Longitudinal patterns of breakfast eating in black and white adolescent girls.

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Longitudinal Patterns of Breakfast Eating in Black and White Adolescent Girls

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Abstract


Objective: The objective was to describe the pattern of breakfast eating over time (“breakfast history”) and examine its associations with BMI and physical activity.

Research Methods and Procedures: This longitudinal investigation of patterns of breakfast eating included 1210 black and 1161 white girls who participated in the 10-year, longitudinal National Heart, Lung, and Blood Institute Growth and Health Study (NGHS). Three-day food records were collected during annual visits beginning at ages 9 or 10 up to age 19. Linear regression and path analysis were used to estimate the associations between breakfast history, BMI, and physical activity.

Results: Among girls with a high BMI at baseline, those who ate breakfast more often had lower BMI at the end of the study (age 19), compared with those who ate breakfast less often. Path analysis indicated that energy intake and physical activity mediated the association between patterns of breakfast eating over time and BMI in late adolescence.

Discussion: The association between regular breakfast consumption over time and moderation of body weight among girls who began the study with relatively high BMI suggests that programs to address overweight in children and adolescents should emphasize the importance of physical activity and eating breakfast consistently.

Key words: body weight, BMI, adolescents, youth, physical activity

Introduction

Breakfast consumption has been linked to better overall nutrition (1), BMI (1,2), higher levels of physical activity (3,4), and overall quality of life (5) in children and adolescents. Despite the positive implications of breakfast consumption, the frequency of eating breakfast decreases from childhood through adolescence. For example, the National Heart, Lung, and Blood Institute Growth and Health Study (NGHS)1 (1) reported that at age 9, approximately 77% of white girls and 57% of black girls ate breakfast on all 3 days for which food records were kept, compared with approximately 32% and 22%, respectively, by age 19. In that study, breakfast eating was associated with lower BMI, but this effect did not hold when socioeconomic status, energy intake, and physical activity were accounted for statistically.

Several studies have confirmed that breakfast eating declines as children grow older (6–8). Among adolescent girls, this trend is partially explained by the fact that skipping breakfast has been shown to be a common method of trying to lose weight (6,8,9). It is possible that regular breakfast eating may be related to a general healthy lifestyle (i.e., higher activity and lower caloric intake), which, in turn, contributes to a lower BMI, but research to date has not examined the mechanisms that might explain how breakfast eating is related to weight in children and adolescents.

An additional question is the degree to which the pattern of breakfast eating over time (“breakfast history”) may...
impact health indicators. Eating breakfast consistently (across a number of years) may be important for long-term management of body weight. With few exceptions, previous studies of breakfast consumption have been cross-sectional, thus precluding prospective analyses to test whether the pattern of breakfast eating over time plays a role in changes in body weight or activity patterns. Two relevant longitudinal studies were identified. Berkey et al. (10) examined whether skipping breakfast was associated with BMI changes over a 3-year period in children who were 9 to 14 years of age at baseline. Specifically, children were asked, “How many times each week (including weekdays and weekends) do you eat breakfast?” Overall, results indicated that children who never ate breakfast had lower total caloric intake than those who ate breakfast nearly daily. Interestingly, overweight children who never ate breakfast decreased in BMI over the following year, relative to overweight children who ate breakfast nearly every day. In contrast, normal-weight children who did not eat breakfast gained weight when compared with their peers who ate breakfast routinely. It should be noted, however, that height and weight were self-reported in this study and overweight children who never ate breakfast may have underreported their height and under-reported their food intake. Furthermore, because breakfast was not defined and was based on children’s retrospective recall in response to one global question, these results need to be interpreted with caution. A second study (11) followed 7745 Finnish adolescents over a 3-year period (ages 16 to 19 years); they found that regularly eating breakfast (every morning) was consistently associated with self-rated good health as well as with “persistent exercise” (engaging in physical activity 4 or 5 times/wk).

Although informative, these studies have several limitations: they span a relatively short time period (3 years), are based on homogeneous (i.e., mostly white) samples, and rely on questionnaire data for reports of breakfast consumption. The current study provides 10-year longitudinal data from a diverse sample whose 3-day food records were verified by dietitians, thus addressing some of these concerns.

