CIMMYT Series on Carbohydrates, Wheat, Grains, and Health

Carbohydrates, Grains, and Whole Grains and Disease Prevention Part I. Body Weight and Obesity[1,2]

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The prominence of carbohydrates (CHOs) and grains in dietary guidance as the base of the diet and as core components for promoting health and preventing disease has recently been called into question. Grain-based foods, and the CHOs they contain, have been accused of promoting obesity, which can be a factor in increased risk of developing certain chronic diseases, such as hypertension, metabolic syndrome (MetS), and diabetes. Increased consumption of CHOs and grains is alleged to initiate changes in the microbiome and metabolic pathways that create conditions that negatively impact health. Specifically, some have charged that wheat- and grain-based foods, especially those with added sugars and highly refined CHOs, add calories to the diet and contribute to increases in obesity, hypertension, MetS, diabetes, and other chronic diseases (1,2). Some even claim that these foods "constitute a greater threat to health than the added effects of smoking and alcohol abuse" (3).

In contrast, a review of the literature discussing the findings from numerous epidemiological and intervention studies shows that grains and grain-based foods, when consumed as part of a healthy and balanced dietary pattern, may actually reduce the risk of weight gain, obesity, hypertension, MetS, and related chronic diseases. In short, studies show that these foods are not part of the problem, but rather can be part of the solution when included in the right amounts as part of a balanced dietary pattern.

The current review is the fourth in a series of papers looking at the role of CHOs, grains, and whole grains in health and will build on the earlier reviews, which addressed their roles in inflammation and glycemic response (4–6), to assess their roles in body weight. Although it is known that different grains may have different effects on health, this review focuses on grains as a group, contrasts the roles of refined and whole grains, and discusses in more detail where specific grains or grain-based foods stand out.

Relationship of CHOs, Grains, Whole Grains, and Dietary Fiber to Body Weight and Obesity

CHO Intake and Measures of Body Weight

Grains, both whole and refined, as well as the CHOs they contain, are among dietary constituents that have been alleged by some to be one of the causes of the worldwide increase in obesity. This charge exists not only in countries with developed economies, but also in countries with emerging and developing economies. At the same time, adequate dietary fiber intake and consumption of an optimal balance of CHO-rich foods are considered by many to be important in maintaining body weight and preventing obesity. Thus, the debate concerning optimal dietary macronutrient distribution, both for attaining optimal body weight, preventing overweight, and promoting and maintaining weight loss, continues unabated.

One prevailing position is that CHO, as it occurs in grains and other staple foods, provides 4 kcal/g, enabling lower calorie intake than fat, which provides 9 kcal/g and, thus, can help to address weight issues. An accompanying view is that excess fat intake, especially saturated fat, can have adverse health effects. Hence, most government regulatory agencies and health promotion organizations suggest that CHOs should contribute a majority of energy (40–65%) in the diet; fats should contribute 20–35% of energy; and proteins should provide the remainder (7).

The opposite position is that CHOs and grains should be eliminated or drastically reduced in the diet because they contribute to obesity and hinder weight loss. Proponents of this theory cite time series data showing that decreasing the percentage of energy ingested from fats while increasing the percentage of energy ingested from CHOs is associated with increased obesity in a population (8). However, drawing such a correlation results in an erroneous deduction. First, associations between increases in body weight and increases in the percentage of energy ingested from CHOs fail to consider total calorie intake. In reality, during the 40 year period cited, calorie intake increased by more than 600 kcal/day (9). Although there have been increases in calorie intake from grain-based foods, there have also been increases in calorie intakes from nearly all food categories. Figure 1 shows the distribution of calorie intake by food

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group using U.S. Department of Agriculture (USDA) disappearance data (9). Thus, the correct deduction is that total calorie intake and calorie intakes from nearly all food groups have increased and are responsible for increases in obesity, rather than the erroneous deduction that the rise in obesity is due mainly to consumption of CHOs and/or grain-based foods.

Furthermore, proponents of the theory that CHOs are the primary cause of increasing obesity rates also state that analysis of National Health and Nutrition Examination Survey (NHANES) data for the past 50 years shows that "general adherence to recommendations to reduce fat consumption has coincided with a substantial increase in obesity" (10). Some even suggest that following government and public health nutrition guidelines are the root cause of the dramatic rise in obesity. As an alternative, these proponents advocate following either a paleo, a low-CHO, or even a very low-CHO (ketogenic) diet, with suggestions that only 10% of energy should come from CHO (11,12). As a consequence, such diets totally eliminate or severely curtail the consumption of grains.

