Effects of eating breakfast compared with skipping breakfast on ratings of appetite and intake at subsequent meals in 8- to 10-y-old children

Tanja VE Kral, Linda M Whiteford, Moonseong Heo, and Myles S Faith

ABSTRACT

Background: Cross-sectional data indicate an inverse relation between breakfast consumption and child weight. It has been suggested that skipping breakfast may adversely affect appetite in children, which could lead to overeating later in the day.

Objective: The aim of this study was to test the effects of consuming breakfast compared with omitting breakfast on appetite ratings and energy intake at subsequent meals in 8- to 10-y-old children.

Design: Twenty-one children participated in 2 test visits during which they were served either a compulsory breakfast or no breakfast. On both visits, subjects were also served lunch, which was consumed ad libitum. Subjects rated their appetite throughout the morning; parents completed food records that captured children’s intake for the remainder of the day.

Results: There was no significant main effect of breakfast condition on energy intake at lunch (P = 0.36) or throughout the remainder of the day (P = 0.85). There was a significant main effect of breakfast condition (P = 0.04) on total daily energy intake, which indicated that on the day when the subjects did not eat breakfast, they consumed 362 fewer calories over the course of the day than when they did eat breakfast. On the day when no breakfast was served, subjects indicated that they were significantly hungrier, less full, and could consume more food before lunch than on the day when they did eat breakfast (P < 0.001).

Conclusions: Omitting breakfast affected children’s appetite ratings but not their energy intake at subsequent meals. The dissonance between children’s subjective ratings of prospective consumption and their actual intake should be further examined.

INTRODUCTION

There has been a steady decline in breakfast consumption in US adults and children over the past 40 y (1–3). Specifically, Siega-Riz et al (3) observed that, from 1965 to 1991, breakfast consumption declined among preschoolers, 8- to 10-y old children, and adolescents by 5%, 9%, and 13–20%, respectively. A recent survey conducted in a nationally representative sample of 11- to 15-y-old youth indicated that only 54% of boys and 42% of girls ate breakfast daily (4). Minority children, and girls in particular, and children from low-income families show increased breakfast skipping (5, 6). The decline in breakfast consumption has coincided with an increase in the prevalence of childhood obesity, suggesting that dietary patterns may be implicated in the overconsumption of calories in young children.

Some (4, 7–11), but not all (12, 13), cross-sectional studies have shown a positive association between skipping breakfast and measures of adiposity in children. It has been suggested that skipping breakfast may lead to overall greater levels of hunger later in the day, which in turn may lead to overeating foods, particularly those that are higher in energy density. Data on the effects of skipping breakfast on children’s appetite and intake later in the day have been conflicting. Cross-sectional studies that used self-report measures of dietary intake indicated that children who regularly consumed breakfast showed higher daily energy intakes than did children who regularly skipped breakfast (14–16).

There have been few laboratory studies that have experimentally tested the effects of breakfast on subsequent intake. There is some evidence that the macronutrient content or glycemic index of breakfast may affect satiety and intake at subsequent meals among youth. For example, a study in breakfast-skipping adolescents showed reduced energy intake at lunch after a protein-rich breakfast compared with no breakfast or a normal-protein breakfast (17). Another study by Warren et al (18) indicated that energy intake at lunch was significantly reduced among 9- to 12-y-old children after they consumed a low–glycemic index breakfast compared with a high–glycemic index breakfast. To our knowledge, no study to date has tested the effects of consuming breakfast compared with skipping breakfast on subsequent energy intake in a younger age group.

The primary aim of this study was to test the effects of consuming breakfast compared with omitting breakfast on energy intake, percentage of calories from fat, and dietary energy density at subsequent meals in children aged between 8 and 10 y. A secondary aim was to examine children’s ratings of appetite throughout the morning after consuming or omitting breakfast. It was hypothesized that on the day when children did not consume...
breakfast, they would be significantly hungrier and would consume more energy at subsequent meals than on the day when they ate breakfast.

SUBJECTS AND METHODS

Experimental design

The study used a crossover design with repeated measures within participants. Children attended 2 test visits at the Center for Weight and Eating Disorders (CWED) at the University of Pennsylvania. Test visits were scheduled 1 wk apart and occurred on the same day of the week. On each test day, the same foods were served for lunch, but children either consumed or did not consume breakfast. On the day when breakfast was served, children were asked to consume the breakfast in full. During lunch, children could eat and drink as much or as little as they desired. The order of presenting the breakfast conditions was randomly assigned across participants.

