High-carbohydrate, high-fiber diets for insulin-treated men with diabetes mellitus[1, 2]

James W. Anderson, M.D. and Kyleen Ward, R.D.

ABSTRACT The effects of high-carbohydrate, high plant fiber (HCF) diets on glucose and lipid metabolism of 20 lean men receiving insulin therapy for diabetes mellitus were evaluated on a metabolic ward. All men received control diets for an average of 7 days followed by HCF diets for an average of 16 days. Diets were designed to be weight-maintaining and there were no significant alterations in body weight. The daily dose of insulin was lower for each patient on the HCF diet than on the control diet. The average insulin dose was reduced from 26 ± 3 units/day (mean ± SEM) on the control diets to 11 ± 3 ($P < 0.001$) on the HCF diets. On the HCF diets, insulin therapy could be discontinued in nine patients receiving 15 to 20 units/day and in two patients receiving 32 units/day. Fasting and 3-hr postprandial plasma glucose values were lower in most patients on the HCF diets than on the control diets despite lower insulin doses. Serum cholesterol values dropped from 206 ± 10 mg/dl on the control diets to 147 ± 5 ($P < 0.001$) on the HCF diet; average fasting serum triglyceride values were not significantly altered on the HCF diets. These studies suggest that HCF diets may be the dietary therapy of choice for certain patients with the maturity-onset type of diabetes. *Am. J. Clin. Nutr.* 32: 2312–2321, 1979.

The proportion of energy that should be provided by either carbohydrate or fat in diets for patients with diabetes mellitus is controversial (1). Traditional diets (1–5) have restricted the intake of carbohydrate and some authorities (5–7) maintain that carbohydrate-restriction is a very important aspect of the management of the diabetic state. Recent recommendations (8–11) suggest that the intake of complex carbohydrate can be liberalized for most patients with diabetes. Unfortunately, recommendations for either carbohydrate-restriction or for a generous intake of carbohydrate are empirical and are not based on careful metabolic studies. We are unaware of any studies in the English language literature that demonstrate convincingly that weight maintaining diets (either low in carbohydrate or high in carbohydrate) lead to reductions in insulin requirements of lean individuals with diabetes.

High-carbohydrate diets have been advocated (12–14) for the management of diabetes, but contradictory results have been reported (15, 16). Using high-carbohydrate diets, the reduction in insulin doses reported by Rabinowitch (13) and by Kempner et al. (14) were also accompanied by significant reductions in body weight. Two relatively long-term studies (15, 16) have failed to demonstrate that diets providing 60% or more of calories as carbohydrate were associated with significant changes in insulin doses (15) or in glucose metabolism (16). Thus, despite the frequent recommendations (8–14) that high-carbohydrate diets are efficacious in treating diabetes, their superiority over traditional diets has not been clearly demonstrated. A disadvantage of certain high-carbohydrate diets, especially for patients with diabetes (17), is a resultant increase in fasting serum triglyceride values (18).

Addition of plant fibers to the diets of patients with diabetes is accompanied by significant reductions in postprandial hyperglycemia (19, 20). Diets containing generous amounts of plant fiber are associated with significant reductions in the quantity of glucose excretion in the urine (21). These studies

[1] From the Medical and Dietetic Services, Veterans Administration Hospital and Department of Medicine, University of Kentucky College of Medicine, Lexington, Kentucky.

[2] Supported in part by Grant 1 RO1 AM20889-01 from the National Institutes of Arthritis, Metabolic and Digestive Diseases.

Downloaded from https://academic.oup.com/ajcn/article-abstract/32/11/2312/4692116 by guest on 12 October 2018

suggest that plant fibers may have a role in the dietary management of patients with diabetes.

Combining a generous intake of plant fibers with a high-carbohydrate diet might be of distinct benefit in the management of certain patients with diabetes. The usefulness of high-carbohydrate, high plant fiber diets (HCF) in treating patients with diabetes has not been evaluated carefully. In a preliminary study (22), we observed that HCF diets were accompanied by lower fasting plasma glucose values and insulin or sulfonylurea doses than observed on control diets. Interpretation of this study is difficult, however, because of the following factors: only eight of the 13 patients were on insulin, five patients were obese, and most patients lost weight on the HCF diet. To evaluate further the potential therapeutic utility of HCF diets, we have extended these studies. Twenty lean men who were receiving insulin therapy were placed on weight-maintaining HCF diets for approximately 16 days after 1 week of observation on a control diet on a metabolic ward.

Methods

Patients

All patients had diabetes mellitus with multiple fasting plasma glucose values above 200 mg/dl and were hospitalized on a metabolic ward for these studies. Insulin therapy had been instituted because of symptomatic hyperglycemia and most patients had received daily injections since the time of diagnosis of their diabetes (Table 1). All patients were lean and none exceeded 113% of their estimated desirable body weight (23).