Claims that increases in body weight are attributable to consumption of CHOs and grain-based foods and promises that elimination of grains will address obesity do not accurately describe what is occurring. In fact, these dietary suggestions may not be helpful because of other problems that contribute to increased body mass index (BMI), including increases in 1) stress, which is a documented contributor to overconsumption, especially of foods not only high in CHOs, but also high in saturated fats (13); 2) screen time; and 3) sedentary pursuits. As a result, while total calorie intake has increased, energy expenditure has decreased dramatically (14).

Population data from many parts of the world do not support the contention that CHO consumption increases body weight. For example, the U.K. Whitehall II Study of more than 6,000 adults shows a link between higher intakes of CHO and lower waist/hip ratios and BMIs (15). A review by Gaesser (16) reveals an inverse relationship in most large prospective cohort studies between CHO intake and BMI or other measures of overweight and body fat, such as waist circumference. Studies done after the Gaesser review (16) continue to show that diets that are higher in fat are associated with measures of increased body fatness and, conversely, that diets that are higher in CHO are associated with measures of decreased body fatness (17–20). CHO intake documented in cohorts around the world show either that there is no relationship with measures of body fatness or that there is an inverse relationship. Data from epidemiological studies have been validated in intervention trials. For example, findings from the Women's Health Initiative Dietary Modification Trial (21) showed that as intake of fruits, vegetables, and whole grains increased, causing CHO intake to increase, body weight decreased. However, as CHO intake increased, dietary fiber also increased, creating a significant confounding.

Expert advisory panels around the world disagree with claims made in the popular press. For example, the U.K. Scientific Advisory Committee on Nutrition (SACN) concluded their analysis with the following statement, "The hypothesis that diets higher in total CHO cause weight gain is not supported by the evidence…" (22). Similarly, in an evidence-based review (EBR) (23) the German Nutrition Society concluded, "The available studies regarding adults mainly suggest that CHO intake or dietary CHO proportion, respectively, is not associated with the risk of obesity. The evidence regarding the lack of a long-term effect of a change in CHO intake on the development of obesity is judged as probable."

Such pronouncements have not quelled the continuing debate, however. Those who hold that CHO causes overweight also sometimes suggest that it is not the amount of CHO, but rather the quality. However, CHO quality has no generally agreed upon definition. The following criteria for CHO quality have been suggested: 1) foods that are whole grain; 2) foods that have a low glycemic response, e.g., low glycemic index (GI) and/or glycemic load (GL) (24); 3) foods that have a proper fiber ratio (25); and 4) foods that are from grains that have neither been bred, modified, nor refined (2,26,27).

Parameters of CHO quality, such as GI, do not necessarily reduce confusion. More studies show either a lack of association or an inverse relationship, rather than a positive relationship, between measures of body weight and the GI or GL of the diet (16,28–30). Confounding occurs because diets that have a low GI often contain foods that have more dietary fiber and contain more recommended dietary components and food groups. So, despite a recent consensus paper (24) stating that GI and GL were useful in preventing and treating obesity, both a recent review of randomized control trials (RCTs) and a meta-analysis show either no or a mixed response when dietary fiber and whole grain intake were considered (31,32).