Participants

Participants in this study were 15 girls and 6 boys living in the greater metropolitan area of Philadelphia. Families of all racial and ethnic backgrounds were recruited through online and newspaper advertisements and local flyers. To be included in the study, children were required to be between 8 and 10 y of age, have a body mass index (BMI)-for-age between the 5th and 94th percentile, and like most foods that were served in the study (see section entitled “Assessment of taste preference”). Children were excluded from participation in this study if they had serious medical conditions known to affect food intake and body weight; any learning disability or visual or auditory impairment; any developmental, medical, or psychiatric conditions that might affect study compliance; any food allergies; or were taking medications known to affect food intake or body weight.

Recruitment and screening

Interested families were screened by phone to determine whether their children met the initial inclusion criteria for the study. Families who prequalified for the study from the telephone interview were invited to attend an onsite screening visit at CWED. During the screening visit, parents and their children received a detailed explanation of all study procedures and were asked to provide voluntary assent (child) and consent (parent) to participate in this study by signing the consent and assent forms. The study was approved by the Institutional Review Board of the University of Pennsylvania.

Assessment of height and weight

At the onsite screening visit, children’s height and weight were measured by trained staff members. Children's weight was measured on a digital scale (Tanita model BWB-800; Tanita Corporation of America Inc, Arlington Heights, IL; accurate to 0.1 kg). Standing height was measured on a wall-mounted stadiometer (accurate to 0.1 cm). All measurements were made with child participants wearing light clothing and without shoes. BMI percentiles and z scores were calculated for children with age- and sex-specific reference data (19). Children were classified as normal weight (BMI-for-age between the 5th and 84th percentile) or overweight (BMI-for-age between the 85th and 94th percentile) by using the Centers for Disease Control and Prevention growth reference standards (19).

Assessment of taste preference

At the onsite screening visit, children’s preference for all foods and beverages served during the study was assessed by using a validated taste preference assessment procedure (20, 21). During the preference assessment, each child tasted a small amount (~2–3 spoonfuls) of each of 3 types of ready-to-eat breakfast cereals and selected lunch foods (pasta with tomato sauce, broccoli, and applesauce). Children rated their preference for milk, orange juice, banana, and chocolate chip cookies without tasting them. Children rated each food by using 3 cartoons depicting a smiling face (“yummy”), a neutral face (“just okay”), or a frowning face (“yucky”). Only children who rated the majority of the foods with a smiling or neutral face were invited to participate in the study. Once children finished rating all foods, a rank-order preference assessment was performed for the ready-to-eat breakfast cereals only. During this rank-order assessment, children were asked to indicate the most “yummy” ready-to-eat breakfast cereal, the second most “yummy” ready-to-eat breakfast cereal, and so forth. In an effort to counterbalance cereal types (an equal number of children received each cereal type), subjects received either their favorite or second favorite cereal (as determined by subjects’ ranking score).

Assessment of dietary intake

The amount and energy content of each food and beverage item served at breakfast and lunch are shown in Table 1. All foods and beverages that were provided during breakfast and lunch were weighed before being served to children and reweighed after children finished eating to determine the amount consumed by each child to the nearest 0.1g.

Breakfast

Breakfast consisted of ready-to-eat breakfast cereal (General Mills Cereals, Minneapolis, MN), milk (1% fat; WAWA, Wawa, PA), banana, and orange juice (Tropicana Products, Chicago, IL). The breakfast containing cereal A provided 12.4 g protein, 68.9 g carbohydrate, 3.8 g fat, 3.9 g fiber, and 42.9 g sugar. The breakfast containing cereal B provided 9.9 g protein, 68.0 g carbohydrate, 5.1 g fat, 2.6 g fiber, and 42.9 g sugar. The breakfast containing cereal C provided 11.3 g protein, 69.1 g carbohydrate, 3.3 g fat, 2.8 g fiber, and 45.9 g sugar. Calories provided during breakfast (350 kcal) comprised ~19% of children’s daily estimated energy requirement. The size of the breakfast was determined on the basis of intakes from previous studies with a similar age group (14, 22).

