Association between Frequency of Ready-to-Eat Cereal Consumption, Nutrient Intakes, and Body Mass Index in Fourth- to Sixth-Grade Low-Income Minority Children

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ABSTRACT

Background The consumption of non-ready-to-eat cereal and ready-to-eat cereal (RTEC) breakfasts have been associated with increased nutrient intakes and lower body mass index (BMI). These relationships have not been examined in low-income minority children.
Objectives To evaluate, in low-income minority children, whether there is a relationship among the frequency of RTEC consumption and nutrient intakes measured at baseline, and whether there is a relationship between the frequency of RTEC and BMI controlling for age, sex, ethnicity, and energy intake.
Design A longitudinal study design where a cohort was followed for 3 years.
Subjects/setting Participants were 625 fourth- through sixth-grade, low-income children living in San Antonio, Texas, and enrolled in the control arm of the Bienestar Diabetes Prevention Program's cluster randomized trial. Three multiple-pass 24-hour dietary recalls were collected at the beginning of their fourth-grade year and at the end of their fifth- and sixth-grade years. Children's age, sex, ethnicity, and height and weight (used to calculate BMI) were collected between August 2001 and May 2004.
Statistical analyses performed Descriptive and inferential statistical analyses were performed. The frequency of breakfast consumption was examined using a 6×4 cross-tabulation table with χ^2 test to establish categorical differences. The degree of association between BMI percentile and frequency of RTEC consumption adjusted for age, sex, ethnicity, and nutrition-related parameters were calculated using a partial correlation multivariate linear model analysis.
Results There was a significant positive relationship between the frequency of RTEC consumption and nutrient intakes measured at baseline. There was also a significant inverse relationship between frequency of RTEC consumption and BMI percentile over the cumulative 3-year period controlling for age, sex, ethnicity, and energy intake.
Conclusions Children who frequently consumed RTEC had greater intakes of essential nutrients at baseline and significantly lower BMI over a 3-year period.
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CHILDHOOD OBESITY HAS REACHED EPIDEMIC PROportions in the United States.[1,2] One in three American children are overweight (body mass index [BMI] ≥85th to 94th percentile) or obese (BMI ≥95th percentile) and at risk for chronic diseases such as type 2 diabetes, metabolic syndrome, and cardiovascular disease.[3-6] Childhood obesity is more common among minority children and children living in poverty. Among children aged 6 to 11 years, the combined prevalence of overweight and obesity was 40% for Mexican-American, 36% for African-American, and 26% for non-Hispanic white children.[7] Socioeconomic status also plays a role in the likelihood of a child being obese. Data from the 2003-2004 National Survey of Children's Health[8] showed that obese children were more likely to be Hispanic and live in households with incomes below 150% of the federal poverty level.

Obesity is a multifactorial condition; however, eating patterns and the nutritional value of food children consume may be a significant contributing factor. Some studies[9-12] have reported an inverse relationship between the frequency of breakfast consumption and BMI and/or weight status. There is also a trend among children as they grow into adolescence to not eat breakfast.[9,13] Moreover, the foods and beverages that comprise break-

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fast may influence body weight. One longitudinal study[9] conducted in girls examined cereal (both ready-to-eat and cooked) consumption and reported an inverse relationship between increased number of days of eating cereal and lower BMI *z*-scores and overweight. Although BMI and body fat increased as girls matured into adolescence, cereal eaters were still leaner than girls who did not eat cereal.[9] These results were supported by another cross-sectional study that examined the relationship of ready-to-eat cereal (RTEC) intake and BMI among children aged 4 to 12 years.[14] There was a significant inverse relationship between frequency of RTEC consumption and BMI. Children who ate ≥8 servings of RTEC during a 2-week period had significantly lower BMI compared with children who ate ≤2 servings during the same time period. Energy intake was not correlated with BMI.[14]

The nutrient density of RTECs, many of which are fortified with vitamins and minerals, can be important contributors to overall diet quality. Children who consume RTEC have increased intakes of calcium, iron, folate, zinc, vitamin A, vitamin B-6, thiamin, riboflavin, niacin, magnesium, fiber, vitamin C, and decreased fat and cholesterol intakes.[9,14-16] The dietary intake of Hispanic children, who were the majority in this study, has been shown to be deficient in essential nutrients such as calcium, potassium, magnesium, phosphorus, fiber, and folate.[17,18] RTEC may provide an important source for these nutrients. The objectives of the present study were to evaluate, in low-income minority children, whether there is a relationship between the frequency of RTEC consumption and nutrient intakes measured at baseline, and whether there is a relationship between the frequency of RTEC consumption and BMI. The hypotheses were there would be a positive relationship between the frequency of RTEC consumption and nutrient intakes, and the frequency of RTEC consumption would have a significant inverse association with BMI.

