEE analyses showed that improvements in biomarkers during the first 3-month period were maintained for the next 4 years (no time trend effects). The

GEE found significant gender differences for high-density lipoprotein-cholesterol, triacylglycerol, and total cholesterol.

No adverse events were reported.

Discussion

There were two significant findings in this study. First, patients reduced energy intake and maintained weight loss for 4 years. Second, maintenance of weight loss promoted sustained improvements in several disease risk factors. The implications of these results are highly relevant, because most individuals have difficulty in maintaining weight loss.

To promote weight maintenance, one meal replacement product was used daily. Meal replacements have been promoted commercially for a number of years; however, this is the first prospective 4-year study to demonstrate their long-term efficacy and safety for weight control. This study also suggests that a meal replacement strategy can also assist in initiating and sustaining healthy eating. Patients showed a reduction in energy intake, as well as a reduction in fat and cholesterol intake.

The benefit of using prepackaged foods has been shown to improve compliance to a specific diet regimen and subsequent weight loss (9–14). The greater compliance is thought to result from a more structured meal plan. Wing et al. (11,12) and others (13) have suggested that structure may be a key element in promoting behavioral change. It reduces the number of decisions required for food choices, aiding in reduction in energy intake.

From the health point of view, the most important observation is that continued use of a meal replacement strategy can improve several important biomarkers of disease risk for an extended time. The mean weight loss of 3.8 $\pm$ 0.08% after 4 years was enough to cause sustained improvement in fasting glucose and insulin (Group A); however, triacylglycerol and blood pressure were only improved with 8.4 $\pm$ 0.08% weight loss. It is often difficult to extrapolate results from a clinical study to the general population of individuals who may decide to initiate a self-help program and purchase products regularly. However, the patients in this study who dropped out for several months then re-entered the program had not gained weight. The convenience and low cost of meal replacements compared with usual higher calorie meals may have favorably influenced their eating patterns.

Acknowledgments

This study was supported in part by Slim·Fast Foods Co., West Palm Beach, FL.

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