Lunch

Lunch consisted of pasta (New World Pasta, Harrisburg, PA), tomato sauce (Campbell Soup Company, Camden, NJ), broccoli (Hanover Foods Corporation, Hanover, PA), applesauce (Mott’s, Rye Brook, NY), chocolate chip cookies (Kraft Foods, East Hanover, NJ), and milk (1% fat; WAWA). The amounts of foods served were determined on the basis of intake data (per eating occasion) from the Continuing Survey of Food Intakes by
TABLE 1
Foods and beverages served to 21 children during breakfast and lunch

<table>
<thead>
<tr>
<th></th>
<th>Energy density</th>
<th>Amount served</th>
<th>Volume</th>
<th>Energy content</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kcal/g</td>
<td>g</td>
<td>cups</td>
<td>kcal</td>
</tr>
<tr>
<td><strong>Breakfast</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Choice of 3 cereals&lt;sup&gt;1&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cereal A</td>
<td>3.9</td>
<td>33</td>
<td>0.75</td>
<td>130</td>
</tr>
<tr>
<td>Cereal B</td>
<td>4.2</td>
<td>31</td>
<td>0.75</td>
<td>130</td>
</tr>
<tr>
<td>Cereal C</td>
<td>4.1</td>
<td>32</td>
<td>0.75</td>
<td>130</td>
</tr>
<tr>
<td>Milk, 1% fat&lt;sup&gt;2&lt;/sup&gt;</td>
<td>0.4</td>
<td>192</td>
<td>0.75</td>
<td>85</td>
</tr>
<tr>
<td>Banana</td>
<td>0.9</td>
<td>60</td>
<td>0.40</td>
<td>53</td>
</tr>
<tr>
<td>Orange juice&lt;sup&gt;3&lt;/sup&gt;</td>
<td>0.4</td>
<td>187</td>
<td>0.75</td>
<td>82</td>
</tr>
<tr>
<td>Total energy</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>350</td>
</tr>
<tr>
<td><strong>Lunch</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rotini with tomato sauce&lt;sup&gt;4&lt;/sup&gt;</td>
<td>1.3</td>
<td>700</td>
<td>3.5</td>
<td>903</td>
</tr>
<tr>
<td>Broccoli&lt;sup&gt;5&lt;/sup&gt;</td>
<td>0.3</td>
<td>140</td>
<td>1</td>
<td>41</td>
</tr>
<tr>
<td>Applesauce (unsweetened)&lt;sup&gt;6&lt;/sup&gt;</td>
<td>0.4</td>
<td>240</td>
<td>1</td>
<td>98</td>
</tr>
<tr>
<td>Chocolate chip cookies (3)&lt;sup&gt;7&lt;/sup&gt;</td>
<td>4.8</td>
<td>30</td>
<td>—</td>
<td>144</td>
</tr>
<tr>
<td>Milk, 1% fat&lt;sup&gt;8&lt;/sup&gt;</td>
<td>0.4</td>
<td>244</td>
<td>1</td>
<td>108</td>
</tr>
<tr>
<td>Total energy</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>1294</td>
</tr>
</tbody>
</table>

<sup>1</sup> Children were required to eat the breakfast in full; lunch was consumed ad libitum.
<sup>2</sup> General Mills Cereals, Minneapolis, MN.
<sup>3</sup> WAWA, Wawa, PA.
<sup>4</sup> Tropicana Products, Chicago, IL.
<sup>5</sup> New World Pasta, Harrisburg, PA, and Campbell Soup Company, Camden, NJ.
<sup>6</sup> Hanover Foods Corporation, Hanover, PA.
<sup>7</sup> Mott’s, Rye Brook, NY.
<sup>8</sup> Kraft Foods, East Hanover, NJ.

Individuals (23) for children aged 6–11 y. The size of the pasta entrée exceeded the 95th percentile of intake; the size of broccoli and applesauce fell between the 75th and 95th percentile of intake; the size of chocolate chip cookies and milk corresponded to the 50th percentile of intake for children in that age group. The meal provided more energy (1294 kcal) than most children were likely to consume. Portion sizes remained constant across experimental conditions.

