

A Randomized Controlled Trial of Low Carbohydrate and Low Fat/High Fiber Diets for Weight Loss

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Abstract: Among 135 overweight subjects, we conducted a three-month randomized controlled trial of two sets of dietary advice, each providing approximately 1,000 calories per day but differing in fiber, carbohydrate, and fat content. Information on weight and eating habits, as well as measures of lipoprotein and glucose metabolism were obtained at entry and one and three months later. We found that dieters given low carbohydrate/low fiber dietary advice tended to lose more weight than those given a higher carbohydrate/higher fiber regimen (5.0 vs 3.7 kg on average at three

months). This pattern was particularly marked among women, and among participants who were under age 40 or of lower social class. There were no differences between the diet groups in the proportion complaining of hunger but, in general, members of the low carbohydrate group complained of more problems in dieting. There were only minor differences in the serum lipoprotein patterns during the diet period. In view of these results, we believe previous claims of the benefits of fiber for weight loss may have been overstated. (*Am J Public Health* 1986; 76:1293-1296.)

Introduction

Obesity and overweight are common in Western society and, as a result, weight loss is often recommended to reduce the morbidity and mortality associated with those conditions.¹⁻³ Health motivation such as this, combined perhaps with cosmetic concerns, has made dieting very common: for example, it has been estimated that over 40 per cent of the British population is trying to lose weight at any one time.¹

Despite this, there has been relatively little study of the many dietary regimens proposed by medical and commercial practitioners. Much of the previous research has had a metabolic focus, with rigidly enforced diets and study procedures that do not correspond to common dieting activities. There has been virtually no comparison of the efficacy, side effects, and acceptability of different sets of dietary advice among ambulatory subjects. As a result, many of the claims made about the diets are unsubstantiated.

This report presents the results of a randomized, controlled trial comparing two currently popular sets of diets that focus in opposite ways on carbohydrate and fiber intake. The low fat/high fiber diets⁴ typically encourage carbohydrate intake, since most fiber-rich foods are also carbohydrate-rich. In contrast, the low carbohydrate diets limit carbohydrate, and therefore fiber, intake. It has been claimed that the low fat/high fiber diets are particularly effective, and that they are associated with changes in blood lipids that might be beneficial with regard to the risk of cardiovascular disease.^{3,4} Although the metabolic effects of each of these diets have been studied, to our knowledge no one has directly compared the two regimens.

Methods

One hundred thirty-five overweight subjects were recruited into the study with the help of six diet clubs and employee groups from the Oxford (United Kingdom) area. To be eligible, a potential subject had to be between the ages of 16 and 70 years, and weigh more than the upper limit of

acceptable weight for a "medium" framed person, from the Metropolitan Life Insurance tables of desirable weights.⁵ Subjects were weighed wearing indoor clothes, but no shoes. Excluded from the study were those who had dieted in the three months prior to recruitment or, in the case of females, those within six months of childbirth or still breastfeeding. The participants agreed to allow random allocation of dietary regimens, and estimated that they could sustain dieting for a three-month period to reach an ideal body weight.

Within each of the participating clubs, subjects were randomly allocated to either a low-carbohydrate diet or a low-fat/high fiber diet. Spouses were randomized together. The two diet programs were both currently used commercially and had been designed for this popular use. Each focused on the restriction of one type of nutrient (carbohydrates or fat, depending on the diet). The regimens were based on two separate systems of assigning numerical units to specific food portions, with each diet limiting daily intake to 10 units as defined by the relevant diet system. In each case, this was designed to be equivalent to 1,000-1,200 calories a day, although a few particularly active subjects were advised to liberalize the diet to 12 units (1,200-1,400 calories) daily. The 10 carbohydrate units permitted a daily carbohydrate intake of at most 50 grams (a less severe limitation than that imposed in low-carbohydrate ketogenic diets).¹ Similarly, the basic low fat diet restricted fat intake to at most 30 grams a day. Each regimen had zero-unit foods that were not restricted directly. For the low-carbohydrate diet, these included meats and cheese; for the low-fat/high fiber diet, bread, potatoes, and fresh fruit. Increased intake of foods rich in fiber was specifically stressed to those in the low-fat group; this advice was not given to the low-carbohydrate dieters. Neither diet required a minimum of any food, although a half pint of milk per day was recommended to the low-carbohydrate dieters. Each subject planned his/her own menus, with the assistance of the group leaders and the study investigators. Thus the dietary advice was in a form typical of that in currently used popular diets. Both diet regimens featured diet instruction sheets with the same format; therefore they were virtually identical in materials and procedures, although they differed substantially in content.