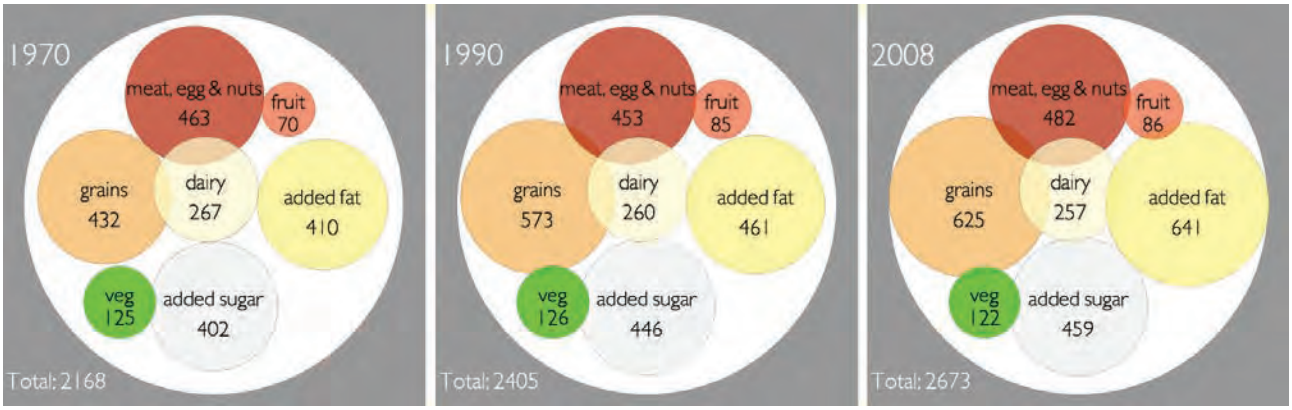

Fig. 1. Comparison of average daily calories per capita available from the U.S. food supply (adjusted for spoilage and other waste) in 1970, 1990, and 2008. Data source: USDA ERS Food Availability (Per Capita) Data System (www.ers.usda.gov/Data/FoodConsumption). (Republished from Norén [7] under CC BY-NC-SA 3.0 US license)

CHOs and Weight Loss and Maintenance

Just as the role played by CHOs in overweight remains unclear, their role in weight loss has been contested in health and nutrition arguments for years. In 1863 William Banting, a noted English undertaker, published the dietary recommendations of physician William Harvey in *A Letter on Corpulence* (33). The pamphlet suggests that diets eliminating CHOs would help with weight loss. Since then, both scientific studies and popular literature have continued to support and refute this approach to dieting (34). Proponents of higher CHO diets recommend them over high-fat diets because fat, compared to CHO, is more efficiently absorbed and relatively resistant to oxidation. Both of these observations support the idea that high-fat diets can impede weight loss and may lead to weight gain. Further, high-fat foods often are highly palatable and only weakly satiating. As such, they may contribute to passive overconsumption and excess energy intake (35).

Lower fat diets may, in fact, be helpful for those trying to maintain their weight. A 2015 systematic review of 32 RCTs of populations not actively trying to change their weight ($N \approx 54{,}000$ participants) shows that diets with a higher CHO content and lower proportion of energy from fat had a more consistent effect on body weight measures (36). Those ingesting higher percentages of CHO had somewhat lower body weights (≤2 kg on average) than those ingesting a typical percentage of fat. The differences became greater for those following diets with more stringent fat reductions (36).

Despite the more than 170 years since Banting's essay on which type of diet is best for weight loss, a definitive answer remains elusive. Findings from RCTs provide evidence that supports both high- and low-CHO diets. However, differences in the number of kilograms lost are small, and any advantage of one diet over another diminishes the longer a group is on a low-CHO diet. For example, data from a number of RCTs show greater short-term weight loss for low-CHO diets than those higher in CHOs (37–40). However, many of these studies fail to show any weight loss advantage at longer time points (41–43). In many studies showing statistically greater weight loss, the actual differences were deemed too small to be physiologically important. On the positive side, there is substantive evidence that for many individuals low-CHO diets can effectively promote weight loss and lead to favorable changes in blood lipids (44). These positives are balanced, however, by the fact that low-CHO diets often lead to decreased intakes of phytochemicals and dietary fiber and may result in decreased glycogen stores. Nevertheless, for those with insulin resistance or those classified as having MetS or prediabetes, there is experimental support for consumption of a moderately restricted CHO diet (<44% of calories from CHO) that emphasizes high-quality CHO sources. This type of dietary pattern also could lead to favorable changes in cardiovascular disease risk factors and minimize possible concerns associated with very restrictive low-CHO diets (45,46).