### Intake for the remainder of the day

At the end of each test visit, parents were instructed to complete a food record, which captured their children’s food and beverage intake throughout the remainder of the day (away from the laboratory). Parents received detailed training on how to correctly complete the food records. The food record training was conducted by a trained clinical research coordinator. With the use of written instructions (ie, handout that was provided to the parents), parents were trained on the details (ie, time, type, preparation method, and amounts of foods and beverages consumed) of accurately completing the food records. The written instructions also included visual aids for portion size estimates. In addition, parents were provided with a sample of a correctly completed food record. Parental assistance with completion of food records has been shown to significantly enhance the accuracy of self-reported dietary intake in children (24). Food records were entered by trained staff members and analyzed by using the Food Processor SQL software (ESHA), version 9.8 (2005; ESHA Research, Salem, OR).

### Appétite ratings

Subjects were asked to rate their perceived hunger, thirst, prospective consumption (how much food they thought they could eat), nausea, and fullness by using a 100-mm visual analog scale (VAS) with opposing anchors (eg, “extremely hungry” or “not at all hungry”). VASs have been successfully used in children and adolescents to assess perceptions of appetite (25, 26) and pain (27, 28). VAS ratings were completed at the following 7 time points throughout each test visit: 0815 (on arrival to the laboratory); 0915 (immediately after breakfast on the day breakfast was served); 0930, 1015, 1100, and 1140 (immediately before lunch); and 1205 (immediately after lunch).

### Procedures

On the day of their test visit, parents/caretakers were instructed to have their child refrain from eating and drinking (except for water) from the time they got up in the morning until the start of their test visit. For each visit, children came to the laboratory individually. On arrival at the center at 0800, parents/caretakers were asked to complete a meal/snack report to ensure that they had complied with the study procedures. Subjects were either served or not served breakfast on the morning of their test visit. On the day when breakfast was served, children were asked to consume the breakfast in full over a period of 30 min. Subjects completed VASs at regular intervals throughout the morning (see the section entitled “Appetite ratings”). Subjects also completed a series of 8 computerized cognitive tasks at 4 different time points throughout the morning (data not shown). During times when no formal activities were scheduled, subjects rested while listening to audio CDs or playing games. Subjects were allowed to drink water throughout the morning, if desired. On both test visits, subjects were served lunch at 1145. During the meal, subjects could eat or drink as much or as little as they desired over a period of 20 min. Subjects consumed breakfast and lunch in the presence of a research assistant who waited in an adjacent room. Parents/caregivers waited at the center or in close proximity for the duration of the study visit.

### Statistical analysis

Subject characteristics are described by means and SDs for continuous variables and by percentages for categorical variables. Both study aims were tested by using mixed-effects linear models for repeated measures (SAS version 9.2 for Windows; SAS Institute Inc, Cary, NC). We first tested for potential carryover effects by testing for significance of a possible order effect of breakfast condition. This was to ensure that the results were not confounded by the order of the breakfast manipulation. There were no significant carryover effects in any primary or secondary outcomes in either aim.

For aim 1, the primary outcome was energy intake at lunch. Secondary outcomes were energy consumed throughout the remainder of the day, total daily energy intake (sum of calories consumed at breakfast, lunch, and during the remainder of the day), percentage of energy consumed from fat, and dietary energy density. Energy density of the food consumed at lunch (laboratory meal) and throughout the remainder of the day (self-reported intake), excluding beverages, was computed by dividing the total energy consumed from food by the total weight of food.
consumed. The fixed effects used in all models were breakfast condition (breakfast or no breakfast) and test week; subject-level intercepts were considered as being random. The interaction between breakfast condition and session (week) was tested for significance in all models and removed if not significant. The influence of children’s sex and BMI z score on all outcome measures was also examined by adding these variables as a covariate to the model. We identified one child who consumed the entire main entrée (defined as eating >95% of the amount served) in one experimental condition. The analysis of the main outcome (energy intake at lunch) was conducted both including and excluding the child who consumed the entire entrée to investigate whether a limitation of main entrée availability influenced the main outcome. The computation of subjects’ daily estimated energy requirement (EER) was based on age-, sex-, and weight-, and height-specific equations (29). Due to the lack of an objective, validated measure to assess subjects’ physical activity level, we assigned all subjects to the “low active” physical activity category, which corresponds to a physical activity coefficient of 1.13 for boys and 1.16 for girls and assumes typical daily living activities plus 30–60 min of daily moderate activity (30, 31).