METHODS

Participants

This study was a secondary analysis of data collected for a primary study, Bienestar: A School-Based Type 2 Diabetes Prevention Program (Bienestar). Children in this study were enrolled in elementary schools of an inner-city school district of San Antonio, TX. The purpose of Bienestar (*bienestar* means "well-being" in Spanish) was to use a culturally appropriate school-based health program to reduce the risk of developing type 2 diabetes mellitus in high-risk children. Results and methods of the primary study have been described elsewhere.[19] Briefly, Bienestar was carried out in 27 schools that were randomized into either control (n=14) or intervention schools (n=13). Children were recruited at the beginning of the fourth grade (2001-2002 school year) and followed through their sixth-grade year (2003-2004 school year). Children in the treatment group, compared with those in the control group, had a significant decrease in fasting blood glucose levels and increase in dietary fiber intake and fitness levels. To avoid confounding results that might be caused by the dietary intervention, only children in the control group were included in this analysis.

Children were recruited by a letter sent to the parent/guardian with a consent/assent form in both English and Spanish. The parent/guardian signed the consent and the child signed the assent at the beginning of the 3-year study. Only children who returned written informed consent forms signed by their parent/guardian and who assented to the study participated in data collection. The main trial was approved by the Institutional Review Board of the University of Texas Health Science Center at San Antonio, and the analysis was approved by the Institutional Review Board of Texas Woman's University, Denton.

Measures

Children provided information during three data collection periods: beginning of the fourth-grade school year, end of the fifth-grade school year, and end of the sixth-grade school year. During these data collection periods children provided three 24-hour dietary recalls (collected from each child during a one-on-one interview) and had their height and weight measured and this information was then used to calculate his or her BMI. Children's data were collected on-site at each elementary school in English or Spanish depending on child's preference. Data collection was conducted during an 8-week period during the first 2 months and/or last 2 months of the school year.

The children's families provided the following information at baseline: family demographic survey to measure parent income; educational attainment; and children's age, sex, and ethnicity. The surveys were given to the students and/or parents at school or were mailed home and then were either returned at the school to a designated private box or collected by trained research staff. The nonresponse surveys were collected by telephone calls to the household.

Dietary recalls have been found to be reliable and valid in children of the ages in this study.[20,21] The dietary data were recorded during 3 consecutive days according to the following schedule: Monday interview recorded what the child ate on Sunday, Tuesday interview recorded what the child ate on Monday, and Wednesday interview recorded what the child ate on Tuesday. The dietary intake data were collected on three different visits to the school so the child only had to recall 1 day's food intake at a time.

Three 24-hour dietary recalls were collected from children by 20 trained interviewers. The interviewers were trained by a registered dietitian who had been certified through Nutrition Data System for Research (NDS-R). An extensive 2-day training and a third day of certification was required for all interviewers. A multiple-pass method was used.[18] Children were prompted to identify the type and brand of cereal consumed and if milk was consumed with cereal they were asked to identify the type of milk. Culture-specific foods were added to NDS-R database.

The 24-hour dietary recall protocol used several techniques to maintain accuracy. The dietary interviewing technique included a script for dialogue, prompting methods, and recording methods. To increase accuracy of portion sizes, food models and measuring utensils were used. Dietary intake data were analyzed using NDS-R version 2006 (Nutrition Coordinating Center at University of Minnesota).

The outcome variable was BMI. BMI was a continuous variable calculated for each participant using the following formula: BMI=weight in kilograms/height in meters^2. Conversion of raw BMI values to BMI percentile was performed using the Centers for Disease Control and Prevention reference chart specific for sex and age.

Child's height was measured to the nearest 0.1 cm with his or her shoes and socks removed using a wall-mounted stadiometer (Seca Bodymeter 206, Seca Corp) and body weight was measured to the nearest 0.1 kg using a combination weight scale/bioelectric impedance instrument (Tanita Corporation of America, Inc). Children's height and weight were collected between August 2001 and May 2004.

