Dietary Intake of Whole and Refined Grain Breakfast Cereals and Weight Gain in Men

Lydia A. Bazzano, Yiqing Song,†‡ Vadim Bubes,† Carolyn K. Good,§ JoAnn E. Manson,†‡ and Simin Liu†‡*

Abstract

BAZZANO, LYDIA A., YIQING SONG, VADIM BUBES, CAROLYN K. GOOD, JOANN E. MANSON, AND SIMIN LIU. Dietary intake of whole and refined grain breakfast cereals and weight gain in men. *Obes Res.* 2005; 13:1952–1960.

Objective: Prospective studies have suggested that substituting whole grain for refined grain products may lower the risk of overweight and obesity. Breakfast cereal intake is a major source of whole and refined grains and has also been associated with having a lower BMI. The aim of this study was to prospectively assess the association between whole and refined grain breakfast cereal intakes and risk of overweight (BMI $\geq$ 25 kg/m^2) and weight gain.

Research Methods and Procedures: We examined 17,881 U.S. male physicians 40 to 84 years of age in 1982 who were free of cardiovascular disease, diabetes mellitus, and cancer at baseline and reported measures of breakfast cereal intake, weight, and height.

Results: Over 8 and 13 years of follow-up, respectively, men who consumed breakfast cereal, regardless of type, consistently weighed less than those who consumed breakfast cereals less often (p value for trend = 0.01). Whole and refined grain breakfast cereal intake was inversely associated with body weight gain over 8 years, after adjustment for age, smoking, baseline BMI, alcohol intake, physical activity, hypertension, high cholesterol, and use of multivitamins. Compared with men who rarely or never consumed breakfast cereals, those who consumed $\geq$1 serving/d of breakfast cereals were 22% and 12% less likely to become overweight during follow-up periods of 8 and 13 years (relative risk, 0.78 and 0.88; 95% confidence interval, 0.67 to 0.91 and 0.76 to 1.00, respectively).

Discussion: BMI and weight gain were inversely associated with intake of breakfast cereals, independently of other risk factors.

Key words: whole grain breakfast cereal, refined grain breakfast cereal, weight gain, overweight, men

Introduction

The prevalence of obesity in the United States has doubled in adults and children and tripled in adolescents over the past two decades. Approximately two-thirds of Americans are overweight or obese (1). In the United States, between 300,000 and 400,000 deaths annually are attributable to obesity, and $75 billion were spent in 2003 on health care and related costs (2,3). Obesity increases risk of hypertension, dyslipidemia, type 2 diabetes, heart disease, cancer, and many other chronic diseases. Despite its epidemic proportions, the long-term efficacy of any specific dietary approach to weight control remains to be determined.

The consumption of whole grains and whole grain products has been recommended as a strategy to maintain a healthy weight. Whole grains may have beneficial effects on weight control through promoting satiety (4–6). The intake of whole grains may also slow starch digestion or absorption, leading to lower insulin and glucose responses that favor the oxidation and lipolysis of fat rather than storage (4–6). However, most grain products consumed in the United States are highly refined and contain more starch but less fiber (7,8). Few studies have directly examined the effects of whole grains, as opposed to refined grains, on body weight and weight changes (9,10). Whole grain breads, breakfast cereals, popcorn, oatmeal, and brown rice are some of the whole grain foods that are most commonly eaten in Western cultures (11). Breakfast cereals are a major

Received for review January 10, 2005.
Accepted in final form September 1, 2005.
The costs of publication of this article were defrayed, in part, by the payment of page charges. This article must, therefore, be hereby marked "advertisement" in accordance with 18 U.S.C. Section 1734 solely to indicate this fact.

*Department of Medicine, Beth Israel Deaconess Hospital, Boston, Massachusetts; †Division of Preventive Medicine, Department of Medicine, Brigham and Women's Hospital and Harvard Medical School, Boston, Massachusetts; ‡Department of Epidemiology, Harvard School of Public Health, Boston, Massachusetts; and §General Mills Bell Institute of Health and Nutrition, Minneapolis, Minnesota.
Address correspondence to Simin Liu, Division of Preventive Medicine, Harvard Medical School and Brigham and Women's Hospital, 900 Commonwealth Avenue, Boston, MA 02215.
E-mail: siminliu@hsph.harvard.edu

source of both whole and refined grains in the American diet. Intake of breakfast cereals has also been related to weight control in several epidemiological studies (12–14); however, to date, studies of breakfast cereals have not examined whole as opposed to refined grains in relation to weight control. To further examine the association between intake of whole and refined grain breakfast cereals to changes in weight over time, we analyzed prospective data in a large cohort of middle-aged and elderly U.S. men from the Physicians' Health Study.

