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The Glycemic Index: What It Is, What It Is Not

Executive Summary

The nutrition community is deeply divided over the role of the glycemic index in preventing disease and managing weight loss. The American Institute for Cancer Research (AICR) has reviewed the current published research on this controversial topic. **Due to insufficient evidence of clinical efficiency and persistent methodological concerns regarding how Glycemic Index values are determined, AICR cautions the public not to make dietary changes based solely on this interesting but still unproven concept.**

There are numerous hypotheses relating high GI foods to increased blood sugar and insulin levels and how this could lead to diseases like obesity, heart disease, diabetes and cancer. While intriguing and worthy of further investigation, these theories have yet to be proven. For example, there is no conclusive evidence that low GI diets promote satiety or reduce hunger for the benefit of weight loss. Nor is it certain that postprandial insulin levels following high GI diets lead to weight gain. Low GI diets appear to help people with diabetes control their blood sugar, but other nutritional interventions may be more effective. In most epidemiological studies on GI and heart disease, low GI diets are associated with lower disease risk, but long-term clinical studies are needed to prove the value of low GI diets in reducing risk. As for cancer prevention, there is not enough evidence to claim a benefit from low GI diets.

Despite these uncertainties about the role of GI, a variety of popular diet books consider glycemic index a powerful weapon in fighting obesity and disease. For example, the cover of *The New Glucose Revolution* refers to the glycemic index as "the dietary solution for lifelong health."

We at AICR believe it is premature to incorporate the GI concept into dietary recommendations for the public until methodological concerns with the GI are resolved. This includes standardizing how GI values are tested and measured, and using one reference food—not two reference foods—as the standard for calculating GI values, to avoid inconsistencies in GI tables. Additionally, the variability in GI, whether it's due to the physical structure of the carbohydrate, the inclusion of carbohydrates in a mixed meal, or the variation in an individual's blood sugar response to a carbohydrate, needs to be clarified so that appropriate dietary guidance on GI can be provided.

Although the glycemic index has the potential to be a valuable clinical tool, more research, including long-term clinical studies, are needed to prove its worth in preventing disease. For now, consumers should focus on eating a mostly plant-based diet that

includes a wide variety of vegetables, fruits, whole grains and legumes. There is much evidence that a mostly plant-based diet can reduce the risk of diseases, like cancer, heart diseases and diabetes. In most cases, such a diet will have a low glycemic index. Whether a low GI diet is the preventive agent in reducing disease or is simply a marker for a varied, healthful diet is yet to be determined, and will likely lead to more debate.

The Glycemic Index: Introduction

The glycemic index was introduced over twenty years ago, yet it remains a highly contentious area of nutritional investigation. Although hundreds of studies have been published on the glycemic index and numerous popular diet books advocate its use, the connection between glycemic index and long-term health has not been established.

The glycemic index is a work in progress. Testing foods for glycemic index is far from complete, and concerns about the measurement and reproducibility of the glycemic index have yet to be resolved. While evidence supporting the disease-preventive role of glycemic index is intriguing, more research is clearly needed. Until more definitive data, including controlled clinical trials, are available, basing dietary decisions on a food's glycemic index is not warranted. However, eating a mostly plant-based diet, rich in vegetables, fruits, whole grains and beans is recommended, and, in most cases, will provide a favorable glycemic index.

History

The glycemic index (GI) was conceived in 1981 by David Jenkins and fellow researchers at the University of Toronto, as a tool for the dietary management of type 1 diabetes. (1). It was originally thought that all simple sugars caused a more rapid rise in blood sugar levels than did complex carbohydrates. But some studies were beginning to emerge that challenged this conventional wisdom about sugars. Jenkins sought to systematically test the impact of different carbohydrates on blood sugar levels, compared to glucose, and ranked the carbohydrates by what became known as the glycemic index. (1,2).

