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Ready-to-Eat Cereal Consumption Patterns and the Association with Body Mass Index and Nutrient Intake in American Adults

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Abstract

Background: To examine the relationship between ready-to-eat (RTE) cereal consumption habits, body mass index (BMI) and nutrient intakes of a nationally representative sample of American adults.

Methods: Population-based survey of American adults. Participants provided 14-day self-reported food diary records during the data collection period of March 2006 through February 2008. Height and weight of the respondents was also reported. Main outcome measures included frequency of RTE cereal consumption, Body Mass Index (BMI), and nutrient intakes. The sample population of 4,414 adults, ages 19-64 years, was divided into three groups by frequency of RTE cereal consumption over the 14-day period: 0 servings, 1-6 servings, and ≥ 7 servings.

Results: Almost three-fourths (71%) of American adults consumed RTE cereal at least once in the two-week collection period. Frequent cereal eaters (≥ 7 servings), both male and female, had lower mean BMI measures overall than infrequent or non-cereal eaters ($P < 0.0001$). Additionally, the proportion of adults classified as overweight or obese (BMI ≥ 25) was significantly lower in the frequent cereal consumption group. Frequent cereal eaters also had macronutrient intake profiles that more closely approximated national recommendations, and were more likely to meet micronutrient intake recommendations.

Conclusion: RTE cereal consumption is related to lower BMI and improved nutrient intakes in American adults.

Keywords: Breakfast; Cereals; Micronutrients; BMI

Background

Obesity rates among U.S. adults remain over 30% for both men and women, and across socioeconomic, racial, and ethnic groups [1]. Obesity, one of the 10 leading U.S. health indicators [2], is associated with increased risk for hypertension, dyslipidemia, coronary heart disease, stroke, type 2 diabetes mellitus, and certain cancers [3-5]. This alarming health crisis has led to widespread interest in dietary patterns that promote healthy body weight.

Obesity experts have used an epidemiological model to illustrate multifaceted interactions between environmental agents, including food, medication, physical inactivity, toxins and viruses, and genetic and physiologic responses of the host [6]. Recent evaluative studies have focused on diet, a significant environmental variable, and specifically, eating patterns, food selection, diet composition, energy density, and physical inactivity with increased body weight [6-14].

Regular breakfast consumption is one dietary pattern promoted as providing positive nutritional benefit, as well as healthy weight maintenance. Growing evidence indicates people of all ages who eat breakfast consistently regulate their body weight and are less likely to be at risk for overweight compared to those who skip breakfast [15-25]. Breakfast eaters of all ages also exhibit improved nutrient intakes and consume lower fat diets than non-breakfast eaters [16-18,20-23].

Ready-to-eat (RTE) cereal is a prevalent U.S. breakfast food and has been associated with regular breakfast consumption [22]. Cereal provides a significant nutrient source in the diets of U.S. children [17,18,20,22-24] and adults [16,23,25]. Previous studies have suggested a relationship between RTE cereal consumption and healthy BMI in children [16,18,20,22]. Supporting (although not specific) information also exists regarding the relationship between RTE cereal consumption and adult BMI [16]. One study revealed a gender-specific effect regarding RTE cereal consumption on BMI [25] in women, and indicated cereal consumption was associated with favourable dietary composition and obesity prevention. In fact, frequency of RTE cereal consumption predicted weight status in adult female study participants.

Relatively few studies have examined the potential relationship between BMI and RTE cereal consumption. This association is difficult to evaluate, given the influence of various dietary patterns on an outcome measure such as BMI, and particularly when only one or two days of food intake have been reported [16,25]. Because most survey data are not amenable to providing an examination of longer-term dietary patterns and their impact on the development of overweight and obesity, the present study uses a 14-day food intake methodology to investigate RTE cereal consumption patterns on BMI and nutrient intake in U.S. men and women aged 19-64.

