The Glycemic Index

Not the most effective nutrition therapy intervention

It is essential that clinicians be aware of expected outcomes from possible nutrition therapy interventions so that they can assist people with diabetes using the best approaches to achieve metabolic goals. Outcomes can be predicted from evidence-based technical reviews or from meta-analyses. Both are now available: the American Diabetes Association (ADA) 2002, Evidence-Based Nutrition Principles and Recommendations for the Treatment and Prevention of Diabetes and Related Complications, technical review (1) and position statement (2), and in this issue of *Diabetes Care*, Brand-Miller et al. (3) report on a performed meta-analysis of low–glycemic index (GI) diets.

The ADA technical review and position statement reviewed the role of the GI in medical nutrition therapy for diabetes. The reports acknowledge that differing food sources of carbohydrates have differing glycemic responses when the food is studied independently, in 50-g portions, and compared with 50 g of either glucose or bread (1). However, after reviewing the evidence, it was concluded that the total amount of available carbohydrate in meals or snacks is more important than the source (starch or sugar) or type (low or high GI) (A-level evidence), and although low-GI foods may reduce postprandial hyperglycemia, there was not sufficient evidence to recommend use of low-GI diets as a primary strategy in food/meal planning (B-level evidence) (2). These statements were based on a review of over 20 studies in which subjects with type 1 or type 2 diabetes ingested a variety of starches or sucrose, both acutely and for up to 6 weeks, with no significant differences in glycemic response if the amount of carbohydrate was similar. This recommendation was questioned in a letter to *Diabetes Care* by Irwin (4) with a reply to the letter by Franz and Bantle (5).

In the reply to Irwin, it was noted that in subjects with type 1 diabetes, four studies compared a low- to a high-GI diet with none reporting statistically significant improvements in HbA_{1c} from the low-GI diet; three reported significant improvements in fructosamine, one did not, and none reported improvements in fasting plasma glucose. Two studies included in the Brand-Miller meta-analysis were not included in the reply to Irwin. In the Gilbertson et al. (6) study, although the children in the low-GI group did have significantly better HbA_{1c} levels than the group using a carbohydrate exchange diet, the study reported no differences in mean GI between the two groups at study end, and the authors stated, "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." Also not included was the study by Giacco et al. (7), in which the low-GI diet contained 50 g/day of fiber compared with 15 g/day in the high-GI diet. It cannot accurately be determined whether the better glycemic outcome was related to the high fiber content or the low-GI diet because dietary fiber content is not consistently related to the GI. The authors stated, "the results obtained can be ascribed only to the different consumption of high fiber foods."

In subjects with type 2 diabetes, nine studies compared a low- to a high-GI diet. One reported a statistically significant improvement of HbA_{1c}, four did not, and three reported statistically significant improvement in fructosamine, while three did not; none reported improvements in fasting plasma glucose. Included in the reply to Irwin was the Heilbronn et al. (8) study (not included in the Brand-Miller et al. meta-analysis) in which there were no significant differences in glycemic control or weight loss between low- and high-GI diets. Brand-Miller also includes the study by Komindr et al. (9) in which ingestion of mungbean noodles (a low-GI diet) produced a nonsignificant lower glycated hemoglobin compared with glutinous rice (a high-GI diet).

Based on the above reviews, the ADA position is that there is not strong supporting evidence for the use of a low-GI diet as a primary nutrition therapy strategy. The meta-analysis by Brand-Miller et al. provides support for this recommendation. They report that implementing a low-GI diet will have a small effect on overall glycemic control in diabetes; low-GI diets reduce overall HbA_{1c} by 0.43% units compared with high-GI diets (representing a 7.4% reduction in HbA_{1c}/fructosamine). In patients with type 1 diabetes, HbA_{1c} was reduced by ~0.4% units and in subjects with type 2 diabetes by ~0.2% units. This latter result is surprising, as one would expect a greater response in subjects with type 2 diabetes who, because of loss of first-phase insulin response, might be expected to benefit more from a low-GI diet than subjects with type 1 diabetes in whom mealtime insulin can be adjusted to control postprandial glycemic responses.