In light of previous literature, we sought to expand what is known about breakfast eating among children and adolescents with 4 aims: 1) to describe the pattern of breakfast eating over time (“breakfast history”), 2) to examine the relationships between breakfast history and BMI and physical activity, 3) to better understand the specific types of physical activity that are associated with breakfast eating over time, and 4) to test the hypothesis that energy intake and physical activity partly explain the relationship between breakfast history and BMI over time.

### Research Methods and Procedures

#### Participants and Recruitment

As previously reported (12), the NGHS recruited 2379 black and white girls at three study sites who were 9 or 10 years old at study entry: University of California at Berkeley, University of Cincinnati/Cincinnati Children’s Hospital Medical Center, and Westat, Inc./Group Health Association in Rockville, MD. Girls were recruited from public and parochial schools or (in Maryland/Washington, DC only) from a membership listing of families who were enrolled in a large health maintenance organization and local Girl Scout troops. Eligible participants identified themselves (using census categories for race/ethnicity) as “black” or “white,” non-Hispanic, with racially concordant parents or guardians. All girls who entered the NGHS assented, and their parents (or guardian) consented to their participation. In each race group, wide ranges of income ($<10,000 to $75,000) and educational levels (less than high school diploma to graduate degree) were represented.

Due to variable annual participation rates, sample sizes varied from visit to visit. Retention rates (in relation to the sample size of 2379 at baseline) were very high at visits 2 to 4 (96%, 94%, 91%), declined to a low of 82% at visit 7, and increased to 89% at visit 10.

#### Measurements and Procedure

A complete description of NGHS procedures and measures has been reported elsewhere (12). Briefly, data were collected annually at participating sites or, if the girl was unable to travel to the site, at her home. The study protocol was approved by the Institutional Review Boards of all participating sites. Only instruments of relevance to the present report are described below.

Breakfast history was the independent variable of primary interest. This measure was based on 3-day food records [previously validated compared with observed intakes during school lunch (13)] collected in study years 1 through 5, 7, 8, and 10. Dietitians used age-appropriate materials to instruct girls to record all food and drink and time of intake for 3 consecutive days that included 2 weekdays and 1 weekend day. Breakfast was defined as any eating that occurred between 5:00 and 10:00 AM on weekdays or between 5:00 and 11:00 AM during weekends. Food records were coded and analyzed for nutrients using Food Table Version 19 of the Nutrition Coordinating Center nutrient database (14). Breakfast history was defined as the total percentage of days that a girl reported eating breakfast across all food record days that a girl reported throughout NGHS. The maximum number of food record days was 24 (8 study years × 3 food record days each), but due to missing visits some girls had fewer than 24 total days of food records. For example, if a girl completed food records in only years 1 to 5, 7, and 10 (7 years ×3 food record days = 21 total food record days) and reported eating breakfast on 12 of those days, then the girl was coded as having eaten breakfast on 57% (12 of 21) of all days reported in the food records.
Demographics. Data regarding race and highest level of parental education were collected at study entry from girls and their parents (or guardians). Race (black or white) was defined by the participant’s self-report at baseline. Parental education was categorized as ≥4 years of college vs. <4 years of college. Education was chosen over income as a proxy of socioeconomic status because NGHS data were collected in three regions differing in median household income and also because previous research has shown that education is a better predictor of health-related outcomes than income (15). Participants’ age was recorded as age at last birthday.

BMI. Annually (all visits), centrally trained examiners obtained height and weight measurements. BMI was calculated as weight in kilograms divided by height in meters squared. Instead of raw BMI, BMI-for-age z-scores [using the Centers for Disease Control and Prevention age- and gender-specific percentiles as the reference distribution (16)] were used in this study because they have the same distribution across different ages. A score of 0 is at the gender- and age-specific mean of BMI, with positive scores indicating above-average BMI for that age and negative scores indicating below-average BMI.

Physical Activity. The analyses included a composite variable representing total energy expended across all activities, based on 3-day physical activity diaries collected in tandem with the food records in study years 1 to 5, 7, 8, and 10. The methodology and revisions over time in the specific activities and categories of activities included have been described in detail elsewhere (17). Briefly, girls indicated the times they woke up and went to bed each day as well as the approximate amount of time they spent engaged in various categories of activities of similar intensity (for example, “running, soccer, track, or field hockey”). Participants completed the diary by selecting the duration of time they spent in each category of activity (1 to 15 minutes, 16 to 30 minutes, or >30 minutes) during specific parts of the day. For all study years, completed diaries were reviewed by centrally trained staff using a common protocol. Metabolic equivalent (MET) values were assigned to each activity grouping, based on a review of existing literature and modified to reflect the age and gender of NGHS participants. Finally, summary MET values were assigned to each girl for each usable diary. For each visit, each girl’s physical activity score was the average MET value of either 2 or 3 usable diary days (if only 1 day of data were usable at a visit, that visit was excluded).

