The Effect of Flexible Low Glycemic Index Dietary Advice Versus Measured Carbohydrate Exchange Diets on Glycemic Control in Children With Type 1 Diabetes

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OBJECTIVE — To determine the long-term effect of low glycemic index dietary advice on metabolic control and quality of life in children with type 1 diabetes.

RESEARCH DESIGN AND METHODS — Children with type 1 diabetes (n = 104) were recruited to a prospective, stratified, randomized, parallel study to examine the effects of a measured carbohydrate exchange (CHOx) diet versus a more flexible low–glycemic index (GI) dietary regimen on HbA_{1c} levels, incidence of hypo- and hyperglycemia, insulin dose, dietary intake, and measures of quality of life over 12 months.

RESULTS — At 12 months, children in the low-GI group had significantly better HbA_{1c} levels than those in the CHOx group (8.05 ± 0.95 vs. 8.61 ± 1.37%, P = 0.05). Rates of excessive hyperglycemia (>15 episodes per month) were significantly lower in the low-GI group (35 vs. 66%, P = 0.006). There were no differences in insulin dose, hypoglycemic episodes, or dietary composition. The low-GI dietary regimen was associated with better quality of life for both children and parents.

CONCLUSIONS — Flexible dietary instruction based on the food pyramid with an emphasis of low-GI foods improves HbA_{1c} levels without increasing the risk of hypoglycemia and enhances the quality of life in children with diabetes.

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Type 1 diabetes is one of the most challenging medical disorders because of the demands it imposes on day-to-day life. Good glycemic control, as judged by HbA_{1c} levels, is clearly related to reduced risk of microvascular complications (1). Although diet plays a major role in the overall management of type 1 diabetes, it is often classed as the most difficult aspect of treatment (2,3). Furthermore, there are surprisingly few long-term studies to support current dietary recommendations. Weighed carbohydrate "exchanges," introduced in the 1950s, have been used to ensure an even distribution of complex carbohydrates throughout the day. Carbohydrate counting and higher carbohydrate intake are now recommended, although in practice, emphasis is still placed on limiting carbohydrates to a specified level and avoiding refined sugars (4,5).

Different carbohydrate foods affect blood glucose levels to varying degrees, as measured by their glycemic index (GI) (6,7). Foods such as legumes and dairy products have a low GI, whereas ordinary breads, potatoes, and rice have a high GI (8). Carbohydrate counting and "exchange" diets imply that equal carbohydrate portions have the same effect on glycemia. Not only is the theoretical basis of the exchange system questionable, it is difficult to understand and implement without knowing the carbohydrate content of food (9). Several studies have shown that exchange diets do not improve glycemic control (9,10) and that many children with diabetes and their parents cannot understand or follow them (11–13). It has also been suggested that quantifying carbohydrate intake may be associated with some physiological and psychological problems, including disordered eating behavior (14). This information and the emerging significance of postprandial glycemia on diabetes-related complications suggest that carbohydrate quantity alone is not an adequate basis for controlling blood glucose levels. Research shows low-GI diets significantly improve metabolic control in adults with type 2 diabetes (15–18). However, there are very few studies on the use of low-GI diets in type 1 diabetes (19–21) and only one small short-term study in children (22). Differences in GI between foods are just as likely to apply to children as to adults (22,23), but more studies are

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Abbreviations: BMR, basal metabolic rate; CHOx, carbohydrate exchange; GI, glycemic index; NMES, nonmilk extrinsic sugars; RCH, Royal Children's Hospital.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

