

High-carbohydrate, high-fibre diets for diabetics

By H. C. R. SIMPSON, *Diabetes Research Laboratory, Radcliffe Infirmary, Oxford*

The concept of a more liberal attitude towards carbohydrate consumption in diabetics is almost as old as the discovery of insulin. Indeed, some of the most elegant studies in this respect were performed by Himsworth (1933). Since then, Kempner has fed rice diets to insulin-requiring diabetics with a large measure of success (Kempner *et al.* 1958), and these contained over 90% of all energy in carbohydrate form. Despite the considerable efforts of these and other workers, carbohydrate restriction has remained standard diabetic dietary practice, perhaps because it seemed logical to limit carbohydrate intake if a patient was deficient in insulin. Even the resurgence of interest in diabetic dietary management over the last 10 years has concentrated rather firmly on the indisputable benefits of fibre as opposed to digestible carbohydrate. Some studies do, however, suggest that the proportion of energy from carbohydrate can have an effect on glucose tolerance separate from that of fibre.

Short-term experiments

Brunzell (1973) compared two liquid formula diets by giving both to a group of nine treated diabetics, six of whom were on insulin and three on sulphonylureas. One contained 45% of energy as carbohydrate and the other 85%, in both cases this being in the form of Dextrin Maltose solution. Surprisingly, after a week on the 85% carbohydrate diet their mean fasting plasma glucose levels were significantly lower than after a week on the 45% carbohydrate diet. (Fig. 1). By contrast, Miranda & Horwitz (1978) compared two diets which had identical amounts of digestible carbohydrate, fat and protein, but one had much more fibre in the form of cellulose-enriched bread. After 10 d on the high fibre diet, the mean plasma glucose levels of eight insulin-dependent diabetics were markedly lower throughout the day than after 10 d on the low fibre diet (Fig. 2). There was, however, no difference in the fasting glucose levels. Brunzell (1973) therefore influenced fasting glucose by altering the digestible carbohydrate only, and Miranda & Horwitz (1978) lowered glucose levels during the day by increasing the fibre content, which suggests there are indeed two separate mechanisms at work.

Longer term experiments

Most of the studies of diabetic diets have been either test meal experiments or very short term. At Oxford, a group has been studying the possible longer term effects on diabetic control of increasing both the carbohydrate and fibre content of the diet.