Diets

All patients were fed weight-maintaining control diets for an average of 7 days (range of 4 to 11 days) after admission to the metabolic ward. These diets provided approximately 43% of calories as carbohydrate (Table 2) and were similar to diets traditionally used to treat patients with diabetes. Then each patient was fed an HCF diet that was designed to maintain their weight at the same level for the duration of the study. These HCF diets (Table 2) provided approximately 70% of calories as carbohydrate, 21% as protein, and only 9% as fat. No sucrose was added to either of these diets and the simple carbohydrate refers to monosaccharides, disaccharides, and trisaccharides contained in milk, grain products, vegetables, and fruits. The plant fiber was provided by:

TABLE 1
Diabetic men

Patient	Age	Duration of diabetes	Weight % of desirable	HCF diet duration
	yr			*days*
1	68	6	96	15
2	56	7	97	15
3	42	14	94	13
4	60	16	96	14
5	55	4	91	19
6	53	1	99	18
7	49	1	109	14
8	57	9	110	21
9	75	20	111	13
10	56	1	113	17
11	32	3	112	16
12	55	1	99	16
13	49	10	70	15
14	45	19	109	16 (24)[a]
15	69	1	109	18
16	62	8	103	16 (33)[a]
17	70	5	112	16
18	42	4	84	16
19	53	8	85	16
20	38	15	82	16
Mean	54	8	99	16
SEM	3	1	33	0.4

[a] Data for 16 days were analyzed (Tables 3 and 4). Numbers in parentheses are total duration of HCF diet.

TABLE 2
Composition of diets[a]

	Control diet		HCF diet	
	g/day	*% kcal*	*g/day*	*% kcal*
Protein	92	20	98	21
Carbohydrate, total[b]	191	43	314	70
Simple	79		91	
Complex	112		223	
Fat, total	74	37	18	9
Saturated	26		5	
Monosaturated	39		5	
Polyunsaturated fatty acids	9		8	
Cholesterol	0.48		0.065	
Plant fiber, total	26		65	
Insoluble	16		53	
Soluble	10		12	

[a] Values are given for representative 1800-kcal diets. [b] Total carbohydrate refers to available carbohydrate and does not include plant fiber (24).

Downloaded from https://academic.oup.com/ajcn/article-abstract/32/11/2312/4692116 by guest on 12 October 2018

whole grain or grain cereals and breads, 40%; starchy vegetables, such as beans, corn, or peas, 20%; other vegetables, 31%; and fruits, 9%. The nutrient, calorie, and fiber contents of each diet were calculated from tables published elsewhere (24). Soluble fibers refer to water soluble fibers such as pectins and gums while insoluble fibers refer to fibers such as cellulose and lignin which are not water soluble.

Procedures

Patients were weighed daily. Each day blood was drawn before breakfast after an 11-hr fast for plasma glucose and serum cholesterol and triglyceride values; at 3 hr after the noon meal, blood was drawn daily for plasma glucose values in 12 patients. Blood glucose and lipid values on the control diets were averaged and compared with values for the last 5 days on the HCF diets. The degree of glycosuria was estimated four times daily by measuring urine glucose concentrations before meals and at 9:00 PM. Urinary glucose excretion over each 24-hr period was measured in eight patients. Glucose, cholesterol, and triglycerides were measured as previously described (22). Statistical comparisons were made using the paired *t* test.

Results

Glucose metabolism on control diets

The response of patient 15 is demonstrated in Figure 1. On the control diet, the insulin dose was increased to maintain fasting plasma glucose values slightly above 150 mg/dl. For the last 6 days on the control diet, the insulin dose was maintained at 32 units/day and the fasting plasma glucose values and 24-hr urine glucose excretion were relatively constant. As indicated in Figure 1 to 3, we