At each center, participating subjects were given a general orientation to dieting. This included a brief discussion of behavioral techniques and the value of exercise, both of which were not specifically encouraged further. After instruction in the appropriate diet, each subject then partici-

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pated in the normal operation of his or her group, which in all cases included weekly meetings. One of the study investigators visited each group regularly during the three-month diet period to offer encouragement and further instruction, if needed. Meanwhile, group leaders regularly weighed participants and avoided activities that might discourage or aid the weight loss of one study diet group compared to the other. At the end of the three-month diet period, subjects were no longer encouraged to diet, although a few chose to do so.

Personal data, and weight and height measurements were obtained at entry; follow-up weights were obtained one and three months later. A brief self-administered dietary questionnaire was completed at each of these observation times, and at the one-month and three-month follow-up sessions the subjects were also questioned about side effects and difficulties they had encountered dieting. To assess the permanence of early changes, subjects were weighed and given a diet questionnaire one year after entry, even though most were not formally dieting at that time.

The dietary questionnaire was that developed by Gear, *et al.* It used a simple frequency-of-eating format, and provided an accurate assessment of dietary fiber intake.⁶ It was not designed to assess total caloric intake or to estimate precisely the intake of other individual nutrients. Social class categories were as designated by the Registrar General for England and Wales.⁷ This is essentially a classification of occupations; and includes six main categories: I (Professional), II (Intermediate), IIIN (Skilled Non-manual), IIIM (Skilled manual), IV (Partly skilled), V (Unskilled). The social class of a participant was taken to be the higher of the social classes of the subject and his/her spouse.

Fasting blood specimens were obtained from all participants at entry, and one and three months later. Serum and plasma samples were promptly processed and frozen at -20°C until analysis. Cholesterol concentrations were determined by an automated Liebermann-Burchardt reaction, and lipoproteins were assayed by precipitation techniques.⁸⁻¹⁰ Triglycerides were measured using a glycerokinase method,¹¹ and plasma glucose using a glucose oxidase method (Boehringer GOD-perid).

Statistical comparison of means was performed using standard t-tests (and 95% confidence limits) or 2×2 contingency tables for proportions.¹² Analysis of covariance was used to assess the influence of any single factor on weight loss.¹²

Results

Baseline characteristics of the participants are summarized in Tables 1 and 2. The two diet groups appeared evenly balanced with regard to weight and other factors. Many more females than males took part, and the participants ranged from barely overweight to frankly obese. Baseline carbohydrate and fiber intakes were similar in the two diet groups.

The cooperation of the subjects was excellent. Over 95 per cent of those initially randomized participated fully in the one- and three-month follow-up sessions, and 88 per cent took part in the one-year measurements. Of the 16 non-respondents at one year, four were pregnant or postpartum, and hence could not meaningfully be included.

During the three-month diet period, the two groups reported contrasting dietary changes (Table 2). The low-carbohydrate subjects decreased their fiber intake; low-fat dieters increased theirs. Consumption of bread and potatoes decreased markedly among the low-carbohydrate group, as did cheese, milk, and meat among the low-fat dieters. At one

TABLE 1—Baseline Characteristics of Diet Participants

Characteristics	Low Carbohydrate Diet	High Carbohydrate/Low Fat Diet
Number	66	69
Per cent male	14	16
Mean age	39.5 \pm 1.3* years	39.7 \pm 1.5 years
Mean baseline weight	78.0 \pm 3.7 kg	77.3 \pm 3.4 kg
Mean baseline Quetelet's index	29.1 \pm .6 kg/m ²	28.5 \pm .5 kg/m ²
Per cent with Quetelet's index greater than 30		26
Per cent overweight at age 16	34	42
Mean parity (women only)	2.0 \pm .2	1.7 \pm .1
Per cent currently smoking	20	19
Mean social class	2.3 \pm .2	2.3 \pm .2
Per cent with history of hypertension	22	17

*Mean \pm standard error.

