Similar weight loss with low- or high-carbohydrate diets[1,2]

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ABSTRACT The goal of this study was to evaluate the effect of diets that were equally low in energy but widely different in relative amounts of fat and carbohydrate on body weight during a 6-wk period of hospitalization. Consequently, 43 adult, obese persons were randomly assigned to receive diets containing 4.2 MJ/d (1000 kcal/d) composed of either 32% protein, 15% carbohydrate, and 53% fat, or 29% protein, 45% carbohydrate, and 26% fat. There was no significant difference in the amount of weight loss in response to diets containing either 15% (8.9 ± 0.6 kg) or 45% (7.5 ± 0.5 kg) carbohydrate. Furthermore, significant decreases in total body fat and waist-to-hip circumference were seen in both groups, and the magnitude of the changes did not vary as a function of diet composition. Fasting plasma glucose, insulin, cholesterol, and triacylglycerol concentrations decreased significantly in patients eating low-energy diets that contained 15% carbohydrate, but neither plasma insulin nor triacylglycerol concentrations fell significantly in response to the higher-carbohydrate diet. The results of this study showed that it was energy intake, not nutrient composition, that determined weight loss in response to low-energy diets over a short time period. *Am J Clin Nutr* 1996;63:174–8.

KEY WORDS Obesity, weight loss, low-carbohydrate diet, high-carbohydrate diet

INTRODUCTION

Although there is little argument that obesity constitutes a health hazard (1–4), there are widely different opinions when attention is focused on how to bring about weight loss in obese individuals. When evaluating the efficacy of weight-loss programs it is necessary to differentiate between considerations of the relation between changes in energy balance and weight loss (5, 6), the ability of individuals to comply with a weight-loss diet (7), and the long-term success of any weight-loss program in preventing a return to the original weight (8–10). The first of these issues appears to be the most straightforward, but even in this instance, consensus has not been reached. For example, it has been argued that low-fat diets lead to better weight loss (11), but data from Alford et al (12) indicate that both weight loss and changes in associated metabolic variables were similar when patients were prescribed 5.0-MJ/d (1200-kcal/d) diets containing low, moderate, and high proportions of carbohydrate. The present study was initiated to extend these observations, and involved a comparison in 43 obese patients of the changes in weight and several facets of carbohydrate and lipoprotein metabolism that followed the initiation of low-energy diets consisting of either 15% or 45% of energy from carbohydrate. To increase dietary compliance, patients were hospitalized for the entire duration of the study, during which time they also received behavioral and nutritional education.

SUBJECTS AND METHODS

Forty-three adult, obese patients were studied before and after a 6-wk period of hospitalization. These subjects had been referred to the Obesity Outpatient Clinic of the Department of Medicine at Geneva University Hospital for dietary treatment of their obesity.

During the first visit, it was decided on the basis of a history of failure to lose weight in response to ambulatory treatment that these individuals would benefit if they were hospitalized for the first 6 wk of treatment. Criteria for admission included a body mass index (kg/m^2) > 30, strong personal motivation, and the ability to participate in the requisite amount of physical activity. Patients with obesity secondary to endocrine disease, as well as those with psychiatric diagnoses, were excluded from the study. The protocol was submitted to and accepted by the ethical committee of the Department of Medicine at Geneva University Hospital.

In addition to a low-energy diet, subjects participated in a structured, multidisciplinary program that included physical activity, nutritional education, and standard behavioral techniques. Exercise consisted of 1 h of aerobic exercise training per day and 1 h of underwater physical activity per day. Nutritional education was provided by a registered dietitian twice a week (once in a group session and once individually). The behavioral approach consisted of six sessions, during which issues of self-control, cognitive restructuring reinforcement, and relapse prevention were addressed.

On admission to the hospital, patients were randomly assigned to receive diets containing 4.2 MJ/d (1000 kcal/d) that consisted of either 15% or 45% of energy as carbohydrate.

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Baseline characteristics of the two experimental groups are listed in **Table 1**. The groups were comparable in terms of sex distribution, age, body mass index, and blood pressure.