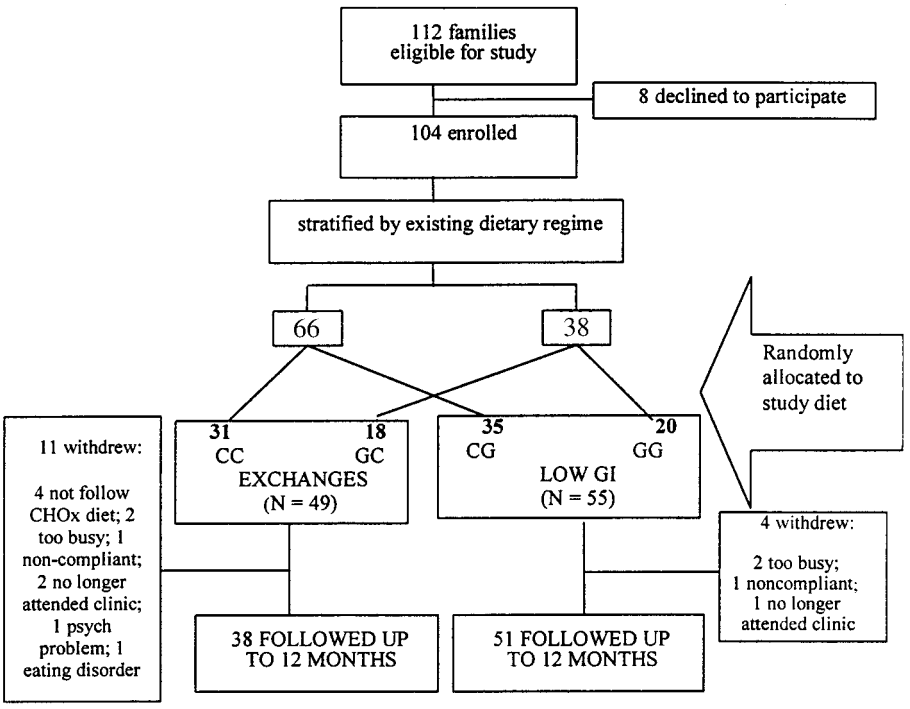

Figure 1—*Trial Profile. CC, those who only received instructions on the CHOx diet both prior and during the study; GG, those only instructed in the low-GI diet both prior and during the study; CG, those randomized to the low-GI diet who had been following a CHOx diet before the study; GC, those randomized to the CHOx diet who had been following the low-GI diet before the study.*

needed on the long-term effect of low-GI diets in children with type 1 diabetes.

We hypothesized that less regimented dietary instruction with an emphasis on the use of low-GI foods may enhance metabolic control and compliance in a pediatric population. This randomized prospective trial compares the effects of flexible, low-GI dietary advice and the measured carbohydrate exchange (CHOx) diet on glycemic control, nutritional intake, and quality-of-life measures in children with type 1 diabetes over a 12-month period.

RESEARCH DESIGN AND METHODS

Study design

Figure 1 summarizes the trial profile used in this study. Children attending the Melbourne Royal Children's Hospital (RCH) Diabetes Clinic were selected using the following criteria: *1*) age between 8 and 13 years, diagnosis of type 1 diabetes for longer than one year, and regular attendance at the clinic (3 monthly); *2*) no additional dietary restrictions; *3*) no other immediate family members with diabetes, *4*) no medications that would affect appetite; and *5*) family able to read and write English.

Agreement from the primary physician was sought. Of 112 eligible families, 104 agreed to participate, and letters were sent outlining their involvement in the study. Formal written consent was obtained. Subjects were assigned random number codes to ensure patient confidentiality. Ethics approval was granted by the RCH Ethics in Human Research Committee.

Diet assessment and education

Individual interviews with the research dietitian were used to collect initial data, instruct the child and parent in the use of food records, and develop a rapport to enhance participation over the 12-month period. Each subject was asked to complete a 3-day food diary. Two weekdays and one weekend day were specified to account for the variation in food intake at weekends (24). Families were encouraged not to alter their usual pattern of food intake during recording periods. A sample food diary and a contact phone number were provided.

At the beginning of the study, subjects were assessed by a dietitian to categorize their existing dietary regime and ensure correct stratification before being randomized to either the CHOx or low-GI diet. Computer-generated random numbers of 1 and 2 were generated in blocks of 10 and assigned consecutively to each subject upon recruitment to the study. Of the 104 subjects recruited, 49 were assigned to the CHOx diet, and 55 were assigned to the low-GI diet (Fig. 1). Education regarding the allocated study diet was then given to the child and parent (Table 1). The diet education session was structured similarly for both groups and executed in an outpatient setting by the same clinical dietitian. A specially made flipchart was used for each of the study diets explaining the principles of the diet. Literature was also provided to reinforce the advice (Table 1). No additional education sessions were planned over the 12-month period apart from usual clinic review. The food diaries were completed at 1, 3, 6, and 12 months, and phone calls were made 2 weeks before the clinic visit to ensure compliance.