Methods

To determine the effect of food consumption patterns on nutrient intakes, a unique, proprietary methodology utilizing The NPD Group's National Eating Trend (NET) 14-day food diary data was developed at the General Mills Bell Institute of Health and Nutrition. This methodology combines NET's 14-day food diary data with portion-size estimates derived from the National Health and Nutrition Examination

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Survey (NHANES) 1999-2004 [26] and nutrient data from the University of Minnesota's Nutrition Data System for Research (NDS-R)® Version 34, 2008 (Nutrition Coordinating Center, Minneapolis, MN). The resulting integrated database is housed and analyzed using SAS® (SAS Institute, Cary, NC). The dynamic system allows the user to categorize the population based on typical food consumption categories, specific foods, and/or specific brands of foods, and determines dietary differences between the study population and their non-consuming counterparts.

Participants/food consumption data

Study findings are based on information provided by more than 5,000 demographically- representative individuals who completed food and beverage consumption journals for a two-week period. The NPD Group's National Eating Trends service, which provided the data, has been continuously tracking the eating habits of U.S. consumers since March 1, 1980. While initially focused on capturing all foods and beverages consumed or carried from home by a representative sample of U.S. households, in 1989 the focus expanded to include foods and beverages consumed from all sources.

Panel households are recruited randomly, with an annual sample consisting of 2,000 households containing approximately 5,100 individuals. This study utilized NET data collected from March 2006 through February 2008. The panel is demographically and geographically calibrated to U.S. Census Bureau statistics each year at the household level (including ages of panel participants, household income level, household size, age of head of household, employment status, and race) [27].

The sample is divided into 52 sub-samples. Each week a group of nearly 60 households begins recording all foods and beverages consumed by every household member. Each household maintains a daily eating diary for two weeks. The person most responsible for meal preparation is instructed to record the name and brand of each food and beverage consumed by all members of the household, including all additives, ingredients and cooking aids.

The diary consists of separate sections for each meal and snack situation, and collects food names, flavour descriptors, brand names, package types, product forms, appliances used in preparation, and any special nutritional attributes, among other details. The same information is collected on ingredient and additive items used to create dishes or meals in the home. At the end of each day, the homemaker is instructed to mail the daily diary back to The NPD Group's offices. After all 14 daily diaries are received from a household; they are coded and made ready for data processing. The annual diary return rate is approximately 97%.

Portion-size data

NET panellists record the foods and beverages consumed by household members, but do not note the quantities. This procedure is standard for panel surveys to minimize recorder burden and thus increase reliability. Portion sizes were estimated by combining data from the NHANES 1999-2004 [26]. Serving weights for individual food codes were aggregated and then collapsed for like-foods to strengthen cell sizes, and statistically smoothed to eliminate outliers. Age- and gender-specific mean serving weights were then determined for over 800 food types. Portion sizes were subsequently assigned to each food recorded and coded in the NET diary.

Nutrient data

Nutrient intakes were estimated according to previously reported procedures [22]. Nutrient values for foods that were recorded and coded in the NET diary were determined using the recipe component of the Nutrition Data System for Research (NDS-R) software. This system is a highly accurate and comprehensive nutrient calculation system that contains complete values for 160 nutrients found in more than 18,000 foods, including many brand-name products.

Each recorded food or recipe was entered into NDS-R per 100 grams of that food, and was closely matched to the description provided in the NET diary. Recipes were created to account for foods with special nutritional attributes (i.e. low fat, fat-free, low cholesterol, calcium fortified, low sodium, or reduced sodium). Additionally, each food was assigned to one of over 100 food groups, making analysis possible by specific food group.

For this study, estimated mean daily intake values were reported for the following nutrients: carbohydrates, sugar, fat, saturated fat, protein, cholesterol, Sodium, dietary fiber, vitamin A, vitamin E, vitamin C, thiamin, riboflavin, niacin, vitamin B-6, folate, calcium, magnesium, iron, zinc, and energy (kilocalories). The percentage of adults falling below their Estimated Average Requirement (EAR) [28] was calculated for the total sample, as well as for adults in each of the RTE cereal consumption categories.