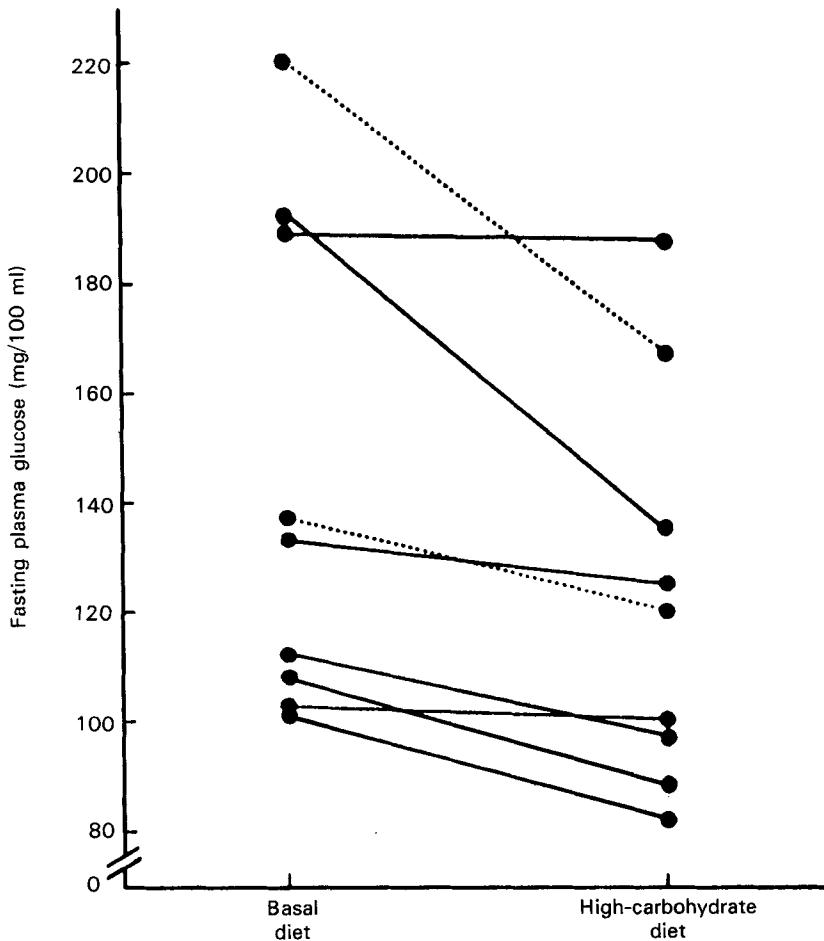


Fig. 1. Fasting plasma glucose levels in treated diabetic subjects on the basal and high-carbohydrate diet. (—) no change in therapeutic dose, (.....) dosage of insulin decreased on high-carbohydrate diet (Brunzell, 1973).

The studies have all had the same basic crossover design, the experimental diet being compared with a control diet in each subject. For 2 weeks after recruitment the experimental diet was explained in detail; the insulin-dependent (IDDM) and non insulin-dependent (NIDDM) patients were then randomized separately to start either the control or experimental diet. In each study the control diet was a standard 'traditional' diabetic diet (SD), containing approximately 40% of energy as carbohydrate and a low (<20 g/24 h) amount of dietary fibre. After 6 weeks, all patients were admitted to hospital for a 24 h metabolic profile, during which blood was taken from an indwelling cannula for estimation of glucose, insulin, triglyceride and haemoglobin A_{1c} percentage. They were then discharged to start the alternative diet, and readmitted 6 weeks later for a second 24 h profile, corresponding meals being isoenergetic. Control was assessed and adjusted

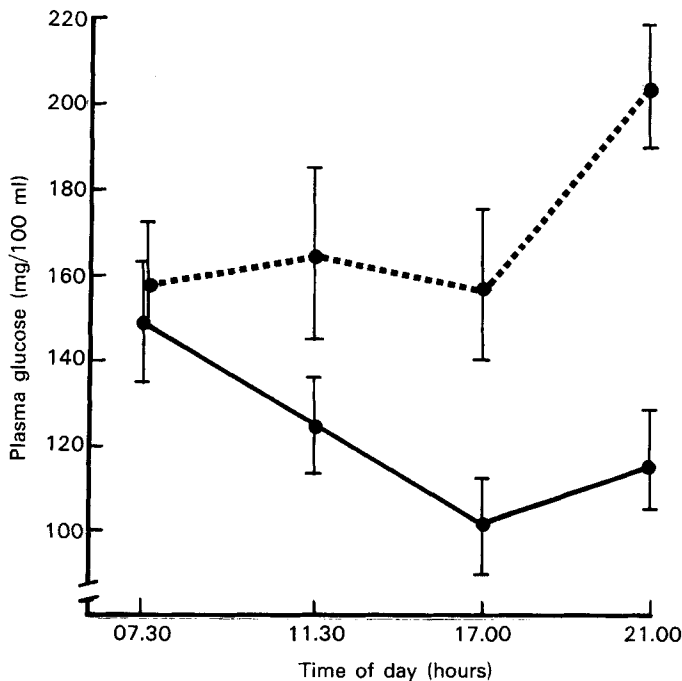


Fig. 2. Mean plasma glucose concentrations for all subjects at different times of the day on low- (---) and high-fibre (—) diets. Values are means with their standard errors represented by vertical bars (Miranda & Horwitz, 1978).

throughout by means of capillary blood glucoses, taken by the patients at home and sent to our laboratory for analysis.

The first diet tested by Simpson and co-workers (Simpson, Mann, Eaton, Moore *et al.* 1979; Simpson, Mann, Eaton, Carter *et al.* 1979) was high in digestible carbohydrate (60% of total energy) and also high in fibre, derived mainly from cereals and tuberous vegetables. On comparing the mean plasma glucoses throughout the 24 h profiles after 6 weeks on each diet, levels were significantly lower on the high-carbohydrate, high-fibre diet during the night and before meals, but there was no difference between the two diets as regards postprandial glycaemia.

