Glycemic Load Comes of Age

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Diet can be categorized according to a great number of biological and physicochemical properties. A key challenge in the formulation of nutritional recommendations is to identify which of these properties have the greatest relevance to health promotion and disease prevention. An article in the current issue of The Journal of Nutrition addresses this issue in relation to dietary carbohydrate (1).

With the recent recognition of the physiological importance of postprandial hyperglycemia, renewed attention has been focused on carbohydrate, the only nutrient that directly alters blood glucose concentration. For individuals with diabetes, postprandial blood glucose may influence metabolic control and risk for complications more strongly than does fasting blood glucose (2). For individuals without diabetes, even moderate elevations in postprandial blood glucose can place metabolic and oxidative stress on the pancreatic B-cell and the cardiovascular system, potentially increasing risk for type 2 diabetes and heart disease (3,4). Therefore, it is of particular interest to quantify the effects of dietary carbohydrate on the glycemic response to food.

Throughout much of the last century, carbohydrate was classified as complex or simple in the belief that saccharide chain length determines the rates of digestion and absorption (5). However, many starchy foods raise blood glucose as much as or more than comparable amounts of table sugar, leading David Jenkins and colleagues at the University of Toronto to propose the concept of glycemic index (GI) in 1981 (6). GI refers to the effect of standard amounts of individual foods (containing 50 g of available carbohydrate) on blood glucose compared with that of a control food. Most of the foods at the base of the USDA’s Food Guide Pyramid (bread, breakfast cereals and rice) and potato products are rapidly hydrolyzed into glucose in the human digestive tract and therefore have a high GI, whereas nonstarchy vegetables, fruits, legumes and nuts generally have a low GI (7). Because foods and meals differ in carbohydrate content, Walter Willett and colleagues at Harvard defined the glycemic load (GL) in 1997 as the arithmetic product of GI and carbohydrate amount (8).

To date, 15 epidemiological studies have examined the relationship between GL and chronic diseases (8–22). GL is associated with several cardiovascular disease risk factors, including low HDL cholesterol (12,14), high triglycerides (14) and elevated C-reactive protein (15). GL appears to be an independent risk factor for myocardial infarction (10), type 2 diabetes (8,9) and cancer (11,13,16,17,19,20) in many but not all analyses (18,21,22). Several recent reviews have explored the physiological mechanisms that might link GL to disease processes (23–26).

Though endorsed by many official health agencies around the world, the principles underlying GL have not been recognized by any governmental or professional entity in the United States. The American Diabetes Association, in a recent review of existing evidence, concluded that glycemic responses to foods may differ, but that “the total amount of carbohydrate in meals and snacks is more important than the source or type” (27). Another concern is that GL, a mathematical concept, has not been physiologically validated as a reliable measure of glycemic response.

To address this controversy, Jennie Brand-Miller at the University of Sydney and colleagues conducted two feeding studies involving healthy young adults (1). In the first study, subjects were given 10 different foods, each calculated to have a GI equal to a serving of white bread, but among which GI and carbohydrate amounts varied threefold. For 9 of these foods, the measured area under the glucose-over-time curve was not different from that for white bread. In the second study, subjects consumed 8 foods, again with different GI and carbohydrate amounts. Each food was consumed in portion sizes calculated to have the GL of 1, 2, 3, 4 or 6 servings of white bread. Incremental increases in GL produced step-wise increases in measured area under the glucose and insulin curves. These results demonstrate that calculated GL can predict the glycemic response to individual foods across a wide range of portion sizes, and call into question the conventional strategy of “carbohydrate counting” for controlling blood glucose levels. GL would seem to be a much better predictor than carbohydrate amount alone, because similar glycemic responses were observed among foods differing in available carbohydrate by more than twofold. This finding is consistent with Wolever and Bolognesi (28) who fed subjects 5 mixed meals of varying macronutrient composition and concluded that both GI and carbohydrate amount are necessary to explain most of the observed variability in glycemic response.

Two study limitations should be noted. First, applicability of these findings to populations at greatest risk for diseases associated with insulin resistance (the obese, the elderly, certain racial/ethnic groups and individuals with diabetes) is not known. Second, these experiments involved individual foods; the ability of GL to predict blood glucose response to mixed meals remains to be determined. However, on both points, a study by Wolever and Mehling provides reassurance (29). They randomly assigned subjects with impaired glucose tolerance to a high carbohydrate/high GI control diet or to one of

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two experimental diets in which GL was reduced by decreasing either total carbohydrate or GI. After 4 mo, mean plasma glucose concentrations over 8 h were lowered by the same amount (0.35 mmol/L) on the low carbohydrate and low GI diets compared with controls.

The ultimate relevance of GL depends upon whether this dietary factor independently predicts disease risk in well-controlled epidemiological studies, and whether incorporation of GL principles into interventional studies produces significant improvements in clinical endpoints. Regarding the first point, as discussed above, a growing number of studies have found associations between GL and important health outcomes that are independent of, and stronger than, those for carbohydrate amount. Regarding the second point, no large scale long-term interventional studies have yet examined GL as a primary aim. However, recent reports of greater weight loss, improved cardiovascular disease risk factors and increased insulin sensitivity on very low carbohydrate (thus, low GL) diets compared with low fat diets may be relevant (30). Such diets might promote satiety and facilitate a negative energy balance by reducing postprandial glucose and insulin responses, as previously discussed with respect to GI and GL (23,25). Nevertheless, in the longest of these studies, substantial weight regain occurred on the very low carbohydrate diet at 1 y, suggesting that subjects eventually have difficulty following such severely restrictive prescriptions. Alternatively, one might lower GL in a much less restrictive fashion with moderate reductions in total carbohydrate and GI; a 30% decrease in both would produce a 51% reduction in GL (1 – 0.7 X 0.7). Along these lines, we recently conducted a pilot study with 16 obese adolescents who were randomly assigned to an ad libitum reduced GL or an energy-restricted reduced fat diet (31). Subjects in both groups made the intended dietary changes in response to outpatient counseling, but only those on the reduced GL diet lost a significant amount of weight after 12 mo. Of particular interest, no weight regain occurred in the reduced GL group between 6 and 12 mo. Thus, low GI/GL diets may constitute an optimal compromise between low fat diets on one hand, and very low carbohydrate diets on the other.

Finally, it is worth noting that two modifications of the Food Guide Pyramid could produce significant reductions in GL and also advance other nutritional goals: moving highly processed grain products and potatoes closer to the apex; and placing nonstarchy vegetables, legumes and fruit at the base.

LITERATURE CITED