For the purpose of this study, breakfast was considered the first meal of the morning consisting of any solid food, beverages, or both and named by the respondent as "breakfast."[22] RTEC was defined as a cereal that is processed to the point that it can be eaten without additional preparation.[23] The independent variable was RTEC breakfast consumption. If any RTEC was consumed, breakfast was classified as RTEC breakfast consumption. If no breakfast was consumed, breakfast was classified as no breakfast consumption. Nontraditional "breakfast cereals" such as granola bars, snack mixes (eg, Chex mix [General Mills, Inc]), and cereal bars (eg, Rice Krispies bars [Kellog Comapnay]) were not considered as RTEC. A day was classified as a dichotomized (any vs none) variable; therefore, any amount of RTEC consumed was classified as RTEC breakfast.

The frequency of RTEC breakfast consumption was a linear variable based on reporting from the child. The frequency of RTEC breakfast consumption was determined as 0=no RTEC breakfast, 1=1 day of eating RTEC breakfast, 2=2 days of eating RTEC breakfast, and 3=3 days of eating RTEC breakfast. Three days of RTEC breakfast per grade level was the highest frequency because of the total of 3 days of dietary recalls collected per grade level. Therefore, the range of RTEC days over the 3 school years was 0 to 9 days.

Data Analysis

Descriptive and inferential statistical analyses were performed using IBM/SPSS for Windows Statistical Software version 19.0 (2010, SPSS Inc). The frequency of breakfast consumption was examined using a 6×4 cross-tabulation table with χ^2 test to establish categorical differences. Multiple linear regressions were conducted to identify predictors of BMI percentile change with RTEC as the primary fixed effect parameter. This was accomplished using iterative growth curve regression model during three time points. A set of independent variables served as covariates to RTEC. These covariates were treated as either interaction effect with RTEC (sex, ethnicity, and age) and/or random effect (energy, total carbohydrates, and total fat) predictors to cumulative linear change in BMI percentile. The degree of association between change of BMI percentile and frequency of RTEC consumption adjusted for age, sex, ethnicity, and the nutrition-related covariates were calculated using a partial correlation multivariate linear model analysis:

$$y_{ij}=\beta_0\,(1)+X_i\,\beta_i+g_{0i}\,(1)+Z_i g_i+e_i$$

where y_{ij} are repeated measures of student's (i) BMI percentile arranged in rows; and rows are nested within grade levels (j). Variables β_0 and β_i are the respective intercept and slope of the multivariate linear model. Variable X_I is the fixed effect vectors (RTEC frequency) and considered as part of the intercept, and Z_i is the random effect model (dummy variables) and acts as an error term. The random part is specified by the equation, $Z_i g_i+e_i$, which represents the variances and covariances. Lastly, BMI percentile by frequency of RTEC breakfast consumption was presented graphically with fitted line equation. Because this equation showed data of the 3 school years, 9 days was the maximum number.

Table 1. Student, household, and parental characteristics at baseline of low-income fourth graders (N=625) participating in a study to examine the relationship among the frequency of ready-to-eat cereal consumption and nutrient intakes

Characteristic	Mean±standard deviation
Age (y)	9.13±0.46
Body mass index percentiles	
Boy	68.32±30.04
Girl	69.02±29.29
Persons per household	4.95±1.73[b]
Monthly household income ($)	1,189.32±475.87[c]

	n	%
Sex		
Boy	309	49
Girl	316	51
Ethnicity		
Hispanic	488	78
African American	74	11.8
Non-Hispanic white	39	6.2
Other	24	3.8
No. of respondents who qualified for FRSM[a]	481	77
No. of missing respondents	144	23
Paternal educational attainment		
Less than high school	131	27.2
High school or General Educational Development diploma	158	32.8
College or higher	72	14.9
Missing	120	24.9
Maternal educational attainment		
Less than high school	108	22.4
High school or General Educational Development diploma	188	39
College or higher	104	21.6
Missing	81	16.8

[a]FRSM=Free and reduced-price school meal program.
[b]n=418.
[c]n=388.

