Dietary variation in diabetics

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SUMMARY The day to day variation in the energy and carbohydrate intake of 168 children with diabetes on Tyneside and Teesside was less than that of 405 non-diabetic children. It was, however, still considerable, the average range of carbohydrate intake over three days being 51 g. The variation in carbohydrate intake was not related to diabetic control nor to the families' knowledge of diabetes. Compliance with the dietary prescription deteriorated during the day. These findings support a qualitative approach to the dietary prescriptions for diabetics.

Regulation of diet is an important aspect of the management of insulin dependent diabetes mellitus. The dietary prescription entails regulating the amount and type of carbohydrate consumed which is distributed to match the action of the insulins injected. The essence of this regimen therefore is a carbohydrate intake that is constant from day to day in both total amount and distribution, extra carbohydrate being allowed only before strenuous exercise.

We report the extent of the day to day variation in the carbohydrate and energy intakes of children with diabetes and its relation to their knowledge about, and control of, their disorder.

Subjects and methods

Between July 1983 and March 1984 children attending diabetic clinics on Tyneside and Teesside were invited to record their intakes of all foods and drinks for three consecutive days. This was done in a diary, kept by parent or child as appropriate, in which the time of consumption was recorded together with a description of what was consumed, and the amount in household measures. At an interview on the fourth day this information was discussed to enhance completeness and detail. The household estimates were converted to estimates of weight of each item recorded using a variety of visual aids.¹ Computerised food tables were used to calculate the intake of energy and carbohydrate for each day.² Each day's intake was allocated to six arbitrary periods corresponding to the prescribed distribution—that is, breakfast, midmorning snack, lunch, mid-afternoon snack, evening meal, and supper snack. The day to day or within subject variation in carbohydrate and energy intakes were calculated for each subject as the standard deviation of the intake

for the three days; this was also expressed as the coefficient of variation, calculated as standard deviation/mean $\times 100$. In addition, the range in carbohydrate and energy intake was calculated for each subject as the difference between the highest and lowest intakes of the three days. The difference between each subject's mean carbohydrate intake and their prescribed carbohydrate intake, which represented their compliance with diet, was also calculated.

A structured questionnaire was used to obtain social information, and a single random blood sample taken for measurement of C peptide and glycated haemoglobin A1 concentrations as measures of control. The parent(s), and child if old enough, also completed a multiple choice questionnaire to assess their knowledge about diabetes.³

Similar data about the diets of 405 non-diabetic children aged 11–12 (193 boys and 212 girls) in South Northumberland were used for comparison. These children had completed a two year longitudinal study of the relation between diet and dental caries that entailed recording intake in a similar way to that described for the diabetic children but on five occasions, each lasting three days. Calculations were made using identical methods from only the first of the five dietary diaries.⁴ The middle age group of diabetics was chosen to be comparable to the age range of the non-diabetics.

All families were classified into socioeconomic groups according to the fathers' present or last known occupation; unemployment was recorded separately. The socioeconomic groups were divided into 4; 1 indicated professional and managerial people, 2 clerical and craftsmen, 3 semi- and unskilled labourers, and 4 those whose occupation was unknown or unclassifiable, or who had retired.

Associations among variables were examined by

Table 1 Mean energy and carbohydrate intake and some measures of within subject variation in diabetic children

	Total No (n=168)	Age group (years)		
		<10.5 (n=68)	10.5-12.5 (n=36)	>12.5 (n=64)
Mean intake of energy (MJ):	8.65	7.58	8.97	9.62
Within subject variation				
Standard deviation	1.09	0.82	1.09	1.38
Coefficient of variation (%)	13	11	12	14
Range	2.08	1.56	2.07	2.63
Mean intake of carbohydrate (g):	229	200	244	252
Within subject variation				
Standard deviation	27	19	30	33
Coefficient of variation (%)	12	10	12	13
Range	51	36	57	64

calculating Pearson's r correlation coefficients, and where confounding factors were indicated partial correlation coefficients were calculated. *t*-Tests or one way analysis of variance, including Scheffe's test for multiple comparisons, were used to calculate the significance of differences. All analyses were performed using the Statistical Package for the Social Sciences.⁵