TABLE 2—Food Consumption of Two Diet Groups

Foods	Intervals	Low Carbohydrate Diet	Low Fat Diet	95% C.I. of Difference*
Whole milk mean servings/wk	baseline	(66) 6.3	(69) 6.7	(-2.0 to 1.1)
	1 month	(62) 3.5	(65) 2.0	(0.0 to 2.9)
	3 months	(63) 3.7	(63) 1.9	(0.4 to 3.2)
	1 year	(61) 4.6	(65) 3.6	(-0.6 to 2.6)
Red Meat mean servings/wk	baseline	(66) 5.0	(69) 5.0	(-2.2 to 0.4)
	1 month	(64) 5.1	(68) 3.4	(0.5 to 2.9)
	3 months	(64) 4.1	(65) 3.6	(-0.6 to 1.6)
	1 year	(61) 3.5	(65) 4.1	(-1.8 to 0.6)
White bread mean slices/wk	baseline	(66) 11.0	(68) 8.0	(-0.6 to 6.5)
	1 month	(64) 2.8	(66) 4.5	(-3.5 to -0.0)
	3 months	(64) 4.7	(66) 5.9	(-4.1 to 1.7)
	1 year	(56) 4.1	(64) 6.6	(-5.4 to 0.2)
Brown bread mean slices/wk	baseline	(66) 8.0	(69) 9.6	(-4.5 to 1.4)
	1 month	(63) 5.1	(68) 10.1	(-7.4 to -2.6)
	3 months	(64) 6.5	(66) 9.6	(-5.3 to -0.8)
	1 year	(60) 8.3	(61) 11.1	(-5.7 to 0.0)
Potatoes mean servings/wk	baseline	(66) 4.3	(69) 4.6	(-1.3 to 0.7)
	1 month	(63) 1.0	(68) 2.9	(-2.7 to -1.2)
	3 months	(64) 1.5	(66) 3.4	(-2.7 to -1.0)
	1 year	(61) 2.6	(64) 4.0	(-2.4 to -0.4)
Total cereal fiber mean grams/day	baseline	(64) 7.7	(65) 7.6	(-1.9 to 2.0)
	1 month	(63) 4.9	(66) 8.6	(-5.5 to -2.0)
	3 months	(63) 6.0	(64) 8.1	(-3.9 to -0.2)
	1 year	(46) 7.4	(55) 8.8	(-3.4 to 0.6)
Total dietary fiber mean grams/day	baseline	(61) 17.1	(63) 17.4	(-2.6 to 2.2)
	1 month	(60) 12.9	(63) 19.7	(-9.3 to -4.3)
	3 months	(62) 13.9	(62) 18.6	(-7.3 to -2.1)
	1 year	(43) 15.1	(52) 18.4	(-6.1 to -0.5)

* Confidence interval for low carbohydrate mean - low fat mean.

* Number of subjects in parentheses.

year, most of these differences had narrowed considerably, although some (e.g., total dietary fiber) remained substantial.

There was moderate weight loss in both groups during the three-month diet period, although at one year much of this had been regained (Table 3). At all weighings, especially among women, the low-carbohydrate subjects had on average lost more weight than the low fat/high carbohydrate group (e.g., 5.0 versus 3.7 kg at three months). The relative effectiveness of the diets was independent of initial weight, and the low carbohydrate diet resulted in greater weight losses both among subjects who were more obese (Quetelet's index greater than 30) and among those who were less obese