RESULTS

Of the 1,024 children assigned to the control group, 706 children had consent/assent forms provided. Among the 706 children, 625 with complete dietary and anthropometric data at baseline were included for this analysis. At baseline the mean age of children was 9.13 years (Table 1) and the majority of children were Hispanic (78%). There was about equal repre-

Table 2. Mean nutrient intake and ready-to-eat cereal (RTEC) frequency of consumption (no. of days) at baseline, of low-income fourth graders (N=625) participating in a study to examine the relationships among frequency of RTEC consumption and nutrient intakes

	No. of Days of Consumption			
Nutrient	**0 (n=208)**	**1 (n=184)**	**2 (n=162)**	**3 (n=71)**
Energy (kcal)	1,602±596.06	1,619±528.48	1,631±560.97	1,713±768.47
Carbohydrate (g)	195±77.60	203±72.85	204±72.05	216±95.77
Fat (g)	65±27.99	64±23.98	64±25.17	67±35.15
Saturated fat (g)	23±10.47	23±8.77	24±9.22	25±12.75
Cholesterol (mg)	269±169.85	242±139.53	225±124.29[a]	215±145.47[b]
Dietary fiber (g)	10±4.82	11±5.32	11±4.36	11±5.39
Vitamin D calciferol (μg)	4.23±2.098	4.67±1.81[c]	5.28±2.021[a]	5.68±2.34[bd]
Vitamin C ascorbic acid (mg)	65.25±41.22	66.41±39.37	74.15±39.63	87.75±45.61[bd]
Riboflavin (mg)	1.46±0.55	1.66±0.53[ce]	1.86±0.63[a]	2.04±0.77[bd]
Niacin (mg)	14.52±6.47	16.48±5.77[e]	18.03±6.05[a]	20.14±7.94[bd]
Vitamin B-12 cobalamin (μg)	3.32±1.71	3.75±2.73	4.06±1.59[a]	4.35±2.02[b]
Vitamin E (mg total α-tocopherol)	4.74±2.212	4.97±2.43	5.07±3.64	5.31±4.68
Calcium (mg)	684.27±270.95	728.73±289.82[c]	833.34±352.25[a]	822.92±347.79[b]
Sodium (mg)	3,104.83±2,863.05	2,982.60±1,108.28	2,871.94±1,029.13	3,000.58±1536.43
Iron (mg)	9.95±4.02	11.41±3.84[ce]	12.80±3.93[af]	14.80±5.36[bd]
Zinc (mg)	8.32±3.49	8.96±2.94[c]	10.04±3.24[a]	11.24±4.01[bd]
Potassium (mg)	1,740.23±634.90	1,824.30±577.48	1,915.41±610.15[a]	2,030.64±771.87[b]

[a]0 d vs 2 d $P\leq0.05$.
[b]0 d vs 3 d $P\leq0.05$.
[c]1 d vs 2 d $P\leq0.05$.
[d]1 d vs 3 d $P\leq0.05$.
[e]0 d vs 1 d $P\leq0.05$.
[f]2 d vs 3 d $P\leq0.05$.

sentation of male (49%) and female (51%) children. Among the survey respondents, there were 62% of families residing in low-income households with the majority of parents having high school education or less (60% of fathers and 61% of mothers).

Frequency and Composition of Breakfast

Of 411 children who had complete longitudinal information for all three time points, the frequency of children consuming 3 days of any type of breakfast (non-RTEC or RTEC) by grade level decreased from fourth (n=264; 64%) to fifth (n=231; 56%) to sixth grades (n=171; 42%) ($P<0.05$). That is, as children progressed in grade level their frequency of eating breakfast decreased.

The most frequently consumed foods for non-RTEC breakfast were juice (7.5%), scrambled eggs (4.2%), white bread (3.6%), breakfast taco (3.1%), sausage (2.7%), biscuit (2.4%), and tortilla (1.7%). The majority of the RTEC consumed contained added sugar. The most frequently consumed RTECs were Frosted Flakes (Kellogg Company) (27.4%), Cheerios (General Mills Inc) (10.5%), and Kix (General Mills Inc) (5.4%). Sixty-two percent of the milk consumed at breakfast was whole milk, followed by low-fat milk (25.6%) and reduced-fat milk (9.9%). Because most of the Hispanic children were Mexican American, traditional Mexican foods such as tortillas and tacos were consumed for non-RTEC breakfast. Other non-RTEC breakfast foods were those prepared with white flour such as biscuits, pancakes, tortillas, and white bread.

Relationship between RTEC Breakfast and Nutrient Intakes

RTEC consumption was associated with increased intakes of essential nutrients (Table 2). An increased frequency of RTEC consumption was significantly related to increased intakes of vitamins D, B-3, B-12, riboflavin, calcium, iron, zinc, and potassium. There was a significant decrease in cholesterol intake with increased days of RTEC consumption.