All food diaries were analyzed by the same research dietitian using the Diet 3.12 computer program (Xyris Software). Portion sizes were estimated against standard portions within the software package based on the household measures recorded. If the food item was not included in the database or if the nutrient profile was incomplete, information from the manufacturer was sought or, alternatively, the most similar food item was substituted. The individual's intake of energy, protein, fat, fiber, total carbohydrates, total sugars (with inclusion and exclusion, respectively, of sugars consumed for hypoglycemic treatment or used during exercise), nonmilk extrinsic sugars (NMES), GI, and carbohydrate distribution were calculated using the food diaries at each time point. NMES content was estimated from the food sources of total sugars, information from the food manufacturer, and food composition tables (25).

Energy intake was independently assessed as being below, within, or above range. Ranges were based on basal metabolic rate (BMR) calculations using cutoff points from published sources. BMR was calculated using Schofield's equation (26). The minimum and maximum cutoff points were derived from the work of, re-

Table 1—*Dietary advice given to subjects randomized to the CHOx or low-GI diet at entry to the study*

	CHOx study diet†‡	Low-GI study diet§‖
Carbohydrate	Measured in 15-g complex CHO quantities and counted as either 'half' or 'full' exchanges	Eat regular meals and snacks based on preferred serving sizes of CHO foods to satisfy appetite A serving is suggested to be the quantity of CHO food that fits into the child's hand (which will vary between individuals)
Recommendations	Based on quantitative CHO intake assuming all complex CHO foods affect the blood sugar level in the same way	Based on qualitative CHO intake using principles of the healthy food pyramid with low GI emphasis, aiming for minimum of one low-GI food per meal per day
Prescription	Set number of exchanges for each meal and snack	Nil prescription given and guide given to number of servings at meals/snacks to ensure appropriate CHO distribution and consistency, but no specific quantity defined
Protein/fat foods	Not measured but eat in moderation Choose low fat sources where appropriate Not counted as part of exchange prescription unless in pastry/battered/ crumbed	Not measured but eat in moderation Choose low fat sources where appropriate Not counted as a serving unless in pastry/battered/ crumbed
Low-CHO foods (most vegetables)	Identify low-CHO food sources, eaten in conjunction with correct exchanges or when hungry as "free" foods	Identify low-CHO food sources, eaten as part of a balanced diet
Diet foods (artificially sweetened)	Use strongly encouraged whenever a diet alternative was available	Use strongly discouraged with preference for use of sugar-sweetened products in moderation (only exception to this being diet drinks)
Sugar	Use limited to treatment of hypoglycemia episodes exercise, or special occasions only	Use in moderation in combination with mixed meals (1.5–2.5 tbsp per day)
Literature provided	Extensive food lists that quantified all foods/ingredients into 15-g CHO measures*†	Basic booklet including list of low-GI food sources§ Low-GI foods listed, but no actual GI values provided
Appetite	Eat only free foods/low-CHO foods if hungry between meals/snacks	Eat extra CHO foods to appetite, particularly low GI foods
Recipe modification	List of diabetes cookbooks recommended Sugar to be substituted with artificial sweetener Shown how to calculate individual recipe ingredients to determine exchange value of baked product	No specific diabetes cookbook recommended Encouraged to modify existing recipes and moderate use of sugar Incorporate low-GI ingredients where appropriate
Label reading	Focus on dividing total grams CHO in nutrition panel by 15 to determine exchange value and limiting/avoiding products high in sugars	Focus on ingredient list and sources of sugars, fats, fiber, and low-GI ingredients and the order in which they appear on the label
Activity/exercise	Eat one extra exchange per hour of strenuous activity	Eat one extra serve of CHO food per hour of strenuous activity

Literature provided to reinforce advice:
**Traffic Light Guide To Eating*. Gilbertson H, Ed. Melbourne, Australia, Nutrition and Dietetic Department, Royal Children's Hospital, 1992; †*The A to Z Carbohydrate Exchange Booklet for Diabetes*. Gilbertson, H, Ed. Melbourne, Australia, Nutrition and Dietetic Department, Royal Children's Hospital, 1993; ‡*Modern Living With Diabetes: For All Ages*. 2nd ed. Court JM, Ed. Melbourne, Australia, Diabetes Australia Victoria, 1991; §*Diabetes: A Guide to Eating*. Gilbertson H, Ed. Melbourne, Australia, Department of Nutrition and Food Services, Royal Children's Hospital, 1996; ‖*The GI Factor: The Glucose Revolution*. Brand-Miller J, Foster-Powell K, Colagiuru S, Eds. Sydney, Australia, Hodder and Stoughton, 1998.