Research Methods and Procedures

Study Population

The Physicians' Health Study is a completed randomized trial of low-dose aspirin and β-carotene in the primary prevention of cardiovascular disease and cancer. The participants, methods, and results have been described in detail previously (15–17). The study population consisted of 22,071 U.S. male physicians 40 to 84 years of age in 1982, with no history of myocardial infarction, stroke, transient cerebral ischemia, or cancer (except non-melanoma skin cancer), who were followed for 13 years. Morbidity and mortality data were available for >99%. At baseline, 22,066 participants (99.9%) reported weight and height. Of these, 635 were excluded because of history of diabetes, cancer, or cardiovascular disease reported at baseline or follow-up, resulting in a study population of 21,431 men. After further excluding those who did not provide information on breakfast cereal intake (16.6%), the final population for analyses consisted of 17,881 men.

Data Collection

Baseline information was self-reported and collected by a mailed questionnaire that asked about many demographic, medical history, and lifestyle variables. Every 6 months for the first year and annually thereafter, participants received follow-up questionnaires asking about compliance with randomized treatment assignments and newly diagnosed conditions, including diabetes, cardiovascular disease, and cancer. Study participants also completed an abbreviated, semiquantitative food-frequency questionnaire (SFFQ)[1] at baseline. The abbreviated SFFQ included two questions on breakfast cereal consumption: "Please fill in your average use, during the past year, of each specified food. Cold Breakfast Cereal (1 cup)." Answers included "never or less than once per month, 1 to 3 per month, 1 per week, 2 to 4 per week, 5 to 6 per week, 1 per day, 2 to 3 per day, 4 to 5 per day, 6+ per day." The second question was "Which cold breakfast cereal do you usually eat? Specify brand and type" with a blank line. The SFFQ included 61 food items divided into five groups and 10 questions on supplements, vitamins, and minerals. These items were selected from a validated SFFQ used in the Nurses' Health Study in 1980 to discriminate and rank dietary intake among participants (18). The reproducibility and validity of the SFFQ in the Nurses' Health Study have previously been described (18), along with the questionnaire's ability to assess intake of individual grain products (19). For example, between the SFFQ and the detailed diet records in a sample of the participants, the correlation coefficient was 0.75 for cold breakfast cereal. For each food item on the questionnaire, most responses ranged from never to ≥2 servings/d. A procedure developed by Jacobs et al. (20) was used to classify breakfast cereals into whole and refined grain. Specifically, the breakfast cereals listed in the SFFQ were evaluated for whole grain and bran content; breakfast cereals that contained ≥25% whole grain or bran by weight were classified as whole grain, which is the classification used by Jacobs et al. and others (11,21). To maintain a high specificity in the definition of whole grain cereals, we included responses in which brand names were missing in the category of refined grains (thereby possibly misclassifying some responses as refined grains), because refined grain cereals were more readily available in the market in the 1980s than were whole grain cereals (7).

Statistical Analysis

Intakes of whole and refined grain breakfast cereals were considered as both continuous (servings per day) and categorical variables. We categorized cereal intake as rarely or never, 1 serving/wk, 2 to 6 servings/wk, and ≥1 serving/d to maintain a gradient of exposure and include adequate sample in each category. We computed means or proportions of baseline risk factors according to categories of whole grain, refined grain, or total cereal intake. Average change in BMI and weight gain in kilograms were calculated using a generalized linear regression model for two time intervals: 96 months (8 years) from baseline and 156 months (13 years) from baseline. Models were adjusted for age and baseline BMI as continuous variables and smoking, alcohol intake, physical activity, history of hypertension, history of high cholesterol, and use of multivitamins as categorical variables. Cox proportional hazards models were used to calculate relative risks (hazards) for attaining a BMI ≥25 or ≥30 kg/m^2 and for body weight gain of ≥10, 15, or 20 kg over the follow-up periods according to breakfast cereal intake. These models were adjusted for the same covariates listed above. Tests for linear trend across increasing categories of breakfast cereal intake were conducted by treating the median intake (servings per day) in each category as a continuous variable. All analyses were conducted with SAS (version 8; SAS Institute, Cary, NC). All p values

[1] Nonstandard abbreviations: SFFQ, semiquantitative food-frequency questionnaire; RR, relative risk; CI, confidence interval.