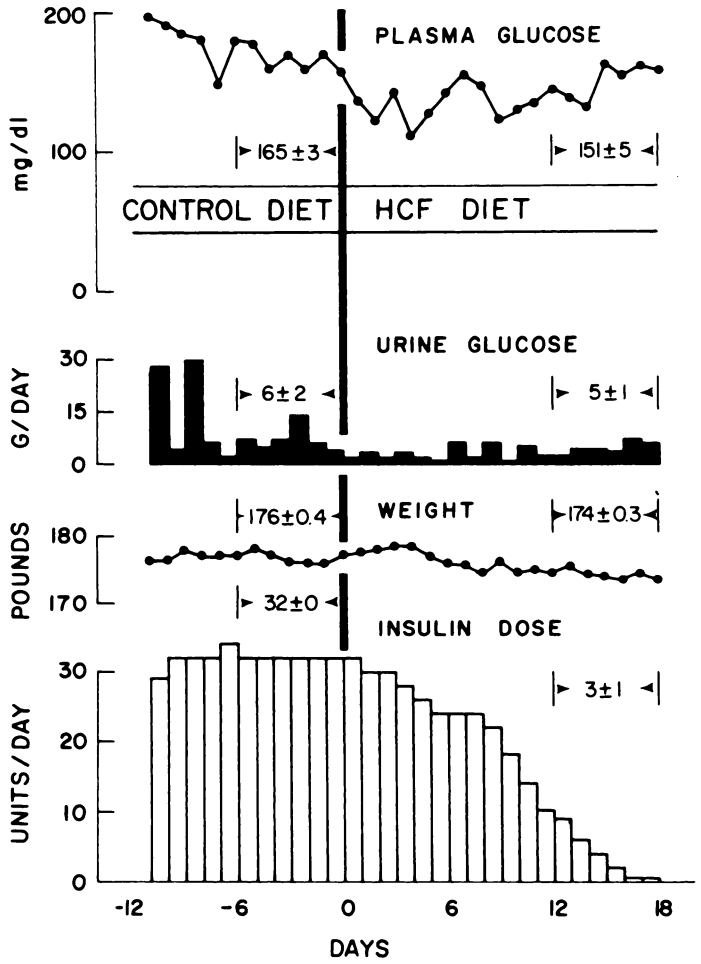

FIG. 1. Glucose metabolism on control and HCF diets. Values between *arrows* are mean ± SEM for the last 6 days on each diet. Reproduced with permission from Anderson (28).

Downloaded from https://academic.oup.com/ajcn/article-abstract/32/11/2312/4692116 by guest on 12 October 2018

observed no significant alterations in insulin doses, plasma glucose values, or urine glucose values in 12 patients maintained for 7 to 11 days on control diets.

Glucose metabolism on HCF diets

Patients were divided into three groups (Table 3) according to their insulin doses on control diets. The 1st group was treated with 15 to 20 units of insulin per day on the control diets and insulin therapy was discontinued in nine of these 10 patients. Because of personal problems, patient 4 had to leave the hospital after 14 days on the HCF diet; we had planned to discontinue insulin therapy on the next day. The response of eight patients in the first group is presented in Figure 2. These eight patients were maintained for at least 6 days on the control diets before initiating the HCF diets. Patients 2 and 7 are excluded from Figure 2 because they were on the control diets for less than 6 days. On control diets, plasma glucose values and insulin doses were fairly constant. After initiating HCF diets, there was a reduction in fasting plasma glucose values and a slight increase in postprandial glucose values as the insulin doses were reduced. During the 2nd week of the HCF diets, fasting plasma glucose values were similar to those on the control diets, and postprandial plasma glucose values were lower than control values despite significantly lower insulin doses. As presented in Table 3, most patients had lower fasting and postprandial glucose values during the last 5 days of the HCF diets than on the control diets despite markedly lower doses of insulin. The insulin dose was reduced approximately 2 units every other day and insulin therapy was discontinued after an average of 14 days in these patients.

The 2nd group of patients (Table 3) was

TABLE 3
Insulin doses and plasma glucose values on control and HCF diets[a]

Patient	Insulin		Plasma glucose[b]			
			Fasting		Postprandial	
	Control	HCF	Control	HCF	Control	HCF
	unit/day		*mg/dl*			
1	15	0	165	128	142	140
2	15	0	157	148	163	111
3	15	0	149	144		
4	15	2	192	170		
5	15	0	138	122	133	130
6	17	0	87	135	146	128
7	17	0	124	101	135	118
8	18	0	239	155	178	111
9	20	0	136	152		
10	20	0	107	114		
Group (10)	17	0.2	149	137	150	123
	1	0.2[c]	14	7	7	5
11	22	5	146	132	223	162
12	28	15	150	239	238	350
13	29	15	211	176	278	304
14	32	18(8)	216	159	182	168
15	32	0	165	151		
16	32	14(0)	158	139		
17	34	20	198	177	123	135
Group (7)	30	12	178	168	209	224
	2	3[c]	11	14	26	43
18	40	35	169	139		
19	46	43	213	198	322	221
20	57	48	159	163		
Group (3)	48	42	180	167		
	5	4	17	17		
Total (20)	26	11	164	152	189	172
	3	3[c]	9	7	18	23

[a] Group values are tabulated as mean ± SEM. [b] Mean of values for last 5 days on each diet. [c] *P* versus control <0.001.