Data tabulation

A minimum submission of seven days of food collection documentation was required for participant inclusion in the study. Of the 4,829 adults who participated, only 53 (1.1%) failed to complete the seven-day diary information minimum; 4,127 (85.5%) provided complete 14-day diaries of food intake data. The number of times RTE cereal was consumed in 14 days was recorded for each participant. Intake of cereal was considered as both a continuous and categorical variable. Because the distribution of cereal consumption was not symmetrical and was somewhat truncated, quartiles were not used to categorize data. Instead, adults were classified into the following three groups based on cereal consumption patterns during their 14-day data collection period: 0 servings, 1-6 servings (infrequent), and ≥ 7 servings (frequent).

For the purposes of this analysis, a serving is defined as one record of cereal consumption. Each serving is assigned an age- and gender-appropriate mean serving amount. For study participants providing 7-13 diary days, cereal consumption was normalized to 14 days by multiplying the rate of RTE consumption per day by 14.

Body mass index

Individual, self-reported heights and weights were recorded in the diary for each respondent and used to calculate BMI according to the formula BMI = weight (kilograms)/height (meters^2). Overweight was defined as a BMI ≥ 25, and obese was defined as a BMI ≥ 30 [29]. Study sample participants who did not record height and/or weight (n = 359) were excluded from the analysis. Individuals reporting less than seven of 14 days of food consumption data were also excluded from the study (n = 28), resulting in a final sample size of 4,414 adults (2015 men and 2399 women).

Statistical analysis

Mean values or proportions were computed according to cereal intake category. Analysis of variance was used to determine whether

Table 1: Cereal consumption patterns of adults (n=4414) aged 19-64.

		Cereal Consumption Pattern		
		None 0 Servings/14d	Infrequent 1-6 Servings/14d	Frequent ≥7 Servings/14d
Gender/Age	Sample Size	n (%)	n (%)	n (%)
All adults ages 19-64	4414	1294 (29.3)	2104 (47.7)	1016 (23.0)
Male ages 19-64	2015	644 (31.9)	917 (45.5)	454 (22.5)
Male ages 19-34	611	181 (29.6)	296 (48.4)	134 (21.9)
Male ages 35-64	1404	463 (32.9)	621 (44.2)	320 (22.8)
Female ages 19-64	2399	650 (27.1)	1187 (49.5)	562 (23.4)
Female ages 19-34	746	160 (21.4)	399 (53.5)	187 (25.1)
Female ages 35-64	1653	490 (29.6)	788 (47.7)	375 (22.7)

Table 2: Mean Body Mass Index for adults (n=4414) by cereal consumption status.

Gender/Age	BMI by Cereal Consumption Pattern			P
	None 0 Servings/14d	Infrequent 1-6 Servings/14d	Frequent ≥7 Servings/14d	
	n (%)	n (%)	n (%)	
Male ages 19-64	28.2[a]	28.2[a]	26.7[b]	<0.0001
Male ages 19-34	27.2[a]	27.5[a]	25.7[b]	0.0156
Male ages 35-64	28.6[a]	28.5[a]	27.0[b]	0.0002
Female ages 19-64	27.6[a]	28.1[a]	26.7[b]	0.0002
Female ages 19-34	27.1[a]	26.9[a]	25.4[b]	0.0331
Female ages 35-64	27.8[ab]	28.8[a]	27.2[b]	0.0015

[a,b]Means within the same row with the same letter are not significantly different ($P < 0.05$).

Table 3: Percentage of adults (n=4414) classified as overweight or obese by cereal consumption pattern.

	Cereal Consumption Pattern			
	None 0 Servings/14d	Infrequent 1-6 Servings/14d	Frequent ≥7 Servings/14d	
Gender/Age	% Overweight/ Obese	% Overweight/ Obese	% Overweight/ Obese	P
Male ages 19-64	69.4[a]	69.3[a]	60.8[b]	0.0051
Male ages 19-34	58.0[a]	62.5[a]	49.3[b]	0.0272
Male ages 35-64	73.9[a]	72.5[a]	65.6[b]	0.0545
Female ages 19-64	58.0[a]	58.1[a]	48.4[b]	0.0004
Female ages 19-34	54.4[a]	49.6[a]	41.2[b]	0.0416
Female ages 35-64	59.2[a]	62.4[a]	52.0[b]	0.0026

[a,b]Proportions of individual at risk within the same row with the same letter are not significantly different ($P < 0.05$).