To identify specific physical activities that were associated with breakfast consumption, a binary variable was formed for specific categories of activities, coded as 1 (girl reported doing the activity on at least one day) or 0 (girl never reported doing the activity). Some activities were grouped in the physical activity records (e.g., walking and bike riding) to reduce the reporting burden on girls. Results for specific activities are reported at the finest level of detail permitted by the data.

Eating Disorder Inventory (EDI). Because NGHS lacked well-validated measures of dieting to lose weight, two subscales of the EDI were used as a proxy for tendencies toward dieting behavior. The Body Dissatisfaction subscale consists of 9 items that measure dissatisfaction with specific body parts or the body in general (18). The Drive for Thinness subscale consists of 7 items that assess the degree to which the respondent thinks about and/or wishes to change her shape and weight. Extensive data regarding reliability and validity have been reported (19) and results from a factor analysis with the NGHS cohort have been published (20). For black girls in NGHS, Cronbach α coefficients for the Body Dissatisfaction subscale ranged from 0.85 (age 11, visit 3) to 0.88 (age 15, visit 7); for the Drive for Thinness subscale, the coefficients were 0.69 (age 11, visit 3) to 0.71 (age 15, visit 7). For white girls, Body Dissatisfaction coefficients ranged from 0.92 to 0.93 and for Drive for Thinness from 0.74 to 0.76, for the same ages. These subscales were administered in years 1, 3, 5, 7, and 10 of NGHS.

Statistical Analysis

BMI-for-age z-scores in the final year of NGHS (Year 10) were modeled as a function of breakfast history, adjusting for study site and other variables associated with BMI in past studies (i.e., race, parental education, physical activity, energy intake, and the EDI subscale scores). In all analyses, baseline values were used for race and parental education; physical activity scores and energy intake were averaged across all study years, analogous to the breakfast history measure; and EDI subscales were taken from the final study year. Preliminary analyses indicated quadratic trends for physical activity and energy intake, so squared terms for these were also included in the final model. The model was adjusted for baseline BMI-for-age z-score, to ensure that associations between breakfast history and Year 10 BMI were not simply due to frequent breakfast-eaters also having higher baseline BMI values; it is important to control for this because BMI is known to track over time (21). Finally, the model included days eating breakfast (0, 1, 2, or 3) based on the food records in Year 10; this was done to ensure that the history of breakfast consumption throughout adolescence has explanatory value, above and beyond breakfast consumption measured concurrently with the outcome (BMI-for-age in Year 10). The model included the interaction between baseline BMI-for-age z-scores and breakfast history. Interactions between breakfast history, race, and physical activity were also considered but not included in the final model because they were not significant in preliminary analyses, nor did their inclusion have a noticeable effect on the other model estimates. The model-
ing technique was linear regression (PROC REG in SAS v9.1.3; SAS Institute, Inc., Cary, NC). Multiple imputation (PROCs MI and MIANALYZE; SAS Institute, Inc.) was used to ensure unbiased estimation in the presence of missing data for some of the analytic variables. A complete-case model (i.e., a model dropping all cases with missing data on any variable) was also estimated to gauge the extent to which the model estimates were affected by the method of handling missing data. The model using multiple imputation was viewed as the primary analysis and the complete-case model was viewed as a sensitivity analysis. Mixed models (PROC MIXED in SAS; SAS Institute, Inc.) were used to estimate linear age trends in the intake of selected nutrients at breakfast, taking into account the repeated measurements of breakfast consumption within girls.

Additional secondary analyses were conducted to gain insight into processes through which breakfast consumption might influence BMI. It seemed plausible that differences in physical activity and energy intake might mediate the association between breakfast history and BMI-for-age \( z \)-scores in Year 10 of NGHS. That is, differences in breakfast habits might lead to differences in physical activity and energy intake throughout the day, which, in turn, would affect BMI in the final study year. Path analysis was used to examine these possibilities. The model consisted of estimated paths (interpreted similarly to regression coefficients) from breakfast history to physical activity and energy intake (defined as in the linear regression model, including the quadratic term), as well as paths from the latter two variables to BMI-for-age \( z \)-score in study Year 10. In addition, because breakfast history might directly influence BMI (above and beyond its indirect effects through the mediating links of physical activity and energy intake), a direct path from breakfast history to BMI-for-age \( z \)-score in study Year 10 was estimated. Similar to the linear regression model, the path model adjusted for study site, race, parental education, and EDI subscales. Path analysis was done using Mplus v3 (Muthen & Muthen, Los Angeles, CA).