Downloaded from https://academic.oup.com/ajcn/article-abstract/32/11/2312/4692116 by guest on 12 October 2018

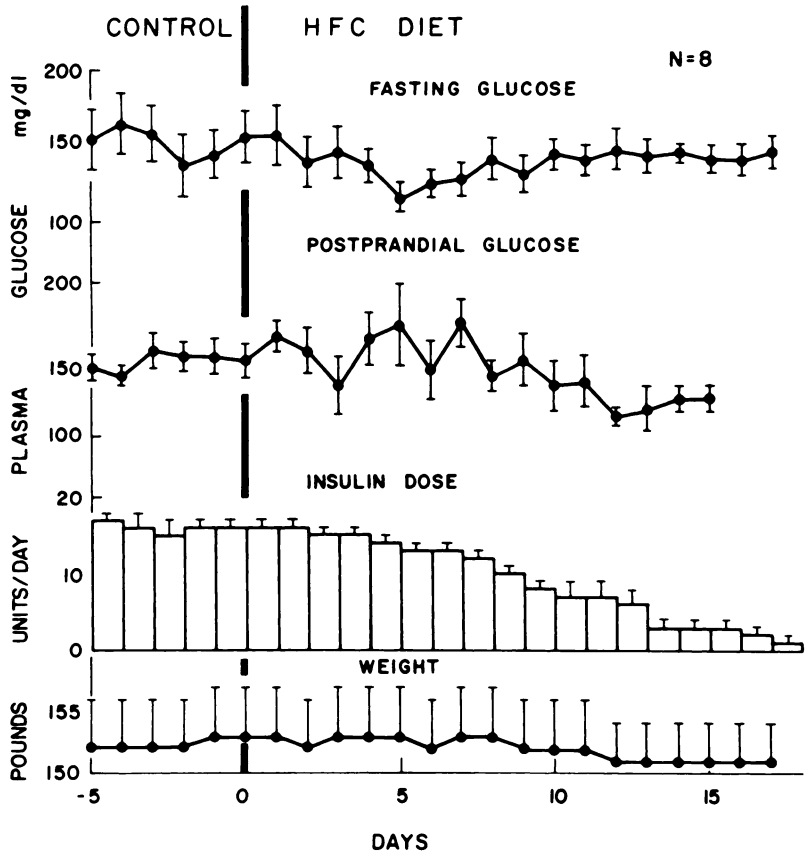

FIG. 2. Glucose metabolism on control and HCF diets. Values represent mean ± SEM for eight men receiving 15 to 20 units/day of insulin (see Table 3).

treated with 22 to 34 units of insulin per day on the control diets. On the HCF diets, there was a gradual reduction in insulin doses to an average of 12 units/day. Most of these patients had lower plasma glucose values and less glycosuria on the HCF diets. Patient 12 is an exception and his diabetic control was worsened when his dose was reduced to 15 units/day; however, on 18 units/day, his fasting and postprandial glucose values were lower on the HCF diet than on the control diet. Similarly, patient 13 showed an improvement in glucose metabolism on the HCF diet, but when his dose was lowered to 15 units/day, his postprandial glucose values were distinctly higher than control values. The diet of patient 14 was continued to 24 days and his insulin was reduced to 8 units/day. Ten weeks after discharge, he was able to discontinue insulin therapy and has gone for 13 months as an outpatient on no insulin while following a maintenance HCF diet (25). Patient 16 was maintained on the HCF diet for 33 days and his insulin was discontinued. After discharge from the hospital, he has maintained satisfactory fasting plasma glucose values for 2 months on the maintenance diet (25). In this group of seven patients on the HCF diet, the insulin dose could be lowered approximately 2 units every other day.

The 3rd group of patients (Table 3) required 40 to 57 units of insulin per day to manage their diabetes. On the HCF diet, there was a slight reduction in insulin doses; average plasma glucose values and urine glucose values were lower on the HCF diet than values on the control diets.

The responses of seven patients from the 2nd and 3rd groups are presented in Figure 3. Diabetic control was not difficult in these seven patients, and they did not have wide swings in their plasma glucose values. Three

Downloaded from https://academic.oup.com/ajcn/article-abstract/32/11/2312/4692116 by guest on 12 October 2018

patients (13, 19, and 20) were excluded from Figure 3 because the assessment of diabetic control was more difficult because of wide swings of their plasma glucose values. The seven patients presented in Figure 3 were maintained on relatively constant insulin doses for at least 7 days during the control period. There was no evidence that their insulin requirements were reduced by the control diet and fasting plasma glucose values were relatively constant for the last 5 days on the control diet. During the 1st week of the HCF diet, fasting plasma glucose values were lower and average insulin doses could be reduced. After an average of 16 days on the HCF diet, the insulin dose was reduced from an average of 31 to 16 units/day ($P < 0.001$). Fasting plasma glucose values were similar during the last week on the HCF diets to values during the 1st week on the control diets.