More than twenty years later, the controversy over the clinical significance and practical application of the glycemic index continues. The glycemic index is the subject of heated debate between scientists who support its use as a tool for controlling blood sugar levels and preventing disease and those who believe that methodological concerns with its measurement and insufficient evidence of long-term benefit make it premature to incorporate the glycemic index concept into dietary recommendations for the public. Despite the controversy, many popular diet books, such as *The New Sugar Busters, Dr. Atkins New Diet Revolution, The Zone, The South Beach Diet and The New Glucose Revolution* have taken a strong stand in support of the glycemic index, espousing the virtues of a low glycemic index diet for promoting weight loss and good health.

What is the Glycemic Index?

The glycemic index ranks carbohydrate-containing foods on how quickly they elevate blood sugar levels. It is measured by comparing the increase in blood sugar after eating 50 grams of carbohydrate from a single food with the increase in blood sugar after eating the same quantity of carbohydrate from a reference food, which is either pure glucose or white bread. The average change in blood sugar levels over the next two hours, compared to the change in blood sugar levels after consuming the reference food, is the glycemic index value of that particular food. The blood sugar response of the reference food is given a value of 100 and all other foods are compared to this value. (2,3).

Foods containing carbohydrates that are quickly digested have the highest glycemic index, since the blood sugar response is fast and high. Slowly digested carbohydrates have a low glycemic index, since they release glucose gradually into the bloodstream. (2,3). In general, most refined carbohydrate-rich foods have a high glycemic index, while nonstarchy vegetables, fruits and legumes tend to have a low glycemic index. (4).

Glycemic index values are grouped into three categories: (3)

High GI	70 or higher
Intermediate GI	56-69
Low GI	0-55

What Determines a Food's Glycemic Index?

Several factors affect the glycemic index of a food: (1,3,5)

- *Cooking method*. Heat, amount of water and cooking time affect a food's GI. During cooking, water and heat expand the starch granules to varying degrees. Foods containing starch that has swollen (or gelatinized) to the bursting point, like boiled or baked potatoes, are more easily digested, and therefore, have higher GIs, than foods containing starch granules that are less gelatinized, like oatmeal, brown rice, and al dente spaghetti. For example, the GI of a baked potato is 85; brown rice is 50. (3,5).

- *Processing method*. Grinding, rolling or milling starchy foods reduces particle size and makes it easier for water to be absorbed and digestive enzymes to attack the food. Processing can also remove the fibrous outer coat of the grain that slows down the access of digestive enzymes to the starch inside. Finely milled flours generally have a high GI. Coarse, stone-ground flours have larger-sized particles and lower GIs. (3,5).

- *Type of starch*. The two types of starch in foods, amylose and amylopectin, have different effects on GI. Amylose molecules are harder to digest than amylopectin molecules. Legumes and basmati rice have a higher ratio of amylose to amylopectin, and therefore, have a lower GI than foods with more amylopectin. For example, the GI of basmati rice is 58; instant rice is 87. (3).

- *Fiber*. The extent that fiber affects GI is unclear.(1). Some researchers believe that viscous, soluble fiber thickens the mixture of food in the digestive tract, which slows

down enzymes from digesting the starch. This results in a lower blood sugar response, and a lower GI. Legumes and oats contain soluble fiber and have low GIs. (3).

- *Sugar.* GI is affected by the type of sugar in a food. Sucrose (table sugar), which is made up of glucose and fructose, has a lower GI than glucose because half of the sucrose molecule is made up of fructose, a type of sugar that elicits a very small blood sugar response. (3). For example, the GI of sucrose is 68; the GI of glucose is 100. It would seem that adding sugar to a meal should lower the GI, but, surprisingly, a few studies have not found this to be so. (1).

- *Fat.* Fat increases the time it takes for food to leave the stomach and enter the intestine. By slowing the rate that carbohydrates are digested in the intestine, fat-containing foods may temper the rise in blood sugar and yield a lower GI than similar foods without fat. For example, the GI of potato chips is 57, French fries is 75 and baked potato is 85. *However, that does not make potato chips a better choice than the more nutritious baked potato.* (3,5).