TABLE 3—Mean Weight Losses in Kilograms of Diet Groups

Diet Participants	Intervals	Low Carbohydrate Diet	Low Fat Diet	95% C.I. of Difference*
All subjects	1 month	(63) *3.9	(68) 2.8	(0.3 to 1.8)
	3 months	(63) 5.0	(66) 3.7	(0.0 to 2.5)
	1 year	(59) 2.3	(61) 1.6	(-1.2 to 2.6)
Women	1 month	(54) 3.8	(57) 2.7	(0.3 to 1.9)
	3 months	(54) 4.8	(55) 3.3	(0.1 to 2.8)
	1 year	(51) 2.4	(50) 0.9	(-0.5 to 3.6)
Age 40 years or less	1 month	(30) 3.9	(32) 2.4	(0.5 to 2.6)
	3 months	(30) 5.2	(33) 2.7	(0.5 to 4.5)
	1 year	(28) 2.0	(30) 0.3	(-0.7 to 4.1)
Social Class III-V	1 month	(41) 4.1	(38) 2.4	(0.7 to 2.7)
	3 months	(42) 5.0	(36) 3.0	(0.3 to 3.9)
	1 year	(39) 2.6	(32) 0.5	(-0.7 to 4.8)
Initial Quetelet's Index 30 or greater	1 month	(20) 5.0	(16) 3.8	(-0.5 to 2.7)
	3 months	(20) 6.5	(16) 4.7	(-1.5 to 5.1)
	1 year	(19) 4.9	(15) 3.7	(-4.2 to 6.6)

+ Confidence interval for low carbohydrate mean - low fat mean.
* Number of subjects in parentheses.

(Quetelet's index less than 30). Among men or older dieters (40 years old or greater) and among the more upper class dieters (social class I or II), the low fat/higher carbohydrate diet resulted in mean weight losses approximately equal to those for the low carbohydrate diet. Conversely, among dieters under 40 years old, or of lower social class (III-V), the low carbohydrate diet was particularly effective. All these results were also found using per cent weight loss for analysis (data not shown; available on request to author).

The diet clubs differed considerably in mean weight loss. Dieters in the most effective club lost on average three times more weight at three months than those in the least effective club. This contrasts with the relatively small difference in weight loss between diet regimens. To explore this further, analysis of covariance was performed on weight loss using sex, initial weight, diet club, and social class as factors for control. These analyses consistently showed club membership to be a better predictor of weight loss than diet allocation, even taking into account social class (data not shown; available on request to author).

Participants continued on the two diets in approximately equal proportions during the diet period, but the low-fat group tended to voice fewer complaints. At three months, more low carbohydrate subjects complained of the expense of their diet (6 per cent versus 0 per cent for the low-fat group). Constipation was also a more common complaint among the low carbohydrate subjects (23 per cent versus 3 per cent) and somewhat fewer of them thought they might use the diet again (81 per cent versus 92 per cent). Subjects in both groups complained of fatigue (22 per cent overall at three months) and difficulty dieting because of emotional stresses (31 per cent).

There were only minor differences between diet groups as to changes in lipoproteins (Table 4).

Discussion

In this randomized, controlled trial of two popular weight loss programs, the confidence intervals exclude a substantial advantage of the higher fiber regimen. However, the low carbohydrate/low fiber dieters appeared less satisfied with their diet experience.

The differences in weight loss might have been due to differences in fluid losses, since some low carbohydrate diets

TABLE 4—Metabolic Measurements* of Diet Groups

Metabolic Measurements	Intervals	Low Carbohydrate Diet	Low Fat Diet	95% C.I. of Difference*
Total cholesterol	baseline	(66) *4.74	(69) 4.89	(- .45 to .15)
	1 month	(63) 4.60	(68) 4.47	(- .12 to .39)
	3 months	(63) 4.87	(66) 4.79	(- .18 to .35)
HDL cholesterol	baseline	(65) 1.47	(69) 1.52	(- .15 to .05)
	1 month	(63) 1.38	(68) 1.33	(- .03 to .13)
	3 months	(63) 1.38	(65) 1.34	(- .06 to .13)
LDL cholesterol	baseline	(65) 2.68	(69) 2.75	(- .31 to .17)
	1 month	(62) 2.80	(68) 2.70	(- .14 to .34)
	3 months	(63) 3.00	(65) 2.90	(- .16 to .36)
VLDL cholesterol	baseline	(64) 0.57	(68) 0.64	(- .21 to .07)
	1 month	(62) 0.43	(68) 0.44	(- .14 to .08)
	3 months	(63) 0.49	(65) 0.54	(- .17 to .05)
Triglycerides	baseline	(66) 1.63	(69) 1.79	(- .49 to .18)
	1 month	(61) 1.41	(66) 1.50	(- .38 to .20)
	3 months	(63) 1.47	(66) 1.60	(- .38 to .13)
HDL/LDL ratio	baseline	(65) 0.60	(69) 0.60	(- .08 to .08)
	1 month	(62) 0.53	(68) 0.52	(- .05 to .07)
	3 months	(63) 0.50	(65) 0.50	(- .07 to .06)
Glucose	baseline	(66) 4.33	(69) 4.29	(- .15 to .24)
	1 month	(56) 4.15	(58) 4.23	(- .32 to .15)
	3 months	(63) 4.14	(66) 4.11	(- .38 to .13)