As a group, these 20 patients showed a significant reduction in their insulin doses ($P < 0.001$) on the HCF diets as compared to the control diets (Table 3). These reductions in insulin doses were accompanied by slight reductions in fasting and postprandial glucose values in these patients.

Body weights

The average weight change (Table 4) was not statistically significant. Some patients lost weight during the 1st week on the HCF diets because they were unable to eat the large servings of vegetables provided; with minor dietary modifications and patient adaptation, most patients were able to eat all of their food by the 2nd week. Otherwise, the diets were well tolerated and patients had minimal gastrointestinal complaints. Most patients noted that stools were bulkier and they expelled more gas while on the HCF diets, but none of these patients developed diarrhea.

Serum lipid responses

The HCF diets were accompanied by reductions in fasting serum cholesterol values in all patients and the reductions averaged 59 mg/dl. The decreases in serum cholesterol values were consistent in all three groups (Table 4). Average fasting serum triglyceride values were similar on the HCF diets to values on the control diets. In some patients, however, there was a slight increase in fasting serum triglyceride values. Serial changes in fasting serum cholesterol, triglyceride, and postprandial triglyceride values will be reported elsewhere.

Discussion

To evaluate the potential beneficial effects

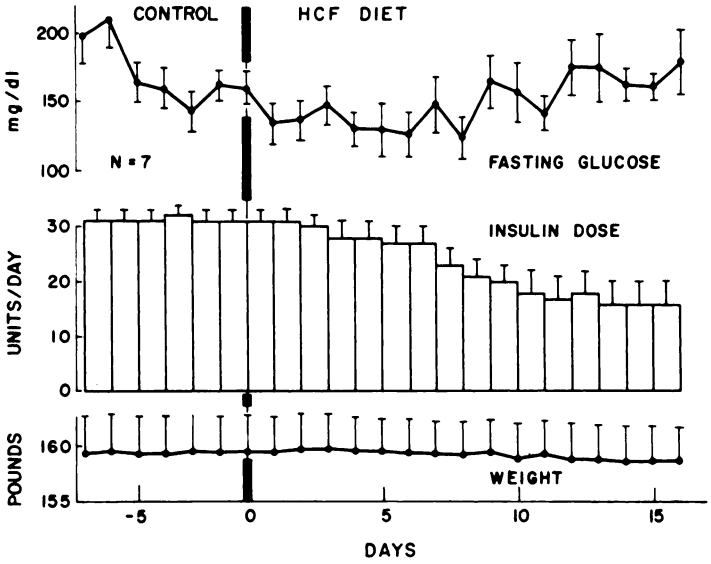

FIG. 3. Glucose metabolism on control and HCF diets. Values represent mean ± SEM for seven men receiving 22 to 40 units/day of insulin (see text and Table 3).

Downloaded from https://academic.oup.com/ajcn/article-abstract/32/11/2312/4692116 by guest on 12 October 2018

TABLE 4
Body weights and fasting serum lipid values on control and HCF diets

Patient	Weight		Serum lipids[a]			
			Cholesterol		Triglycerides	
	Control	HCF	Control	HCF	Control	HCF
	lb		*mg/dl*			
1	139.8	135.9	212	136	74	61
2	136.1	133.6	172	128	72	73
3	141.2	142.2	137	132	119	132
4	168.7	168.8	206	151	139	148
5	144.0	144.0	141	130	156	169
6	147.6	148.7	269	200	109	107
7	170.1	169.2	206	149	141	109
8	159.6	161.1	156	133	111	117
9	156.3	159.4	227	135	135	134
10	159.3	157.1	246	188	231	263
11	182.8	180.5	226	132	156	140
12	144.0	142.0	212	132	74	78
13	104.2	104.5	181	141	77	55
14	145.5	144.4	228	158	126	85
15	176.8	174.2	333	201	314	316
16	163.8	161.3	183	152	122	129
17	166.4	165.8	215	147	176	175
18	132.0	135.3	168	132	93	82
19	139.5	137.9	208	142	90	96
20	131.4	130.6	185	130	105	90
Mean	150.4	149.8	206	147	131	128
SEM	4.2	4.1	10	5[b]	13	15

[a] Mean of values for last 5 days on each diet. [b] P versus control <0.001.

of HCF diets in insulin-treated, lean men we fed control diets for approximately 7 days followed by HCF diets for an average of 16 days. The HCF diets were accompanied by a significant lowering of insulin doses and slightly lower plasma glucose values than observed on control diets. Our current studies do not answer four important questions. *1)* Would 3 weeks of treatment in the hospital with control diets be accompanied by similar reductions in insulin doses? *2)* Would high-fiber diets containing the same quantity of carbohydrate as the control diets be accompanied by similar reductions in insulin doses? *3)* Would high-carbohydrate diets that are low in plant fiber be accompanied by similar reductions in insulin doses? *4)* After a reduction in insulin doses on the HCF diets, would insulin doses increase if patients were restarted on the control diets? We are currently examining these questions; however, data are available to answer in part these questions.