- *Acidity.* Acid in food slows down stomach emptying, which slows the rate that carbohydrates are digested. Increasing the acidity in a meal can lower its GI and the blood sugar response. Vinegar, lemon juice and sourdough bread provide this benefit. (1,3).

Why is the Glycemic Index So Controversial?

The glycemic index is a work in progress. As such, there are concerns about its use and relevance that keep the controversy going. These include its variability, usefulness in diet planning, standards for measurement, and clinical value in protecting against disease. Below are some of the criticisms of the GI and the opposing responses to these issues.

- *The glycemic index is highly variable.* As summarized above, a number of factors influence the GI of a food, including the physical structure of the carbohydrate, the presence of other nutrients (e.g., fat, fiber), and the way the food is processed and prepared. Opponents question the practicality of instructing people to eat foods cooked or processed in one way but not another, or of eating certain types of a particular food because the GI is lower. For example, macaroni has a GI of 47, but spaghetti has a GI of 38; thin linguini is 52 on the GI scale, but thick linguini is 46. (3). Some proponents say to focus, instead, on the categories of GI values and to choose more foods from the low GI group (0-55 GI) than from the high GI group (70 or higher), rather than trying to track and control the GI of every food that is eaten. (6). Yet, some popular diet books advocate avoidance of high GI foods.

  The glycemic index can also vary within the same person and among different individuals. The scientists who authored The *New Glucose Revolution* say that to reduce day-to-day variation in a person's blood sugar response, the foods are tested two to three times and the average glycemic index value is calculated. To account for

variations in blood sugar response among individuals, the glycemic index value for a food is usually the average value found in eight to ten people. (3).

- *The glycemic index does not take into account the amount of carbohydrate typically consumed.* The extent that blood sugar rises depends on the amount of carbohydrate in the food or meal and its GI value. The glycemic index is based on 50 grams of carbohydrate, an amount that does not always coincide with the amount of carbohydrate ordinarily eaten. For example, 50 grams of carbohydrate from carrots is close to 1½ pounds of carrots, obviously a much greater portion than a person would normally eat. This makes the GI value of carrots higher than it would be if a typical serving size were used in the calculation. To resolve this problem, the glycemic load was developed. It takes serving size into account, thereby offering a more realistic measure of a food's effect on blood sugar. The glycemic load of a food is determined by multiplying the GI of a food by the amount of carbohydrate per serving and dividing by 100. However, some critics contend that the glycemic load takes an already imprecise measure (i.e., GI) and magnifies it even more through the calculation. (1,2).

- *Since fat lowers the glycemic index, high-fat foods may be seen as good dietary choices.* Both the GI and the nutrients in a food need to be considered when choosing foods to eat. Many GI advocates agree that the glycemic index is not the only, nor the most important, criterion by which to judge a food. (3,6). Some low GI foods are not better from a nutritional standpoint. For example, potato chips have a lower GI than plain popcorn, at 57 vs. 72 GI; cashews have a low GI of 22. (3).

- *A mixed meal alters the glycemic index of a food.* When a particular food is eaten along with other foods, the blood glucose response and glycemic index will vary, depending on the proportion of carbohydrate, protein, and fat in the mixed meal. Adding protein to a meal containing carbohydrate increases the insulin response to the meal, but blood sugar does not change much or actually decreases. (1). Adding fat to a carbohydrate meal increases insulin secretion but decreases blood sugar response. (1). Therefore, critics contend that the glycemic index loses its utility in a mixed meal. Supporters of the glycemic index counter that it is possible to predict the blood glucose response to mixed meals from the GIs of individual foods. Studies have shown that although fat and protein affect the actual glycemic response of a meal, they do not affect the relative differences in glycemic index between carbohydrate-containing foods. Therefore, the concept of GI is useful even in mixed meals. (2,3,7).