Table 1. Baseline characteristics according to intakes of whole grain, refined grain, and total breakfast cereals in the Physicians' Health Study I ($N = 17{,}881$ men) in 1982*

	Whole grain		Refined grain		Total breakfast cereals	
Characteristics	**Rarely**	**≥1 serving/d**	**Rarely**	**≥1 serving/d**	**Rarely**	**≥1 serving/d**
Number of participants	10,867	2365	12,863	1016	5849	3381
Age (mean ± SD, years)	52 ± 9	54 ± 9	52 ± 9	55 ± 10	52 ± 8	54 ± 9
BMI (mean ± SD, kg/m^2)	24.8 ± 2.7	24.1 ± 2.3	24.7 ± 2.7	24.2 ± 2.4	24.9 ± 2.8	24.2 ± 2.3
BMI ≥ 25 kg/m^2 (%)	43	33	42	34	45	33
Vigorous exercise (%)						
<1 time/wk	29	23	27	23	32	23
1/wk	19	17	19	17	20	17
2 to 4 times/wk	37	41	38	40	34	41
≥5 times/wk	15	20	16	19	14	20
Cigarette smoking (%)						
Never	48	58	50	56	44	58
Past	40	37	39	38	42	37
Current, <20 cigarettes/d	4	2	4	3	5	2
Current, ≥20 cigarettes/d	8	3	7	3	10	3
Alcohol consumption (%)						
Daily	26	25	24	25	29	25
Weekly	50	47	51	45	48	47
Monthly	12	11	11	13	11	12
Rarely/never	13	17	14	17	12	17
Current use of multivitamin supplement (%)	18	22	19	20	18	21
History of hypertension (%)	23	18	21	22	23	19
History of high cholesterol (%)	12	12	12	13	12	12

* p values for trend for all the variables except history of high cholesterol and history of hypertension for refined grain intake were <0.05.

were two-sided. Both whole and refined grain cereals were included in the same regression models, and associations were unchanged.

Results

At baseline, ~19% of men reported consuming, on average, ≥1 serving/d breakfast cereal, and 13% reported consuming ≥1 serving/d whole grain breakfast cereal. Men who ate breakfast cereals more often tended to be older and tended to exercise, and were less likely to be overweight, smokers, or use multivitamin supplements than their counterparts with infrequent cereal intakes. Men with high intake of whole grain or total breakfast cereals were also less likely to have a history of hypertension than those with low intake. History of high cholesterol did not vary significantly across categories of breakfast cereal intake (Table 1).

At baseline in 1982, men in the lowest category of whole grain breakfast cereal intake were significantly heavier than those in the highest category of whole grain intake (BMI: 24.8 versus 24.1 kg/m^2; p for trend < 0.0001; Table 1). The same was true at follow-ups of 8 and 13 years (data not shown). Among consumers of refined grain breakfast cereals, men consuming ≥1 serving/d also weighed less than their counterparts who rarely or never consumed breakfast cereals (BMI: 24.7 versus 24.2 kg/m^2; p for trend < 0.0001). Again, the same was true at follow-ups of 8 and 13 years (p for trend < 0.0001).

As shown in Table 2, over the 8-year follow-up period, men with higher intake of breakfast cereals had significantly less weight gain regardless of grain type, age, smoking, baseline BMI, alcohol intake, physical activity, history of hypertension, history of high cholesterol, and use of multivitamins. After 13 years, mean weight gain was signifi-

Table 2. Adjusted mean in body weight gain (in kg) according to intakes of whole grain, refined grain, and total breakfast cereals during an 8-year follow-up (from 1982 to 1990) and a 13-year follow-up (from 1982 to 1995)

	Adjusted mean of body weight gain (kg)				
	Rarely	1 serving/wk	2 to 6 servings/wk	≥1 serving/d	*p* for trend*
Whole grain breakfast cereals					
8-year follow-up					
Model 1†	1.61 ± 0.05	1.53 ± 0.11	1.41 ± 0.09	1.13 ± 0.10	0.0001
Model 2‡	1.55 ± 0.05	1.40 ± 0.12	1.37 ± 0.10	1.13 ± 0.11	0.003
13-year follow-up					
Model 1†	2.28 ± 0.06	2.39 ± 0.14	2.17 ± 0.11	1.87 ± 0.12	0.014
Model 2‡	2.18 ± 0.06	2.24 ± 0.15	2.07 ± 0.12	1.83 ± 0.13	0.08
Refined grain breakfast cereals					
8-year follow-up					
Model 1†	1.53 ± 0.04	1.60 ± 0.10	1.47 ± 0.12	1.00 ± 0.15	0.005
Model 2‡	1.46 ± 0.05	1.63 ± 0.11	1.48 ± 0.13	0.94 ± 0.16	0.005
13-year follow-up					
Model 1†	2.27 ± 0.05	2.21 ± 0.12	2.08 ± 0.15	1.83 ± 0.19	0.11
Model 2‡	2.14 ± 0.06	2.19 ± 0.13	2.13 ± 0.16	1.77 ± 0.20	0.33
Total breakfast cereals					
8-year follow-up					
Model 1†	1.76 ± 0.06	1.57 ± 0.07	1.43 ± 0.07	1.09 ± 0.08	<0.0001
Model 2‡	1.66 ± 0.07	1.53 ± 0.08	1.40 ± 0.08	1.07 ± 0.09	<0.0001
13-year follow-up					
Model 1†	2.44 ± 0.08	2.29 ± 0.09	2.13 ± 0.09	1.86 ± 0.10	<0.0001
Model 2‡	2.27 ± 0.08	2.22 ± 0.10	2.09 ± 0.10	1.81 ± 0.11	0.007

* Tests for a linear trend are conducted by treating the median intake in each category as a continuous variable.