BMI differed among the cereal consumption categories. Pair-wise t-tests were performed when differences were found among the cereal intake categories. Logistic regression was used to analyze the association between cereal consumption patterns and risk for overweight in each of the age and gender groups. Contrasts were examined between possible pairs of cereal consumption categories using the Wald chi-square.

The analysis was performed after adjusting for age, age^2, energy intake, fruits, vegetables and dairy intake and household income. Comparisons were made using analysis of variance on intakes of 21 key nutrients among RTE cereal consumption categories. An alpha level of 0.05 was used to determine significance for the analysis of variance comparisons, except where otherwise noted. All analyses were performed using SAS® version 9.2 (SAS Institute, Cary, NC, 2008).

Results

Frequency of consumption of cereals for 4,414 adults ages 19-64 is shown in Table 1. Overall, 70.7% of adults reported eating cereal at least once during their 14-day reporting window. The total population was analyzed according to the RTE cereal consumption categories Frequent (23.0%), Infrequent (47.7%), and None (29.3%). More than 20% of men and women were classified as frequent cereal eaters. Younger women (19-34 years) were found to be more frequent cereal eaters (25.1%) than younger men (21.9%). Consumption of cereal ranged from 0 to 29 servings in 14 days.

A statistically significant, inverse relationship was identified between BMI and frequency of RTE cereal consumption for men and women (Table 2). Significantly lower BMI was found to be associated with adults who ate more than seven servings of RTE cereal during a two-week period. Significantly lower BMI was also found in frequent cereal eaters for all men and women in both age groups (19-34 years and 35-64 years). BMI was higher for men and women ages 35-64 compared to those ages 19-34, but in each age category, frequent cereal eaters exhibited the lowest BMI.

A significant inverse relationship was found between frequency of cereal consumption and that portion of the population classified as overweight (Table 3). Frequent cereal eaters (7 or more servings per 14 days) were less likely to be overweight or obese compared to those who ate cereal infrequently (1-6 servings per 14 days) or not at all. Sixty-one percent of males and 48 % of females who consumed seven or more RTE cereal servings in two weeks were classified as overweight, compared with 69% of males and 58% of females who consumed no cereal.

Micronutrient and macronutrient consumption (including energy intake) differed significantly across cereal consumption groups, with higher reported nutrient intakes (except fat intake) in those consuming

Table 4: Mean daily nutrient intake for adult men (n=2015), ages 19-64, by cereal consumption pattern.

Nutrient	Nutrient Intake by Cereal Consumption Pattern			P
	None 0 Serving/14d	Infrequent 1-6 Servings/14d	Frequent ≥7 Servings/14d	
	Mean ± SD	Mean ± SD	Mean ± SD	
Energy (kcal)	1949 ± 609[a]	2167 ± 620[b]	2345 ± 627[c]	<0.0001
Carbohydrates (g)	227 ± 86[a]	263 ± 87[b]	303 ± 88[c]	<0.0001
Fat (g)	79 ± 26[a]	86 ± 26[b]	86 ± 27[b]	<0.0001
Saturated fat (g)	27 ± 9[a]	29 ± 10[b]	29 ± 10[b]	<0.0001
Protein (g)	79 ± 22[a]	85 ± 22[b]	92 ± 22[c]	<0.0001
%Kcal from carbohydrate	45 ± 7[a]	48 ± 6[b]	51 ± 5[c]	<0.0001
%Kcal from protein	16.4 ± 3[a]	15.8 ± 2[b]	15.8 ± 2[b]	<0.0001
%Kcal from fats	36 ± 5[a]	35 ± 4[b]	32 ± 4[c]	<0.0001
Cholesterol (mg)	281 ± 128[ab]	294 ± 114[a]	269 ± 100[b]	0.0003
Sodium (mg)	3614 ± 1048[a]	3877 ± 1037[b]	4021 ± 1088[b]	<0.0001
Dietary fiber (g)	14 ± 6[a]	16 ± 5[b]	19 ± 6[c]	<0.0001
Vitamin A (mcg RAE)	570 ± 474[a]	677 ± 357[b]	900 ± 385[c]	<0.0001
Vitamin E (mg α-toc)	6.6 ± 4[a]	7.4 ± 4[b]	8.9 ± 5[c]	<0.0001
Vitamin C (mg)	67 ± 57[a]	84 ± 61[b]	107 ± 70[c]	<0.0001
Thiamin (mg)	1.6 ± 0.6[a]	1.8 ± 0.5[b]	2.3 ± 0.6[c]	<0.0001
Riboflavin (mg)	1.9 ± 0.7[a]	2.3 ± 0.7[b]	2.9 ± 0.8[c]	<0.0001
Niacin (mg)	22 ± 7[a]	25 ± 6[b]	30 ± 8[c]	<0.0001
Vitamin B-6 (mg)	1.6 ± 0.5[a]	1.9 ± 0.5[b]	2.5 ± 0.7[c]	<0.0001
Folate (mcg DFE)	416 ± 140[a]	560 ± 166[b]	854 ± 272[c]	<0.0001
Calcium (mg)	728 ± 356[a]	908 ± 342[b]	1208 ± 394[c]	<0.0001
Magnesium (mg)	223 ± 81[a]	256 ± 77[b]	317 ± 91[c]	<0.0001
Iron (mg)	13 ± 4[a]	16 ± 4[b]	22 ± 6[c]	<0.0001
Zinc (mg)	10 ± 3[a]	12 ± 3[b]	15 ± 5[c]	<0.0001