For certain body weight measures and health outcomes, a low-fat diet may be better than a low-CHO diet. For example, in an RCT of isocaloric diets, body fat loss was significantly greater with a very low-fat diet than with a very low-CHO diet (47). The authors of this study suggest that this finding gives a low-fat (higher CHO) diet an edge when it comes to overall health, arguing that the loss of fat is more important to health than overall loss of weight. Such findings also debunk claims that fat loss does not occur in the presence of CHO as has been alleged by some (48). However, as is discussed in the fifth review in this series, which focuses on blood pressure, MetS, and diabetes (44), some health outcomes are better when diets are lower in CHO. Nonetheless, an EBR conducted by the Spanish Federation of Nutrition, Food and Dietetic Associations (FESNAD) with the Spanish Association for the Study of Obesity (SEEDO) concluded that there are fewer adverse long-term health effects for those following a low-fat diet than for those following a low-CHO diet, especially if the latter is high in animal fat (43).

More research is needed because many things impact weight. Gender, sleep duration, and the metabolic state of the dieter all interact with the level of CHO intake and may account for variations in study outcomes (49). For example, in a short-term study, in individuals with diabetes a decrease in CHO intake from 50 to 40% of calories was associated with a reduction in visceral adipose tissue in men, but not in women (50). However, in insulin-sensitive obese women high-CHO (60% of energy), low-fat (20% of energy) diets caused significantly greater weight loss than low-CHO (40% of energy), high-fat (40% of energy) diets (3.5 versus 6.8% of initial body weight, respectively). In insulin-resistant women, significantly more weight was lost by those following a low-CHO diet than by those following a high-CHO diet (3.4 versus 8.5% of initial body weight, respectively). Furthermore, dietary adherence varied with insulin sensitivity. There was poorer adherence to a low-fat diet for those with insulin resistance (51). This is significant because adherence to a diet has been shown to be necessary for success with weight loss and maintenance (52–54). Dietary advice tailored to individual preferences also appears to be key to adherence to a diet.

Dietary Fiber, Cereal Fiber, and Whole Grains and Body Weight

The data concerning the impact of dietary fiber on body weight measures is mixed, with clinical trials and epidemiological studies showing lack of agreement. Several clinical trials show little or no effect on body weight of dietary fiber alone or as part of whole grain (55–57), whereas many epidemiological studies do show a relationship. In a cross-sectional study of the dietary patterns of ≈1,800 men and women entering a weight loss trial, baseline intakes of both total dietary fiber and cereal fiber were associated with lower BMIs at the study outset (58). In the Baltimore Longitudinal Study of Aging, inverse correlations were shown between BMI and cereal fiber intake (59). In the Male Health Professionals' and the Nurses' Health Study cohorts, intake of bran was associated with less weight gain over the 8–12 year follow-up period (60,61). In a subset of the European Prospective Investigation into Cancer and Nutrition (EPIC) cohort of 89,423 men and women, those with the highest total and cereal fiber intakes at baseline had the least weight gain and increase in waist circumference over the 6.5 year follow-up period (62). Intake of total dietary fiber and cereal fiber in the Netherlands cohort study ($N = 4{,}237$ adults, 55–69 years old) was inversely associated with BMI only in men (63). However, a retrospective analysis of this cohort looking at weight gain after the age of 20 years found that baseline dietary fiber intake showed a slight inverse association. A recent review combining data sets for the 12 publications from Diet, Obesity and Genes (DiOGenes) and 6 from EPIC-PANACEA showed that dietary fiber, especially cereal fiber, was inversely associated with changes in measures of body weight (64).

Although many studies show some relationship, albeit weak, between dietary fiber intake and body weight and weight gain, not all show a significant relationship. For example, for the 18,146 women aged ≥45 years who participated in the Women's Health Study who had BMIs in the normal range, intakes of dietary fiber at baseline were not associated with a lower risk of gaining weight over time (65).

Data from cohort studies on cereal fiber and whole grains are often derived from the same groups and, therefore, yield similar findings; only inclusion of the intake of cereal bran and germ would make the data different (66). In an EBR using 45 years of scientific research on populations and subgroups from around the world, both cereal fiber and whole grain are associated with small, but significant, reductions in weight gain (66). According to a review of epidemiological studies, for adults higher intakes of whole grain is associated with lower body weight, BMI, waist circumference, abdominal adiposity, and weight gain (67). The evidence is graded as moderate. Similar trends have been found in studies of young children. For example, rural elementary school children who consumed 1.5 servings or more of whole grains/day had a 40% lower risk of being obese compared with children who consumed <1 serving/day (68).