Results

Of the 234 children attending the clinics 170 agreed

Table 2 Mean intake of energy and carbohydrate and within subject variation in 405 non-diabetic children calculated from the Northumberland study

	Energy (MJ)	Carbohydrate (g)
Mean intake	8.48	261
Within subject variation:		
Standard deviation	1.63	53
Coefficient of variation (%)	19	20
Range	3.09	100

Table 3 Mean intake of energy and carbohydrate and some measures of within subject variation according to time of day

	Breakfast	Mid-morning	Lunch	Mid-afternoon	Evening meal	Supper
Mean intake of energy (MJ):	1.46	0.69	2.23	0.76	2.46	1.17
Within subject variation:						
Standard deviation	0.32	0.30	0.59	0.41	0.84	0.50
Coefficient of variation (%)	22	44	26	54	34	43
Range	0.66	0.62	1.10	0.80	1.61	0.98
Mean intake of carbohydrate (g)	43	20	57	22	59	32
Within subject variation:						
Standard deviation	8	8	15	11	19	13
Coefficient of variation	19	40	26	50	32	30
Range	17	15	29	21	37	25
Prescribed amount: (g)	39	17	47	18	45	24
Difference between intake and prescription: (%)	11	17	22	27	34	37

mean range of intake over the three days, either between the sexes or the social classes ($p>0.05$ in both cases). The carbohydrate intake of the youngest children, however, varied less from day to day than that of the other age groups ($p<0.05$). The mean range in carbohydrate intake from day to day was 51 g for all subjects, 36 g for the youngest group, and 64 g for the oldest.

Table 2 gives similar information about the 405 non-diabetic children and shows that the within subject variations of energy and carbohydrate intakes were greater than for the diabetic children of similar age.

Table 3 shows average estimates of the day to day or within subject variations in energy and carbohydrate intakes related to the prescribed meal pattern. The mean within subject coefficient of variation and the mean range of energy and carbohydrate intake are wide at each specified time. The mean within subject range of energy intake for the three day period varied from 0.6 MJ at the midmorning snack to 1.6 MJ at the evening meal, and that of the carbohydrate intake varied from 15 g at the midmorning snack to 37 g at the evening meal. The intake of carbohydrate was always greater than the prescription and the difference increased considerably as the day wore on.

There was a significant but low positive partial correlation between glycated haemoglobin concentration and the within subject coefficient of variation for energy, but not for that of carbohydrate even after allowing for the effects of mean energy intake, age, and C peptide concentration (table 4). Only the variation in the energy intake at the evening

meal correlated with glycated haemoglobin concentration after allowing for C peptide concentration, age, mean energy intake at that meal, and the variation in carbohydrate intake at that meal. The variation in the energy intake at the evening meal appeared to be responsible for the apparent correlation between glycated haemoglobin concentration and the variation in carbohydrate intake at the evening meal. No significant correlations were found among mothers', fathers', or children's knowledge about diabetes, or the within subject variation in energy or carbohydrate intake.

Discussion

There was wide within subject or day to day variation in the energy and carbohydrate intake of the children with diabetes. Errors in the dietary survey method may account for some of the variation. Patients are, however, likely to make errors of a similar type and degree each day when estimating the sizes of portions if food is not weighed. The intake of the children during such a study was probably closer to their dietary prescription than usual. The true variation in the intake of diabetics is therefore unlikely to be less than that reported here.