Relationship between RTEC and BMI

Table 3 represents a multivariate linear regression analysis of BMI percentile. Of the three interacting variances (main effects), the frequency of RTEC consumption provided the most useful predictor of BMI change (β_0 at 27.981±1.62 percentile). Frequency of RTEC consumption significantly (P=0.001) affected a child's BMI (R^2 change=0.031) with a decrease of 2 percentiles (−1.977±0.209) for every day of RTEC consump-

Table 3. Multivariate effects of number of days of ready-to-eat-cereal (RTEC) consumption, sex, age, and grade level (time) on body mass index (BMI) percentile of low-income fourth graders (N=625) participating in a study to examine the relationship among the frequency of RTEC consumption and nutrient intakes

Multivariate parameter estimates on BMI %tile	Estimate±standard error	df	*F*	*P* value	R^2
Main effects					
Intercept (β_0)	27.981±1.620	1	21.916	0.001	0.226
Days of RTEC (β_1)	−1.977±0.209	2	13.177	0.001	0.031
Sex (β_2)	−0.131±0.480	1	1.630	0.202	0.004
Time/grade level (β_3)	−6.450±5.680	3	0.298	0.742	0.001
Interaction effects					
Days of RTEC×sex	−2.901±7.620	6	2.213	0.020	0.045
Days of RTEC×time	−1.401±5.090	13	1.730	0.084	0.045
Days of RTEC×time×sex	−3.880±0.982	13	2.388	0.037	0.046
Covariates					
Ethnicity	0.000	4	0.882	0.378	0.000
Age (8-13 y)	−.578±0.545	6	0.470	0.493	0.000
Energy (kcal)	−.001±0.001	6	0.162	0.688	0.000
Total carbohydrate (g)	−19.170±28.170	6	0.470	0.336	0.000
Total fat (g)	−0.216±0.480	6	3.716	0.045	0.009

tion, whereas sex, ethnicity, age, and time had no effect. To further explain the influence of RTEC consumption on BMI in terms of macronutrient intake, the amount of fat consumption (total fat) was a significant (P=0.045) determinant to BMI percentile change (R^2 change=0.009) resulting in −0.216±0.480 percentile change from β_0, whereas total energy and carbohydrate had no significant effect.

The Figure shows the relationship between BMI percentile and number of days RTEC consumed during the 3 school years. There was a significant inverse relationship between days of RTEC consumption and BMI percentile.

DISCUSSION

In this study the frequency of eating RTEC breakfast was investigated as it relates to nutrient intakes and BMI in mostly minority children living in households from low socioeconomic status. Results indicated that there was a decrease in frequency of eating breakfast (non-RTEC and RTEC breakfast) as children grew older. Children who consumed RTEC frequently had significantly increased intakes of essential nutrients. There was a significant inverse association between the frequency of RTEC consumption and BMI percentile across the 3 school years.

Frequency of Breakfast Consumption among Youth

Several studies have reported the decline of breakfast consumption as children age. In one study, breakfast consumption declined in three age groups between 1965 and 1991: preschoolers, 8- to 10-year-olds, and adolescents by 5%, 9%, and 13% to 20%, respectively.[24] The greatest decrease was among adolescent girls aged 15 to 18 years whose breakfast consumption declined 20%. In another study[13] with an ethnically diverse population, breakfast consumption decreased over 10 years. At age 9 years, 77% of non-Hispanic white girls and 57% of African-American girls consumed breakfast on all 3 days compared with approximately 32% and 22%, respectively, by age 19 years. A third study also showed that breakfast consumption decreased over 5 years.[11] At baseline, breakfast was eaten on 4.34±0.06 days over a 1-week period. At the 5-year follow-up, breakfast consumption decreased to an average of 3.09±0.05 days. The present study also found youth decreased their breakfast consumption as they grew older.