For aim 2, for each VAS (ie, hunger, thirst, nausea, prospective consumption, and fullness) the full mixed-effects model included breakfast condition, time, session, baseline VAS, and breakfast condition-by-time interaction as fixed effects and both the third-level (subject-level) and second-level (treatment-level nested within subjects) intercepts as random effects. Subjects’ baseline VAS (ie, obtained at 0815) was included as a covariate in the model. Data are presented as model-based means ± SEMs unless otherwise indicated. For all analyses, results were considered significant at $P < 0.05$.

RESULTS

Subject characteristics

Anthropometric and demographic characteristics of child participants are shown in Table 2. The majority of the sample was female (71.4%) and African American (76.2%). Approximately one-third of the sample (28.6%) was considered overweight. Child participants’ daily breakfast consumption patterns are shown in Table 3. The majority of the children consumed breakfast on a daily basis both during weekdays (90.5%) and on weekends (95.2%). Approximately half of the sample (52.4%) consumed cereal for breakfast 3 d/wk.

### Preference ratings for experimental foods and beverages

The proportion of children who rated the breakfast foods acceptable (“yummy” or “just okay”) was 95% for cereal A, 100% for cereal B, 86% for cereal C, 100% for banana, and 100% for orange juice. The proportion of children who rated the lunch foods acceptable was 100% for pasta, 76% for broccoli, 95% for applesauce, 95% for chocolate chip cookies, and 76% for milk.

### Effects of breakfast on intake

As indicated in Table 4, there was no significant main effect of breakfast condition ($P = 0.36$) or test week ($P = 0.84$) on the amount of calories children consumed at lunch. Hence, subjects showed similar energy intakes at lunch after consuming breakfast (634 ± 50 kcal) compared with after skipping breakfast (593 ± 50 kcal). The results did not change when excluding the one subject who finished all of the pasta from the analyses (main effect of breakfast condition: $P = 0.32$).

There was also no significant main effect of breakfast condition ($P = 0.85$) on the amount of calories children consumed for the remainder of the day [1207 ± 134 kcal (breakfast) compared with 1237 ± 134 kcal (no breakfast)]. There was a trend ($P = 0.08$) for energy intake for the remainder of the day to be higher during the first test week (1364 ± 134 kcal) than during the second test week (1080 ± 134 kcal).

There was a significant main effect of breakfast condition ($P = 0.04$) on total daily energy intake. On the day when subjects ate breakfast, they consumed 362 more calories over the course of the day and thereby exceeded their daily EER by ≈20% compared with the day when they did not eat breakfast (Figure 1).

### Table 2

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>9.2 ± 0.8*</td>
</tr>
<tr>
<td>Sex [n (%)]</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>6 (28.6)</td>
</tr>
<tr>
<td>Female</td>
<td>15 (71.4)</td>
</tr>
<tr>
<td>Race [n (%)]</td>
<td></td>
</tr>
<tr>
<td>African American</td>
<td>16 (76.2)</td>
</tr>
<tr>
<td>White</td>
<td>4 (19.0)</td>
</tr>
<tr>
<td>Mixed race</td>
<td>1 (4.8)</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>17.4 ± 2.5</td>
</tr>
<tr>
<td>BMI z score</td>
<td>0.25 ± 0.9</td>
</tr>
<tr>
<td>BMI-for-age percentile</td>
<td>57.3 ± 29.4</td>
</tr>
<tr>
<td>Weight status [n (%)]</td>
<td></td>
</tr>
<tr>
<td>Normal weight</td>
<td>15 (71.4)</td>
</tr>
<tr>
<td>Overweight</td>
<td>6 (28.6)</td>
</tr>
</tbody>
</table>

*Mean ± SD (all such values).

### Table 3

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children who eat breakfast</td>
<td></td>
</tr>
<tr>
<td>3 d/wk</td>
<td>1 (4.8)</td>
</tr>
<tr>
<td>4 d/wk</td>
<td>1 (4.8)</td>
</tr>
<tr>
<td>5 d/wk</td>
<td>19 (90.5)</td>
</tr>
<tr>
<td>Children who eat breakfast</td>
<td></td>
</tr>
<tr>
<td>1 d/weekend</td>
<td>1 (4.8)</td>
</tr>
<tr>
<td>2 d/weekend</td>
<td>20 (95.2)</td>
</tr>
<tr>
<td>Children who eat cereal for breakfast</td>
<td></td>
</tr>
</tbody>
</table>
None of the results changed when the model was adjusted for children’s sex or BMI z score.