When control diets were fed to 12 of these patients for 7 to 11 days (mean of 8 days) we observed no alterations in insulin doses. (Figs. 1 to 3). After 8 days on the HCF diets, however, insulin doses were significantly lower (Figs. 1 to 3). We have fed conventional diabetic diets to patients hospitalized for prolonged periods without observing significant alterations in insulin doses (J. W. Anderson, unpublished observations). Furthermore, we are aware of no reports in the English language literature that demonstrate that weight-maintaining diets are accompanied by significant reductions in insulin doses in lean individuals with diabetes.

The influence of large amounts of dietary fiber on glucose metabolism in these studies is unclear. In meal-feeding experiments, high-fiber meals were accompanied by significantly lower postprandial glucose values than observed after fiber-free meals (19). Two groups have investigated the influence of feeding moderate to large amounts of plant fiber for 5, 7, or 10 days (20, 21). Jenkins et al. (21) observed that when 25 g of guar gum were added to the diet of six lean, insulin-treated individuals for a period of 5 to 7 days, urine glucose values were reduced to approximately half of values on the control diet. Insulin doses, however, were maintained con-

Downloaded from https://academic.oup.com/ajcn/article-abstract/32/11/2312/4692116 by guest on 12 October 2018

stant during these studies. Similarly, Miranda and Horwitz (20) fed high-fiber diets to eight lean, insulin-treated patients for 10 days; postprandial glucose values were significantly lower but fasting plasma glucose values were not changed and insulin doses were maintained constant. In contrast to these studies, our HCF diets were accompanied by a prompt reduction in fasting plasma glucose values (Figs. 1 to 3) and insulin doses had to be reduced within the first 3 to 5 days to prevent hypoglycemia in most patients. Thus, it seems unlikely that the plant fiber content of our HCF diets is the major factor in determining the reduction in insulin doses of our patients. However, the additive or synergistic role that plant fibers may have in inducing these changes in glucose metabolism cannot be fully assessed at this time.

The high-carbohydrate and low-fat content of our HCF diet may play the predominant role in the reduction in insulin doses that we observed. Our studies (18) and those of Brunzell et al. (26) demonstrated that diets containing 75 to 85% of calories as carbohydrate with 10% or less of calories as fat were accompanied by distinct improvement in glucose metabolism in patients with mild diabetes. The formula diets of Brunzell et al. (26) contained no plant fibers and our solid diets were low in plant fiber. Furthermore, we have fed 10 insulin-treated individuals with 70% carbohydrate diets that were either low or high in plant fiber content for 10 days in an alternating sequence (27, 28). The changes in insulin doses and fasting plasma glucose values were similar on the low-fiber diets to those observed on the high-fiber diet. Thus, from the available data we believe that the high-carbohydrate content of the HCF diets plays the predominant role in lowering fasting plasma glucose values and insulin doses on these diets.

When patients resume eating conventional diets (similar to our control diets) after 2 or 3 weeks on HCF diets their insulin doses usually return to values similar to those observed on the control diets. We have placed nine patients on weight-maintaining control-type diets after the HCF diets; three patients were observed for 10 to 17 days on the metabolic ward and six patients were followed closely as outpatients for a minimum of 3 months. Insulin doses were adjusted to maintain fasting plasma glucose values of approximately 150 mg/dl. For the three patients treated in the hospital insulin doses were: 29, 17, and 15 units/day on the control diets; 15, 0, and 0 units/day on the HCF diets; and 30, 15, and 15 on the second period of control diets. Insulin doses for the nine patients were: 23 ± 4 units/day (mean ± SEM) on the control diets, 8 ± 4 units/day on the HCF diets, and 27 ± 3 after an average of 3 months on the control-type diets as outpatients. Further studies are required to compare the long-term effects of HCF-type diets (25) with control-type diets. Nevertheless, our preliminary observations suggest that those patients who follow HCF-type diets at home are able to maintain lower insulin doses than on control diets whereas those patients who resume control-type diets have similar insulin doses to those observed in the hospital on the control diets.

Two previous studies have failed to demonstrate a reduction in insulin doses (15) or improvement in glucose metabolism (16) when patients were fed diets containing 60 or 62% of calories as carbohydrate. Presumably the plant fiber content of these diets was low since the authors did not mention plant fiber and did not attempt to provide a generous intake of plant fiber. Their diets were also lower in total carbohydrate and higher in fat than our HCF diets. Their failure to demonstrate a favorable response to high carbohydrate diets might be related to the lower fiber content of their diets or to the lower carbohydrate and higher fat contents of their diets. We have observed that the response of glucose metabolism to 60% carbohydrate, high-fiber diets (25) is much slower than the response reported here with 70% carbohydrate diets (J. W. Anderson, unpublished observations).

