The 3 R's of Glycemic Index: Recommendations, Research, and the Real World

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The ability to achieve optimal glycemic control in diabetes management is highly influenced by food intake. The initial focus for nutrition education messages is to aim for consistency in both type and quantity of carbohydrates consumed. However, research in the past decade has acknowledged that not all carbohydrates effect blood glucose levels in the same way. One of the methods for evaluating this effect is known as the glycemic index (GI).

Using the GI in meal planning can improve diabetes control and other health parameters. Understanding the benefits of the GI and how one can implement it into the diet, allows health care practitioners to educate patients about its use. This article will define GI; highlight key recommendations regarding the use of GI scales; summarize recent research related to the impact of choosing lower-GI foods on diabetes control, lipids, and weight; and conclude with some practical, real-world tips for using the GI when counseling patients.

The GI is a ranking system that indicates how quickly a carbohydrate food raises blood glucose. This is determined by measuring the area under the curve in the 2 hours after the consumption of a test food. These values are then compared to the area under the curve 2 hours after the consumption of a similar weight of glucose or bread. Foods ranked < 55 are considered to have a low GI. Low-GI foods include many fruits and vegetables, legumes, whole grains, and dairy products. Foods with a ranking between 56 and 75 are considered to have a moderate GI. High-GI foods, those with a ranking between 76 and 100, often include highly processed and refined carbohydrates such as instant oatmeal, white bread, and cornflakes (Table 1).

Although the GI ranking compares standard carbohydrate portions (usually 25 or 50 g), the amount of food tested to derive the GI may not reflect usual amounts consumed. Thus, another measure, the glycemic load (GL), has been defined and is calculated based on both the GI and the portion size of the food eaten (GL = [GI value × carbohydrate per serving]/100). Similar to the GI, the GL also has a scale, with values < 10 being considered low and those > 20 considered high. Although popcorn has a relatively high GI (72), because it is low in carbohydrate per serving (11 g per 1.5 cups), the calculated GL comes out to 8 for this serving size. Thus, popcorn would have an overall lower impact or glycemic load based on the portion size eaten.

When describing the overall glycemic effects of a food and taking into consideration both the GI and the GL levels, it is often more practical to talk in generalities about a food's "glycemic impact" instead of its specific GI or GL values. The patient information page handout provided on page 161 of this issue of *Clinical Diabetes* does just that.

There are a variety of factors that can account for the GI of different foods. Some of these characteristics are naturally occurring, whereas others are affected in commercialization or home preparation.

- Physical form: Generally, the more processed a food, the higher its GI. For example, instant oatmeal has a GI of 79, whereas steel cut rolled oats has a GI of 55.
- Food combinations: When carbohydrate foods are eaten as part of a meal, the GI of the meal changes based on the average of all the GI values factored together. Thus, a useful message for patients is to complement a high-GI food (such as rice) with low-GI foods (such red beans or legumes).
- Cooking time: Longer cooking times may increase the glycemic impact of a food by breaking down the starch or carbohydrate and allowing it to pass through the body more quickly when consumed. Pasta cooked al dente (for 5–10 minutes) has a slightly lower GI than pasta cooked longer.
- Acidity: The more acidic a food is (e.g., pickled food or those containing vinegar or lemon juice), the lower the GI. For example, sourdough bread, which uses a lactobacillus or lactic acid culture as part of the leavening process, has a lower GI than white bread.
- Physical entrapment: The fibrous coat around beans, seeds, and plant

Table 1. GI and GL Rankings[14]

Food	Food Item Number	GI (based on glucose = 100)	Serving Size; Carbohydrate Content	GL
Bagel, white	101	69	2 oz; 35 g	24
Healthy Choice Hearty 100% whole grain	261	62	1 slice; 14 g	9
Hearty rye bread	152	62	1 slice; 15 g	7
Wonder enriched white	197	73	1 slice; 14 g	10
Pita bread, white	295	68	1 small pocket; 15 g	10
All-bran cereal	298	38	1/3 cup; 21 g	8
Cornflakes	325	93	1 cup; 25 g	23
Brown steamed rice	588	50	3/4 cup; 33 g	16
Instant rice	599	87	1 cup; 42 g	36
White spaghetti	1374	46	1 cup; 47 g	22
Apple	945	39	1 small; 16 g	6
Orange	995	40	1 small; 11 g	4
Orange juice	1049	46	1/2 cup; 15 g	7

cell walls in whole grains acts as a physical barrier, slowing access of digestive enzymes to break down the carbohydrate. Thus, many whole grains and legumes have a lower GI.