† Linear regression model 1 adjusted for age.

‡ Linear regression model 2 adjusted for age, smoking, baseline BMI, alcohol, physical activity, history of hypertension, history of high cholesterol, and use of multivitamins.

cantly lower among participants consuming whole grain cereals at least 1 serving/d compared with those who rarely or never consumed whole grain cereals (2.28 ± 0.06 kg compared with 1.87 ± 0.12 kg; p for trend < 0.05) after adjustment for age. Additional adjustments attenuated the strength of this association. Corresponding trends were seen among men across intakes of refined grain breakfast cereals, but these did not reach the customary level of statistical significance. When intake of total breakfast cereals was examined among men, those with lower intakes gained more than those with higher intakes, independently of age and other covariates over the course of 13 years of follow-up.

We calculated adjusted relative risks for attaining a BMI in the overweight (≥25 kg/m^2) range (Table 3; Figure 1) during the course of 8 and 13 years of follow-up. Men consuming more breakfast cereals, on average, were less likely to become overweight during the follow-up periods. Compared with men who rarely or never consumed breakfast cereals, those who ate ≥1 serving/d of total breakfast cereals were 22% and 12% less likely to become overweight over 8 and 13 years of follow-up, respectively [relative risk (RR), 0.78 and 0.88; 95% confidence interval (CI), 0.67 to 0.91 and 0.76 to 1.00, respectively). When cereal intakes were divided by type of grain, trends for attaining BMI ≥25 kg/m^2 were present but did not reach statistical significance after adjustment. The same was true when breakfast cereal intakes were used to predict attaining a BMI ≥30 kg/m^2, after adjustment for age and other covariates (data not shown).

Table 3. Adjusted RRs and 95% CIs for attained BMI ≥25 kg/m^2 according to intakes of whole grain, refined grain, and total breakfast cereals over an 8-year follow-up (from 1982 to 1990) and a 13-year follow-up (from 1982 to 1995)

	RR (95% CI) for BMI ≥ 25 kg/m^2				
	Rarely/ never	1 serving/wk	2 to 6 servings/wk	≥1 serving/d	*p* for trend*
8-year follow-up					
Whole grain breakfast cereals					
Number of cases	1286	222	339	234	
Model 1†	1.00	0.99 (0.85 to 1.15)	1.03 (0.90 to 1.17)	0.86 (0.74 to 1.00)	0.09
Model 2‡	1.00	1.04 (0.88 to 1.23)	1.05 (0.91 to 1.21)	0.83 (0.71 to 0.98)	0.06
Refined grain breakfast cereals					
Number of cases	1530	282	171	98	
Model 1†	1.00	0.98 (0.86 to 1.13)	0.88 (0.74 to 1.04)	0.85 (0.69 to 1.06)	0.06
Model 2‡	1.00	1.02 (0.88 to 1.19)	0.86 (0.71 to 1.04)	0.81 (0.64 to 1.03)	0.03
Total breakfast cereals					
Number of cases	735	504	510	332	
Model 1†	1.00	0.93 (0.83 to 1.05)	0.92 (0.81 to 1.04)	0.81 (0.71 to 0.93)	0.005
Model 2‡	1.00	0.98 (0.86 to 1.12)	0.93 (0.81 to 1.06)	0.78 (0.67 to 0.91)	0.001
13-year follow-up					
Whole grain breakfast cereals					
Number of cases	1682	273	415	343	
Model 1†	1.00	0.91 (0.79 to 1.04)	0.95 (0.84 to 1.07)	0.99 (0.87 to 1.13)	0.76
Model 2‡	1.00	0.97 (0.83 to 1.13)	0.93 (0.82 to 1.06)	0.91 (0.79 to 1.05)	0.13
Refined grain breakfast cereals					
Number of cases	1943	401	247	122	
Model 1†	1.00	1.12 (0.99 to 1.26)	1.03 (0.89 to 1.19)	0.85 (0.69 to 1.03)	0.15
Model 2‡	1.00	1.19 (1.05 to 1.36)	1.01 (0.86 to 1.19)	0.81 (0.65 to 1.01)	0.08
Total breakfast cereals					
Number of cases	912	674	662	465	
Model 1†	1.00	1.01 (0.91 to 1.13)	0.97 (0.87 to 1.08)	0.94 (0.84 to 1.07)	0.26
Model 2‡	1.00	1.07 (0.95 to 1.21)	0.95 (0.84 to 1.08)	0.88 (0.76 to 1.00)	0.01

* Tests for a linear trend are conducted by treating the median intake in each category as a continuous variable.