RTEC Breakfast and Nutrient Intakes

RTEC consumption did contribute significantly to intakes of vitamins D, B-3, B-12, riboflavin, calcium, iron, zinc, and potassium and decreased cholesterol intake. More days of RTEC consumption were related to increases in three of the four nutrients of concern (ie, calcium, vitamin D, and potassium) as stated by the Dietary Guidelines for Americans, 2010. Most Americans—children and adults—are not consuming adequate amounts of the nutrients of concern (ie, calcium, vitamin D, potassium, and fiber).[25] A previous study reported that cereal itself offered more micronutrients relative to other foods eaten during breakfast and may facilitate the intake of

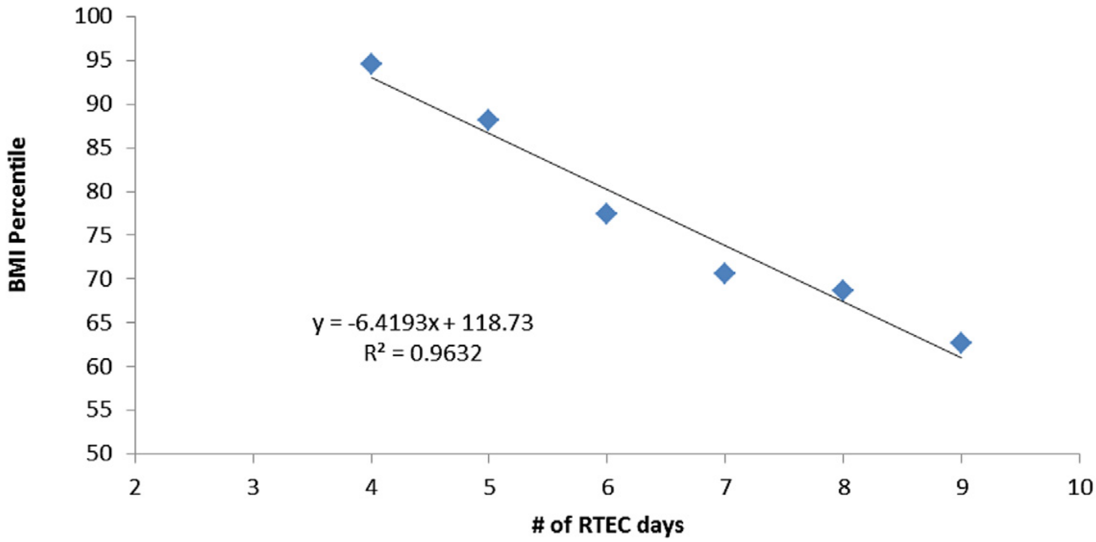

Figure. Relationship between body mass index (BMI) percentile and days of ready-to-eat-cereal (RTEC) consumption (# days) in fourth- through sixth-grade, low-income children.

other healthful foods at breakfast and displace less healthful foods.[16]

RTEC at breakfast is often eaten with milk that may contribute to the intake of calcium.[26] Milk is the number-one food source of three of the four nutrients of concern, namely calcium, vitamin D, and potassium.[27] Adequate intake of calcium during childhood and adolescence is critical for the body to reach peak bone mass, which may reduce the risk of fractures and osteoporosis later in life.[28]

Of the respondents to the baseline demographic survey, 77% of children were eligible for free or reduced-price school meals. The National School Breakfast Program must provide, on average over each school week, at least 25% of the daily Recommended Dietary Allowances for protein, iron, calcium, and vitamins A and C.[29] However, students' actual participation in the breakfast and lunch programs was not tracked in this study.

Breakfast and BMI

Studies to determine the relationship between breakfast and BMI have shown mixed results. Several studies have reported an inverse relationship between breakfast consumption and BMI. The National Heart, Lung, and Blood Institute Growth and Health Study (a longitudinal cohort study of 1,166 non-Hispanic white and 1,213 African-American girls aged 9 or 10 years at baseline) reported that breakfast consumption by African-American and non-Hispanic white adolescent girls was negatively correlated with BMI.[13] A cross-sectional study of 3,275 children aged 5 to 14 years was conducted in New Zealand. Not consuming breakfast was associated with a higher BMI.[30] Another cross-sectional study[12] of 4,049 middle-school students was conducted in central Kentucky. A "healthy weight" was described as BMI for age between the fifth and 84th percentile; healthy weight students consumed breakfast more frequently than overweight and obese students.

Conversely, several other studies have reported that there was no relationship between breakfast and BMI. Among 1,151 low-income African-American children attending second through fifth grades in New Jersey, 36% of children were obese, which was not related to breakfast consumption.[31] A survey of 3,007 Australians aged 2 to 18 years also reported no association between breakfast consumption and BMI.[32]

RTEC Consumption and BMI

Previous longitudinal studies have reported the association between RTEC breakfast consumption and BMI. The National Heart, Lung, and Blood Institute Growth and Health Study reported the frequency of eating RTEC breakfast was predictive of lower BMI.[9] Another study[33] of 660 children aged 8 to 10 years at baseline and followed for a mean of 7.5 years showed that a lower BMI was associated with more days of RTEC consumption for boys.