#All measurements are mmol/l on fasting AM specimens.
* Number of subjects in parentheses.
+ Confidence interval for low carbohydrate mean - low fat mean.

have been shown to promote a diuresis.¹³ These low carbohydrate diets, however, were designed to be ketogenic and imposed a limitation on dietary carbohydrate more severe than that used in this investigation.

One of the strengths of our study was its real-life setting, a contrast with most metabolic studies. However, this meant that the dietary regimens could only be recommended and not enforced. While the weight loss and dietary questionnaires indicate that, in general, the participants did alter their diets in accordance with their assigned regimens, this study remains a comparison of dietary advice rather than of diets. Similar factors prevent this investigation from having been double-blind. However, the design of the trial facilitated a valid comparison of the content of the two diet plans, since the study groups differed only in dietary advice, and not in procedures, rituals, or paraphernalia.

Most of our subjects were not grossly obese, and a few were just barely overweight, if at all. This spectrum of overweight is common in diet clubs¹ and, in this sense, the participants in this study are typical of Western dieters. There was consistency of results, however, in that our more obese subjects tended to lose more weight on the low carbohydrate diet, as did the less obese. As in previous investigation of dieting, the amount of weight lost was modest and tended to be regained.¹⁻³

The initial mean dietary fiber intake in both diet groups was lower than that measured among non-vegetarian subjects from the same geographic area who took part in an earlier study.⁶ This may reflect a low fiber intake among the obese,^{1,2,14} but our investigation was not designed to address that issue. Alternatively, some of our subjects may actually have been dieting at the start of the study, despite the entry requirements. During the diet period, the total dietary fiber intake increased only modestly (14 per cent) among the low fat dieters. However, total caloric intake also decreased, so considered as grams of fiber per 1,000 calories, the rise was likely much greater.

Our results do not confirm claims that fiber intake will

facilitate weight loss through an increased sensation of satiety.^{14,15} Not only did those in the low carbohydrate (lower fiber) group lose more weight, but they also complained of hunger with about the same frequency as the low fat (higher fiber) dieters. Several previous investigators have also failed to find benefit from fiber or bulk agents in the promotion of weight loss or the prevention of weight gain.^{1,14,15} It is conceivable, however, that a greater emphasis on fiber intake might have made the low fat diet more effective.

The large differences in weight loss between diet clubs contrasted with the more modest differences between dietary regimens. The lack of a striking effect from any diet has long been known, but the differences between the clubs was unexpected. This could be due to the nature of the participants in each of them or to the effectiveness of their leaders. Social class did not explain the differences.

Changes in lipoproteins during the diet period were not great, and the experience here failed to support the fears of marked hyperlipidemia during low carbohydrate dieting.¹⁶ The modest fall in total cholesterol and HDL (high density lipoprotein) cholesterol among the low fat dieters at one month is consistent with previous investigation of fiber-supplemented diets.¹⁷⁻²¹ The soluble types of fiber have been shown to have the most potent hypolipidemic effect^{20,21} and it is possible that emphasis on the intake of these types of fiber might have resulted in more marked lipid reductions. However, the very similarity between diet groups as to changes in metabolic measurements suggests that these changes may be due to either the caloric restriction or the weight loss rather than to the particular diets. Previous reports have also noted that weight loss in overweight subjects results in a lowering of total cholesterol, triglycerides, and fasting blood sugar.²²

In summary, we performed a randomized controlled trial of dietary advice for two regimens that differed greatly in carbohydrate, fiber, and fat content. Despite current claims, we found no support for a particular effectiveness of dietary fiber in weight loss, although the low fat (higher carbohydrate) dieters appeared somewhat happier with their diet.

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