† Cox proportional hazards model 1 adjusted for age.

‡ Cox proportional hazards model 2 adjusted for age, smoking, baseline BMI, alcohol, physical activity, history of hypertension, history of high cholesterol, and use of multivitamins.

Adjusted RRs for having a weight gain of 10 or 15 kg were also calculated and are shown in Table 4. At the 13-year follow-up, risk for major weight gain (≥10 kg) was significantly lower among participants who were in the highest category of whole and refined grain breakfast cereal intakes than their counterparts with lower intake, after adjustment for age and other risk factors (Table 4). For example, participants consuming ≥1 serving/d of whole grain breakfast cereals were 22% less likely (RR, 0.78; 95% CI, 0.64 to 0.96; p for trend < 0.01) to experience a weight gain of ≥10 kg over the follow-up period. We also calculated RRs of weight gain ≥20 kg. These results followed the

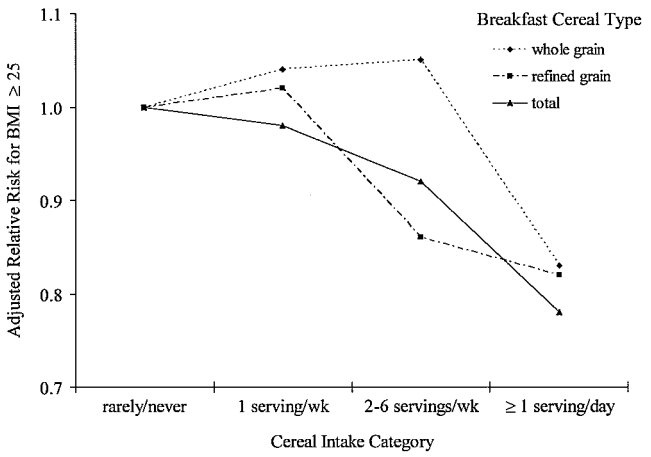

Figure 1: Multivariate adjusted relative risks for attained BMI ≥ 25 kg/m^2 according to intakes of whole grain, refined grain, and total breakfast cereals over 8 years of follow-up (from 1982 to 1990).

same trends as those for weight gain of ≥10 and ≥15 kg. Because of a much smaller event rate, CIs were wider, and significant trends were present for total cereals only (data not shown).

Discussion

In this 13-year prospective study of U.S. male physicians, we identified an inverse relationship between intake of breakfast cereals and body weight and changes in weight over time. Few epidemiological studies have examined the role of breakfast cereals in weight control. Those that have were generally cross-sectional or short-term dietary interventions. This is one of the first large prospective studies to examine breakfast cereal intake, a major source of whole grains, in relation to long-term weight gain. Higher intake of breakfast cereals was associated with lower BMI, lower risk of becoming overweight or obese, and lower risk of major weight gain during the study follow-up periods. These results have important clinical and public health implications, given the growing prevalence of obesity in the United States and worldwide. Our findings suggest that greater intake of breakfast cereals may help to decrease weight gain over time. Given their contributions to health, whole grain breakfast cereals, in particular, may be beneficial in avoiding weight gain and maintaining an optimal weight in the long term.

Breakfast is generally the first meal of the day and plays an important role in determining total intake of energy for the day, hence affecting weight control. The effect of breakfast type on total daily energy intake and BMI was examined cross-sectionally by Cho et al. (12) in the Third National Health and Nutrition Examination Survey. They found that participants consuming ready-to-eat cereals or cooked cereals for breakfast had lower BMI after adjustment for age, sex, race, smoking, alcohol intake, physical activity, and poverty index ratio compared with their counterparts eating other types of breakfasts or skipping breakfast (12). Similarly, in a cross-sectional analysis, Albertson et al. (13) found that among 4- to 12-year-old children, ready-to-eat cereal consumption was inversely associated with mean BMI ($p < 0.01$). They also found that the proportion of children at risk for being overweight or already overweight was significantly lower in the upper tertile of cereal consumption ($p < 0.05$). Waller et al. (14) tested the hypothesis that providing a structured snack in the form of a ready-to-eat breakfast cereal would help regulate energy intake and contribute to weight loss in night snackers. Forty-four women and 14 men between 18 and 65 years of age with BMI ≥25 kg/m^2 and self-reported night snacking behaviors were randomized into a cereal group and a no cereal group. During a period of 4 weeks, the cereal group was instructed to consume a serving of ready-to-eat cereal with low-fat milk 90 minutes after their evening meal, whereas the no cereal group continued their regular diet. Participants in the cereal group lost a small amount of weight and decreased their after dinner calorie intake in comparison with those in the no cereal group; however, these results were not statistically significant. In our study, we found that more frequent breakfast cereal consumption was associated with lower BMI at baseline and less weight gain over the course of both 8 and 13 years of follow-up.