After baseline metabolic data were acquired, the patients were started on one of the two experimental diets. Compositions of the two diets are shown in **Table 2**. Both diets consisted of natural foods. Recipes and menus of various food items were standardized. A 7-d rotational menu was used. The menus provided similar nutrient composition but offered diverse foods. Itemized compositions of meals from 1 d of the rotation menu for the low-carbohydrate and high-carbohydrate diets are given in **Table 3**.

Daily energy intake was distributed among breakfast (22%), lunch (33%), dinner (33%), and bedtime snack (12%). The total energy and protein contents of the two diets were similar. Energy intake was carefully measured for each patient. All subjects were instructed to eat all foods and a dietitian was present during each meal to improve compliance. To verify compliance with the diet, patients completed a 1-d food record once a week during the 6 wk of the study. These food records took the quality and the quantity of food consumed into account. The software PRODI3+ was used to calculate alimentary plans and food records (13). Food composition tables used were from Souci et al (14) and Renaud and Attil (15).

The absolute amount of carbohydrate was three times higher in the 45%-carbohydrate diet than in the 15%-carbohydrate diet (115 ± 14 compared with 37 ± 5 g), and the amount of fat was less in the 45%-carbohydrate diet (30 ± 5 compared with 60 ± 5 g). Both diets contained similar amounts of saturated fat (≈14 g/d) and cholesterol (≈230 mg/d).

Blood was drawn after a 14-h overnight fast before and after 6 wk of the low-energy diets for measurements of plasma glucose (16), plasma immunoreactive insulin (17), cholesterol (18), high-density-lipoprotein (HDL)-cholesterol, and triacylglycerol concentrations (19). Nitrogen balance was measured to compare the protein-sparing effect of the two low-energy diets. Urinary nitrogen was measured by the Kjeldahl method (20).

Twenty-four–hour urine samples were collected every week and average daily urinary loss was computed on the basis of these six collections. Integumental and stool losses were estimated on the basis of previously reported studies: 5 and 10 mg/kg body wt, respectively (21). Daily nitrogen balance was calculated by subtracting total output (urine, stool, and integumental losses) from dietary input.

Body fat composition and percentage of adiposity were determined by two different techniques: skinfold-thickness measurements at biceps, triceps, subscapula, and suprailiac (22), and bioelectrical impedance analysis (23). Body composition values as assessed by these two techniques were significantly correlated and linear ($r = 0.64$, $P < 0.0001$). Percentage of fat was expressed as a mean of these two measurements (skinfold thickness and bioelectrical impedance).

Data are expressed as means ± SEMs and were analyzed with the general-linear-models procedure of SAS (SAS Institute Inc, Cary, NC). To evaluate the difference between the two groups of obese patients, before and after weight loss, data were analyzed by two-way analysis of variance, with the multiple-comparison approach of Scheffé (24, 25).

TABLE 1
Physical characteristics of the subjects[1]

	15% Carbohydrate (n = 3M, 19F)	45% Carbohydrate (n = 6M, 15F)
Age (y)	41 ± 9	45 ± 18
Weight (kg)	107 ± 23	102 ± 18
Height (cm)	162 ± 9	164 ± 9
BMI (kg/m^2)	41 ± 9	38 ± 5
Systolic BP (mm Hg)	138 ± 14	136 ± 18
Diastolic BP (mm Hg)	89 ± 9	85 ± 14

[1] $\bar{x}$ ± SD. BP, blood pressure.

TABLE 2
Composition of diets[1]

	15% Carbohydrate	45% Carbohydrate
Energy (kJ/d)	4214 ± 315	4296 ± 320
Carbohydrate		
(g/d)	37 ± 5	115 ± 14
(%)	15 ± 5	45 ± 5
Fat		
(g/d)	60 ± 5	30 ± 5
(%)	53 ± 5	26 ± 5
Protein		
(g/d)	79 ± 9	73 ± 5
(%)	32 ± 5	29 ± 5

[1] $\bar{x}$ ± SD.

RESULTS

Values for total body weight, body fat, waist and hip circumferences, and waist-to-hip ratio before the diets are given in **Table 4**. These values were not significantly different between the two groups at baseline nor was there a significant difference in the amount of weight loss in response to diets containing either 15% or 45% carbohydrate. Furthermore, total body fat, waist and hip circumference, and waist-to-hip ratio decreased significantly in both groups, and the magnitude of the changes did not vary as a function of diet composition. The percentage weight loss and the percentage fat loss were more similar in the two groups than were the absolute changes.

