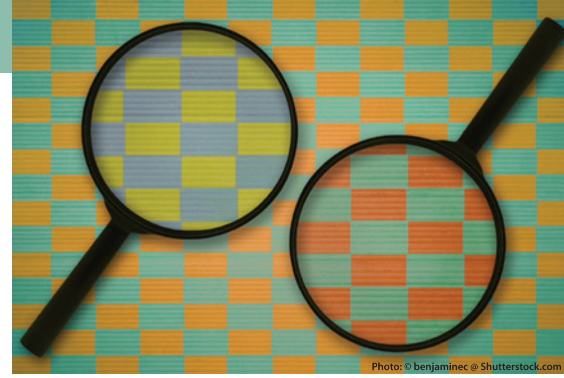
Counterpoint: Glycemic Index and Glycemic Load Add Complexity and Have Marginal Value for Helping Consumers Choose Quality Carbohydrates



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ABSTRACT

Glycemic index (GI) and glycemic load (GL) were proposed in the 1980s as ways to measure carbohydrate quality. Despite extensive research, findings published in the literature are inconsistent with respect to most health outcomes. In addition, GI values published in tables and on food packaging may not characterize the glycemic response of a food as eaten, especially when it is eaten as part of a meal. Further, these values do not consider variability introduced by any number of factors, such as variety, ripeness, degree and mode of cooking or processing, presence of other foods or ingredients, temperature of food when eaten, amount eaten, etc. The use of GI as a touchstone in food selection, diet planning, and other applications is concerning due to its wide variability and limited precision and accuracy. With standard deviations that are equal to class boundaries for medium-GI foods, designation of foods as high, medium, or low GI is prone to error. This discussion identifies some of the limitations surrounding the measure and its use and outlines the weak evidence for many health outcomes. Further, the assignment of GI values to food intake data collected in dietary surveys by food frequency and other vehicles is questioned. It is unclear whether GI and GL can help consumers determine carbohydrate quality and guide them to make food choices that may reduce their risk of associated chronic diseases. Although a group of noted scientists has met and published a consensus on carbohydrate quality, their findings are not aligned with those of other recognized health-promotion organizations, such as the American Diabetes Association or the Academy of Nutrition and Dietetics Evidence Analysis Library. Thus, their conclusion that GI and GL are measures of carbohydrate quality is not substantiated by the state of the research at this point in time, making the publication of a consensus on the subject premature.

In the 1980s, David Jenkins and colleagues developed the glycemic index (GI), a measure that compares the blood glucose response to various carbohydrates with the blood glucose response to a standard amount of glucose, for use as a tool in diabetes research (1). Their work not only sparked development of the companion measure, glycemic load (GL), which considers the quantity of carbohydrate as well, but also fostered extensive research. However, a recently published consensus statement that posits that these measures be used to determine carbohydrate quality and aide in food selection has stirred controversy (2).

This article delineates the reasons for concern about the published consensus statement and provides evidence-based arguments describing the potential for alternate conclusions. Issues discussed range from the inherent variability in GI caused by food-specific factors, such as species, variety, and cooking method, to the effects of accompanying foods, total diet, and the physiological parameters of the individual consumer. The wide variability in GI values raises concerns about their use in tables (3,4) or on food packaging to delineate carbohydrate quality, especially as touchstones for selection of foods in the diet (5). Further, inconsistencies in observed health outcomes among both intervention and epidemiological studies raise additional concerns (6–8).

Inherent Variability of the Measure

Interlaboratory (ring) tests, using strictly proscribed protocols, show significant variability among testing centers and subjects and within subjects, suggesting GI measures lack the standards of accuracy and precision required for labeling and other purposes (2,3,9,10). The wide variability of the measure is attributed to many factors, starting with the calculation, rather than direct measurement, of available carbohydrate (9,11,12). (In *Food Energy—Methods of Analysis and Conversion Factors* [11] the Food and Agriculture Organization of the United Nations [FAO] states, "Obtaining values by difference should be discouraged because these values include the cumulative errors from the analytical measures of each of the other non-carbohydrate compounds; these errors are not included in direct analyses.")

Glucose or white bread is used as the control in establishing a GI value. The coefficient of variation (CV) for white bread is high, averaging ~30% and ranging from 13.9 to 45.3% in various studies (13–15). In one study of 63 adults, the CV for the GI of white bread compared with a glucose control was 62 ± 15. The mean intra- and interindividual CV was 20 and 25%, respectively (14). Increasing sample size, replication of reference and test foods, and length of time for blood sampling did not improve the CV. The authors (14) note that such variation makes food selection using GI unlikely to be helpful. This is true because foods are categorized as medium GI if values fall between 56 and 69. Because standard deviation (SD) equals the width of the class boundaries for medium-GI foods, the designation of a food as low (GI < 55 on the glucose scale), medium (GI 55–69), or high (GI ≥ 70) is fraught with error.