[a,b,c]Means within the same row with the same letter are not significantly different ($P < 0.01$).

Table 5: Mean daily nutrient intake for adult women (n=2399), ages 19-64, by cereal consumption pattern.

Nutrient	Nutrient Intake by Cereal Consumption Pattern			P
	None 0 Servings/14d	Infrequent 1-6 Servings/14d	Frequent ≥7 Servings/14d	
	Mean ± SD	Mean ± SD	Mean ± SD	
Energy (kcal)	1508 ± 448[a]	1650 ± 484[b]	1801 ± 544[c]	<0.0001
Carbohydrates (g)	180 ± 64[a]	207 ± 71[b]	237 ± 80[c]	<0.0001
Fat (g)	61 ± 19[a]	64 ± 20[b]	66 ± 23[b]	<0.0001
Saturated fat (g)	20 ± 7[a]	22 ± 7[b]	23 ± 8[b]	<0.0001
Protein (g)	60 ± 16[a]	64 ± 16[b]	69 ± 17[c]	<0.0001
%Kcal from carbohydrate	47 ± 7[a]	49 ± 6[b]	51 ± 5[c]	<0.0001
%Kcal from protein	16.0 ± 3[a]	15.6 ± 2[b]	15.5 ± 3[b]	0.0077
%Kcal from fats	36 ± 5[a]	35 ± 4[b]	32 ± 4[c]	<0.0001
Cholesterol (mg)	213 ± 96[ab]	219 ± 84[a]	205 ± 81[b]	0.0041
Sodium (mg)	2710 ± 788[a]	2930 ± 772[b]	3034 ± 868[b]	<0.0001
Dietary fiber (g)	11 ± 4[a]	13 ± 4[b]	15 ± 6[c]	<0.0001
VitaminA (mcgRAE)	488 ± 298[a]	559 ± 295[b]	695 ± 267[c]	<0.0001
Vitamin E (mg α-toc)	5.5 ± 3a	5.9 ± 3b	7.2 ± 5c	<0.0001
Vitamin C (mg)	58 ± 45[a]	68 ± 45[b]	86 ± 61[c]	<0.0001
Thiamin (mg)	1.2 ± 0.4[a]	1.4 ± 0.4[b]	1.7 ± 0.5[c]	<0.0001
Riboflavin (mg)	1.5 ± 0.5[a]	1.8 ± 0.5[b]	2.2 ± 0.7[c]	<0.0001
Niacin (mg)	17 ± 5[a]	19 ± 5[b]	22 ± 6[c]	<0.0001
Vitamin B_6 (mg)	1.2 ± 0.4[a]	1.4 ± 0.4[b]	1.9 ± 0.7[c]	<0.0001
Folate (mcg DFE)	330 ± 109[a]	442 ± 134[b]	653 ± 230[c]	<0.0001
Calcium (mg)	592 ± 250[a]	710 ± 264[b]	911 ± 338[c]	<0.0001
Magnesium (mg)	180 ± 61[a]	202 ± 64[b]	245 ± 81[c]	<0.0001
Iron (mg)	9.9 ± 3[a]	12.5 ± 4[b]	16.8 ± 5[c]	<0.0001
Zinc (mg)	7.5 ± 2[a]	8.5 ± 2[b]	10.6 ± 3[c]	<0.0001

[a,b,c]Means within the same row with the same letter are not significantly different (P < 0.01).

