

Dietary Approaches to Prevent the Metabolic Syndrome

Quality versus quantity of carbohydrates

The metabolic syndrome refers to a cluster of specific abnormalities with insulin resistance as the underlying pathophysiological defect. Its clinical identification is based on measures of abdominal obesity, atherogenic dyslipidemia, raised blood pressure, and glucose intolerance (1). About one-fourth of U.S. adults have the metabolic syndrome, according to the criteria defined by the Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (NCEP ATP III) (2). Given the continuing epidemic of overweight and obesity, it is likely that the prevalence of the metabolic syndrome will continue to grow. The metabolic syndrome is a precursor to type 2 diabetes and a strong risk factor for coronary heart disease (CHD) and stroke (1).

The metabolic syndrome has been identified as a target for dietary therapies to reduce cardiovascular disease risk other than LDL cholesterol lowering by the NCEP ATP III (1). Although clear evidence from metabolic studies, epidemiological studies, and clinical trials supports the consumption of unsaturated fats from natural liquid vegetable oils and nuts at the expense of saturated and *trans* fats (rather than simply lowering total fat) in the treatment of various components of the metabolic syndrome (e.g., dyslipidemia, insulin resistance, and glucose intolerance) and in the prevention of CHD (3), the optimal types and amounts of carbohydrates in the diet remain controversial. It is now well established that low-fat, high-carbohydrate diets not only lower HDL and raise triglycerides but also generally produce higher postprandial glucose and insulin responses. However, metabolic consequences of carbohydrates depend not only on their quantity but also on their quality. The glycemic response of a given carbohydrate load depends on the food source, which has led to the development of the glycemic index, ranking foods by their ability to raise postprandial

blood glucose levels. In addition, effects on blood glucose and lipid metabolism by carbohydrate-rich foods depend on fiber content and type. Controlled feeding studies have found benefits of whole grains on insulin sensitivity and glucose (4) and lipid metabolism (5) compared with refined grains. In addition, several epidemiological studies found that diets rich in whole grains may protect against cardiovascular disease, stroke, and type 2 diabetes (5).

In this issue of *Diabetes Care*, McKeown et al. (6) add epidemiological data linking high-fiber, whole grain foods and low-glycemic index diets to lower insulin resistance and a lower risk of the metabolic syndrome. In a cross-sectional study among 2,834 participants of the Framingham Offspring Study, total fiber, cereal fiber, fruit fiber, and whole grain intakes were associated with lower insulin resistance (as measured with the homeostasis model assessment for insulin resistance [HOMA-IR]), while glycemic index and load were positively associated with insulin resistance. Furthermore, whole grain and cereal fiber intakes were associated with a reduced risk of the metabolic syndrome, with cereal fiber accounting for most of the whole grain effect. A higher glycemic index was associated with a higher risk of the metabolic syndrome, while no associations were observed for glycemic load, total carbohydrate intake, refined grain intake, or other sources of dietary fiber. The validated food frequency questionnaire applied in this study to assess dietary exposure was designed to capture not only absolute quantity of carbohydrates, but also quality aspects of carbohydrate-containing foods, particularly cereals. While associations between dietary variables and HOMA-IR were independent of obesity, it remains unclear whether the associations with the metabolic syndrome were largely mediated by effects on obesity or by effects on insulin resistance and blood lipids as well

because whole grain intake was not significantly related to blood pressure, HDL cholesterol, triglycerides, or fasting glucose after controlling for BMI in an earlier report from this study population (7). In a recent report from the Insulin Resistance Atherosclerosis Study (8), the inverse association between whole grain intake and insulin resistance remained significant but was attenuated after adjustment for BMI and waist circumference, suggesting that benefits of whole grain intake on the metabolic syndrome are in part mediated through obesity.

Despite compelling evidence supporting a role of whole grain consumption in chronic disease prevention, different types of fibers from whole grain foods appear to have different metabolic effects. Whole grain products from oat, barley, rye, and psyllium are high in soluble fiber, while wheat and corn typically contain insoluble fiber. Lipid-lowering properties were generally observed for grain products rich in soluble fiber, but not for those rich in insoluble fiber (9). In epidemiological studies, however, insoluble fiber—but not soluble fiber—was found to be inversely associated with diabetes risk (10,11), and cereal fiber was found to have stronger effects on diabetes and cardiovascular disease risk (3) compared with fiber sources particularly rich in soluble fiber. Other characteristics of whole grain foods, besides their high fiber content, might also be important in glucose and lipid metabolism, for example, the physical form and degree of processing of whole grains and the presence of organic acids, enzyme inhibitors, and other bioactive compounds (12). Epidemiological studies are unlikely to yield detailed evaluations of these pathways, and basic and experimental research is clearly warranted.

The concept of glycemic index remains controversial. At extremes, it is either dismissed as an irrelevant indicator (13) or embraced as the sole yardstick

with which to classify “good” or “bad” foods, especially in popular diets. Major health organizations in the U.S., including the American Diabetes Association, discourage the use of the glycemic index in nutritional therapy, despite the fact that the concept has now been widely adopted by many international organizations. The weight of current evidence, including data from the present study, indicates that the glycemic index is useful in characterizing the quality of carbohydrates beyond dietary fiber. However, the glycemic index database needs to be further developed and standardized, particularly in different populations and in the context of mixed meals. The concept of glycemic load is appealing because it captures both the quality and quantity of carbohydrates as well as potential interactions between them. In practice, glycemic load can be lowered by reducing the total amount of carbohydrates in the diet, the overall dietary glycemic index, or both, although reducing the amount of carbohydrates (especially refined carbohydrates) is more effective in lowering glycemic load than reducing the overall dietary glycemic index alone.

Prevailing dietary guidelines continue to recommend very high intakes of grain products without a clear distinction between whole and refined grains (14). Many popular diets that focus on weight loss, on the other hand, have jumped on the low-carbohydrate bandwagon, prohibiting virtually all carbohydrates, especially in the initial phase of the diet. Both approaches are incompatible with current scientific evidence and can have long-term adverse health implications. With the growing epidemic of obesity and the

metabolic syndrome, reduction in the consumption of refined carbohydrates and sugar, replaced by either minimally processed whole grain products and healthy sources of fats and protein, should become a major public health priority, together with regular physical activity and weight maintenance.

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