Whole grain consumption has been associated with reduced risk of both weight gain and the development of obesity in large cohorts of both middle-aged women (9) and men (10). In the first study, women who consumed more whole grains weighed significantly less than did women who consumed fewer whole grains. Those who increased their dietary fiber intake over the 12 years of follow-up gained significantly less weight than those who did not increase their dietary fiber intake, independently of body weight at baseline, age, and changes in covariates. Women in the highest quintile of dietary fiber intake had a 9% lower risk of major weight gain than did women in the lowest quintile (odds ratio, 0.51; 95% CI, 0.39 to 0.67; p for trend < 0.0001). Similarly, a study by Koh-Banerjee et al. (10) found that men who consumed more whole grains weighed significantly less than men who consumed fewer whole grains. Increases in consumption of whole grain over the 8-year follow-up period were inversely related to weight gain, even after adjustment for weight at baseline, age, and changes in covariates and other dietary factors (p for trend < 0.01). It is worth noting that whole grain breakfast cereals contributed the most to overall whole grain intakes (37.6%), and 70.2% of the male cohort reported eating whole grain breakfast cereals.

In our study, associations did not differ by type of grain in breakfast cereal. However, we were not able to evaluate

Table 4. Adjusted RRs and 95% CIs for attained body weight gain ≥10 or ≥15 kg according to intakes of whole grain, refined grain, and total breakfast cereals over a 13-year follow-up (from 1982 to 1995)

	RR (95% CI)				
	Rarely/ never	1 serving/wk	2 to 6 servings/wk	≥1 serving/d	*p* for trend*
Whole grain breakfast cereals					
Number of cases (weight gain ≥10 kg)	1005	176	226	143	
Model 1†	1.00	0.98 (0.82 to 1.16)	0.85 (0.73 to 0.99)	0.68 (0.57 to 0.82)	<0.0001
Model 2‡	1.00	0.90 (0.75 to 1.10)	0.86 (0.72 to 1.02)	0.78 (0.64 to 0.96)	0.01
Number of cases (weight gain ≥15 kg)	362	59	87	43	
Model 1†	1.00	0.90 (0.68 to 1.20)	0.92 (0.73 to 1.17)	0.58 (0.42 to 0.80)	0.001
Model 2‡	1.00	0.84 (0.61 to 1.15)	0.94 (0.71 to 1.25)	0.82 (0.58 to 1.16)	0.27
Refined grain breakfast cereals					
Number of cases (weight gain ≥10 kg)	1158	218	114	60	
Model 1†	1.00	0.98 (0.84 to 1.15)	0.78 (0.64 to 0.96)	0.72 (0.55 to 0.94)	0.002
Model 2‡	1.00	1.02 (0.86 to 1.21)	0.87 (0.70 to 1.09)	0.77 (0.56 to 1.06)	0.05
Number of cases (weight gain ≥15 kg)	409	83	44	15	
Model 1†	1.00	1.06 (0.83 to 1.35)	0.87 (0.64 to 1.20)	0.52 (0.31 to 0.87)	0.01
Model 2‡	1.00	1.10 (0.84 to 1.43)	0.96 (0.67 to 1.37)	0.69 (0.39 to 1.22)	0.21
Total grain breakfast cereals					
Number of cases (weight gain ≥10 kg)	613	394	340	203	
Model 1†	1.00	0.85 (0.74 to 0.97)	0.72 (0.63 to 0.83)	0.60 (0.51 to 0.71)	<0.0001
Model 2‡	1.00	0.87 (0.75 to 1.01)	0.78 (0.66 to 0.91)	0.70 (0.58 to 0.85)	0.0003
Number of cases (weight gain ≥15 kg)	220	142	131	58	
Model 1†	1.00	0.86 (0.69 to 1.07)	0.79 (0.64 to 0.99)	0.50 (0.37 to 0.67)	<0.0001
Model 2‡	1.00	0.92 (0.72 to 1.17)	0.89 (0.69 to 1.16)	0.74 (0.54 to 1.02)	0.08

* Tests for a linear trend are conducted by treating the median intake in each category as a continuous variable.

† Cox proportional hazards model 1 adjusted for age.