spectively, Goldberg et al. (27), using a value of 0.8 × BMR × activity factor, and Torun et al. (28). Activity levels were individually assessed and defined as light (<2 organized activities per week), moderate (2–5 organized activities per week), and heavy (>5 organized activities per week). Activity factors were 1.55, 1.75, and 1.95, respectively.

For the purpose of dietary analysis, the daily GI (relative to a standard glucose value of 100) was calculated by summing the following: [grams of carbohydrate from the food item / total daily carbohydrate × 100 × GI of food item]. GI values were derived from published GI tables (8) and unpublished data from the Human Nutrition Unit, University of Sydney. Of 284 carbohydrate-containing foods, 194 were assigned a known GI, but 90 were given "estimated" values based on the GI of similar foods.

Outcome measures

The following measures were recorded at entry to the study and at 3, 6, and 12 months: HbA_{1c} level, weight, height, dietary intake information, and incidence of hypoglycemia (<3.5 mmol/l) and hyperglycemia (>15 mmol/l) as determined by preprandial breakfast, dinner, and supper levels charted in the child's self-reported record book during the 1 month before each visit. In addition, a quality-of-life

Table 2—*Demographic data, baseline and outcome measures for subjects assigned to the CHOx and low-GI diet groups*

Variable	Study diet: CHOx (n = 49)	Study diet: Low GI (n = 55)	P	Study diet: CHOx (n = 38)	Study diet: Low GI (n = 51)	P*
Demographic data:						
Sex (% male)	51	49	0.84			
Age (years)	10.2 ± 1.6	10.7 ± 1.6	0.11			
Duration of diabetes (years)‡	4.0 (1.1–9.9)	3.4 (1.3–12.2)	0.83			
Parents' marital status (% married)†	84	89	0.69			
Socioeconomic status§						
Father's occupation	4.2 (2.3–6.5)	4.1 (1.5–6.6)	0.89			
Mother's occupation	5.3 (3.6–6.66)	5.3 (2.3–6.4)	0.10			
	Baseline values			12 Months		
Clinical measures:						
HbA_{1c} (%)	8.6 ± 1.4	8.3 ± 1.3	0.12	8.6 ± 1.4	8.0 ± 1.0	0.05
Insulin dose (U/kg)	0.9 ± 0.3	1.0 ± 0.3	0.15	1.0 ± 0.3	1.1 ± 0.3	0.87
Insulin injection regimen (% on two injections per day)†	98	95	0.62	98	91	0.21
Episodes of hyperglycemia (mean number per month)	14.8 ± 11.2	11.7 ± 9.4	0.08	116.8 ± 11.8	11.2 ± 9.8	0.06
Episodes of hypoglycemia (mean number per month)	7.3 ± 5.7	6.9 ± 6.2	0.73	5.8 ± 5.5	6.9 ± 6.8	0.37

Data are mean ± SD or %. *P using multiple linear regression adjusting for the appropriate baseline measure; †P using Pearson's χ^2 analysis or Fisher's exact test where appropriate; ‡P using Wilcoxon's rank-sum test without adjustment for baseline measure; §Daniel's Prestige Scale, reported as median (range), P using Wilcoxon's rank-sum test.

questionnaire was completed independently by the parent and child (via separate interview) at each time point. HbA_{1c} measurements were routinely performed in the clinic using the DCA 2000 Analyser (Bayer) on capillary blood samples obtained by fingerprick (mean coefficient of variation 3.8%).

Statistical analysis

The sample size of 104 families allowed for a 15% dropout rate and provided 80% power to reject the null hypothesis, which stated that mean HbA_{1c} levels after 12 months were the same in the two groups if a 10% difference (i.e., a difference in measured HbA_{1c} of ≃1%) was found. Significance was set at 5%. The sample size calculation was based on an effect size of 0.625 SD. A subgroup analysis was planned prospectively that divided the subjects into four subgroups, as illustrated by Fig. 1. An intent-to-treat analysis was performed on the assumption that subjects adhered to the dietary advice provided at entry to the study. Data analysis and clinical outcome measures were assessed by researchers unaware of the treatment allocation.