To gain a sense of specific types of physical activity that were frequent among girls who often ate breakfast, breakfast history was examined in relation to categories of physical activity measured in the physical activity records in Table 1.

### Table 1. Descriptive statistics for measures used in the analysis

<table>
<thead>
<tr>
<th>Measure</th>
<th>Sample size</th>
<th>Mean (SD); range; 25th/50th/75th percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw BMI, baseline</td>
<td>2352</td>
<td>18.6 (3.8); range: 11.2–35.3; 15.8/17.6/20.5</td>
</tr>
<tr>
<td>BMI-for-age ( z )-score, baseline</td>
<td>2352</td>
<td>0.3 (1.1); range: −4.8–2.7; −0.5/0.3/1.1</td>
</tr>
<tr>
<td>Raw BMI, study year 10</td>
<td>2066</td>
<td>25.6 (6.8); range: 15.8–55.6; 20.7/23.6/28.7</td>
</tr>
<tr>
<td>BMI-for-age ( z )-score, year 10</td>
<td>2066</td>
<td>0.5 (1.1); range: −3.1–2.6; −0.3/0.5/1.4</td>
</tr>
<tr>
<td>Breakfast history (% days eating breakfast) (years 0–10)</td>
<td>2371</td>
<td>70.6 (19.2); range: 0.0–100.0; 58.3/72.7/85.7*</td>
</tr>
<tr>
<td>Average energy intake (kcal/1000) (years 0–10)</td>
<td>2371</td>
<td>1.9 (0.4); range: 0.7–4.1; 1.6/1.8/2.1</td>
</tr>
<tr>
<td>Average physical activity score (years 0–10)</td>
<td>2368</td>
<td>452.5 (260.9); range: 49.5–2894.1; 280.6/395.1/553.5</td>
</tr>
<tr>
<td>EDI drive-for-thinness (year 10)</td>
<td>2069</td>
<td>5.1 (5.7); range: 0.0–21.0; 0.0/3.0/9.0</td>
</tr>
<tr>
<td>EDI body dissatisfaction (year 10)</td>
<td>2065</td>
<td>9.0 (7.8); range: 0.0–27.0; 2.0/7.0/14.0</td>
</tr>
<tr>
<td>Days eating breakfast (year 10)</td>
<td>1896</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>22.4%</td>
<td></td>
</tr>
<tr>
<td>1 day</td>
<td>26.1%</td>
<td></td>
</tr>
<tr>
<td>2 days</td>
<td>25.8%</td>
<td></td>
</tr>
<tr>
<td>3 days</td>
<td>25.7%</td>
<td></td>
</tr>
<tr>
<td>Race: black</td>
<td>2371</td>
<td>51.0%</td>
</tr>
<tr>
<td>Study site</td>
<td>2371</td>
<td></td>
</tr>
<tr>
<td>California</td>
<td>37.3%</td>
<td></td>
</tr>
<tr>
<td>Ohio</td>
<td>36.5%</td>
<td></td>
</tr>
<tr>
<td>Washington, DC</td>
<td>26.2%</td>
<td></td>
</tr>
<tr>
<td>Parental education: 4+ years college</td>
<td>2369</td>
<td>35.1%</td>
</tr>
</tbody>
</table>

* Additional percentiles for breakfast history are 33.3 (5th percentile), 42.9 (10th percentile), 94.4 (90th percentile), and 100.0 (95th percentile).
study Year 10. Breakfast history was categorized into 9
groups of increasing percentage of days with breakfast, and
the percentage of girls exhibiting each type of activity on
one or more days was computed for each category. Using
logistic regression (PROC GENMOD in SAS; SAS Insti-
tute, Inc.), a linear trend of association was estimated for
each category of activity; this provides a test of whether
rates of the activity tend to increase (or decrease) as the
percentage of days eating breakfast increases. The criterion
of statistical significance in all analyses was
\[ p < 0.05. \]

### Results

The analysis included the 2371 NGHS participants
(99.7% of the 2379 total) who completed food records in
one or more study years. Sample size for individual vari-
ables varied by study year and the specific measures used
(Table 1).