There was also no significant main effect of breakfast condition or test week on percentage of energy consumed from fat at lunch (breakfast condition: \( P = 0.80 \); test week: \( P = 0.12 \)) or throughout the remainder of the day (breakfast condition: \( P = 0.34 \); test week: \( P = 0.90 \); Table 4). There was no significant main effect of breakfast condition or test week on the overall energy density of foods that children consumed at lunch (breakfast condition: \( P = 0.91 \); test week: \( P = 0.65 \)) or throughout the remainder of the day (breakfast condition: \( P = 0.68 \); test week: \( P = 0.36 \)).

**Ratings of appetite**

Model-based means for child ratings of hunger, thirst, prospective consumption, and fullness throughout the morning are shown in Figure 2. There was a significant breakfast condition-by-time interaction \( (P < 0.001) \) on ratings of hunger, indicating that on the day when children did not consume breakfast they felt significantly hungrier throughout the morning (0915, 0930, 1015, 1100, and 1140) than when they did consume breakfast. There was also a borderline significant breakfast condition-by-time interaction \( (P = 0.05) \) on ratings of thirst, indicating that on the day when children did not eat breakfast, they were significantly thirstier at 0915 \( (P = 0.002) \) than on the day when they did consume breakfast. Furthermore, there was a significant breakfast condition-by-time interaction \( (P < 0.001) \) on children’s ratings of prospective consumption, indicating that on the day when children did not eat breakfast, they indicated that they could eat significantly more food before lunch (0915, 0930, 1015, 1100, and 1140; \( P < 0.001 \)) than on the day when they were served breakfast. There also was a significant breakfast condition-by-time interaction \( (P < 0.001) \) on ratings of fullness, indicating that on the day when children were not fed breakfast they felt significantly less full throughout the morning (0915, 0930, 1015, 1100, and 1140; \( P < 0.001 \)) than on the day when they ate breakfast. There was no significant main effect \( (P = 0.39) \) of breakfast condition or breakfast condition-by-time interaction \( (P = 0.07) \) on children’s level of nausea.

**DISCUSSION**

This study showed that when children, the majority of whom were regular breakfast eaters, did not eat breakfast on a single day, they did not make up for the missing calories from breakfast by eating more calories at lunch or throughout the remainder of the day. The dietary energy density and percentage of energy consumed from fat at subsequent meals also did not differ across experimental conditions. On the day when no breakfast was served, children indicated that they were significantly hungrier, less full, and could consume more food before lunch than on the day when they did eat breakfast.

In this study, skipping breakfast affected children’s appetite ratings but not their energy intake at subsequent meals. Therefore, on the day when children did eat breakfast, they consumed 362 more calories than on the day when they skipped breakfast. This finding corroborates results from studies based on self-reported intake that showed a higher daily energy intake among children who regularly consumed breakfast compared with those who regularly skipped breakfast (14–16). In the current study, on the day when child participants consumed breakfast, they exceeded their daily EER by \( \approx 20\% \). Although interesting, this finding should be interpreted with caution by taking into account the estimated, rather than observed, energy intake throughout the remainder of the day as well as children’s estimated physical

### Table 4

Energy intake, percentage of energy from fat, and energy density (food only) consumed at lunch and throughout the remainder of the day by breakfast condition \( (n = 21) \)

<table>
<thead>
<tr>
<th></th>
<th>No breakfast</th>
<th>Breakfast</th>
<th>( P ) value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lunch</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy intake (kcal)</td>
<td>593 ± 50</td>
<td>634 ± 50</td>
<td>0.36</td>
</tr>
<tr>
<td>Percentage of energy from fat (%)</td>
<td>15.3 ± 1.0</td>
<td>15.0 ± 1.0</td>
<td>0.80</td>
</tr>
<tr>
<td>Energy density (kcal/g)</td>
<td>1.25 ± 0.06</td>
<td>1.25 ± 0.06</td>
<td>0.91</td>
</tr>
<tr>
<td><strong>Remainder of day</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy intake (kcal)</td>
<td>1237 ± 134</td>
<td>1207 ± 134</td>
<td>0.85</td>
</tr>
<tr>
<td>Percentage of energy from fat (%)</td>
<td>32.9 ± 2.3</td>
<td>29.9 ± 2.3</td>
<td>0.34</td>
</tr>
<tr>
<td>Energy density (kcal/g)</td>
<td>2.08 ± 0.16</td>
<td>2.16 ± 0.16</td>
<td>0.68</td>
</tr>
</tbody>
</table>

\* Significance difference in total energy intake between experimental conditions \( (P < 0.05) \).