- *In order for the glycemic index to have value, the methodology used for measuring glycemic index needs to be standardized.* Critics state that to even consider the value of the glycemic index, disagreements on the best methodology for testing and measuring GI need to be resolved. The glycemic index measures blood sugar changes above the beginning fasting glucose level. Several times during the two hours after a person eats a standard amount of carbohydrate, blood glucose levels are recorded and plotted on a graph and the area under the curve is calculated. An individual's blood sugar response, as determined by the area under the curve, is used to obtain the

glycemic index of a food. Some experts feel that a better way to measure glucose availability is to use the whole area under the curve and not just the area above the fasting blood glucose level. If the whole area under the curve were used for the calculation, the differences in GI between foods would be less. (1,8).

Another criticism concerns the time that elapses before determining the GI of a food. Two hours is the standard used for ending the test that measures blood sugar response to a food. However, individuals with diabetes need longer than two hours for their blood sugar concentrations to return to normal. Critics contend that the differences in GI between foods would be considerably less if the area under the curve were calculated using a more realistic after-meal period of four hours. Consequently, the actual blood sugar response in people with diabetes is not being identified. Additionally, GI testing is measured in the morning following an overnight fast. Some studies have shown that if GI is measured after lunch rather than after breakfast, the differences in GI between foods would be considerably less. (1,8).

Standardizing the methodology for GI testing is essential. Carrots are a classic example of why standardization is needed. In the early days of GI testing, carrots were given a high GI of 92. Only five people were used in the testing and there was a large variation in glucose response among the participants. As a result of these tests, many popular diet books tell readers not to eat carrots. Critics use carrots as an example of how the GI approach unfairly maligns a nutritious food because of its high GI. However, carrots were retested recently using ten people and the variation among the participants was narrower than was previously obtained. The new GI of carrots was downgraded to an average of 47, putting it into the low GI category. (3). The *New Glucose Revolution* lists the newer and lower GI of carrots; other books still use the higher GI values. (5).

- *The use of two reference foods for comparing GI values is confusing.* Glucose and white bread are the two standard reference foods upon which GI values of all other foods are compared. Some researchers use 50 grams of carbohydrate from white bread as the reference food because it is more typical of what people eat. (3). But having two reference standards has led to confusion because published GI values conflict. For example, *The New Glucose Revolution* lists GI based on glucose as the standard and states that to avoid confusion, using glucose as the reference is now recommended. *The South Beach Diet* uses white bread as the standard. So, the GI values for the same foods will not necessarily be the same in all GI-based diet books.

  It is possible to convert from the white bread scale to the glucose scale using a factor of 0.7. This factor is used since the GI value of white bread is 70 when the glucose scale equals 100. For example, fat-free milk on the white bread scale has a GI of 46; on the glucose scale, the GI is 32. (3,9).

- *Some nutritious foods are not encouraged or permitted on GI diets, while less healthful foods are allowed*. This is one of the most-often repeated criticisms of the glycemic index. Critics point to the inappropriateness of excluding certain vegetables

and fruits because of their high GI, without considering the fiber, antioxidants, vitamins or minerals these foods have to offer. For example, many popular diet books forbid potatoes because of their high GI values. Whole wheat bread has about the same GI as white bread, but it contains more fiber and phytochemicals than white bread and should not be overlooked because of its high GI. This points to the importance of not using the glycemic index as the sole criterion for determining food choices. It is only one tool for deciding what to eat and should not be used in isolation. (3,5,6).

Does the Glycemic Index Have a Role in Preventing Disease?

The hypothesis that regular consumption of high GI foods increases the risk of disease is based upon laboratory and epidemiological studies and some clinical trials. High GI meals cause an inordinate rise in blood glucose and insulin levels, which, in many people, is followed by a rapid drop in blood glucose levels. As a result, counterregulatory hormones are secreted to bring blood sugar levels back to normal, and free fatty acid concentrations are elevated. These events are believed to promote excessive food intake, impaired pancreatic beta cell function and endothelial function, and abnormal blood lipid levels. (4). This, in turn, may increase the risk of obesity, diabetes, heart disease, and possibly, cancer.