As shown in Table 1, on average, girls ate breakfast on
70.6% of days and one fourth of the girls ate breakfast on
>85% of days. Even girls at the 5th percentile consumed
breakfast on 33.3% of days, indicating that the large major-
ity of girls consumed breakfast at least occasionally (only 3
girls, or 0.1%, reported consuming breakfast on 0 days).

Over the years, girls who ate breakfast tended to consume
more energy at breakfast time (an average increase of 5.1
kcal per year, \( p < 0.0001 \)). Adjusting for age-related
changes in energy intake at breakfast, over the years, girls
who ate breakfast consumed more sucrose (0.39 g per year,
\( p < 0.0001 \)), caffeine (1.6 mg per year, \( p < 0.0001 \)) and
sodium (4.9 mg per year, \( p < 0.0001 \)), and less calcium
(\(-1.4 \) mg per year, \( p = 0.005 \)) at breakfast time; intake of
fat, protein, and cholesterol neither increased nor decreased
(\( p > 0.10 \)).

Results of the model of BMI-for-age \( z \)-scores in study
Year 10 are shown in Table 2. The two methods of handling
missing data (multiple imputation and complete case anal-
ysis) resulted in similar parameter estimates, including
nearly identical estimates for the effects of primary interest
(breakfast history and breakfast history by baseline BMI-
for-age). Controlling for baseline BMI, energy intake, phys-
ical activity, EDI subscale scores, and study site, race, and
parental education, the main effect of breakfast history was
not significant. However, the significant breakfast history
by baseline BMI interaction indicates that the association of
breakfast history with BMI \( z \)-scores in Year 10 depended on
BMI-for-age in Year 0 (baseline), as illustrated in Figure 1.
Among girls with a high BMI-for-age at baseline, those who
ate breakfast more often had lower BMI-for-age at the end
of the study (Year 10), compared with those who ate break-
fast less often. In other words, eating breakfast more often

### Table 2. Parameter estimates of the model of BMI-for-age \( z \)-score in study year 10

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Parameter estimate (SE)</th>
<th>Parameter estimate (SE)</th>
<th>Semi-partial correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Multiple imputation of missing data</td>
<td>Drop cases with missing values</td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>0.1577 (0.0785)‡</td>
<td>0.1482 (0.0795)†</td>
<td>NA</td>
</tr>
<tr>
<td>Breakfast history (% days eating breakfast)</td>
<td>0.0013 (0.0011)</td>
<td>0.0015 (0.0011)</td>
<td>0.0038</td>
</tr>
<tr>
<td>Breakfast history by baseline BMI-for-age</td>
<td>-0.0026 (0.0007)</td>
<td></td>
<td>-0.0027 (0.0007)§</td>
</tr>
<tr>
<td>Baseline BMI-for-age</td>
<td>0.7919 (0.0490)</td>
<td></td>
<td>0.7984 (0.0537)</td>
</tr>
<tr>
<td>Days eating breakfast (year 10)</td>
<td>0.0080 (0.0177)</td>
<td>0.0085 (0.0170)</td>
<td>0.00005</td>
</tr>
<tr>
<td>Average energy intake (kcal/1000)</td>
<td>0.0942 (0.0461)‡</td>
<td>0.0788 (0.0467)†</td>
<td>0.00059</td>
</tr>
<tr>
<td>Average energy intake (kcal/1000)²</td>
<td>-0.0623 (0.0490)</td>
<td>-0.0508 (0.0559)</td>
<td>0.00017</td>
</tr>
<tr>
<td>Average physical activity score (log)</td>
<td>0.0781 (0.0352)‡</td>
<td>0.0727 (0.0337)‡</td>
<td>0.00097</td>
</tr>
<tr>
<td>Average physical activity score (log)²</td>
<td>-0.0480 (0.0384)</td>
<td>-0.0834 (0.0417)‡</td>
<td>0.00083</td>
</tr>
<tr>
<td>Race: black</td>
<td>0.2618 (0.0339)</td>
<td></td>
<td>0.2788 (0.0364)</td>
</tr>
<tr>
<td>Parental education: 4+ years college</td>
<td>-0.1043 (0.0350)§</td>
<td>-0.1095 (0.0356)§</td>
<td>0.00197</td>
</tr>
<tr>
<td>Study site California*</td>
<td>-0.1074 (0.0417)‡</td>
<td>-0.1071 (0.0427)‡</td>
<td>0.00131</td>
</tr>
<tr>
<td>Study site Ohio</td>
<td>0.0287 (0.0449)</td>
<td>0.0272 (0.0421)</td>
<td>0.00009</td>
</tr>
<tr>
<td>EDI drive-for-thinness (year 10)</td>
<td>0.0069 (0.0036)‡</td>
<td>0.0068 (0.0039)‡</td>
<td>0.00063</td>
</tr>
<tr>
<td>EDI body dissatisfaction (year 10)</td>
<td>0.0325 (0.0029)</td>
<td></td>
<td>0.0316 (0.0030)</td>
</tr>
</tbody>
</table>