≥ 7 cereal servings in two weeks (P < 0.01) (Tables 4 and 5). Overall, frequent cereal eaters had significantly higher intakes of fibre, vitamins, and minerals (P < 0.0001), and lower intakes of cholesterol (P < 0.0001). Macronutrients, as a percentage of energy, differed by cereal consumption category, with frequent cereal eaters consuming a higher percentage of calories from carbohydrates and a lower percentage of calories from fat.

The percent of the population consuming below 100% of the EAR was also examined for adults in the three cereal consumption categories (Table 6). Sizable proportions of adults did not meet the EAR for vitamin E (89% of men and 93% of women) and magnesium (81% of men and 80% of women). However, among both men and women, frequent cereal consumption was associated with significantly fewer failing to meet the EAR (p < 0.01) for all micronutrients (except vitamin E in women).

Significantly fewer individuals failed to meet the EAR for calcium among cereal eaters (11.7% of men and 49.3% of women) as compared to non cereal eaters (67.7% of men and 85.4% of women) (p < 0·01). 95.9% of frequent cereal consuming women failed to meet the EAR for vitamin D when compared to 99.2% infrequent cereal eaters and 99.4% of none cereal eaters (Table 6).

Discussion

Results from this study of RTE cereal consumption, BMI, and nutrient intakes demonstrate the important role that cereal plays in the diets of U.S. adults. Frequent cereal consumption was associated with more healthy body weights and improved nutrient profiles. Among those who consumed cereal, fewer adults fell below the EAR, indicating that cereal consumers had more adequate diets than those who did not consume cereal.

Although difficult to compare directly because of differences in methodology, cereal consumption among adults in this study is comparable to patterns reported in other nationally representative samples in the U.S. In this study, 23% of adults consumed cereal frequently (≥ 7 times in 14 days). In single, 24-hour recall data collected from NHANES III during the years 1988-91 and 1991-94, 17.1% of the population ages 18 and older were categorized as RTE cereal eaters [16].

Data from the 1999-2000 NHANES documents single-day cereal consumption among adults at 21.7% [19]. Single-day cereal consumption reports necessarily include both frequent and infrequent cereal eaters, thus explaining the somewhat lower number of frequent RTE cereal consumers in the present study. Cereal consumption among adults has been reported to increase with age [24]. However, this result was not obtained in the present study. Instead, older adults (ages 35-64) reported eating cereal less often than those under age 35.

Frequent cereal eaters in this study were found to have lower BMI measures than those who consumed cereal less frequently or not at all. The average BMI for frequent cereal eaters in this study was 26.7 for both men and women. This result is consistent with the reported BMI of 26.0 among adult RTE cereal consumers in NHANES III [16]. Body mass index in men who ate one or more servings of cereal per day in the Physicians' Health Study was lower (BMI = 24.4) [30], but this is likely due to the unique composition of the study population (male physicians, rather than a sample matched to the heterogeneous demographics of the U.S. population).

Several possible explanations may explain the association between cereal consumption and body weight. First, RTE cereal consumption may be a marker for other healthy lifestyle factors. Dietary patterns featuring RTE cereal consumption have been associated with increased levels of physical activity [21], smaller weight gains in women and smaller waist circumference increases in both men and women [31], and lower BMI with reduced mortality rates in men [30]. In addition, adults who eat cereal frequently are most likely to eat breakfast. Thus,

Table 6: Percentage of adults (n=4414) falling below the Estimated Average Requirement (EAR) by cereal consumption category.