Some studies suggest that low GI diets play a role in preventing these diseases. The evidence to date is summarized below.

Glycemic Index and Obesity

A variety of popular weight-loss books blame high GI diets for our obesity woes. They claim that the high insulin levels that result from eating high GI foods stimulate hunger, increase enzymes that promote fat storage, and reduce the body's ability to burn fat for energy. (2,10). Low GI foods, on the other hand, delay hunger and help the body burn more fat and less muscle. (3). By increasing satiety, or fullness after eating, low GI foods help reduce the calories consumed later in the day. (11).

In support of this theory, 15 of 16 single-day studies in humans found that high GI meals led to lower satiety, increased hunger or greater food intake than did low GI meals. (4). In one study, a 50% increase in the GI of a meal (from a low GI of 50 to a high GI of 75) led to a 50% decrease in satiety. (11).

However, not all studies support this position. In a recent review of 10 studies measuring hunger and satiety, no consistent effect of a high GI food compared to a low GI food was found. (1). In six studies that measured actual food intake at a subsequent meal, only three studies found that high GI foods increased intake. (1).

Some studies have found that individuals eating low GI diets lose more weight or body fat than those eating high GI diets that are similar in calories. In a South African study of obese females, those eating a low GI diet for 12 weeks lost 4 pounds more than women

eating a high GI diet. (3,12). In a French study of obese men, those following a low GI diet for five weeks had less abdominal fat and total body fat than they did on a high GI diet, but their body weight did not change when eating the low GI diet. (3,13).

It is often stated that high insulin levels, brought on by eating high GI foods, increase food intake and lead to obesity. However, animal research has shown that insulin reduces food intake and suppresses appetite. (1,10). While studies using very large doses of insulin have induced overfeeding in rodents and weight gain in patients with type 2 diabetes, there is no clear-cut evidence that normal, postprandial insulin concentrations lead to weight gain. (1).

It's important to note that most studies on GI and weight regulation have been short-term or small-scale human studies or animal studies. There are no long-term clinical trials on glycemic index and body weight. (4). Despite the tendency of diet books to blame high GI foods for our weight and health problems, research has clearly shown that many factors, including genes, lifestyle, emotions and dietary habits, combine to impact a person's weight. Glycemic index is just one more factor to possibly add to the mix.

Glycemic Index and Diabetes

The utility of the glycemic index in managing diabetes is fraught with controversy. The American Diabetes Association (ADA) reviewed the evidence on glycemic index as a nutrition therapy intervention for diabetes and concluded that the total amount of carbohydrate is more important than the source (starch or sugar) or type (low or high GI). While acknowledging that low GI foods may reduce postprandial blood glucose levels, they assert that there is insufficient evidence of long-term benefit to recommend using low GI diets as a primary strategy in meal planning. (14).

The ADA position is not universal. The European Association for the Study of Diabetes recommends that people with diabetes choose foods with a low GI. (15). Diabetes Australia, in conjunction with the University of Sydney and the Juvenile Diabetes Research Foundation, has endorsed a program that would label food with its GI value, provided the food meets specified nutritional criteria and the GI testing is performed by an approved laboratory. (16).

Type 1 Diabetes

The concept of glycemic index was initially introduced as a tool for the dietary management of type 1 diabetes. However, there is no agreement that glycemic index is any better than other methods for maintaining blood glucose control. A small number of studies have looked at glycemic index and type 1 diabetes, but they are generally short in duration and do not include many subjects. No long-term studies are available. (2,17).