Results were expressed as the mean ± SD, unless otherwise stated, and were analyzed using multiple linear regression or Spearman's correlation for continuous variables or with a combination of logistic regression or Pearson's χ^2 analysis for categorical data. Nonnormal data were analyzed using Wilcoxon's rank-sum test and expressed as medians and ranges. Clinical data were adjusted for baseline values where specified. All statistical analysis was performed using the Intercooled Stata 5.0 Statistical package (Stata Corporation).

RESULTS — There were no significant differences in baseline measures or demographic data between the two study groups (Table 2). A total of 15 subjects (14%) dropped out during the study period: 11 from the CHOx group and 4 from the low-GI group. There was a significantly higher dropout rate from the

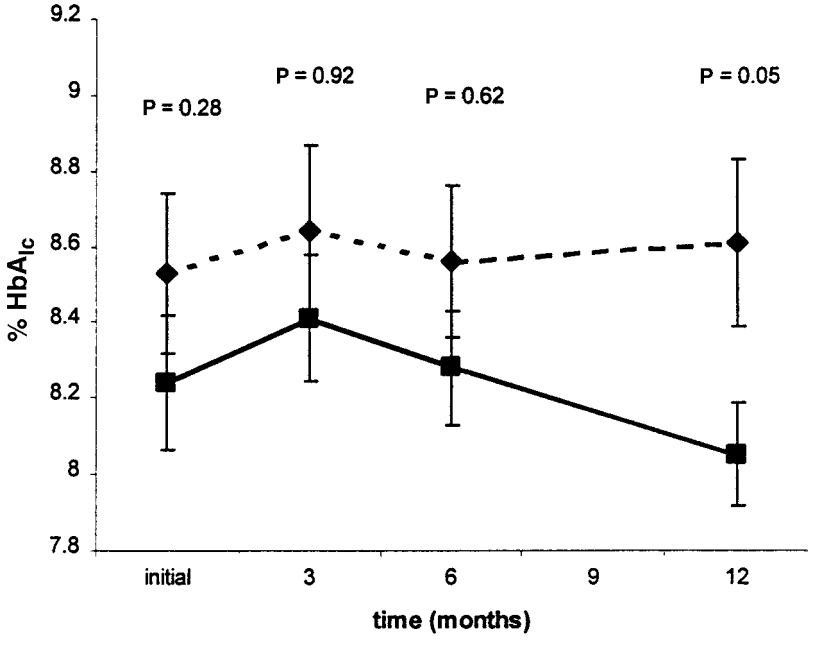

Figure 2—*Mean (± SE) HbA_{1c} measurements over 12 months for CHOx (–◆–) and low-GI (–■–) subjects who completed the study* (n = *38 and 51, respectively). Analysis adjusted for baseline HbA_{1c} values.*

Table 3—*Comparison of responses of subjects from each subgroup who expressed a preference*

Question/Response	Child diet subgroup				Parent diet subgroup			
	CHOx only	Low GI only	Both types†	*P**	CHOx only	Low GI only	Both types*	*P**
Which diet do you believe would be easier to follow?‡								
n	14	11	22	—	13	13	23	—
Exchanges	57	0	36	—	69	0	9	—
Low-GI	43	100	64	<0.01	31	100	91	<0.001
Which diet do you believe would lead to better control of blood sugar levels?								
n	15	6	25	—	10	10	17	—
Exchanges	87	33	64	—	100	0	6	—
Low-GI	13	67	36	0.05	0	100	94	<0.001
Now that you have completed the study, which diet will you choose to continue?								
n	26	17	45	—	24	17	43	—
Exchanges	92	6	27	—	88	0	12	—
Low-GI	8	88	71	—	8	100	70	—
Combination of both	0	6	2	<0.001	4	0	18	<0.001

Data are %. **P* value using Fisher's exact test; †subjects who had been exposed to the two different dietary regimes; ‡subjects who either expressed no preference or were unsure were excluded from this analysis. Percentage responding with preference: child, 43% CHOx vs. 61% low-GI, $P = 0.13$; parent, 49% CHOx vs. 61% low-GI, $P = 0.28$; §subjects who either expressed no preference or were unsure were excluded from this analysis. Percentage responding with preference: child, 59% CHOx vs. 47% low-GI, $P = 0.29$; parent, 35% CHOx vs. 48% low-GI, $P = 0.28$.