Daily dietary nitrogen intake was similar [12.6 ± 0.3 g (15%-carbohydrate diet) compared with 11.7 ± 0.2 g (45%-carbohydrate diet)] and nitrogen losses were not significantly different [13.9 ± 1.7 g (15%-carbohydrate diet) compared with 11.2 ± 0.9 g (45%-carbohydrate diet)] between groups. The protein-sparing effect of both diets was equal: nitrogen balance was 1.3 ± 0.5 (15%-carbohydrate diet) compared with −0.5 ± 0.6 g (45%-carbohydrate diet). Nitrogen balance was more negative with each diet during the first week [−1.5 ± 0.2 (15% carbohydrate) and −1.8 ± 0.2 g (45% carbohydrate)] than during the last 5 wk.

Table 5 lists values for fasting plasma glucose, insulin, cholesterol, HDL-cholesterol, and triacylglycerol concentrations before and after the dietary intervention, and shows that these indexes were not significantly different between the two groups before dieting. These data also show that fasting plasma glucose, insulin, cholesterol, HDL-cholesterol, and triacylglycerol concentrations decreased significantly in patients eating the low-energy diets, which contained 15% carbohydrate. Although trends in a similar direction were seen when patients ate

TABLE 3
Itemized composition of diets

Food items	Weight
15% Carbohydrate	*g*
Breakfast	
Low-fat fresh cheese (20% fat)	150
Low-fat ham	50
Lunch	
Low-fat meat or fish	100
Vegetable	100
Oil	15
Snack	
Low-fat, artificially sweetened yogurt	180
Dinner	
Low-fat meat or eggs	100
Vegetable	100
Whole-wheat bread	25
Oil	15
Snack	
Low-fat fresh cheese (20% fat)	50
45% Carbohydrate	
Breakfast	
Low-fat skimmed milk (0% fat)	150
Whole-wheat bread	50
Butter or margarine	5
Lunch	
Low-fat meat or fish	100
Vegetable	150
Rice, pasta, or cereals	60
Fruit	100
Oil	5
Snack	
Low-fat, artificially sweetened yogurt	180
Dinner	
Low-fat meat or eggs	100
Vegetable	150
Rice, pasta, or cereals	60
Oil	5
Snack	
Low-fat fresh cheese (20% fat)	50
Fruit	100

the low-energy diets containing 45% carbohydrate, the magnitude of the differences was attenuated and neither plasma insulin nor triacylglycerol concentrations fell significantly in response to the higher-carbohydrate diet.

DISCUSSION

In this study we evaluated the effects of low-energy diets that varied substantially in their relative proportions of fat and carbohydrate on both weight loss and various metabolic end-points. The amount of weight loss was similar in response to the two diets, and was apparently independent of the amount of fat or carbohydrate in the two test diets, being related most closely to total energy intake (Table 3). On the other hand, variations in dietary composition did appear to modify the beneficial effects of weight loss on certain measures of carbohydrate and lipid metabolism. More specifically, the fall in fasting plasma glucose, insulin, cholesterol, triacylglycerol, and HDL-cholesterol concentrations was decreased in subjects eating a low-energy diet relatively high in carbohydrate, and the changes in plasma insulin and triacylglycerol concentrations were not statistically significant in these subjects.

To put the results of the current study into perspective, two issues must be addressed. The first is a pragmatic one, and involves the publications of Rabast et al (11), who reported that obese individuals lost more weight consuming diets low in carbohydrate, and that a simple decrease in dietary fat intake can lead to weight loss. There are two crucial differences between our results and those of Rabast et al. First, and probably most important, the current studies were performed on inpatients, not outpatients. Second, subjects in our study also participated in programs of physical exercise and both behavioral and nutritional education. Consequently, we believe that the results of our study emphasize issues of energy intake and output, and are less dependent on variations in degree of dietary compliance.