- Protein/fat: Adding protein or fat, which have minimal effects on glycemic excursions, to a high-GI food will decrease the GI of that food. For example, adding cheese to a slice of bread would decrease the GI.
- Soluble fiber: In general, the higher the food is in viscous or soluble fiber, the lower its GI will be. By increasing the viscosity of the intestinal contents, the interaction between the starch and the digestive enzymes is slowed, resulting in slower and lower glycemic excursions. Beans are a great example of a food high in soluble fiber.

GI Recommendations

The American Diabetes Association's standards of care recommend that "the use of the glycemic index and glycemic load may provide a modest additional benefit for glycemic control over that observed when total carbohydrate is considered alone" and gives this recommendation a "B" evidence grade.[1] The American Dietetic Association reviewed the evidence available on the value of the GI[2] and concluded that dietitians need to counsel patients that there is conflicting evidence regarding the overall benefit and that further research is needed to strengthen the claims. At the Joslin Diabetes Center in Boston, Mass., patients are counseled on the use of the GI as a tool to improve their glycemic control and overall health. In the center's guidelines for patients with type 2 diabetes who are overweight or obese, use of the GI is encouraged as another way to improve the quality of carbohydrates consumed.[3] Although these organizations remain cautious about strongly recommending the use of the GI in meal planning, it is helpful to look at research related to the particular benefits of using the GI for controlling glycemia, lipids, and weight.

The GI and Glycemic Control

There is increasing evidence that choosing foods with a low GI and GL has a favorable impact on glycemic response. The GI indicates the rate at which food enters the bloodstream. Therefore, foods with lower GI enter at a slower rate, which reduces both the glycemic response and the corresponding insulin release. There is a positive correlation between consumption of high-GI foods and an increases incidence of type 2 diabetes.[4] Decreasing the GI of the diet may improve insulin sensitivity, reducing the risk for disease.

Eating a lower-GI diet may also decrease the risk for complications in those previously diagnosed with diabetes. A Cochrane review of 11 randomized, controlled trials involving 402 patients with diabetes revealed that low-GI diets significantly lowered A1C by 0.5% compared to the A1C of subjects following a high-GI diet.[5] The effect of the GI on hypoglycemia also has been evaluated. Following a low-GI diet was found to decrease hypoglycemia compared to either a high-GI diet or a diet based on Exchange lists.[5] The ability to achieve better control with reduced hypoglycemia indicates that decreasing the GI of the diet may reduce glycemic variability. Overall improvements in glycemic variability and control have been shown to reduce the incidence and risk for microvascular complications associated with diabetes.

The GI and Lipids

A diet composed of lower-GI foods may result in lower LDL cholesterol and improved HDL cholesterol.[6,7] Although research findings vary, most agree that there seems to be a favorable effect on HDL cholesterol after consumption of a low-GI diet. This may be the result of decreased gluconeogenesis after the consumption of low-GI foods that may suppress nonesterified fatty acid (NEFA) release and ultimately result in increased HDL levels.[4] There is also some evidence to suggest that lowering the GI may decrease the inflammatory response, which can also result in higher HDL levels.[8,9]

The evidence for low-GI diets lowering LDL cholesterol is less conclusive. Seven out of 10 studies were able to demonstrate a positive change in LDL following a low-GI diet. However, the results did not reach significance.