In four studies comparing low GI to high GI diets in type 1 diabetes, three reported statistically significant improvements in fructosamine from the low GI diet and one did not; none reported significant improvements in hemoglobin A_{1C}. (8,17). (Hemoglobin

A_{1C} [HbA_{1C}] reflects average blood glucose levels over the previous 6-12 weeks; fructosamine level reflects blood glucose control over the previous 2-4 weeks and may be a better indicator of diabetes control than HbA_{1C} in shorter studies).(15). In one of the studies with nine well-controlled patients on intensive insulin therapy, major changes in the GI and fiber content of meals induced small changes in the glucose profile, but in everyday life, changes in GI did not produce clinically significant changes in blood glucose. (18). For patients treated with multiple insulin injections, the combination of carbohydrate counting and insulin adjustment for carbohydrate content offers greater flexibility than a low GI diet. (8,18).

In a meta-analysis of 14 randomized controlled trials that compared the effect of low GI diets to high GI diets on blood glucose control, patients with type 1 or type 2 diabetes who were following low GI diets had HbA_{1C} levels 0.43% units lower (representing a 7.4% decrease in HbA_{1C} /fructosamine) than those eating high GI diets. (8,15).

However, randomized controlled trials and observational studies of medical nutrition therapy for diabetes have shown decreases in HbA_{1C} of about 1-2% units (representing a 15-22% decrease in HbA_{1C}). Nutrition interventions included carbohydrate counting with mealtime insulin adjustments and reduced-calorie diets for weight loss. (8). Although low GI diets can have a positive effect on blood glucose control, they don't appear to be as effective as other nutrition interventions. However, eating low GI foods may enhance other dietary strategies, helping to further improve glycemic control.

Type 2 Diabetes

The use of glycemic index to prevent or treat type 2 diabetes is also controversial. It is believed that high blood sugar levels lead to the loss of function of pancreatic beta cells—the cells that produce insulin—and in susceptible people, may result in diabetes. One theory suggests that a high GI diet, which raises blood sugar levels and increases insulin demand, overburdens the ability of the pancreas to produce insulin, thereby increasing the risk of type 2 diabetes. (7,10).

Research suggests that the effects of a high GI diet vary greatly among individuals and are influenced by the degree of insulin resistance. Since obesity and inactivity are believed to promote insulin resistance, the adverse health effects of high GI foods may be worse in overweight, sedentary or genetically susceptible people. (7,10). However, not all studies connect high GI diets with insulin resistance. Some studies have found greater insulin sensitivity with high GI or high carbohydrate diets. (1).

Three observational studies looked at the effects of glycemic index in reducing the risk of type 2 diabetes. In the Nurses' Health Study, using data from over 65,000 women, those eating the highest glycemic load diets had a 40% greater risk of type 2 diabetes than women with the lowest glycemic load. A high glycemic load and a low cereal fiber intake increased the diabetes risk by 2.5-fold. (7). In the Physicians' Health Study, using data from over 42,000 males, those in the highest category of glycemic load and lowest cereal fiber intake had a 2-fold increase in diabetes risk. (7).

Critics of these findings question the validity of the food frequency questionnaires used in the studies and the precision of the numbers used to derive these results. (1). In the Iowa Women's Study of nearly 36,000 postmenopausal women, there was no association between glycemic index or glycemic load and diabetes incidence. (7,19). It's important to realize that epidemiological studies, like these observational studies, can only show associations; controlled clinical trials are needed to prove cause and effect.

There are a limited number of studies on glycemic index in people who have type 2 diabetes. Most of the studies are short in duration and the findings are inconsistent. In nine studies comparing low GI diets to high GI diets, three reported statistically significant improvements in fructoseamine, while three did not. One reported significant improvement in HbA_{1C}, while five did not. (8,17).