Prospective observational studies of both men and women also have shown that whole grain consumption is associated with a tendency toward lower weight gain over time (60,61,69,70). Such studies show that higher intakes of whole grains (≈3 servings [a minimum of 48 g of whole grain] per day) are associated with lower BMI, smaller waist circumference, and lower body fat levels. However, the findings must be considered with the knowledge that people who eat more whole grain servings tend to have healthier lifestyles and dietary habits than those who eat less than 1 serving of whole grains/day.

Data from RCT diets comparing those whose diets are rich in whole grain foods with those whose diets are low in whole grain foods present a less consistent picture than findings from epidemiological studies. Although a few short-term studies show a possible trend toward lower weight with more whole grains in the diet, many fail to show significant differences in body weight or BMI (71–73). A few intervention trials show changes in other measures, such as percent body fat, body mass, or waist circumference (74–76). These studies are consistent with the findings of a review of 26 studies, which shows no overall effect of whole grains on body weight but a possible beneficial effect on the level of body fat (77). The authors of the review theorize that the conclusions may be partly due to short duration, as well as sample size and composition. Another possible reason for the inconsistency among study findings is the lack of an agreed upon definition of whole grain and differences caused by the effects of whole grain processing (66).


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The evidence linking refined grain product intake and risk of obesity also is confusing because it shows both increased and decreased risk. For example, data from the Danish Diet, Cancer and Health Study ($N \approx 43{,}000$) show that higher CHO intake due to refined grain products and potatoes was associated with an increase in waist circumference (78). However, two EBRs assessing the existing data regarding the role of refined grains conclude there is weak evidence that high intakes of refined grains may cause small increases in waist circumference in women (79). Similarly, after conducting an EBR the German Nutrition Society concluded "the evidence regarding the relevance of refined grain products for the risk of obesity is judged as insufficient" (23). In contrast, the same EBR found strong evidence that a diet high in whole grains is associated with lower BMI, smaller waist circumference, and reduced risk of being overweight; a diet high in whole grains and legumes can help reduce weight gain; and significant weight loss is achievable with energy-controlled diets that are high in cereals and legumes (79).

Grain-Based Foods and the Affect of Satiety on Body Weight

Satiety. Satiety is thought to influence how much is eaten, although a direct link has been difficult to show. In some studies bread has been shown to impact satiety, but not all bread types have this impact. For example, in a 2010 study participants consuming whole grain breads reported feeling fuller and more satiated than those eating refined grain breads (80). Puzzlingly, despite these differences in satiety ratings, there was no difference in overall energy intake. Other studies showed that breads containing a variety of flours, seeds and nuts, legumes, and whole kernels had higher satiety values compared with breads containing refined flour, although not all studies found significant differences (81–84). In addition, sourdough breads made with refined flours were shown to be more satiating than some whole grain breads due to their effects on the satiety hormone, a glucagon-like peptide (85). To date, increases in satiety due to whole grain intake have only been weakly associated with lower calorie intake or body weight (67).

Whole Grain Breads. Some popular authors and bloggers recommend restricting or even eliminating bread from the diet. However, these recommendations are at odds with the findings of a review of 38 epidemiological studies published over the past 30 years. The review found that dietary patterns that include whole grain breads are not associated with weight gain and might be beneficially linked to one or more measures showing reduced body fatness (86). Diets including the recommended amount of whole grain and whole grain breads have been shown to help with weight management. In healthy, postmenopausal Finnish women whole grain rye bread as 20% of energy intake was shown to help in weight control (87).

Refined Grain Breads. Findings are mixed concerning the role of refined grain (white) breads in weight, both among and between epidemiological studies and clinical trials. Although the majority of cross-sectional studies show that dietary patterns, including refined grain breads, are associated with lower measures of body fatness, most cohort