The effect of low-GI intake on triglycerides is also inconclusive. Six of 13 studies showed improvement in triglycerides but were not statistically significant.[4] Postmeal insulin resistance may occur after consumption of a high-GI meal, resulting in an increase in NEFA, which ultimately may increase triglycerides and very-low-density lipoprotein cholesterol levels in the body.[8] The effect of GI on total cholesterol was more pronounced, with several studies showing a significant improvement after the introduction of a low-GI diet.[4] In these same studies, no effect was seen for the individual components of cholesterol.

There is some evidence available that lowering the GI of the diet may be helpful in improving lipid profiles and reducing the risk for cardiac disease. More studies are needed to confirm this, but there are no data indicating any detrimental cardiac effects from consuming a lower-GI diet.

The GI and Obesity

Emphasizing low-GI foods in the diet may facilitate weight loss and weight maintenance.[10] A weight loss of 5–10% can yield significant improvements in insulin sensitivity, resulting in a decreased need for medications while improving glycemic control.[11]

GI Case Study

Mrs. J. is a 45-year-old woman who was diagnosed with type 2 diabetes 5 years ago. Her most recent A1C level was 7.5%, and her pre- and postmeal blood glucose monitoring often reveals an elevation in blood glucose of 70–100 points (from 130 mg/dl before meals to > 200 mg/dl after meals). She has been trying to keep her carbohydrate intake consistent at meals and has lost 5 lb in the past 8 months because of caloric restriction and increased physical activity. She asks about the elevated blood glucose levels after meals and complains of hunger after meals as well.

Review of her food logs reveals that she consistently eats about 45 g of carbohydrate at breakfast, 60 g at lunch, and 75 g at dinner. Her diet history shows the following pattern:

- Usual breakfast: cornflakes with milk or frozen waffles with sugar-free syrup
- Usual lunch: sandwich of lean meat on white bread and a granola bar
- Usual supper: grilled chicken or fish with potatoes, a small serving of vegetables, and a roll

Using the list of high-, medium-, and low-GI foods, Mrs. J. identified the foods in her diet that may be exacerbating higher postmeal glycemic responses. She decided to make the following substitutions and changes in her diet:

- All-bran cereal for cornflakes
- A hearty rye or whole-grain bread for white bread
- Converted rice for potatoes
- More whole fruits (apples, oranges, and bananas) and vegetables for snacks instead of refined carbohydrates

It was also discussed that many of these foods are also higher in dietary fiber and may contribute to increasing her feeling of satiety. A review of her pre- and postmeal glucose levels at the next visit 3 months later showed reduced postprandial excursions, with most values increasing < 70 points after meals. She reported increased satiety and had lost an additional 3 lb.

Through decreased satiety signaling and decreased fat oxidation, it appears that increasing the GI of the diet may have detrimental effects on both weight and overall health.

Decreased caloric intake throughout the day has been shown after consumption of a low-GI meal. Lowering the GI in the diet increased cholecystokinin (CCK) release, ultimately resulting in greater satiety for 180 minutes.[12] A 50% increase in GI resulted in a 50% decrease in satiety, and 16 of 17 studies were able to demonstrate an increased sense of fullness with lower-GI meals.[12] This may be attributed to the lower-GI foods moving more slowly through the gastrointestinal tract and prolonging the signaling to CCK and glucose-like peptide-1, which are partially responsible for sending satiety signals to the brain. The rapid transit of high-GI foods has been shown to result in postprandial hyperglycemia immediately after a meal, with potential hypoglycemia subsequently. This pattern of blood glucose response may result in increased hunger.

Fat oxidation is also affected by the GI content of a meal. After a rise in hyperglycemia and insulinemia from a high-GI meal, increases in carbohydrate oxidation are also observed.[12] This reduces fatty acid oxidation at the expense of the carbohydrate oxidation that is occurring postprandially. Decreased fatty acid oxidation is present in obese individuals. A low-GI, high-protein diet resulted in more successful weight maintenance in people after weight loss than high- or low-protein diets and high-protein, low-GI diets.[13]

Real World: Talking With Patients About the GI and Glycemic Impact

Perhaps the biggest challenge in discussing the GI with patients is knowing where to turn for information about GI values. The International Tables of Glycemic Index and Glycemic Load, which list information on > 2,400 food items, are acknowledged to be the go-to source for the most scientifically accurate information.[14] However, reviewing the lists and looking for a practical guide may leave practitioners feeling overwhelmed by too much information. For example, the tables list the GI for 104 types of rice.