Actual GI of the usual diet is also controversial. Brand-Miller suggests that the high-GI diet (83) in their meta-analysis represents usual GI. However, the GI quintiles for women in the Nurses' Health Study and for men in the Health Professionals' study range from 64 to 77 and 65 to 79, respectively (10). The highest number would be less than the high GI (83), and the lower number would be similar to the low GI (65). This is also a relatively small range, suggesting that it may be difficult to move the GI down a few units in individuals with diabetes.

In their article, Brand-Miller et al. compare the low-GI diet's effect to that of the effect of pharmacological agents that also target postprandial hyperglycemia. However, it may be more appropriate to compare the outcomes of the low-GI diet to the outcomes from other nutrition interventions. Doing this allows clinicians to select an approach that is likely to result in the most beneficial outcomes for the individual with diabetes. Therefore, the question becomes, what primary nutrition therapy interventions lead to better outcomes?

Primary nutrition therapy intervention strategies

Randomized controlled trials and observational studies of medical nutrition therapy for diabetes have demonstrated improved glycemic outcomes on the order of decreases in HbA_{1c} of ~1–2% units (a 15–22% decrease in HbA_{1c}) (11,12). Interventions used include carbohydrate counting, both basic and advanced, and reduced energy intake resulting in modest weight loss. This is in contrast to the reduction in HbA_{1c} by 0.43% units (a 7.4% decrease in glycated protein) from low-GI diets.

Type 1 diabetes. Studies that adjust mealtime (bolus) insulin dosage based on the total carbohydrate content of the meal (or snack) report a 1–1.5% units decrease in HbA_{1c}. In the Dose Adjusted for Normal Eating (DAFNE) study (13), subjects were taught carbohydrate counting by dietitians and adjusted their mealtime insulin accordingly. At 6 months, there was an overall mean reduction in HbA_{1c} of 1% units with no differences in the incidence of hypoglycemia compared with the control group who continued their usual fixed meal carbohydrate and insulin approach. Not surprisingly, quality-of-life scores also improved. This approach was based on a program developed in Dusseldorf, Germany, in which reductions in HbA_{1c} of 1.5% units 1 year after training were reported and with similar improvements maintained for 3–6 years (14). Other studies support this approach. In individuals receiving intensive insulin therapy, when mealtime insulin was adjusted based on the total carbohydrate content of the meal, the postprandial glycemic rise remained constant over a wide range of carbohydrate ingested and was not affected by the GI, fiber, and caloric and fat content of the meals (15). LaFrance et al. (16) reported that major alterations in the GI of meals produced small changes in the glucose profile; however, on a day-to-day basis, alterations in GI did not induce any clinically significant change in glycemia. They concluded that for patients treated with multiple insulin injections, the combination of carbohydrate counting and specific algorithms for adjusting insulin per gram of carbohydrate offers greater flexibility in choosing foods, portion size, timing of meals, and physical activity than implementation of a low-GI diet.

The DAFNE study reports an 11% reduction and the Dusseldorf program a 14% reduction in HbA_{1c} compared with the 7.4% reduction reported by Brand-Miller et al. Therefore, in subjects with type 1 diabetes, the outcomes from adjusting insulin based on the carbohydrate content of the meal would appear to be a better primary strategy than a low-GI diet. This approach allows individuals with diabetes to select foods they enjoy while maintaining glycemic control.

Type 2 diabetes. Studies using other nutrition approaches in subjects with type 2 diabetes report a 1–2% unit decrease in HbA_{1c}. In the U.K. Prospective Diabetes Study, subjects were diagnosed with type 2 diabetes with average HbA_{1c} values of 9% (17). After 3 months of intensive nutrition intervention, HbA_{1c} levels decreased to 7%. Subjects were then randomized into study groups. The 2% unit decrease in HbA_{1c} (22% decrease) was attributed by the study investigators to a reduced energy intake rather than weight loss per se as only those subjects who maintained a reduced energy intake maintained HbA_{1c} levels in that range. In other subjects (even if weight loss was maintained), if energy intake increased, HbA_{1c} also increased.

In the clinical trial of the nutrition practice guidelines for type 2 diabetes (18), in subjects with a diabetes duration of <6 months, HbA_{1c} levels were reduced by ~2% units (a 22% decrease), and in subjects with an average 4-year duration of diabetes, HbA_{1c} levels were reduced by ~1% units (a 11% decrease). In another study involving subjects with type 2 diabetes in which carbohydrate counting was the nutrition approach used, HbA_{1c} levels also dropped by ~2% units (19).