Studies using nutrition approaches other than GI in people with type 2 diabetes report a 1-2% unit decrease in HbA_{1C} (representing a 11-22% decrease in HbA_{1C}). (8). In the UK Prospective Diabetes Study, a 2% unit decrease in HbA_{1C} was attributed to reduced energy intake. (8,20). In a study that used carbohydrate counting as its nutritional approach, a 2% drop in HbA_{1C} was seen at 6 months. (21). In type 2 diabetes, primary nutrition intervention strategies that use reduced calorie intake, modest weight loss, and carbohydrate counting have been shown to produce better outcomes than a low GI diet approach, reducing HbA_{1C} by about 20% compared to 7.4% from a low GI diet. (8,15).

Glycemic Index and Heart Disease

Glycemic index or glycemic load have been linked to heart disease in several ways. The high blood sugar and insulin levels that result after eating a high GI diet may increase the risk for heart disease via the insulin resistance syndrome (also known as metabolic syndrome or Syndrome X). (4). This syndrome is a cluster of metabolic abnormalities that includes high blood levels of insulin, glucose and triglycerides; low levels of HDL (good) cholesterol; and high blood pressure. A high glycemic index or glycemic load is believed to induce high blood sugar and insulin levels, which can lead to high blood pressure, abnormal blood lipids and possibly impaired blood clotting tendencies, all of which can increase the risk of heart disease. (22).

Glycemic index or glycemic load may be related to heart disease risk and blood lipid levels. In the Nurses' Health Study, a large epidemiological study, a diet high in glycemic load was linked to increased heart disease risk. The association was most evident in women with a body mass index greater than 23, indicating above average body weight. There was little relation between glycemic load and heart disease risk in women who were not overweight. (22). Using data from nearly 14,000 participants in the Third National Health and Nutrition Examination Study (NHANES III), high glycemic index and glycemic load were associated with lower HDL cholesterol levels. (23,24). Intervention studies have shown that substituting low GI foods for high GI foods in a low-fat, high-carbohydrate diet lowers blood triglycerides by 15 to 25 percent. (25).

However, one epidemiological study of 4,000 Dutch men found no association between glycemic index and lipid levels. (26).

It's been hypothesized that the postprandial rise in blood glucose following high GI meals may increase heart disease risk by causing oxidative stress. (4). High blood glucose levels were shown to lower antioxidant concentrations and increase free radicals, changes that are associated with increased blood pressure, blood clot formation and reduced endothelial-dependent blood flow. This suggests a beneficial role for low GI diets by reducing oxidative damage, thereby lowering heart disease risk. (4,27).

Glycemic index or glycemic load may alter other risk factors for heart disease. Inflammation plays a role in the development of arterial disease, and high sensitivity C-reactive protein (hsCRP), a market for inflammation, can help identify individuals at high risk for ischemic heart disease. In a study of over 240 healthy women, glycemic load was directly related to plasma C-reactive protein. Researchers suggest that a high glycemic load diet may exacerbate the proinflammatory process, increasing the risk of ischemic heart disease, especially in overweight women prone to insulin resistance. (28).

In patients undergoing coronary artery bypass surgery, insulin sensitivity, as measured by insulin-stimulated glucose uptake by fat cells, was higher in patients who ate a low GI diet for four weeks prior to surgery compared to those who ate a high GI diet. (29).

Although these studies suggest that a low GI diet improves insulin sensitivity and risk factors for heart disease, additional research that includes long-term clinical trials is needed to prove the value of low GI diets in people at risk for, or who already have, heart disease.

Glycemic Index and Cancer

The relationship of glycemic index and cancer is just beginning to be studied. It has been suggested that high GI foods increase circulating insulin levels, which may raise levels of insulin-like growth factors and the possible risk of certain cancers, including breast and colon cancers. (30,31).

One case-control study of over 5,000 Italian women found a moderate, direct association between high glycemic index and glycemic load and breast cancer risk. (30). But in a study on postmenopausal breast cancer risk among 63,300 American women, glycemic index and glycemic load were not associated with risk. (32).