The within subject variation of both energy and carbohydrate was least in the younger children. This may indicate the extra influence of their parents who were perhaps more successful in restricting intake, or they may have reported only that intake observed or approved by them. The within subject variation in intake, however, was most impressive and ends the notion that the dietary intake of diabetics is

Table 4 Partial correlation coefficients among some measures of day to day or within subject variation in dietary intake and glycated haemoglobin concentrations controlled for C peptide concentrations, age, and intake

Variables		Controlling: third order C peptide + age +		Fourth order C peptide + age +
Dependent variable glycated haemoglobin with:				
Independent variable				
Energy				
Standard deviation	by	Mean daily energy +0.19 $p<0.05$		
Carbohydrate				
Standard deviation	by	Mean daily carbohydrate +0.02 $p>0.05$		
Evening meal energy				
Standard deviation	by	Evening meal energy +0.25 $p<0.01$	or by	Evening meal energy + carbohydrate SD +0.21 $p<0.05$
Evening meal carbohydrate				
Standard deviation	by	Evening meal carbohydrate +0.23 $p<0.01$	or by	Evening meal carbohydrate + evening meal energy SD -0.06 $p>0.05$

constant from day to day. Compliance, defined as the difference between intake and prescription, also was generally poor and deteriorated during the day. Nevertheless the day to day variation was less than that of the non-diabetic children and the proportion of the carbohydrate consumed at each meal or snack was similar to that prescribed. These findings, together with previously reported differences in the composition of the diet of these diabetic children compared with that of non-diabetics,⁶ indicate the considerable efforts made to comply with dietary instructions.

Henry *et al* reported large variations in the intakes of 16 adult diabetics and concluded that adherence to a controlled carbohydrate diet was a fallacy.⁷ In reply, Black pointed out that their carbohydrate intakes were lower, and the variation less, than those seen in other population groups.⁸ The results of our survey support both views; a constant carbohydrate diet was certainly a fallacy, but considerable regulation was apparent. Reports of poor adherence to dietary prescriptions are widespread⁹⁻¹² and perhaps should be considered normal.¹³ There are, however, two components to adherence: a mean intake that is close to the diet prescription (defined as compliance in this paper) and low day to day within subject variation. The importance of these two aspects is not clear. Although among our patients those who complied most strictly with their diets were better controlled,⁶ this may have been coincidental. Observational studies cannot determine cause and effect and there does not appear to have been a controlled trial of truly free diet for diabetic children.

This study showed that there was no association between glycaemic control based on a single estimate of glycated haemoglobin concentration and variation in carbohydrate intake. There was, however, a weak association between control and the variation in energy intake, which suggests that there may be some benefit in the regulation of food intake. The association between control and the variation in energy intake at the evening meal may have arisen simply because that meal was the largest and most variable. A second possibility is that intake at that time of day was not adequately covered by insulin, perhaps for fear of hypoglycaemia during the night. Further experimental studies are required to investigate these points in detail.

A fundamental fallacy of dietary regulation for diabetics is suggested by the considerable fluctuation in the day to day energy intake of non-diabetic children as reported here and elsewhere.¹⁴ This probably indicates that their energy needs, especially for activity, also vary considerably. The mean energy intake of children with diabetes is

similar to that of non-diabetic children⁶ and there is no reason to expect that the day to day variation in their activity is different from that of non-diabetic children. Furthermore, even under laboratory conditions the effect of food intake on blood glucose in the same subject may vary greatly both with different foods with the same content of carbohydrate or even with the same food on different occasions.^{15 16} Such considerations suggest that even a monotonous diet and a restricted lifestyle would not prevent large variations in blood glucose concentration.

These results support the idea that dietary advice for diabetics should be qualitative or at most semiquantitative. Detailed suggestions for achieving this have been made elsewhere.¹⁷ The only way to reduce the day to day variability in intake further would be to restrict the choice of foods to those of stable, known composition, to weigh or to measure all food accurately in some other way, and to limit activity. Clearly none of these is acceptable in the light of the questionable benefits. We would advocate the alternative, which is to allow free consumption of high carbohydrate, preferably high fibre, foods at relatively constant meal and snack times together with a flexible insulin regimen, in return for regular monitoring of the effects.

The results of this study show that despite considerable efforts to comply with the comprehensive dietary instructions given, children with diabetes do not follow a constant diet. We suggest that this is inevitable if children with diabetes are to be as active as their peers. Although it is feasible for children with diabetes to alter the type of food consumed, and to some extent its distribution, the quantity is determined by the child's appetite.

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