The mechanisms for improvement of glucose metabolism on high-carbohydrate diets have not been clarified. Extensive studies in normal individuals have demonstrated that high-fat diets impair glucose tolerance while high-carbohydrate diets improve glucose metabolism (26, 29, 30). Weight-maintaining, high-carbohydrate, low-fat diets are accompanied by lower plasma insulin values and by lower plasma insulin responses to oral glucose

Downloaded from https://academic.oup.com/ajcn/article-abstract/32/11/2312/4692116 by guest on 12 October 2018

administration in lean individuals (26, 29). These observations coupled with out present study suggest that high-carbohydrate, low-fat diets may increase the sensitivity of various tissues to insulin.

The dramatic lowering of serum cholesterol values that we observed is probably related to the lower cholesterol and fat content as well as the high-fiber content of these diets. Soluble fibers have distinct hypocholesterolemic effects in man (31, 32). Supplementation of the diet with pectin or guar gum (31) is accompanied by significant reductions in serum cholesterol values. The available data (32) suggest that soluble plant fibers may lower serum cholesterol values by decreasing bile salt absorption.

The changes in serum triglyceride concentrations of the HCF diets cannot readily be explained. When we fed high-carbohydrate, lower fiber diets to patients with chemical diabetes, serum triglyceride values increased by an average of 55% (18). These diets, however, contained less than half as much simple carbohydrate as our present diets. Therefore, the changes in fasting serum triglycerides currently noted cannot be related to a restriction of simple carbohydrates since the HCF diets contained more simple carbohydrate than the control diets (Table 2) or the high-carbohydrate, low-fiber diets (18). Our previous observations (32, 33) suggest that the incorporation of large amounts of plant fibers into the HCF diets has prevented this hypertriglyceridemia and resulted in the stability of average fasting serum triglyceride values. Further studies are required to delineate the influence of plant fibers on fasting serum triglyceride values.

Our studies suggest that HCF diets may be the therapy of choice for certain patients with the maturity-onset type of diabetes. These studies do not reveal how much carbohydrate or how much plant fiber is required to induce these beneficial effects on carbohydrate and lipid metabolism. While these diets containing 70% carbohydrate and 65 g of plant fiber are palatable and can easily be prepared in a metabolic kitchen, patients have difficulty duplicating these diets at home. Therefore, after patients have demonstrated a favorable response to these diets in the hospital we instruct them in maintenance diets containing 55 to 60% carbohydrate and 40 to 50 g of plant fiber for home use (25). Ten patients have followed these maintenance diets at home and have maintained stable insulin doses, blood glucose, and lipid values for up to 3 years after discharge from the hospital (25). Further studies are required to document the long-term effects of these HCF diets on glucose and lipid metabolism of patients with diabetes.

The authors appreciate the assistance of Tae G. Kiehm, M.D., and Barbara Reiser.

References

1. TRUSWELL, A. S., B. J. THOMAS AND A. M. BROWN. Survey of dietary policy and management in British diabetic clinics. Brit. Med. J. 4: 7, 1975.
2. DAUGHADAY, W. H. Dietary treatment of adults with diabetes mellitus. J. Am. Med. Assoc. 167: 859, 1958.
3. ALLAN, F. N. Dietetic treatment of diabetes. Med. Clin. North Am. 44: 423, 1960.
4. JOSLIN, A. P., AND P. WHITE. The dietary management of diabetes. Med. Clin. North Am. 49: 905, 1965.
5. PERKINS, J. R., T. E. T. WEST, P. H. SONKSEN, C. LOWY AND C. ILES. The effect of energy and carbohydrate restriction in patients with chronic diabetes mellitus. Diabetologia 13: 607, 1977.
6. WALL, J. R., D. A. PYKE AND W. G. OAKLEY. Effect of carbohydrate restriction in obese diabetics: relationship of control to weight loss. Brit. Med. J. 1: 577, 1973.
7. HADDEN, D. R., D. A. D. MONTGOMERY, R. J. SHELLY, E. R. TRIMBLE, J. A. WEAVER, E. A. WILSON AND K. D. BUCHANON. Maturity onset diabetes mellitus: response to intensive dietary management. Brit. Med. J. 3:276, 1975.
8. BIERMAN, E. L., M. J. ALBRINK, R. A. ARKY, W. E. CONNER, S. DAYTON, N. SPRITZ AND D. STEINBERG. Principles of nutrition and dietary recommendations for patients with diabetes mellitus: 1971. Diabetes 20: 633, 1979.
9. WEST, K. M. Prevention and therapy of diabetes mellitus. Nutr. Rev. 33: 193, 1975.
10. BIERMAN, E. L., AND R. NELSON. Carbohydrate, diabetes and blood lipids. World Rev. Nutr. Dietet. 22: 280, 1975.
11. A Guide for Professionals: The Effective Application of "Exchange Lists of Meal Planning." New York: American Diabetes Association and American Dietetic Association, 1977.
12. SINGH, I. Low-fat diet and therapeutic doses of insulin in diabetes mellitus. Lancet 1: 422, 1975.
13. RABINOWITCH, I. M. Effects of the high carbohydrate-low calorie diet upon carbohydrate tolerance in diabetes mellitus. Can. Med. Assoc. J. 33: 136, 1935.
14. KEMPNER, W., R. L. PESCHEL AND C. SCHLAYER. Effect of rice diet on diabetes mellitus associated