In case-controlled studies, a high GI diet was linked to a greater risk of colon cancer. (33,34). In a prospective cohort study, glycemic load was not related to colorectal cancer risk. (31).

Using data from the Nurses' Health Study, a high glycemic load was associated with an increased risk of pancreatic cancer. The risk was most apparent in women who were

overweight and sedentary, suggesting that a high glycemic load diet may increase pancreatic cancer risk in women who are insulin resistant. (35).

Ovarian and endometrial cancer risk may also be associated with glycemic index or glycemic load. (36,37). Whether a low GI diet could prevent cancer is not known. Clearly, more long-term studies on GI and cancer prevention are needed.

Conclusion

The nutrition community is deeply divided over the role of the glycemic index in preventing disease. Lack of support is due to insufficient evidence of clinical efficacy, methodological concerns with determining glycemic index values, and a reluctance to initiate a public health campaign around a complex and unproven concept. (6).

There are numerous hypotheses relating high GI foods to increased blood sugar and insulin levels and how this could lead to diseases like obesity, heart disease, diabetes and cancer. While intriguing and worthy of further investigation, these theories have yet to be proven. For example, there is no conclusive evidence that low GI diets promote satiety or reduce hunger for the benefit of weight loss. Nor is it certain that postprandial insulin levels following high GI diets lead to weight gain. Low GI diets appear to help people with diabetes control their blood sugar, but other nutritional interventions may be more effective. In most epidemiological studies on GI and heart disease, low GI diets are associated with lower disease risk, but long-term clinical studies are needed to prove the value of low GI diets in reducing risk. As for cancer prevention, there is not enough evidence to claim a benefit from low GI diets.

Despite these uncertainties about the role of GI, a variety of popular diet books consider glycemic index a powerful weapon in fighting obesity and disease. For example, the cover of *The New Glucose Revolution* refers to the glycemic index as “the dietary solution for lifelong health.”

AICR believes that it is premature to incorporate the GI concept into dietary recommendations for the public until methodological concerns with the GI are resolved. This includes standardizing how GI values are tested and measured, and using one reference food—not two reference foods—as the standard for calculating GI values, to avoid inconsistencies in GI tables. Additionally, the variability in GI, whether it’s due to the physical structure of the carbohydrate, the inclusion of carbohydrates in a mixed meal, or the variation in an individual’s blood sugar response to a carbohydrate, needs to be clarified so that appropriate dietary guidance on GI can be provided.

Additionally, strategies for teaching the GI concept are needed so that the take-home message is not misunderstood. For example, since the carbohydrate content of a food most directly affects its GI, some diet books mislead consumers into believing that all carbohydrates are bad. This negates the inherent concept behind the glycemic index, which is to lower blood glucose response by replacing higher GI foods with lower GI foods, rather than discouraging the consumption of carbohydrates. (6).

Other GI diet books may leave consumers thinking that some carbohydrates are good and some are bad, but the bad ones—the ones with a high GI—should be avoided. This is also not advisable since people who restrict their diets to low GI foods may miss out on the nutritional and health benefits of wholesome foods, like those vegetables, fruits and whole grain foods that happen to have higher GI values. Since these foods tend to be rich in vitamins, minerals, fiber and phytochemicals, they are considered good food choices, no matter where they fall on the GI scale. On the other hand, foods that are high in fat, like potato chips or chocolate covered peanuts, should be eaten sparingly, even though they have a low GI.

Although the glycemic index has the potential to be a valuable clinical tool, more research, including long-term clinical studies, are needed to prove its worth in preventing disease. For now, consumers should focus on eating a mostly plant-based diet that includes a wide variety of vegetables, fruits, whole grains and legumes. There is much evidence that a mostly plant-based diet can reduce the risk of diseases, like cancer, heart diseases and diabetes. In most cases, such a diet will have a low glycemic index. Whether a low GI diet is the preventive agent in reducing disease or is simply a marker for a varied, healthful diet is yet to be determined, and will likely lead to more debate.

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