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None of the results changed when the model was adjusted for children’s sex or BMI z score.

There was also no significant main effect of breakfast condition or test week on percentage of energy consumed from fat at lunch (breakfast condition: \( P = 0.80 \); test week: \( P = 0.12 \)) or throughout the remainder of the day (breakfast condition: \( P = 0.34 \); test week: \( P = 0.90 \); Table 4). There was no significant main effect of breakfast condition or test week on the overall energy density of foods that children consumed at lunch (breakfast condition: \( P = 0.91 \); test week: \( P = 0.65 \)) or throughout the remainder of the day (breakfast condition: \( P = 0.68 \); test week: \( P = 0.36 \)).

**Ratings of appetite**

Model-based means for child ratings of hunger, thirst, prospective consumption, and fullness throughout the morning are shown in Figure 2. There was a significant breakfast condition-by-time interaction \( (P < 0.001) \) on ratings of hunger, indicating that on the day when children did not consume breakfast they felt significantly hungrier throughout the morning (0915, 0930, 1015, 1100, and 1140) than when they did consume breakfast. There was also a borderline significant breakfast condition-by-time interaction \( (P = 0.05) \) on ratings of thirst, indicating that on the day when children did not eat breakfast, they were significantly thirstier at 0915 \( (P = 0.002) \) than on the day when they did consume breakfast. Furthermore, there was a significant breakfast condition-by-time interaction \( (P < 0.001) \) on children’s ratings of prospective consumption, indicating that on the day when children did not eat breakfast, they indicated that they could eat significantly more food before lunch (0915, 0930, 1015, 1100, and 1140; \( P < 0.001 \)) than on the day when they were served breakfast. There also was a significant breakfast condition-by-time interaction \( (P < 0.001) \) on ratings of fullness, indicating that on the day when children were not fed breakfast they felt significantly less full throughout the morning (0915, 0930, 1015, 1100, and 1140; \( P < 0.001 \)) than on the day when they ate breakfast. There was no significant main effect \( (P = 0.39) \) of breakfast condition or breakfast condition-by-time interaction \( (P = 0.07) \) on children’s level of nausea.

**DISCUSSION**

This study showed that when children, the majority of whom were regular breakfast eaters, did not eat breakfast on a single day, they did not make up for the missing calories from breakfast by eating more calories at lunch or throughout the remainder of the day. The dietary energy density and percentage of energy consumed from fat at subsequent meals also did not differ across experimental conditions. On the day when no breakfast was served, children indicated that they were significantly hungrier, less full, and could consume more food before lunch than on the day when they did eat breakfast.

In this study, skipping breakfast affected children’s appetite ratings but not their energy intake at subsequent meals. Therefore, on the day when children did eat breakfast, they consumed 362 more calories than on the day when they skipped breakfast. This finding corroborates results from studies based on self-reported intake that showed a higher daily energy intake among children who regularly consumed breakfast compared with those who regularly skipped breakfast (14–16). In the current study, on the day when child participants consumed breakfast, they exceeded their daily EER by \( \approx 20\% \). Although interesting, this finding should be interpreted with caution by taking into account the estimated, rather than observed, energy intake throughout the remainder of the day as well as children’s estimated physical...
activity level to compute their daily EER. Furthermore, with 76% of mothers in the current study classified as either overweight or obese (data not shown), the majority of the children, despite being of normal weight, were predisposed to obesity. Parental obesity, and maternal obesity in particular, is a significant predictor of obesity in the offspring (32). It is possible that the widespread familial predisposition to obesity in this cohort of children may in part help explain children’s high daily energy intake. More studies are needed that experimentally test the effects of eating compared with skipping breakfast on measured intake over multiple meals to more accurately investigate children’s longer-term energy intake regulation.