‡ Cox proportional hazards model 2 adjusted for age, smoking, baseline BMI, alcohol, physical activity, history of hypertension, history of high cholesterol, and use of multivitamins.

total whole or refined grain intake but only that available in breakfast cereals. In addition, we used the definition of Jacobs et al. (20), in which cereals with ≥25% whole grain or bran content were defined as whole grain. This definition was used so that our results would be more comparable with those of other studies (11,21); however, this definition may lead to misclassification that would bias our results toward similar associations between whole and refined grains. Our findings may suggest that eating breakfast cereals is part of an overall prudent dietary pattern that contributes to weight management. With the data from our SFFQ, we are unable to compare breakfast cereal intake to other types of breakfast foods or to skipping breakfast. As discussed previously, the SFFQ in this study was an abbreviated version that did not provide a comprehensive assessment of the participants' usual diet; thus, we could not evaluate or adjust for dietary intakes of some other foods that may contribute to a healthy lifestyle (e.g., whole grain breads). We were able to adjust for fruit, vegetable, and dairy intake, which did not change trends of adjusted mean weight gain over 8 or 13 years for

whole grain, refined grain, and total cereals but attenuated all associations for attaining BMI in the overweight or obese ranges. In addition, a smaller portion of the cohort was available for analysis in this study compared with others (22).

While our study did not show a difference between weight gain with whole compared with refined grain breakfast cereal consumption, evidence suggests that whole grains may have other important health benefits. For example, in the Physician's Health Study cohort (22), whole grain, not refined grain, breakfast cereal consumption was inversely related to total and cardiovascular disease–specific mortality, independently of age, BMI, smoking, alcohol intake, physical activity, history of diabetes, hypertension or high cholesterol, and use of multivitamins. Compared with men who rarely or never consumed whole grain cereal, men in the highest category of whole grain cereal intake ($\geq$1 serving/d) had multivariate adjusted RRs of 0.83 (95% CI, 0.73 to 0.94; p for trend < 0.001) for total mortality and 0.80 (95% CI, 0.66 to 0.97; p for trend < 0.001) for cardiovascular disease–specific mortality. Participants eating refined grain breakfast cereals had no significant differences by category of intake in total or cardiovascular disease–specific mortality. Several other large prospective studies have examined the relationship between total whole grain intake and the risk of chronic diseases and have found that increased intakes of whole grain rather than refined grain products are associated with reduced risks of type 2 diabetes (21,23), hypertension (24,25), and cardiovascular disease (11,20,26).

This study has the advantage of a large cohort with prospective data and 13 years of follow-up over which to examine weight changes. In addition, we were able to differentiate whole and refined grain breakfast cereal intake. Some potential limitations of our study include confounding by lifestyle, dietary change, and measurement error. First, the observed inverse association between breakfast cereal intake and BMI could be caused by confounding of other lifestyle factors such as smoking, exercise, and alcohol intake. To address this issue, we adjusted for these factors and others in multivariate models; however, the possibility of residual confounding cannot be excluded in any observational study. Second, the diagnosis of certain conditions such as hyperlipidemia and hypertension may lead to changes in eating habits and, therefore, confound the association between breakfast cereal intakes and weight gain or BMI. We adjusted multivariate models for history of hypertension and hyperlipidemia at baseline. Finally, measurement error is inherent in any dietary assessment method. The SFFQ used in this study assessed a limited number of foods, which hindered our ability to adjust for total energy intake and other dietary factors that may affect weight gain.

In conclusion, in this large cohort of male physicians, development of overweight or obesity and weight gain over time were inversely associated with the intake of breakfast cereals. As in any observational study, there is the possibility of residual or unknown confounders that may affect results. Nevertheless, it seems that there is growing evidence suggesting that whole grain foods, of which breakfast cereals are a major source, contribute to attaining and maintaining a healthy weight. Interpreted with caution, our findings may suggest that intake of breakfast cereals could be a facet of some dietary strategies to prevent obesity.

Acknowledgments

This work was supported by NIH Grants CA-34944, CA-40360, HL-26490, and HL-34595 and by a grant from the General Mills Corporation. The sponsor of the study had no role in study design, data collection, data analysis, or data interpretation. C.K.G. is employed by General Mills, Bell Institute of Health and Nutrition, Minneapolis, MN, and is a stock shareholder of this corporation. S.L. received honorarium and consulting fees from General Mills.

