Compensation for Energy Intake From Fast Food Among Overweight and Lean Adolescents

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Consumption of fast food has increased rapidly since the 1970s among adolescents from all socioeconomic and racial/ethnic groups across the United States. Fast food is ubiquitously available and heavily marketed to adolescents. An estimated 75% of adolescents eat fast food 1 or more times per week.

The increase in fast food consumption parallels the escalating obesity epidemic, raising the possibility that these 2 trends are causally related. Characteristics of fast food previously linked to excess energy intake or adiposity include enormous portion size, high energy density, palatability, excessive amounts of refined starch and added sugars, high fat content, and low levels of dietary fiber. Previous studies, which used between- and within-subject comparisons, consistently demonstrate that consumption of fast food is directly related to total energy intake and inversely related to diet quality. Some studies, although not all, have found a direct association between fast food and body weight.

These studies raise a fundamental question: if most children eat fast food regularly, why do some become overweight, whereas others do not? Per...
haps certain individuals are susceptible and others relatively resistant to the adverse effects of fast food. Therefore, we hypothesized that adolescents who eat fast food regularly but are not overweight compensate for the excessive energy in a fast food meal by commensurately decreasing energy intake throughout the day; in contrast, overweight adolescents do not have this tendency.

The purpose of this investigation, which was composed of 2 studies, was to evaluate the effects of fast food on energy intake in overweight vs lean adolescents. In study 1, we assessed energy intake during a fast food meal consumed in a naturalistic setting. In study 2, we compared energy intake under free-living conditions on days when fast food was consumed and days when it was not consumed.

METHODS Participants
We enrolled 54 adolescents (26 overweight, 28 lean) aged 13 to 17 years who reported eating fast food at least 1 time per week. Fifty-one (24 overweight, 27 lean) of the 54 participants enrolled in study 1 also completed study 2. Newspaper advertisements and fliers, stating that the purpose of the project was to collect information on why and how teenagers eat fast food, were used to recruit participants.

Weight and height were measured using an electronic scale (model 6702, Scale-Tronix, White Plains, NY) and a wall-mounted stadiometer (Holtain Limited, Crymych, Wales), respectively. Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters. The Centers for Disease Control and Prevention defines childhood overweight as a BMI exceeding sex- and age-specific 95th percentiles and at risk of overweight as a BMI between the 85th and 95th percentiles, using the 2000 growth charts. In this investigation, we grouped adolescents who were overweight and at risk of overweight and herein refer to them as overweight. Adolescents with a BMI not exceeding the 85th percentiles were considered lean. We did not enroll adolescents with a BMI below the 50th percentile or above the 98th percentile and also excluded those diagnosed as having any major medical illness or eating disorder. None of the participants was taking prescription medications or dieting for the purpose of weight loss. As an incentive, we offered each participant two $30 gift certificates, one following completion of each study.

The protocol was approved by the institutional review board at Children’s Hospital, Boston, Mass. Written informed consent and assent were obtained from parents and participants, respectively. Data were collected between July 2002 and March 2003.

Study 1 Participation involved 1 study visit. We instructed the participants to eat a standard breakfast of cold cereal and milk at 8:30 AM on the day of the visit and then to refrain from eating and drinking (except water) until after the visit. At 1 PM, we fed the participants a fast food meal from a national chain at a food court. All feedings were conducted in groups of 4 participants, on average, to foster socializing that is often part of the fast food experience among adolescents. Participants were grouped by sex and weight status to avoid any self-consciousness about eating that may be associated with these variables (eg, girls eating less in the presence of boys, overweight adolescents eating less in the presence of their lean peers).

The same meal, modeled after prevailing “extra large” fast food fare (Table 1), was served to each participant. The following standard instructions were read to the participants before the meal: “In a few minutes, we will bring each of you a meal. Eat as much or as little as you like, until you have had enough. There is more food available, and you may eat as much as you want. Please do not share your food with others in the group. If you need more of anything, just ask.” The length of the meal was 1 hour. During this time, a research assistant discreetly monitored food intake to ensure that ample food was always available.

Whenever approximately three fourths of the meal portion of chicken nuggets, fries, or cookies was consumed, a refill portion of the item was added to the tray (Table 1). Empty cola containers were immediately replaced with full containers. Participants could obtain ketchup and sweet and sour sauce from the middle of the table at any time during the meal. This standardized protocol allowed us to provide more of the items that each individual enjoyed the most and, thus, would be likely to order in large portions if given the option. Following the meal, each participant estimated the relative size of the meal consumed during the study compared with the size of fast food meals that he or she typically consumed, using a verbally anchored, 10-cm visual analog scale, rang-