The current study used a fairly homogenous sample with respect to children’s habitual breakfast habits and weight status. The majority of children in the current study were regular breakfast eaters. It is possible that children who regularly skip breakfast may show different energy intake patterns throughout the day compared with children who regularly eat breakfast and who may skip breakfast only occasionally. In other words, the long-term effects of skipping breakfast on energy intake may develop over time and may involve learning of new eating patterns. Furthermore, the current study was limited to normal-weight and some overweight child participants. It is possible that obese children (ie, those with a BMI-for-age ≥95th percentile) may have responded differently in that they may have consumed more calories later in the day after skipping breakfast compared with predominantly normal-weight children. Data from a prospective cohort study with 9- to 14-y-old children showed that overweight children who never ate breakfast lost weight over a 1-y period compared with overweight children who consumed breakfast nearly every day (33). In contrast, there was a trend for normal-weight children who never ate breakfast to gain weight compared with their normal-weight peers who ate breakfast nearly every day. These findings suggest that skipping breakfast may affect children differently and may depend on child characteristics, such as their weight status.

With respect to ratings of appetite, children indicated that they were significantly hungrier and less full on the day when they did not consume breakfast. This finding confirms our initial hypothesis and suggests that children, the majority of whom in our study were habitual breakfast eaters, do show changes in their hunger and fullness when deprived of breakfast. On the day when children did not eat breakfast, children indicated that they could eat significantly more food before lunch compared with when they did consume breakfast. Given that there were no significant differences in energy intake at lunch between experimental conditions, this finding is interesting. It suggests that there was a dissonance between children’s subjective ratings of how much they thought they could eat and their actual intake at lunch. Whereas VAS ratings have shown sensitivity to experimental conditions, subjectively expressed hunger or appetite is not necessarily predictive of actual food intake (34). It is possible that the standardization of the lunch meal (same types and amounts of foods served across experimental conditions) or other laboratory factors may have contributed to similar intakes between conditions despite differences in appetite ratings. More studies are

**FIGURE 2.** Mean (±SE) ratings of appetite using visual analog scales by breakfast condition (n = 21). Data were analyzed by using a mixed-effects linear model with repeated measures. There was a significant breakfast condition-by-time interaction for ratings of hunger (P < 0.001), thirst (P = 0.05), prospective consumption (P < 0.001), and fullness (P < 0.001). Gray dotted lines indicate no-breakfast condition; black solid lines indicate breakfast condition. *Significant difference between experimental conditions (P < 0.05).
needed that systematically study the effects of meal patterns and food components on satiety in children.

Due to the greater risk of obesity and obesity-related diseases among minority populations (35, 36), it is important to study eating behaviors and eating patterns in minority children. Therefore, we consider the large number of African American children in this study (76%) to be a strength of this study. The study also had several limitations. First, it included a small sample of children of a narrow age range (8–10 y) and excluded children who were obese, which precludes generalization of the findings to other age groups or children with a higher weight status. Second, the study used an estimated (“low active”), rather than observed, measure of physical activity for the computation of child participants’ EER, which could have under- or over-estimated their true physical activity level. Future studies should make use of objective techniques (eg, doubly labeled water method) to measure children’s total energy expenditure to discuss future findings in the context of their measured daily energy needs. Third, children’s intake was measured in the laboratory during a single meal only and children’s intake for the remainder of the day was based on maternal self-report. It is possible that providing children with a wider variety of foods and beverages (eg, buffet-style meal) during lunch may have affected their intake differently. Therefore, future research should extend this design to assess multiple meals that include a wider range of foods and beverages. It is also important in future studies to test the effects of skipping breakfast on children’s selection and consumption of a midmorning snack. Fourth, we did not assess the time at which subjects usually ate a midmorning snack or lunch. Last, our ability to detect significant findings was constrained by our sample size, despite our use of a within-subjects design. The effect size for measured energy intake at lunch was small (Cohen’s d = 0.20). A post hoc power analysis indicated that a sample size of 184 subjects would be needed to confirm the results for measured energy intake at lunch at 80% statistical power. Future studies addressing this topic might require larger samples, depending on the particular hypothesis and measures that are used.

In conclusion, the findings from this study showed that despite differences in subjective feelings of hunger and appetite, children who regularly consume breakfast did not compensate or over-compensate for the missing calories from a skipped breakfast on a single occasion by eating more later in the day.

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