Numerous differences in physiology, hormones, and digestion among individuals, as well lifestyle factors such as exercise, increase variability (9,10,15). Differences in metabolism, blood glucose clearance, hemoglobin A1c (HbA1c), and insulin sensitivity, and even the degree of mastication, can affect glycemic response (16,17). Further, GI values published in tables or on food packaging fail to reflect radically different glycemic responses to a single high-GI food eaten all at once (in a large bolus) versus sipping or nibbling of the same food over several hours (10,18). An individual's overall diet, foods eaten during

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previous days and meals, and glucose tolerance can also affect glycemic response (19,20).

Wide Variability of GI Values due to Food Factors

Factors inherent in a food and its preparation or other components in a food have a tremendous impact on glycemic response (21). For a particular food, GI values differ widely depending on variety, species, cultivar, ripeness, particle size, food form, mode of preparation and storage, and temperature of the food when eaten; type and amount of sugars, starches, and fibers; and the presence of fat, protein, acid, or phytonutrients (8,13,22–32). Because most foods are eaten with other foods, the glycemic response to a food tested singly does not accurately predict the glucose response when the food is customarily eaten as part of mixed snacks and meals (13,33,34). One study showed that published GI values overestimated glycemic response by as much as 50% when the food was consumed as part of a meal (26). The GI of previous meals consumed also affects the glycemic response to subsequent meals (35). This "second meal" effect, when used wisely, shows benefits for diabetics, but also documents it as a potential source of variation (36).

Because food amounts consumed may be quite different from those used for the GI test, GL was introduced as an additional measure. The GL is calculated by multiplying the GI of the food by the number of grams of total carbohydrate in the food. Because GI values can have high SDs, multiplication of the grams of available carbohydrate to calculate GL has the potential to amplify any inherent error, diminishing the accuracy of GL as a measure.

Assigning GI or GL values to food intake data from surveys or food frequency studies and using them to link health outcomes can also be problematic. The probability that the values assigned reflect glycemic response is limited because survey instruments rarely collect data on the many factors that impact GI variability. This could explain the inconsistent findings among studies that associate GI and GL with various health outcomes.

Some argue that, for many nutrients, as with the GI, the amount of nutrient delivered when a food is eaten may be quite different from that published in tables or on food packaging (37). However, unlike the GI or GL, other published nutrient values are rarely used as touchstones to determine whether a specific food should be selected or excluded when constructing a normal diet.

Inconsistent Findings Fail to Show Wide Consensus

Meta-analyses and systematic reviews show inconsistent health outcomes for most measures. Neither dietary GI nor GL was independently associated with the risk of gastric, pancreatic, or colorectal cancers (38–41). GI was not associated with endometrial cancer risk but had a moderate association with GL (odds ratio [OR] = 1.21) (42). There was an extremely weak association for GI and GL with breast cancer (relative risk [RR] = 1.01 and 1.04, respectively) (43).

For body mass index (BMI), there was no association for GI in either adults or adolescents (41,43–45). With respect to weight loss, findings from the Diogenes cohort and a historical review suggest that a modest reduction in GI (4.7 GI units) coupled with a modest increase in protein could aide in maintenance of weight loss (46,47). (The Diet, Obesity and Genes [Diogenes] dietary intervention study includes 97,942 subjects from 7 cohorts involved in the European Prospective Investigation into Cancer and Nutrition [EPIC] study participating in the Diogenes project. For this cohort weight measurements were taken at baseline and follow-up, which were used to predict future obesity prevalence using various regression models.) In contrast, the Norwegian Institute of Public Health deems the efficacy of low GI diets for weight loss in adolescents to be "inconclusive" (48). The Academy of Nutrition and Dietetics Evidence Analysis Library (AND EAL) and position papers on overweight have found that evidence from randomized control trials is nonsupportive of GI (without calorie restriction) used for weight loss or maintenance (49,50). Diets with a greater likelihood of compliance, or rich in dietary fiber and multiple functional foods, not GI alone, appear to play positive roles in weight and health (51,52). Further, satiety and short-term energy intake do not seem to be impacted by GI in most studies (13,53–56).

Low-GI diets may have weak positive effects on type 2 diabetes, but caution is urged because of high heterogeneity and the nature of the studies (57). One study notes that GL and carbohydrate intake were positively associated with the risk of hyperglycemia in diabetic patients, but that recommendations regarding low-GI diets should also control carbohydrate and energy intakes (58).

In terms of blood lipids, a low-GI diet may help lower total and LDL cholesterol. However, there was confounding with both dietary fiber and diets rich in functional foods, in that cholesterol reduction was greatest when these occurred in tandem (41, 53,59). Low-GI and -GL diets showed a potentially beneficial effect in obese adolescents in terms of triglycerides but had no impact on other measures (44). Fleming and Godwin (60) note the limited generalizability of findings due to heterogeneity among studies of diets and definitions of low and high GI. The American Heart Association notes mixed findings and recommends further study (61).