studies demonstrate a possible positive relationship between white bread intake and excess abdominal fat (86). For example, increased consumption of refined grain breads by those in the Danish Diet, Cancer and Health Cohort ($N \approx 43{,}000$) was associated with an increase in waist circumference, but only in women (78). Although the ingestion of high amounts of bread may be partially to blame, such results may be due to an interaction or occur because of confounding. For example, those who eat refined grain breads may make other lifestyle choices that adversely impact their weight (88–90). One review focused on the effects of changing the type of bread chosen in Mediterranean-style food patterns. It showed that reducing white (refined) bread, but not whole grain bread, consumption was associated with lower gains in weight and abdominal fat over time (91). Among the more than 2,000 participants in the Spanish cohort of the PREDIMED study of the Mediterranean diet, those in the highest quartile of change in white bread intake gained 0.76 kg more than those in the lowest quartile and increased waist circumference 1.3 cm more than those in the lowest quartile (92). However, bread consumption during the 4 year follow-up period was not associated with gaining more than 2 kg of weight or increasing waist circumference by more than 2 cm. Those in the highest quartile of changes in white bread intake had a 33% lower chance of losing >2 kg or reducing waist circumference by >2 cm. This suggests that decreasing white bread consumption, but not whole grain bread consumption, within a Mediterranean-style food pattern is associated with lower gains in weight and abdominal fat.

Furthermore, bread inclusion versus exclusion in an RCT with reduced-calorie diets for middle-aged, overweight or obese women was shown to actually help with weight loss (93). Not only did those assigned to the bread group increase their percentage of calories from CHO, they reduced their percentage of calories from fat, which resulted in a net decrease in calories. Further, fewer (2%) subjects in the bread group than the nonbread group (6%) dropped out, and those in the bread group reported feeling more satiated (94). Inclusion of bread for those on low-calorie regimens appears to help with satiety and compliance, both of which may be helpful in long-term weight reduction success.

Rice and Oats. The few studies looking specifically at the impact of rice intake, the main source of CHOs in many cultures, suggest it is not related to measures of body weight. For example, a recent cross-sectional study of Iranian men (95) found no difference in BMI based on rice consumption. In fact, mean BMIs were not significantly different for those consuming white rice fewer than 7 times per week and those consuming rice 7–14 times per week. Some studies actually show lower measures of body weight for those consuming higher levels of rice.

Analysis of the NHANES databases shows that adults who consume higher amounts of rice, including white and brown rice (96), or oats (97) are more likely to have a lower body mass and waist circumference. Similarly, a study of elderly Chinese adults shows that individuals consuming more than 400 g of rice/day had lower weight gain (but increased elevated glucose) than those consuming 200 g/day (98).

Breakfast Cereals. Breakfast cereal intake, including both whole and refined grains, tends to be inversely related to measures associated with body weight. An EBR of studies of large prospective cohorts shows that men who frequently consumed

breakfast cereals (regardless of type) consistently weighed less than those who consumed breakfast cereals infrequently. Further, over an 8 year time span, those who ate breakfast cereals were less likely to gain weight than those who consumed little or no breakfast cereal (99). The reviewers concluded "there is no evidence that LCDs [low-CHO diets] restricting cereal intakes offer long-term advantages for sustained weight loss" (99).

Both a meta-analysis (100) and a study of minority children and adolescents (101) show a similar positive effect on weight for those who ate breakfast cereals. Regular consumers of breakfast cereals compared with children and adolescents who consumed breakfast cereals infrequently had a lower prevalence of overweight. This is interesting because the analysis shows that energy intakes tended to be higher for regular consumers of breakfast cereals, suggesting the possibility that those who eat breakfast cereals may be less likely to underreport intakes on questionnaires or that they have other healthy lifestyle aspects, such as increased exercise, that help with weight control. There was even weak support ("grade C" rating on a scale of A [can be trusted] to D [weak, apply with caution]) in one EBR showing consumption of presweetened breakfast cereals did not increase the risk of overweight and obesity in children (102).

Assessing Studies on Refined and Whole Grains and Body Weight

It is often difficult to tease out the facts concerning the impact consuming refined grain-based staple foods has on body weight because of the way in which grains are categorized in epidemiological studies. In most studies grain-based foods are classified as either refined or whole. Confounding is inherent in such a categorization structure. First, refined grains include both grain-based staple foods, such as breads and pastas, and indulgent grain-based foods, such as cakes and doughnuts. At the time many cohort studies were undertaken to assess health outcomes associated with intake of refined and whole grain foods, indulgent grain products nearly always were formulated with refined grains. Only rarely were such products formulated with whole grains. Further, the intake of whole grains was <1 serving. Thus, combining refined indulgent and refined grain-based staple foods into a single category called "refined grains" confounds the attribution of the cause of observed health outcomes. The observed association could be due to 1) consumption of too many grain servings overall (103); 2) overconsumption of refined grains overall; 3) consumption of too many indulgent grain-based foods; 4) an imbalance in consumption of indulgent and refined grain-based staple foods; or 5) inadequate fiber and micronutrient intakes due to lack of whole grain consumption or poor diet quality.