A second important issue to address is the evidence that the thermic effect of carbohydrate (8%) is higher than that of fat (4%) (26). As a consequence of these considerations, it has been suggested that the higher the ratio of carbohydrate to fat, the less the tendency to gain weight (27). On the other hand, the relevance of this information to the effect of low-energy diets must be questioned. For example, when diets containing 4.2 MJ are ingested, the thermic effect of 45% of carbohydrate is 150 J, compared with a thermic effect of 50 J associated with eating 15% carbohydrate, ie, a 100-J difference per day. Thus, it is theoretically unlikely that increasing the relative proportion of carbohydrate to fat in hypoenergetic diets will have a significant effect on the weight loss that ensues in compliant patients.

TABLE 4
Body composition before and after weight loss[1]

	15% Carbohydrate		45% Carbohydrate	
	Before	After	Before	After
Total body weight (kg)	107 ± 5	99 ± 4[2]	102 ± 4	95 ± 3[2]
Weight loss (%)	—	8.3 ± 0.5	—	7.4 ± 0.6
Body fat (kg)	47 ± 3	38 ± 2[2]	41 ± 2	34 ± 2[2]
Fat loss (%)	—	17.7 ± 1.0	—	16.8 ± 1.2
Waist circumference (cm)	115 ± 4	104 ± 3[2]	113 ± 3	103 ± 3[2]
Hip circumference (cm)	126 ± 4	117 ± 3[2]	121 ± 2	112 ± 2[2]
Waist-to-hip ratio	0.91 ± 0.02	0.88 ± 0.01[3]	0.93 ± 0.02	0.91 ± 0.02[4]

[1] $\bar{x}$ ± SEM.
[2–4] Significantly different from before weight loss: [2] $P < 0.001$, [3] $P < 0.01$, [4] $P < 0.05$.

TABLE 5
Biochemical indexes before and after weight loss[1]

	15% Carbohydrate		45% Carbohydrate	
	Before	After	Before	After
Plasma glucose (mmol/L)	5.3 ± 0.2	4.4 ± 0.1[2]	5.4 ± 0.3	5.0 ± 0.2[3]
Plasma insulin (pmol/L)	106.8 ± 15.6	57.6 ± 6.6[2]	96.0 ± 13.2	88.2 ± 9.6
Plasma cholesterol (mmol/L)	5.7 ± 0.3	4.5 ± 0.2[2]	6.1 ± 0.4	5.3 ± 0.3[3]
Plasma HDL cholesterol (mmol/L)	1.1 ± 0.1	0.9 ± 0.1[2]	1.1 ± 0.1	1.0 ± 0.1[4]
Plasma triacylglycerol (mmol/L)	1.7 ± 0.1	1.4 ± 0.1[3]	2.2 ± 0.2	1.8 ± 0.2

[1] $\bar{x}$ ± SEM.
[2–4] Significantly different from before weight loss: [2] $P < 0.001$, [3] $P < 0.01$, [4] $P < 0.05$.

In conclusion, our results emphasize that substantial weight loss can occur when subjects consume low-energy diets as inpatients, and that this effect, as shown by Alford et al (12), is independent of the relative proportion of dietary fat and carbohydrate. Indeed, if anything, consumption of the kind of low-fat, high-carbohydrate diets for weight maintenance advocated by the National Cholesterol Education Program (28) seems to minimize the fall in plasma insulin and triacylglycerol concentrations. This is most likely related to previous results showing that both plasma insulin and triacylglycerol concentrations increase in proportion to dietary carbohydrate consumption (29). In addition, the HDL-cholesterol concentration has been shown to decrease significantly in women consuming a low-energy, low-fat, high-carbohydrate diet (30). Given the current observation that weight loss was similar when obese subjects ate low-energy diets, irrespective of the proportion of fat and carbohydrate in these diets, and the fact that low-energy diets that are low in fat and high in carbohydrate lead to smaller changes in insulin and lipid metabolism compared with low-carbohydrate diets, it seems reasonable to question the advocacy of this dietary approach. Although it is often suggested that low-fat diets will have a better long-term benefit with a weight-maintenance diet, we are unaware of persuasive data in support of this view with a weight-loss diet. Until such information becomes available, it seems reasonable to suggest that it is energy intake, not energy composition, that determines weight loss in response to low-energy diets.

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