* For study site, Washington, DC served as the reference level.
† \( p < 0.10 \); ‡ \( p < 0.05 \); § \( p < 0.01 \); ‖ \( p < 0.0001 \).
NA, not applicable.
was associated with decreased BMI at the end of the study, but only among girls who had relatively high BMI at the beginning of the study. One indicator of effect size is to estimate the impact of eating breakfast one additional day per week, which would increase days eating breakfast by $\sim 14\%$ (1 of 7 days). Among girls with median baseline BMI-for-age, eating breakfast one more day per week is estimated to result in an increase of 0.02 (95% confidence interval, 0.01, 0.05) in BMI-for-age in Year 10; this estimate was not significantly different from 0 ($p = 0.17$). However, among girls with baseline BMI at the 95th percentile, eating breakfast one more day per week is expected to result in a significant decrease of $-0.04$ (95% confidence interval, $-0.08, -0.01$) in BMI-for-age in Year 10 ($p = 0.04$). There was an even greater decrease in Year 10 BMI-for-age among girls with baseline BMI at the 97th percentile (decrease = $-0.05$; 95% confidence interval, $-0.10, -0.01$, $p = 0.01$).

Results of the model of BMI-for-age in study Year 10 indicate that both physical activity and energy intake were associated with BMI. Possibly, breakfast history contributes to BMI through the intermediating influence of these variables; specifically, it may be the case that girls who eat breakfast more often have higher overall energy intake as well as greater physical activity, and the latter variables, in turn, are associated with BMI-for-age in study Year 10. A path model was used to examine whether the data in NGHS were consistent with this hypothesis. The results are shown in Figure 2. As hypothesized, eating breakfast more often predicted significantly greater physical activity (standardized coefficient = 0.063, $p = 0.004$); and, in turn, very high physical activity predicted lower BMI-for-age. Interestingly, the association of physical activity and BMI-for-age, adjusting for the other variables in the model, was U-shaped (Figure 3), based on the significant estimates for physical activity (standardized coefficient = 0.038, $p = 0.02$) and physical activity squared (standardized coefficient = $-0.029$, $p = 0.05$). Further, eating breakfast more often predicted greater overall energy intake (standardized coefficient = 0.096, $p < 0.0001$), which, in turn, was associated with BMI-for-age in study Year 10. A linear representation seems appropriate for the association between energy intake and Year 10 BMI-for-age, given the significant linear component (standardized coefficient = 0.037, $p = 0.02$) and non-significant quadratic term (standardized coefficient = $-0.021$, $p = 0.15$). Finally, girls who were more physically active consumed significantly more calories, possibly to support their increased energy needs. After these associations were taken into account, breakfast did not exert any additional, direct influence on Year 10 BMI-for-age ($p = 0.31$). The model is consistent with the possibility that the association between breakfast history and Year 10 BMI-for-age is explained by the mediating effects of energy intake and physical activity.