An intervention study[34] with 147 overweight or at risk of overweight 6- to 12-year-old Mexican children examined whether an increase in RTEC intake was an effective strategy to decrease excess body weight. Children consumed from four different types of RTEC: corn flakes; a presweetened corn-based RTEC; a presweetened corn-based, chocolate-flavored RTEC; and a presweetened rice-based, chocolate-flavored RTEC. After 12 weeks of intervention, an increase in RTEC consumption was effective in reducing body weight and body fat only when nutrition education was part of the treatment compared with the control group.

Several cross-sectional studies have reported an inverse association between RTEC and BMI. A study of 603 children aged 4 to 12 years reported this finding with a sample of 87% non-Hispanic white and 13% "other" children.[14] Within tertiles of RTEC consumption, children in the upper tertile of consumption had lower mean BMI vs children in the lowest tertile of RTEC consumption. A Greek study[35] of 2,008 adolescents aged 12 to 17 years reported RTEC breakfast consumption was associated with lower BMI in boys (P=0.08) and girls (P=0.019), regardless of age and physical activity. Another finding was that the consumption of presweetened cereals was associated with lower BMI for both girls and boys ($P<0.001$). These findings are supported by the present study.

Other studies, however, have reported no relationship between RTEC breakfast consumption and BMI. A study[36] of 1,015 children aged 12 to 15 years in Northern Ireland showed no relationship between RTEC consumption and BMI. Another study[37] of 200 children in Spain aged 9 to 13 years found no relationship between RTEC consumption and BMI.

The lack of an inverse association between RTEC consumption and BMI in some studies may be due to several possible factors. There are methodologic issues in previous studies that may account for the discrepancy such as the definition of "breakfast" varied without a description of food usually being offered. The definition and measurement of breakfast frequently varied without a rationale usually being offered. Other studies have used three 24-hour recalls; however, they defined breakfast based on the time of day and established cut-offs for breakfast as eating between 5:00 AM to 10:00 AM on weekdays and 5:00 AM to 11:00 AM on weekends.[9,13] Another study[31] collected a 24-hour diet recall and a Morning Eating Behavior Survey. Some studies used food frequency questionnaires to assess breakfast consumption by inquiring about typical breakfast consumption during a 1-week timeframe. However, the responses were collected in different formats and then often categorized differently. For example, one study used self-reporting of breakfast by asking, "How many days did you eat breakfast during the past 7 days?" There were eight responses that ranged from "none" to "all 7 days." The researchers then collapsed the categories into "did not consume," "1-3 days in the past week," "4-6 days in the past week," and "every day."[12] Another study asked the same question; however, they did not categorize the responses; instead the responses were reported as a continuous variable ranging from 0 days to 7 days.[11] There was also translation of responses; for example, one study asked, "Over the past week, did you eat or drink something before you left home for school in the morning?" The responses were "yes, usually," "yes, sometimes," or "no." Because there were few "no" responses, the researchers categorized the responses into "usually=regular breakfast eater" and "sometimes/none=breakfast skipper."[30] Overall, the food frequency questionnaires typically asked about a typical week's breakfast consumption in slightly different formats. The difference lies in how the responses were categorized and each study chose a different format to report typical breakfast consumption. The present study used 24-hour dietary recalls and distinguished breakfast by whether it was non-RTEC or RTEC. In addition, it was defined as breakfast if it was self-reported by students and if it was the first meal in the morning. Anthropometric data were self-reported in one study[12] vs using trained staff to measure height and weight by standardized methods[30-32] as was done in the present study. There is also discrepancy with either using a continuous or categorical measurement of BMI.

The Role of RTEC Consumption in Obesity Prevention

RTEC consumption may be a marker of an overall healthy lifestyle.[9,14,16] Breakfast consumption, specifically RTEC consumption, may indicate eating patterns that are more favorable for weight maintenance. It is possible that a breakfast including RTEC may provide satiety and prevent consumption of less nutrient-dense foods later in the day. Because RTEC is typically lower in fat than other breakfast options, fat intakes have been lower in adults and children who eat RTEC.[38-40] Lower fat intake may help maintain a favorable energy balance and ultimately a favorable BMI. If RTEC consumption is associated with these healthy eating behaviors, then it may be a useful behavior to incorporate for obesity prevention.