Nutrient	Cereal Consumption Pattern					
	None 0 Servings/14 d		Infrequent 1-6 Servings/14 d		Frequent ≥7 Servings/14d	
	Men	Women	Men	Women	Men	Women
Vitamin A[a,b]	40.9	37.2	23.9	25	19.6	18
Vitamin E[a]	79.2	92.1	73.6	91.7	70.3	88.3
Vitamin C[a,b]	42.6	41	29.6	29.9	23.9	28.8
Thiamin[a,b]	5.5	8.2	0.3	2	1	1.5
Riboflavin[a,b]	7.7	6	1	1.4	1.6	1.2
Niacin[b]	3.3	3.8	0.3	1.4	1	1.2
Vitamin B_6[a,b]	8.8	21.3	2.6	8.2	2.3	3
Folate[a,b]	21.9	23.9	3.2	2.2	0.7	0
Magnesium[a,b]	71.3	71.7	63.3	59.9	52.6	52.9
Iron[b]	2.4	9	0	2.4	0	0.9
Zinc[a,b]	17.5	15.8	9.4	7.9	6.9	5.7
Calcium[a,b]	67.7	85.4	41.4	72.8	11.7	49.3
Vitamin D[a,b]	97.7	99.4	95.7	99.2	85.2	95.9

[a]Significantly fewer men failed to meet the EAR for nutrients among cereal eaters compared to those who did not eat cereal (P < 0.01).
[b]Significantly fewer women failed to meet the EAR for nutrients among cereal eaters compared to those who did not eat cereal (P < 0.01).

the association may reflect eating patterns that are more beneficial for the regulation of body weight.

For example, breakfast skipping has been associated with higher BMI in adults [15,17,19], and additional weight gain as children grow through adolescence [18,20,22,32]. Furthermore, breakfast consumption and low-fat intake are characteristics common to people who have successfully maintained long-term weight loss [31,33]. Because RTE cereals are lower in fat content compared to other breakfast alternatives, overall daily fat intakes are lower for adults who consume RTE cereal [16,20,24,25]. Lower fat intake may contribute to a more favourable energy balance and, hence, healthy BMI.

Consumption of RTE cereal has been shown to improve intakes of macronutrients, dietary fibre, and micronutrients [16,20-24]. The frequent cereal consumers in this study had significantly higher intakes of carbohydrates and dietary fibre, and significantly lower intakes of fat as a percentage of total calories. Frequent cereal eaters also had higher intakes of micronutrients and were more likely to meet the recommended levels. Higher intakes of B-vitamins, calcium, iron, and zinc, in particular, are characteristic of breakfasts including fortified RTE cereals eaten with milk. An improved nutrient intake profile appears to be largely related to the consumption of RTE cereal and the breakfast foods it may replace, as well as a pattern of healthy eating throughout the day.

This study has certain inherent limitations. First, the data are self-reported. However, The NPD Group provides instruction for panellists to fully describe food intakes, and diaries are returned on a daily basis. Second, estimates of portion size are applied based on average serving size for 15 age and gender groups reported in national surveys. This method assumes that the average serving size applies to all individuals of the same age and gender, which clearly provides errors of the estimate for the individual. However, when applied to the total sample, it is expected that mean serving size intakes will approximate estimates of intake provided by dietary survey data. This appears to be true because of the agreement with previously published population-based surveys [16-22].

In addition, it should be noted that differences in the mean comparisons across categories of RTE cereal consumption cannot be explained by an error in the accuracy of the estimate of total intake, an error which would be present across all categories. Thus, the conclusion remains that the most frequent consumers of RTE cereals have better nutrient intakes compared with those who consume RTE cereals least frequently. A strong element of this survey design is the recording of 14 days of food intake information. Thus, it is possible to determine additional associations between other food patterns and BMI, and will lead to continued research in this area.

Conclusions

Regular cereal consumption is related to lower BMI and improved nutrient intakes in adults. While cereal eating by itself may not ensure a healthy body weight, cereal consumption plays a significant role as part of a healthful eating pattern that includes regular breakfast consumption and appropriate energy intakes. Thus, the consumption of RTE cereals should be encouraged as a component of an eating pattern promoting the maintenance of healthy body weights and nutrient intakes by adults.

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