References

1. **Ogden CL, Flegal KM, Carroll MD, Johnson CL.** Prevalence and trends in overweight among US children and adolescents, 1999–2000. *JAMA*. 2002;288:1728–32.
2. **Finkelstein EA, Fiebelkorn IC, Wang G.** State-level estimates of annual medical expenditures attributable to obesity. *Obes Res*. 2004;12:18–24.
3. **Allison DB, Fontaine KR, Manson JE, Stevens J, VanItallie TB.** Annual deaths attributable to obesity in the United States. *JAMA*. 1999;282:1530–8.
4. **Jenkins DJ, Jenkins AL, Wolever TM, et al.** Starchy foods and fiber: reduced rate of digestion and improved carbohydrate metabolism. *Scand J Gastroenterol Suppl*. 1987;129:132–41.
5. **Jenkins DJ, Wesson V, Wolever TM, et al.** Wholemeal versus wholegrain breads: proportion of whole or cracked grain and the glycaemic response. *BMJ*. 1988;297:958–60.
6. **Slavin JL, Martini MC, Jacobs DR Jr, Marquart L.** Plausible mechanisms for the protectiveness of whole grains. *Am J Clin Nutr*. 1999;70(3 Suppl):459S–63S.
7. **Putnam J, Gerrior S.** *Trends in the US Food Supply, 1970–97, in America's Eating Habits: Changes and Consequences*. Washington, DC: Economic Research Service, U.S. Department of Agriculture; 1999.
8. **Putnam J, Allshouse J, Kantor L.** US per capita food supply trends: more calories, refined carbohydrates, and fats. *Food Rev*. 2002;25:2–15.
9. **Liu S, Willett WC, Manson JE, et al.** Relation between changes in intakes of dietary fiber and grain products and changes in weight and development of obesity among middle-aged women. *Am J Clin Nutr*. 2003;78:920–7.
10. **Koh-Banerjee P, Franz M, Sampson L, et al.** Changes in whole-grain, bran, and cereal fiber consumption in relation to 8-y weight gain among men. *Am J Clin Nutr*. 2004;80:1237–45.
11. **Liu S, Stampfer MJ, Hu FB, et al.** Whole-grain consumption and risk of coronary heart disease: results from the Nurses' Health Study. *Am J Clin Nutr*. 1999;70:412–9.

12. **Cho S, Dietrich M, Brown CJ, Clark CA, Block G.** The effect of breakfast type on total daily energy intake and body mass index: results from the Third National Health and Nutrition Examination Survey (NHANES III). *J Am Coll Nutr*. 2003;22:296–302.
13. **Albertson AM, Anderson GH, Crockett SJ, Goebel MT.** Ready-to-eat cereal consumption: its relationship with BMI and nutrient intake of children aged 4 to 12 years. *J Am Diet Assoc*. 2003;103:1613–9.
14. **Waller SM, Vander Wal JS, Klurfeld DM, et al.** Evening ready-to-eat cereal consumption contributes to weight management. *J Am Coll Nutr*. 2004;23:316–21.
15. **Manson JE, Stampfer MJ, Colditz GA, et al.** A prospective study of aspirin use and primary prevention of cardiovascular disease in women. *JAMA*. 1991;266:521–7.
16. **Hennekens CH, Buring JE, Manson JE, et al.** Lack of effect of long-term supplementation with beta carotene on the incidence of malignant neoplasms and cardiovascular disease. *N Engl J Med*. 1996;334:1145–9.
17. **Hennekens CH, Buring JE.** Methodologic considerations in the design and conduct of randomized trials: the U.S. Physicians' Health Study. *Control Clin Trials*. 1989;10(4 Suppl): 142S–50S.
18. **Willett WC, Sampson L, Stampfer MJ, et al.** Reproducibility and validity of a semiquantitative food frequency questionnaire. *Am J Epidemiol*. 1985;122:51–65.
19. **Salvini S, Hunter DJ, Sampson L, et al.** Food-based validation of a dietary questionnaire: the effects of week-to-week variation in food consumption. *Int J Epidemiol*. 1989;18:858–67.
20. **Jacobs DR Jr, Meyer KA, Kushi LH, Folsom AR.** Whole-grain intake may reduce the risk of ischemic heart disease death in postmenopausal women: the Iowa Women's Health Study. *Am J Clin Nutr*. 1998;68:248–57.
21. **Meyer KA, Kushi LH, Jacobs DR Jr, et al.** Carbohydrates, dietary fiber, and incident type 2 diabetes in older women. *Am J Clin Nutr*. 2000;71:921–30.
22. **Liu S, Sesso HD, Manson JE, Willett WC, Buring JE.** Is intake of breakfast cereals related to total and cause-specific mortality in men? *Am J Clin Nutr*. 2003;77:594–9.
23. **Liu S, Manson JE, Stampfer MJ, et al.** A prospective study of whole-grain intake and risk of type 2 diabetes mellitus in US women. *Am J Public Health*. 2000;90:1409–15.
24. **Appel LJ, Moore TJ, Obarzanek E, et al.** A clinical trial of the effects of dietary patterns on blood pressure. DASH Collaborative Research Group. *N Engl J Med*. 1997;336:1117–24.
25. **Liu S, Manson JE.** Dietary carbohydrates, physical inactivity, obesity, and the 'metabolic syndrome' as predictors of coronary heart disease. *Curr Opin Lipidol*. 2001;12:395–404.
26. **Liu S, Manson JE, Stampfer MJ, et al.** Whole grain consumption and risk of ischemic stroke in women: a prospective study. *JAMA*. 2000;284:1534–40.