Downloaded from https://academic.oup.com/ajcn/article-abstract/32/11/2312/4692116 by guest on 12 October 2018

with vascular disease. Postgrad. Med. 24: 359, 1958.
15. STONE, D. B., AND W. E. CONNOR. The prolonged effects of a low cholesterol, high carbohydrate diet on the serum lipids in diabetic patients. Diabetes 12: 127, 1963.
16. WEINSIER, R. L., A. SEEMAN AND G. HERRERA. High- and low-carbohydrate diets in diabetes mellitus. Ann. Internal Med. 80: 332, 1974.
17. BRUNZELL, J. D., D. PORTE, JR. AND E. L. BIERMAN. Reversible abnormalities in postheparin lipolytic activity during the late phase of release in diabetes mellitus. Metabolism 24: 1123, 1975.
18. ANDERSON, J. W. Effect of carbohydrate restriction and high carbohydrate diets on men with chemical diabetes. Am. J. Clin. Nutr. 30: 402, 1977.
19. JENKINS, D. J. A., A. R. LEEDS AND M. A. GASSULL. Unabsorbable carbohydrates and diabetes: decreased postprandial hyperglycaemia. Lancet 2: 172, 1976.
20. MIRANDA, P. M., AND D. L. HORWITZ. High-fiber diets in the treatment of diabetes mellitus. Ann. Internal Med. 88: 482, 1978.
21. JENKINS, D. J. A., T. M. S. WOLEVER AND T. D. R. HOCKADAY. Treatment of diabetes with guar gum. Lancet 2: 779, 1977.
22. KIEHM, T. G., J. W. ANDERSON AND K. WARD. Beneficial effects of a high carbohydrate, high fiber diet on hyperglycemic diabetic men. Am. J. Clin. Nutr. 29: 895, 1976.
23. New weight standards for men and women. Metropolitan Life Ins. Statis. Bull. 40:1, 1959.
24. ANDERSON, J. W., W. CHEN AND K. WARD. Composition of foods commonly used in diets for persons with diabetes. Diabetes Care 1:293, 1978.
25. ANDERSON, J. W., AND K. WARD. Long-term effects of high carbohydrate, high fiber diets on glucose and lipid metabolism. A preliminary report on patients with diabetes. Diabetes Care 1: 77, 1978.
26. BRUNZELL, J. D., R. L. LERNER AND W. R. HAZZARD. Improved glucose tolerance with high carbohydrate feeding in mild diabetes. New Engl. J. Med. 284: 521, 1971.
27. ANDERSON, J. W. Triglyceride lowering effects of high carbohydrate, high fiber diets. Clin Res. 26: 719A, 1978.
28. ANDERSON, J. W. High carbohydrate, high fiber diets for patients with diabetes. IV International Symposium on Early Diabetes, edited by R. A. Camerini-Davalos and B. Hanover. New York: Plenum, 1979.
29. ANDERSON, J. W., R. H. HERMAN AND D. ZAKIM. Effect of high glucose and high sucrose diets on glucose tolerance of normal men. Am. J. Clin. Nutr. 25: 600, 1973.
30. HIMSWORTH, H. P. The physiological activation of insulin. Clin. Sci. 1: 1, 1933.
31. JENKINS, D. J. A., A. R. LEEDS AND C. NEWTON. Effects of pectin, guar gum and wheat fiber on serum-cholesterol. Lancet 1:1116, 1975.
32. ANDERSON, J. W., AND CHEN, W. L. Plant fiber: Carbohydrate and lipid metabolism. Am. J. Clin. Nutr. 32: 346, 1979.
33. ANDERSON, J. W. High polysaccharide diet studies in patients with diabetes and vascular disease. Cereal Foods World 22: 12, 1977.

Downloaded from https://academic.oup.com/ajcn/article-abstract/32/11/2312/4692116 by guest on 12 October 2018