With regard to diabetes, a large-scale randomized trial in Canada showed little impact of low GI on measures indicative of diabetes, except for a marker of inflammation (62). The U.S. Dietary Guidelines Advisory Committee states that a moderate body of inconsistent evidence supports a relationship between high GI and type 2 diabetes. However, they also note that strong and convincing evidence shows little association between GL and type 2 diabetes (41). The American Diabetes Association position statement notes, "Studies show the total amount of carb is a stronger predictor of blood glucose response than GI," but GI might be used as an adjunct to carbohydrate counting (63). The American Heart Association states that GI is an oversimplification and a "limited tool for managing diabetes" (64). The AND EAL affirms GI has little impact on HbA1c and does not recommend GI as a tool for management or therapy for diabetes (65).

The AND EAL and authoritative bodies in France, Germany, Scandinavia, and the United Kingdom have published scientific reviews noting inconclusive findings and stating that evidence does not support use of GI and GL in health promotion and disease prevention (66). Nevertheless, some countries allow GI labeling on food products. In contrast, the European Food Safety Authority (EFSA) has rejected a low GI claim, noting that although it may have some favorable effect on metabolic risk its role in weight management and prevention of diet-related diseases is inconclusive (67).

Health Canada's assessment of GI for labeling purposes affirms that the GI measure has poor accuracy and precision for labeling purposes and does not reflect glycemic response, which varies with the amount of food eaten and by replacement of some available carbohydrates with unavailable carbohydrates (10). They note that an unintended focus on GI for food selection could lead to food choices that are inconsistent with national guidelines. Hence, Health Canada's current opinion is that the inclusion of the GI value on the label of eligible food products would be misleading and would not add value to nutrition labeling and dietary guidelines for assisting consumers with making healthier food choices.

Confusion about the Measure

There are several sources of confusion among the general public. Consumers and many of those providing popular dietary guidance do not

1) Understand available carbohydrate, and, therefore, are unaware that GI values may not be applied to 50 g of food or to the portion they are eating.
2) Realize the amount of food needed to reach 50 g of available carbohydrate may be large if the food is high in fiber and water.
3) Understand that the GI of foods such as inulin-based pasta cannot be accurately determined because there is so little available carbohydrate that the quantity needed is beyond what an individual can eat in a single setting.
4) Recognize that comparisons stating that candy bars have lower GIs than whole wheat bread misuse the GI concept.

Confusion Leads to Misguided Food Choices

Using single attributes, such as GI or GL, to select or evaluate foods can have unintended consequences (10). First, GI and GL do not represent the overall nutrient content (vitamins, minerals, fiber, etc.) of a food. Second, the GI of a food can be lowered by replacing a high-GI sugar (e.g., glucose) with a lower GI sugar (e.g., fructose or sucrose) or by adding fat or protein. In addition, such changes may reduce the nutritional quality of a food and increase risk for cardiovascular disease (CVD), metabolic syndrome, and obesity—ironically, the same diseases that a low-GI diet is purported to address.

Conclusions

GI has several limitations. The GI of a food, even when determined under controlled laboratory settings and by experienced researchers, can have a large SD, calling into question the precision and accuracy of the measure. Table values for GI may not accurately reflect what is eaten in terms of variety, cooking methods, amounts, and processing. The use of GI and GL might do little to improve food choices and nutrient quality because they could lead consumers to choose bacon rinds over watermelon or a candy bar over carrots.

Further, GI and GL are of limited value in predicting a number of health outcomes. Specifically, evidence for use of GI to prevent or manage CVD and diabetes is nonsupportive or inconclusive (66). Because different diets may have the same GI score, conclusions about the health effects of these diets are inconsistent from study to study. This variability has led many authoritative organizations to question the validity and value of the GI in guiding consumer food choices. Thus, a consensus statement (2) seems both premature and contradictory to the results of reviews performed by authoritative bodies, as well as other analyses (68,69).

Key Definitions

Based on definitions described in the ICQC consensus paper (2)

Glycemic Index (GI)—The 2 hr blood glucose excursion after ingesting 50 g of available carbohydrate from a test food compared with the blood glucose response after ingesting 50 g of glucose. The index is derived by calculating the ratio of the two areas under each blood glucose curve. The speed at which carbohydrate foods are digested, absorbed, and metabolized determines their classification: high-GI foods are quickly metabolized (GI > 70 on the glucose scale), whereas low-GI foods (GI < 55) are more slowly metabolized.

Glycemic Load (GL)—To correct for the extremely large serving sizes required to deliver 50 g of available carbohydrate for some foods (e.g., 4.5 cups of watermelon or 4 cups of beets), the amount of available carbohydrate in a given serving of a food is multiplied by the GI of that food and then divided by 100.

Glycemic Response (GR)—Postprandial blood glucose response (change in concentration) resulting from ingesting a food or meal containing carbohydrate.

Available Carbohydrate—The carbohydrate in foods that is digested, absorbed, and metabolized as carbohydrate. Available carbohydrate is sometimes referred to as glycemic carbohydrate.

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