CHOx group (22 vs. 7% in the CHOx and low-GI groups, respectively, $P = 0.03$). Specifically, there was a differential dropout rate of 39% for subgroup GC, who had been assigned to the CHOx diet for the study after previously following the low-GI diet, versus subgroups CC (13%), GG (15%), and CG (3%) ($P < 0.01$), who were, respectively, only instructed in the CHOx diet, only instructed in the low-GI diet, or randomized to the low-GI diet after following a CHOx diet prior to the study. Apart from dietary assignment, there were no other significant differences at baseline between these subjects.

At baseline, 3, and 6 months, there were no statistically significant differences in HbA_{1c} levels between the groups. However, by 12 months the mean HbA_{1c} level had fallen in those provided low-GI dietary instruction while remaining essentially unchanged in the CHOx group (Fig. 2). The difference between groups at 12 months was significant, even after adjusting for baseline values ($P = 0.05$, Table 2). Subjects who had been given low-GI dietary instruction both before and during the study (subgroup GG) had markedly lower HbA_{1c} values at the end of 12 months (7.77 ± 0.79%) compared with subjects who had only received CHOx advice (subgroup CC) (8.76 ± 1.07%, $P = 0.002$).

The differences in HbA_{1c} levels were not related to variations in insulin therapy because there were no significant differences in insulin dose at 12 months nor were there changes to insulin dose over the 12 months (Table 2). The majority of subjects from both groups were on a twice-daily insulin regimen (Table 2), using regular short- and long-acting insulin types at baseline (96 vs. 98% in the CHOx and low-GI groups, respectively, $P = 0.27$) and at 12 months (89 vs. 88%, $P = 0.21$).

The proportions of subjects from each study group within acceptable and unacceptable HbA_{1c} ranges were compared. The acceptable cutoff was <8% (29) and levels >9% were considered suboptimal. At 12 months, twice as many subjects from the low-GI group (45%) had HbA_{1c} values within the acceptable range compared with subjects in the CHOx group (22%) ($P = 0.02$ after adjustment for baseline values). Subjects in the CHOx group were ~3 times more likely to have undesirable HbA_{1c} values compared with the low-GI group (47 vs. 18%, $P = 0.004$ after adjustment for baseline values).

A significantly larger proportion of subjects from the CHOx group reported more frequent episodes of hyperglycemia at 12 months, defined as >15 episodes per month (66 vs. 35%, $P = 0.006$ after adjustment for baseline values). There were no significant differences in hypoglycemic episodes (Table 2).

Of the 89 subjects who completed the study, 6 did not complete a food diary. The two study groups showed no significant differences in any of the dietary variables measured at 12 months. On average, the children consumed 17% energy as protein, 34% as fat, 49% as carbohydrate, and 7% as NMES, and they consumed 21 g fiber per day. However, there was a high proportion of subjects who appeared to underreport food intake in both groups (53 vs. 46% in the CHOx and low-GI groups, respectively), casting doubt on the reliability of the food diaries. The dietary variables were reanalyzed, excluding underreporters but otherwise remaining essentially unchanged.

Surprisingly, despite differences in dietary instruction, there was no difference in mean GI between the two groups (56.5 ± 4.0 and 55.3 ± 4.8 in the CHOx and low-GI groups, respectively, $P = 0.26$). Because GI is not a precise measure, we compared the proportions of subjects that had a low (<55), moderate (55–60), and high (>60) GI. At all time points, the low-GI group showed a greater proportion of subjects within the low (GI <55) range (low GI: 62, 47, 47,

and 44%; CHOx: 37, 40, 36, and 30% at 1, 3, 6, and 12 months, respectively), but the difference reached statistical significance only at one month ($P = 0.02$). The low-GI group also contained more subjects who achieved an extremely low average GI (<50%), (0 vs. 14% in the CHOx and low-GI groups, respectively, $P = 0.04$ at 12 months). From a food variety perspective, the average number of different carbohydrate food choices per day was similar between the two groups (9.9 ± 2.5 vs. 10.8 ± 2.4, $P = 0.10$).