Of interest is a controlled clinical study using a community-based, group-centered education intervention in rural Costa Rica (20). Graduate nutrition students implemented a 12-week nutrition and exercise program that focused on portion control, use of healthier food substitutes and walking group sessions. The intervention group experienced a decrease in HbA_{1c} of 1.8% units (21% decrease) compared with a control group who received a lecture on diabetes and whose HbA_{1c} decreased by 0.4% units.

Therefore, primary nutrition interventions in type 2 diabetes can focus on educational approaches such as reduced energy intake, modest weight loss, and basic carbohydrate counting, which have been demonstrated to produce better outcomes than from a low-GI diet approach; they reduce HbA_{1c} by ~20% compared with the 7.4% from the low-GI diet.

Problems with GI

If foods do have different glycemic responses, why have the studies not reported outcomes comparable or better than the nutrition intervention studies described above? Several problems with the methodology used to determine GI have been noted by Pi-Sunyer (10). First, 50 g of carbohydrate from foods is used for the comparison. Although this would seem logical, in reality it does not reflect actual amounts of carbohydrate contributed by individual foods in the usual diet. For example, carrots in usual portion sizes would contribute minimal amounts of carbohydrate and despite having a high GI would not elicit much of a glycemic response. Pizza may have a lower GI number, but the usual portion size consumed would contribute a considerably greater amount of total carbohydrate, resulting in a higher glycemic response.

Furthermore, the GI only measures glucose above the beginning fasting glucose and only for 2 h. If it measured what occurs naturally, the fasting glucose value would decrease over time and the area under the curve (AUC) would be greater. Therefore, Pi-Sunyer favors the use of the whole AUC as the real measure of glucose availability. If the AUC is calculated in this manner, the differences in GIs between foods are greatly attenuated. For example, a person with a fasting glucose of 75 mg/dl ingests two foods, one with a GI of 100 and the other a GI of 72. If the GI were calculated by using the whole glucose AUC instead of only the area above the fasting glucose, the values would be 100 and 92, respectively. The difference changes from 29 to 8 units.

Another problem with GI is the use of the 2-h standard for ending the test. Individuals with diabetes, particularly type 2 diabetes, require longer than 2 h for their blood glucose concentrations to return to normal, if at all. Thus the differences in GI also would be considerably less if the AUC were calculated for a more reasonable postprandial period of 4 h. Furthermore, GI is measured in the morning after an overnight fast. Several studies have reported that if GI is measured after lunch, the differences in GI would be considerably less than after breakfast. Therefore, it is very likely that a true AUC for individ-

uals with diabetes is not being determined.

Although Brand-Miller et al. point out that more foods need to be tested for GI, perhaps a better, more standardized methodology for determining glycemic responses should be determined before food companies invest resources in testing for GI. We are fortunate in the U.S. to have Nutrition Facts on food labels. Individuals with diabetes can easily and quickly determine portion size and the total amount of carbohydrate in that portion size. By using information from food labels, more accurate portion sizes can be selected.

The bottom line

There appears to be a small effect from a low-GI diet over a high-GI diet, primarily on postprandial glycemia, although these values are not consistently measured or noted. Not surprisingly, use of a low-GI diet does not affect fasting plasma glucose values. Although the evidence suggests that other nutrition interventions can lead to greater improvements in overall glycemic control than implementation of a low-GI diet, the GI concept can be used as an adjunct to help "fine-tune" glycemic control. For example, some individuals may benefit from choosing low-GI foods, especially at breakfast, and others may not. By testing pre- and postmeal glucose, individuals may be able to determine whether some foods raise their blood glucose levels more than others. However, for the testing to be accurate, blood glucose levels must be near normal before the meal and the carbohydrate content of the foods tested must be the same. It is important for individuals to do this for themselves, as the standard deviations of the GI for foods are relatively large, suggesting a wide variation in individual responses to the same food. Using the information from testing foods that contain carbohydrate can help individuals decide if they need to choose smaller portions of the foods that raised their blood glucose levels more than other foods or if they can cover these foods with the right amount of diabetes medication.

Finally, for a primary nutrition therapy intervention, an approach documented to have the greatest impact on metabolic outcomes should be selected. Information on glycemic responses of foods can perhaps best be used for fine-tuning glycemic control.

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