

The dietary pyramid: does the foundation need repair?^{1,2}

Walter C Willett

A dominant nutritional message has been that diets high in complex carbohydrates promote good health. This belief has been translated into the foundation of the US dietary pyramid, which emphasizes high intakes of breads, cereal products, and potatoes, suggesting 6–11 servings per day (1). In fact, there is little empirical evidence that positive health benefits result from such diets, and much evidence suggests a more complex picture. As described by Jenkins et al (2) and others, insulin and glucose responses to carbohydrate can vary substantially depending on the physical (eg, particle size) and chemical (eg, fiber content and form of starch) characteristics of the food. This has been summarized as the glycemic index; multiplying the glycemic index of a food by its carbohydrate content defines the food's glycemic load. High glycemic load is associated with increased risk of adult-onset diabetes in both women (3) and men (4), especially in combination with low cereal fiber intake. High dietary glycemic load also appears to increase the risk of myocardial infarction (5). The adverse metabolic responses to a high glycemic load (hyperinsulinemia, hypertriglyceridemia, and low HDL cholesterol) are strongly related to an individual's underlying degree of insulin resistance (6). Finally, the substantial evidence of widespread suboptimal micronutrient intakes in the US population has heightened the importance of micronutrient losses as the result of grain refinement.

The paper by Jacobs et al (7) in this issue contributes importantly to knowledge about carbohydrate intake and health by specifically examining intakes of whole and refined grains in relation to risk of ischemic heart disease. In this analysis, consumption of whole grains was associated with a decreased risk whereas intake of refined grains was associated with an increased risk, although the latter trend was not significant. Although this way of viewing dietary carbohydrate is unique among prospective studies of heart disease, it is consistent with a considerable body of evidence suggesting an inverse relation between dietary fiber and heart disease risk. Of 10 studies that have reported on this relation, an inverse relation was seen in 8 (8). Moreover, when examined by source of dietary fiber, the apparent protective effect has been most clear for cereal fiber (9, 10). Thus, direct and indirect epidemiologic evidence strongly support a protective effect of whole-grain consumption on risk of ischemic heart disease.

The mechanisms by which whole-grain consumption may reduce the risk of ischemic heart disease remain unresolved, but are probably multiple. Higher intake of fiber, especially soluble fiber, reduces blood lipids, but this effect is small and not sufficient to account for the associations observed. Some of this beneficial effect is likely mediated by higher intakes of folate, vita-

min E, and possibly magnesium. However, after adjusting statistically for these and additional micronutrients, Jacobs et al (7) continued to observe an inverse trend, suggesting additional beneficial contributions by whole grains. Some of the remaining benefit may result from displacement of refined grains and potatoes, the major contributors to glycemic load in our diets, as well as displacement of saturated and *trans* fats. However, as pointed out by Jacobs et al, dietary guidance need not await the full elucidation of mechanisms by which whole grains confer benefit.

Large potential benefits of increased whole-grain consumption are suggested by the data of Jacobs et al. Women in the top quintile of whole-grain consumption (a median of 23 servings/wk, a readily achievable intake) experienced an ≈30% lower risk of ischemic heart disease compared with women in the lowest quintile (median: 1.5 servings/wk). According to data from metabolic studies in combination with epidemiologic investigations of serum cholesterol and ischemic heart disease risk, a decrease in saturated fat intake by 5% of energy would reduce ischemic heart disease rates by only ≈6–8%, and even less if the adverse effects of replacement by typical carbohydrates on HDL cholesterol and triacylglycerol concentrations are considered. Such a decrease would mean a shift in intake by the US population from the current average intake of ≈13% of energy from saturated fat to almost the 7% suggested by the American Heart Association Step 2 diet, which would require major changes in behavior and agricultural production. The estimate of risk reduction in the study by Jacobs et al is rough because the CI was wide but is consistent with estimates reported in other studies of cereal fiber intake. Because the estimate was based on a single and inevitably imperfect measure of intake, the magnitude of the association may well be underestimated.


Considerable work remains to achieve an understanding of how consumption of whole grains and the form of dietary carbohydrate are related to health outcomes. As noted by Jacobs et al, studies of ischemic heart disease incidence as well as mortality are desirable. Additional studies, particularly if the data are pooled, can provide more precise quantitative estimates of benefit and the shape of the dose-response relation.

The physical form of whole grains can vary from intact kernels (for which we should probably reserve the term *whole grain*) to finely milled flour (whole-grain flour). Because particle

¹From the Departments of Epidemiology and Nutrition, Harvard School of Public Health, Boston.

²Address reprint requests to WC Willett, Department of Nutrition, Harvard School of Public Health, 665 Huntington Avenue, Boston, MA 02115.

size affects the glycemic index, it may therefore also influence risks of heart disease and diabetes, but this aspect of whole-grain consumption has not been examined in detail epidemiologically. Careful examination of whole-grain consumption in relation to other diseases is also needed when considering dietary advice. Somewhat surprisingly, dietary fiber intake, in particular cereal fiber, has not been clearly related to colon or breast cancer incidence, despite initial enthusiasm for these hypotheses.

Although further research is needed on the health effects of whole grains and type of dietary carbohydrate, the evidence is sufficient to place greater emphasis on the type of carbohydrate in the diet. Encouraging complex carbohydrate consumption is not sufficient because foods such as white bread and potatoes are so rapidly converted to simple sugars that the distinction from simple sugar is not likely to be important. Moreover, there is little empirical evidence that such foods are beneficial, and metabolic and epidemiologic data actually suggest that high intakes may be harmful. Already, the current dietary pyramid is seriously flawed by its failure to distinguish among types of fat (11); the work of Jacobs et al provides further evidence that the pyramid's foundation is also in need of repair. Emphasizing whole grains as the primary form of carbohydrate in the diet would be a good place to start. 

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