Further, the research definition of whole grain varies markedly among studies, with some using 51% of the product by weight, some 25%, and others using 8 g/serving (66). Still others count grams of whole grain. In addition, some epidemiological studies have errors in classification, such as counting all couscous and all dark breads as whole grain, and many counting either bran- or germ-based foods as whole grain

foods. These categorization errors may account for some of the variability found among studies (104).

Another problem in data analysis is that there is inadequate intake of both dietary fiber and whole grain across populations; as a result, <4% of the population meets recommendations for whole grain, fiber, and other constituent intakes (103). Those who come closest to meeting whole grain and fiber recommendations tend to come closer to meeting other lifestyle and dietary recommendations than those who do not consume adequate levels of dietary fiber or whole grain. For example, a cross-sectional study of adolescents that used data from NHANES, 1999–2004, found that higher whole grain intake was associated with lower BMI and waist, thigh, and arm circumferences only among boys, but the association in boys lost its statistical significance after adjustment for intake of other food groups (105). For measures of body weight this confusion presents special difficulty. Studies show that individuals ingesting foods with lower energy density have lower body weights and higher intakes of dietary fiber, cereals, fruits, vegetables, and grains, including rice, and that a lower percentage of these individuals consume baked goods and fried potatoes (106,107).

Grains, Whole Grains, and Dietary Fiber and Body Weight—A Summary

Habitual whole grain consumption is related in many epidemiological studies to lower measures of body weight and a decreased tendency to gain weight over time. Whole grains and cereal fiber may help with weight control for the following reasons:

1) Diets with adequate dietary fiber tend to include nutrient-rich fruits and vegetables and whole grains; as a result, they are usually more nutrient dense and less energy dense.
2) Diets with adequate whole grain and cereal fiber intakes may affect food volume and gastric emptying. Because these types of diets include larger food volumes, they tend to stay in the stomach longer and may enhance feelings of fullness and reduce hunger (108).
3) Fermentation of fiber, including resistant starch, from whole grains may alter the secretion of gut hormones that influence satiety or cause other changes in the gut and microbiome that impact satiety (109,110).
4) The intake of whole grain foods and cereal fiber is associated with lower markers of inflammation, such as C-reactive peptide and other cytokines. This may cause beneficial changes in metabolism and enable weight maintenance.

Dietary patterns that include CHOs, whole grains, breads, and cereals in the right balance are associated with lower measures of body weight and less weight gain over time. Although diets high in refined grain breads and meats are associated with greater measures of body fatness in some studies, the data are unclear with respect to the role of refined grain breads and cereals, especially when the refined grain category contains not only refined grain-based staple foods but also grain-based desserts and snacks. More research is needed regarding the optimal balance of these CHO-rich staple foods.

Conclusions

Body weight and obesity appear to be addressed and prevented best by diets enabling weight maintenance and loss, when necessary, that focus not on the elimination of CHOs and grains, but rather on the consumption of foods and nutrients within tested, balanced dietary patterns. Such diets generally would contain from 45 to 65% CHO, including high levels of the dietary fiber and phytochemicals present in whole grains. Both are associated with a lower risk of elevated body weight, as well as a lower risk of hypertension, MetS, and diabetes (44).

Patterns such as the DASH (Dietary Approaches to Stop Hypertension), Mediterranean, and New Nordic diets and the USDA MyPlate recommendations, as well as many others, that include balanced amounts of all macronutrients, vitamins, minerals, and phytonutrients do not eschew any food groups, including grains and breads, meet this balance (103). Sadly, only 3–8% of Americans eat according to such patterns. Less than 4% of Americans meet the dietary fiber intake requirement, and less than 1% meet the whole grain intake requirement. Data from many other countries also show a large gap between recommended patterns and actual intakes. For many, servings are too large, and grain-based desserts and other high-calorie, low-nutrient foods provide too many calories at the expense of nutrient-rich fruits and vegetables and whole and refined grain staple foods. General diets do need improvement, but elimination of CHOs and grain-based foods will not provide the improvements needed for most individuals.

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