In correlation analyses, no dietary factor correlated significantly with HbA_{1c} levels. The reported physical activity level was not different between the dietary groups (median number of organized activities per week [range]: 4.0[1–10] and 4.5[1–10] in the CHOx and low-GI groups, respectively, $P = 0.75$) and showed no relationship to HbA_{1c} level.

Quality of life was influenced significantly by type of dietary instruction. Twice as many parents in the low-GI group stated that their child had no difficulties in selecting their own meals at the 12-month time point (51 vs. 24% $P = 0.01$). Almost twice as many parents from the low-GI group reported that diabetes never limited the types of activities pursued as a family (53 vs. 27% $P = 0.02$) and that diabetes had never been a source of tension or conflict within the family (55 vs. 27% $P = 0.01$). There was a trend for the majority of parents from the low-GI group to believe that diabetes never interrupted various everyday family activities (53 vs. 32% $P = 0.06$).

The 53 children (and their parents) that had experienced both types of dietary approaches (subgroups CG and GC) expressed an overall preference for the low-GI diet compared with the CHOx diet (Table 3, $P < 0.01$ and $P < 0.001$ for the children and parents, respectively). The same subgroup of parents believed that the low-GI diet led to better control of blood glucose levels compared with the CHOx diet ($P < 0.001$). The low-GI diet was the dietary regime that most parents and children selected to continue after completion of the study ($P < 0.001$ and $P < 0.001$ for the children and parents, respectively).

CONCLUSIONS — This study demonstrated that children with type 1 diabetes who were given flexible dietary instruction based on the food pyramid and low-GI choices achieved significantly better HbA_{1c} levels after 12 months compared with those who received more traditional dietary advice. Twice as many children in the low-GI group achieved acceptable HbA_{1c} levels at 12 months without any increase in the frequency of hypoglycemic episodes. Insulin dose and injection regime did not change or differ between the groups.

The difference in glycemic control was greater and more significant in the children who had received the same dietary instruction both before and throughout the study. This suggests that some aspect of the flexible low-GI approach was associated with gradual but sustained improvement in HbA_{1c} levels. However, it is difficult to attribute the lower HbA_{1c} levels solely to differences in diet, particularly when there was no apparent difference in mean GI.

The dietary records showed that macronutrient and fiber intakes were very close to that of children in the general Australian population (30) and were similar in both groups. However, the dietary data need to be interpreted cautiously because of the unacceptably high prevalence of underreporting. About half the records revealed energy intakes that were not likely to reflect the child's habitual intake. This criticism plagues all dietary assessment studies (31,32) and is especially true of those in children. The high rate of underreporting may have affected the ability to detect subtle differences in carbohydrate quality (mean GI) between the two study groups. The large number of foods with estimated GI values may also have contributed. Despite these limitations, the assumption that a low-GI diet might restrict food variety and increase fat or sugar intake was not borne out by the data (33). Many low-GI foods were particularly favored by the children, including peanut butter, pasta, baked beans, and dairy foods. Given the documented differences in hyperglycemic episodes between the two groups, the dietary data on the whole suggest that individuals in the low-GI group were consuming more low-GI foods than those in the CHOx group.

The quality-of-life questions revealed an obvious preference for the flexible low-GI dietary regimen among the children (and parents) who had experienced both types of dietary instruction. There were significant differences in measures such as family conflict, limitations placed on family activities, difficulties for the child in selecting their own meals, and a clear preference to continue on the low-GI diet. These findings are important and challenge the belief that low-GI diets might be difficult to follow and a burden for people with diabetes. Furthermore, they need to be considered alongside the fact that glycemic control was superior among those who received the simpler, less regimented dietary advice. Using CHOx is often quoted as the most challenging aspect of managing diabetes (2,3).

The findings of this large long-term prospective study suggest that more flexible dietary instruction based on the food pyramid and with an emphasis on low-GI foods has demonstrable benefits for children with diabetes. Weighed-carbohydrate exchange dietary advice was associated with inferior glycemic control and measures of quality of life.

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