In an effort to influence postprandial glucose levels as well as basal glucose levels, the next diet (HL) tested contained a higher amount of dietary fibre (Simpson *et al.* 1981), approximately 85 g/24 h, this being mainly in the form of leguminous vegetables. Carbohydrate still accounted for 60% of total energy. Basic trial design was the same, each patient taking the trial diet for 6 weeks and the standard low-carbohydrate, low-fibre diet (SD) for 6 weeks. Mean plasma glucose levels (\pm standard deviation) on the two diets are shown in Fig. 3 for the eighteen NIDDM patients and in Fig. 4 for the nine IDDM patients. Statistical analysis (Table 1) confirms the visual impression that not only were blood sugars

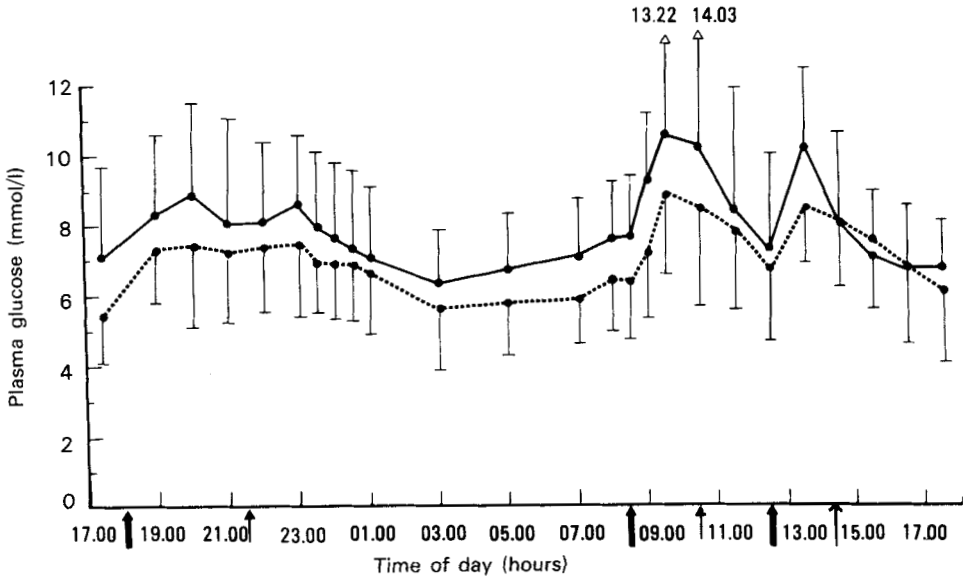


Fig. 3. Plasma glucose values during 24 h profiles of non insulin-dependent patients on standard (—) and high-fibre (.....) diets. Bold arrows show times of main meals; small arrows show times of snacks. Values are means with their standard deviations represented by vertical bars.

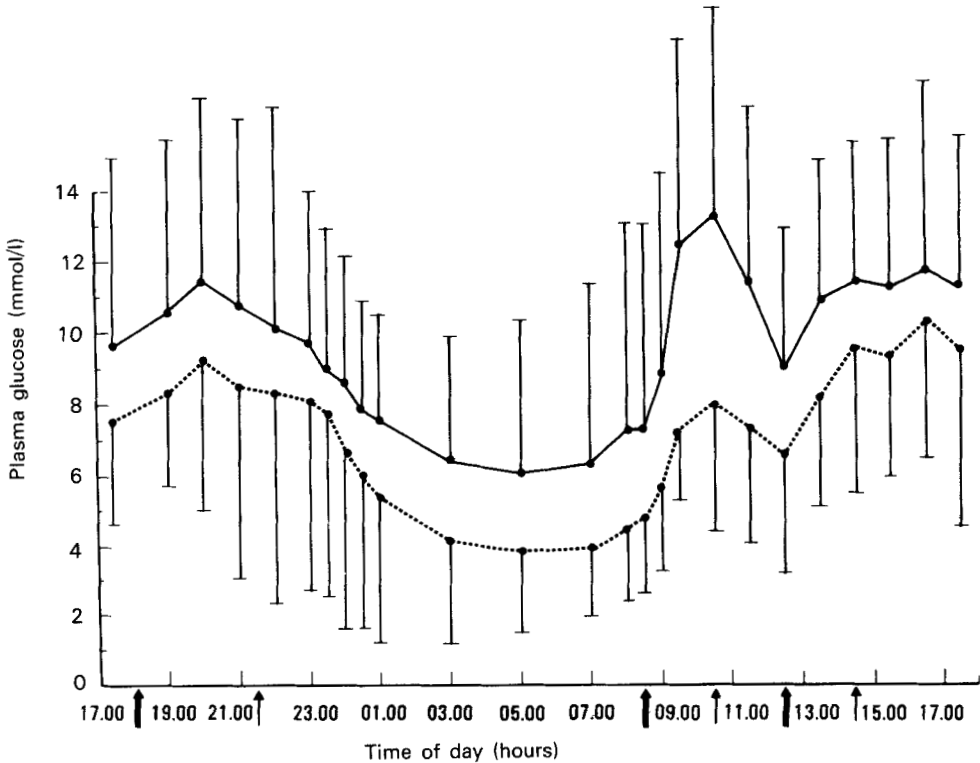


Fig. 4. Plasma glucose values during 24 h profiles of insulin-dependent patients on standard (—) and high-fibre (.....) diets. Bold arrows show times of main meals; small arrows show times of snacks. Values are means with their standard deviations represented by vertical bars.