Because girls who ate breakfast more often were significantly more active, it is of interest to know whether certain kinds of physical activity were associated with breakfast history. Table 3 shows the association of spe-
cific types of physical activity with breakfast history. Significance tests examined the association between breakfast history and physical activity after adjusting for site, race, and parental education. In the category of sports, girls who ate breakfast more often were more likely to participate in basketball or weight training/golf/badminton. In the category of individual physical activities, breakfast history was associated with greater rates of walking for exercise or bike riding; running/soccer/track/field hockey; jogging/aerobics; and walking to go someplace/mall walking. Finally, no categories of housework/chores (such as cooking/dishwashing or mop-

**Figure 2:** Parameter estimates in the path model of BMI in study Year 10. *p < 0.05; **p < 0.01; ***p < 0.0001.

**Figure 3:** Modeled association of BMI in study Year 10 as a function of physical activity (estimated in path model).
Table 3. Percent of girls participating in physical activities by breakfast history and type of physical activity

<table>
<thead>
<tr>
<th>% days eating breakfast</th>
<th>Softball, baseball, volleyball, frisbee</th>
<th>Basketball</th>
<th>Swimming or tennis</th>
<th>Bowling or archery</th>
<th>Weight training, golf, or badminton</th>
<th>Walking to go to some place or walking at a mall</th>
<th>Walking for exercise or bike riding</th>
<th>Running, soccer, track, or field hockey</th>
<th>Jogging, aerobics, skating, or rollerblading</th>
<th>Dancing, cheerleading, gymnastics, or baton twirling</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–30%</td>
<td>0.0</td>
<td>0.0</td>
<td>1.9</td>
<td>0.0</td>
<td>0.0</td>
<td>75.9</td>
<td>7.4</td>
<td>1.9</td>
<td>1.9</td>
<td>24.1</td>
</tr>
<tr>
<td>31–40%</td>
<td>0.0</td>
<td>5.0</td>
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Discussion

Breakfast eating is known to be related to positive health outcomes in children (1,5). In the current study, we have shown that the pattern of breakfast eating over time (“breakfast history”) has an important association with weight and physical activity. The association between breakfast consumption and BMI-for-age among girls at the 10-year follow-up was dependent on baseline BMI. Specifically, among girls who were relatively heavy at the beginning of the study (95th or 97th percentile of BMI-for-age), frequent breakfast consumption was significantly associated with decreased BMI after 10 years, even after adjusting for potential confounding variables (e.g., physical activity). There was no association among girls who began the study with weight in the normal range (50th percentile). Furthermore, the association between increased breakfast consumption and Year 10 BMI may be explained by the mediating effects of energy intake and physical activity.

Our findings suggest a pattern whereby breakfast eating, overall energy intake, and activity levels are associated with each other as well as with BMI. Girls who ate breakfast more often consumed more energy, but they were also more likely to participate in a variety of physical activities. That is, breakfast consumption was associated with increased caloric intake (predicting increased BMI-for-age), but this appeared to be partially offset by the association between breakfast consumption and physical activity (high physical activity predicted decreased BMI-for-age). Although it is not altogether clear which comes first, our data are consistent with the interpretation that overweight girls who engage in a regular pattern of eating breakfast may be more likely to attain a healthier weight, perhaps in part by balancing energy in with energy out. Possibly, girls who are heavy in early adolescence are encouraged by their physicians and parents to eat breakfast regularly and to be physically active—behaviors that, in combination, lead to decreases in BMI. Parents who encourage regular breakfast eating, particularly through the adolescent years when breakfast consumption often decreases dramatically (1), may be more likely to highlight the importance of overall healthy eating and regular physical activity (2). Future research might examine the role that families play in patterns of breakfast eating over the course of childhood.

The pattern of results suggests that both physical activity and breakfast history were associated with BMI-for-age z-scores in the final year. Results of the path analysis model are consistent with the possibility that, holding breakfast history constant, increased physical activity over the 10 years is associated with decreased BMI z-scores in the final year, at least at very high levels of physical activity as suggested by the U-shaped association (Figure 3). Future work should examine in more detail the combined and independent influences of breakfast consumption and physical activity on adiposity.

Our findings and those of others indicate that simple linear association poorly represents the relation between breakfast and BMI. Generalizations such as “eating breakfast more often is associated with decreased BMI” may not be accurate. Instead, the relation is complex and is likely to differ across groups (e.g., individuals differing on baseline weight and physical activity). For example, we found that regular breakfast consumption may be especially important among relatively higher weight children, in that breakfast history was related to a decrease in later BMI in this group. Another complexity is that diverse patterns are likely to underlie the breakfast history measure and different patterns may be associated with different outcomes. For example, consider two girls who ate breakfast on 67% of the days; one girl might eat breakfast on 2 of 3 days during every study year, while the second girl eats breakfast on 3 of 3 days during study Years 1 to 5, 1 of 3 days in study Year 7, then she skips breakfast altogether thereafter. Future work should examine such patterns and the associated outcomes.