As illustrated in Table 2, the GI can vary greatly within a category, making it difficult to put a single GI ranking on a particular food. Although a GI value is listed on many food labels in Australia, the values are not available for most food products in the United States. Thus, general food tables, such as the one shown in this issue's Patient Information page (p. 161), rely on averages and best clinical judgment when putting foods into certain categories.

The most helpful message for patients is to not focus on the numerical GI or GL values of foods, but rather to think about the overall glycemic impact of the food. Keep in mind that many foods that are encouraged in a healthy meal plan such as broccoli, spinach, lettuce, and cucumbers have not been evaluated for a GI level. But because of their relatively low carbohydrate content, we know they have an overall low glycemic impact. Also, when heart-healthy fats and lean proteins in the form of nut butters, low-fat cheeses, and lean meats are added to a meal or snack, the overall glycemic impact will be lower. Thus, it is most helpful to give patients general guidance to limit their intake of foods with a higher GI such as white, highly processed breads and grains and replace these with lower-GI foods such as most fruits and vegetables, dairy products, beans and legumes, and whole grains.

The following tips may be helpful discussion points when talking about glycemic impact with patients.

Table 2. Variations in the GI of Rice[14]

Food	Food Item Number	GI (based on glucose = 100)
Brown steamed rice (United States)	588	50
Brown boiled rice in excess water for 25 minutes (Australia)	589	72
Brown rice (China)	590	87
Instant rice, white (Australia)	23	87
Converted white boiled rice (Uncle Ben's; United States)	603	38
Basmati Rice, white boiled (United Kingdom)	557	52

1. Choose more fruits and vegetables.
This message is part of all healthy-eating guidelines, but it is especially true for people with diabetes, those needing to control blood pressure (using the Dietary Approaches to Stop Hypertension, or DASH, diet), and those seeking to decrease weight. Nearly all fruits and vegetables have a low GI value. Aim to have one to two fruit and vegetable servings at every meal and snack. Use the image of the plate to encourage patients to eat at least half a plate of vegetables, including salads, at lunch or dinner.

2. Increase soluble fiber.
Soluble fiber decreases the GI through its role in decreasing gastrointestinal transit time, which results in decreased postprandial blood glucose. Foods high in soluble fiber include apples, citrus fruits, oat bran, oatmeal, dried beans and peas, and many vegetables.

3. Complement high-GI foods with low-GI foods.
High- and moderate-GI choices may be improved by pairing them with low-GI foods or healthy sources of lean protein or unsaturated fats. For example, the GI of white bread will be lowered if it is eaten with a bowl of chili or spread with peanut butter. Think about choosing low-GI foods at every meal.

4. Choose fewer processed foods.
Talk with patients about choosing more whole-grain products and fewer refined, white carbohydrates. Suggest that patients look for "whole grain" listed on the label, and remind them that just because bread is brown does not mean that it is a good source of fiber or has a low GI value.

5. Use blood glucose monitoring to analyze individual responses to specific foods.
Postprandial glucose results are highly correlated to the GI and composition of the meals or snacks consumed. Because of the metabolic variability that occurs with ingestion of nutrients from one individual to another, sometimes the best way to know how a person responds to a given food is to monitor the glucose response after that person eats the food. Instruct patients to check their blood glucose levels before meals and 2 hours after meals to identify their personal responses to particular foods or meals.

The more we understand about how foods affect glycemic control, the more able we may be to make positive changes. Small adjustments to dietary intake with regard to the GI may yield significant results. When both patients and providers recognize that different carbohydrates may have different effects on blood glucose levels, the result may be effective dietary changes that not only improve glycemic control but also provide benefits in terms of lipids and weight.

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