Table 1. Diabetic control in insulin-dependent (IDDM) and non insulin-dependent (NIDDM) patients during profiles on standard (SD) or high-fibre (HL) diets

(Values are means with standard deviations)

	NIDDM			IDDM			Statistical significance P
	Mean	SD	HL	Mean	SD	HL	
Glucose concentration (mmol/l)*	6.7	1.5	5.7	6.3	4.1	3.9	NS
Preprandial concentration† (mmol/l)	7.3	2.1	6.2	8.6	3.3	6.3	<0.05
Postprandial concentration‡ (mmol/l)	9.1	2.3	8.1	12.1	3.4	9.1	<0.02
Total area under curve§	7.9	1.8	6.9	9.2	2.4	6.9	<0.02
Area under postprandial curves¶	9.0	1.9	7.6	10.5	3.1	7.8	<0.05
Urine glucose (mmol/24 h)¶¶	31	51	2	85	70	17	0.05
HbA _{1c} (%)	9.6	2.3	8.6	10.0	2.3	9.8	NS

NS, not significant.

*Mean of samples taken at 03.00, 05.00, 07.00 hours.

†Mean of samples before each main meal.

‡Mean of samples 2 h after each main meal.

§Time averaged mean for whole 24 h profile.

¶Time averaged mean for 2 h after each main meal (mean of three values).

¶¶Significance assessed by Wilcoxon Matched-Pairs Signed-Ranks test.

significantly lower during the night and before meals, but postprandial glycaemia was also significantly reduced on HL. In fact, almost all aspects of diabetic control, including 24 h urine glucose output, were improved on HL. In the NIDDM group, mean plasma insulins were the same on both diets, thus excluding the possibility of increased insulin secretion to explain the improvement in glucoses in this group. It is also worth noting that there was no increase in plasma triglyceride values on the high-carbohydrate diet, which confirms previous findings.

These results show that it is possible to achieve a marked over-all improvement in diabetic control with a diet containing appreciable quantities of digestible carbohydrate and fibre, compared to the standard low-carbohydrate diet still in widespread use throughout the United Kingdom, this being independent of energy intake. It has, however, needed about five times as much fibre as is eaten on average by the British public to influence postprandial glucose, and even so the improvement was less striking than the reduction of basal glucose levels. Test meal studies have suggested that it might be fairly easy to reduce postprandial glycaemia, which emphasizes the need to do long-term studies. It would seem from our studies that lowering the baseline glucose is an easier goal than reduction of incremental glucose after meals.

Acceptability

Although the diets we have tested are realistic in the sense that all foods used could be bought in most supermarkets, extreme amounts of carbohydrate and fibre were used in order to show a clear cut difference between the diets. We do not propose that either of the diets tested are suitable for long-term consumption. Despite the very high amount of fibre in the leguminous diet, however, it is worth commenting that this was generally well received, the main complaint being that it was rather monotonous. Some patients remarked on increased flatulence but none found this a serious problem, and only three patients out of a total of thirty failed to complete the study.

Conclusions

It would appear from our studies and those of others, that an increase in the proportion of energy from carbohydrate, together with an increase in the fibre content, has a generally favourable effect on control of blood glucose in both non insulin-dependent and insulin-dependent diabetics. Furthermore, there seem to be two separate effects; a reduction in postprandial glycaemia due possibly to slowing of carbohydrate absorption by fibre and a more long-term reduction of basal glucose levels associated with digestible carbohydrate intake alone. It should be stressed that the major part of the carbohydrate in our studies was in complex form and no increase in intake of simple sugars is being suggested.

At present, the most important practical conclusion is that carbohydrate restriction, still recommended to the majority of diabetics in this country, is unnecessary, and may well be preventing insulin-dependent and non insulin-dependent patients from achieving optimal diabetic control.

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