The amount of sugar in some RTEC may raise some concern. According to National Health and Nutrition Examination Survey 2005-2006 data,[41] RTECs (including presweetened cereals) contributed <5% of children's daily sugar intake. More than 45% of added sugar in children's diets was from fruit drinks and carbonated soft drinks that are not providing other essential nutrients along with the energy. Barton and colleagues[9] reported cereal eaters were leaner than noncereal eaters and 41% of the cereals eaten were presweetened. According to the 2010 Dietary Guidelines,[42] sugar added to nutrient-dense foods like whole-grain cereal and fat-free milk products may improve palatability thereby increasing intakes of essential nutrients.

In light of the risk for disease in obese children, measures should be taken to educate families and children about empowering them to make well-balanced food decisions. Minority children are at an even greater risk for obesity and type 2 diabetes; therefore, nutrition education efforts should also focus on eating a nutrient-dense breakfast that helps promote a healthy weight and overall well-balanced nutrient intake.[9] Economical nutrient-dense breakfast foods that are convenient may be more easily incorporated into busy lifestyles. Because 92% of RTECs are fortified with essential micronutrients, they are convenient and nutritious breakfast options for children.[43] Milk is typically consumed with RTEC, thereby increasing the consumption of essential nutrients such as calcium.[26,44]

Health practitioners, especially those involved with nutrition education, should continue to promote the importance of eating a nourishing breakfast with RTEC as a nutritious option in lieu of other, less nutrient-dense foods. Parents also have the potential to be powerful role models for their children. Parents who understand this role may set an example for their children by eating a nutritious breakfast daily. Schools may be a suitable setting for interventions aimed at developing positive eating behaviors such as consuming a nutrient-dense breakfast that includes whole-grain cereals, low-fat milk, and fresh fruit as part of the School Breakfast Program.[45,46]

Limitations

Four limitations must be noted. First, this was a longitudinal study design where participants were followed during 3 years; thus, we cannot determine whether the relationship between frequency of RTEC consumption and BMI observed in this study are sustained long term. Second, during the data screening process, scatterplots suggested a lack of homoscedasticity of variance. There was a cone-shaped pattern on the scatterplots instead of the expected rectangular pattern. This may be indicative of a slight reduction of power and, thus, a limitation. However, the number of participants provided a large sample and power was obtained from this large sample size. Third, the dietary data were self-reported by children. Recall bias and memory reliance may lead to inaccurate dietary intake information.[47] Obese individuals may underreport food intake, thereby possibly underreporting their breakfast intake.[48] However, the present study used three 24-hour diet recalls (2 weekdays and 1 weekend day) that may capture typical breakfast eating habits better than using only one 24-hour diet recall. The trained staff helped ensure that results were collected in uniform manner. The recalls were collected on three separate site visits so the participant only had to recall 1 prior day's diet intake at a time. Lastly, we examined a sample of mostly minority children residing in low-income households, which is not representative of the US children population.[18]

Strengths

There were several strengths to this study. First, this study was a collaboration effort between a community-based research center, a university, and a school district. This collaboration allowed opportunity for community engagement and advancement in health education and health promotion. Second, this study examined the association between breakfast type consumption and BMI in a disparate population of low-income minority children, 78% of whom were Hispanic. This is important because minority children and those living in poverty are at higher risk for obesity.[6,49-51] Lastly, the present study added to the growing body of evidence that the frequency of RTEC consumption was associated with a lower BMI.

CONCLUSIONS

This study found that as children grew older they were less likely to consume breakfast, that RTEC consumption was positively associated with intakes of essential nutrients, and that BMI percentile was lower in children who frequently consumed RTEC breakfast across the three grade levels. These findings are important because it suggests that type of breakfast may influence BMI. The promotion of a well-balanced breakfast that includes RTEC may be a way to favorably influence BMI and overall eating habits. The National School Breakfast program may be an opportunity to offer RTEC with minimal added sugar more frequently and low-fat and/or fat-free milk to optimize nutrient intake value and reduce risk of obesity in low-income children. This study helped address the gap in the literature on breakfast and RTEC consumption among low-income minority children.

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STATEMENT OF POTENTIAL CONFLICT OF INTEREST

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