Strategies for addressing childhood overweight include a focus on caloric consumption, increase in physical activity, and perhaps most importantly, the involvement of family in making changes in eating behaviors and activity levels (22). Closer inspection of obesity treatment programs (23,24) indicates that nutrition education is an important component, with an emphasis on regular meals and overall healthy eating habits, among other topics. Highlighting the importance of regular breakfast consumption may be an important addition to obesity treatment programs for children and adolescents. Although we found that breakfast history was associated with decreases in BMI among heavier girls, it is not clear that breakfast consumption contributes to weight maintenance among normal-weight girls; among girls who began the study with median baseline BMI-for-age, breakfast history was not associated with BMI-for-age in the final study year.

The association between breakfast history and BMI in Year 10 held even after controlling for breakfast consumption in Year 10; this suggests that the longer-term history of breakfast consumption is important, not just breakfast consumption measured concurrently with BMI. Although past research has examined the cross-sectional associations between breakfast eating in childhood and a variety of health outcomes, additional studies are needed to determine whether the same associations might be true longitudinally between adolescence and adulthood.

Girls who ate breakfast more often were more likely to engage in various physical activities, particularly individual activities such as running, walking, and jogging, as well as some team sports. It is not altogether clear why some forms of physical activity were associated with patterns of break-
fast eating whereas others were not, although it is possible that season of the year may account for the differences (certain sports are only played at certain times, which may not have coincided with when the NGHS assessment took place). The differences may also be accounted for by the type of physical activity. Activities that have more of an emphasis on appearance such as dancing, cheerleading, and gymnastics, were not associated with more frequent breakfast consumption in our study. These results are in contrast to a recent study by Croll et al. (25), in which breakfast consumption was significantly more frequent among girls involved in weight-related sports (dancing, cheerleading, gymnastics, yoga, ice skating, and wrestling) when compared with girls involved in team sports (volleyball, basketball, baseball, softball, hockey, football, soccer, and field hockey) or girls not involved in any sports. However, the analyses conducted by Croll et al. (25) adjusted for ethnicity and socioeconomic status only, while the analyses in the present study adjusted for Drive for Thinness and Body Dissatisfaction. Our findings suggest that, when you take these factors into account, the relationship between breakfast eating and weight-related physical activities may not hold in adolescent girls.

The frequency of breakfast eating is known to decrease as children move into and through adolescence. Yet, our data show the importance of breakfast consumption in regard to weight and physical activity among overweight girls. In earlier work (26), we showed that eating cereal at breakfast was predictive of lower BMI, suggesting that the consumption of specific foods might be more beneficial than consuming breakfast per se. Campaigns to address some adolescent nutrition behaviors (e.g., increasing fruit and vegetable intake) have been successful (27,28). One implication of our findings is that strategies designed to increase breakfast consumption in adolescents are needed to reverse the trend of skipping this important meal.

The quality of foods consumed at breakfast tended to decrease over the years; as they grew older, girls consumed more caffeine, sucrose, and sodium and less calcium at breakfast. These changes may, in part, be due to the age-related increases in soda and coffee consumption and decreases in milk consumption that have been documented in the NGHS cohort (29). It is possible that the observed associations between breakfast history and BMI might be magnified in girls who tend to consume higher-quality breakfasts; this deserves attention in future work.

A limitation is that our data focused only on girls of two races; further studies are needed that include boys and other ethnic groups. Another limitation is that this study was a secondary analysis of survey data; some questions could not be answered using this dataset. Although our prospective data indicate longitudinal associations, causality and causal direction cannot be determined on the basis of these data. For example, the study design did not enable us to determine whether increased breakfast consumption causes increased physical activity or vice versa. The paths estimated in path analysis were based on the theory that increased breakfast consumption leads to increased physical activity, but the fact that the data were consistent with this theory does not imply that the data would not also be consistent with competing theories, e.g., a theory in which increased physical activity leads to increased breakfast consumption. An experimental design would be required to unambiguously answer such questions about causal direction. These limitations are offset by the lengthy follow-up period, low attrition rate, large sample size, racial diversity, and the objective assessment of weight and verification of nutritional data.

Overall, our findings indicate an important relationship between breakfast consumption and moderation of body weight among girls of relatively higher BMI. Furthering our understanding of the links between nutrition intake, meal consumption, and physical activity is an important goal toward addressing childhood and adolescent obesity.

Acknowledgments

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