Table 1. Characteristics of Fast Food Meal Fed During Study 1

<table>
<thead>
<tr>
<th>Menu Item</th>
<th>Portion</th>
<th>Energy, kcal</th>
<th>Menu Item</th>
<th>Portion</th>
<th>Energy, kcal</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Extra Large</em></td>
<td>“Portion”</td>
<td></td>
<td><em>Refill</em></td>
<td>Portion”</td>
<td></td>
</tr>
<tr>
<td>Chicken nuggets</td>
<td>9 pieces, 162.45 g</td>
<td>438</td>
<td>4 pieces, 72.29 g</td>
<td>195</td>
<td></td>
</tr>
<tr>
<td>French fries</td>
<td>1 “extra large,” 199.68 g</td>
<td>584</td>
<td>1 small, 76.04 g</td>
<td>223</td>
<td></td>
</tr>
<tr>
<td>Cookies</td>
<td>2 bags, 115.28 g</td>
<td>460</td>
<td>1 bag, 57.64 g</td>
<td>230</td>
<td></td>
</tr>
<tr>
<td>Cola†</td>
<td>1 bottle, 20 fl oz</td>
<td>254</td>
<td>1 bottle, 20 fl oz</td>
<td>254</td>
<td></td>
</tr>
<tr>
<td>Ketchup</td>
<td>4 packets, 34.40 g</td>
<td>36</td>
<td>Readily available on the table</td>
<td>. . .</td>
<td></td>
</tr>
<tr>
<td>Sweet and sour sauce</td>
<td>2 packets, 56.84 g</td>
<td>69</td>
<td>Readily available on the table</td>
<td>. . .</td>
<td></td>
</tr>
</tbody>
</table>

*Energy values represent data derived from the Nutrition Data System for Research Software and are based on the gram weights of the “reference unit.” The total energy value for the “extra large” meal was 1841 kcal.
†A refrigerated bottle of cola, rather than a cup of soda, was provided to avoid measurement inaccuracies associated with variable amounts of ice.

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FAST FOOD INTAKE AMONG ADOLESCENTS

ing from “much smaller than usual” to “much larger than usual.”

The difference in weight between the amount of each menu item provided and that remaining on the tray after the meal was used to calculate energy intake. In preparation for data collection, 20 reference units of each menu item were purchased and weighed to evaluate variability in portion sizes. Coefficients of variation, ranging from 0.8% for a packet of sweet and sour sauce to 9.2% for an order of “extra large” french fries, confirmed that portions are highly standardized. Thus, amounts of food provided during the feeding study were estimated based on mean weights of the reference units. Using this method, we were able to serve food immediately after purchasing it, thereby maintaining the temperature, palatability, and visual appearance that are expected by consumers. Leftovers were weighed on an electronic scale (item E1D120, Ohaus Corporation, Florham Park, NJ). The Nutrition Data System for Research Software (NDS-R; versions 4.04 and 4.05, Nutrition Coordinating Center, University of Minnesota, Minneapolis) was used to convert the gram weight consumed to energy intake (in kilocalories). We relied on the NDS-R, rather than nutrition information available from the restaurant, to allow direct comparison with 24-hour dietary recall data collected for study 2.

Study 2

Four dietary and physical activity recall interviews, 2 for fast food days and 2 for non–fast food days, were administered by telephone to assess energy intake under free-living conditions. We used the NDS-R multiple-pass, 24-hour dietary recall method, which prompted the participant to list in sequence what foods and beverages were consumed during the preceding day, identify gaps in the initial list, and then provide details concerning each reported item. At the end of each recall, participants were asked to confirm the information provided and categorize the amount of food intake for the day as “usual,” “more than usual,” or “less than usual.” Physical activity was quantified using a 24-hour recall protocol modeled after the method of Pate et al.19 In brief, participants were asked to recall the activity performed most during respective 15-minute time blocks throughout the day and then to rate the relative intensity of each activity as light, moderate, hard, or very hard. A metabolic equivalent (MET level) was assigned to each reported activity to calculate a physical activity factor. As points of reference, resting has a MET level of 1.0, and brisk walking has a level of 3.0.20 Total energy expenditure (in kilocalories per day) was estimated by multiplying basal metabolic rate, calculated from validated Food and Agriculture Organization, World Health Organization, United Nations University equations that include weight and height as independent variables,21 by the physical activity factor derived from the four 24-hour recalls.

Two criteria were used to define a fast food day. Criterion 1 specified that the participant eat at 1 of the 5 leading fast food establishments: McDonald's, Burger King, KFC, Wendy's, or Taco Bell.22 Criterion 2 specified that the participant consume at least 1 menu item containing meat (beef, pork), chicken, fish, beans, or egg plus 1 additional item (eg, fries, beverage, dessert). A non–fast food day was one that did not meet criterion 1. Days when participants ate at other restaurants, including pizza and sandwich shops, were classified as non–fast food days. Because we were evaluating the effects of fast food meals, as opposed to single menu items, intake was not assessed on days when criterion 1 but not criterion 2 was satisfied. Recalls were unannounced, to avoid reactivity, and conducted on nonconsecutive days. On average, we contacted each participant a mean (SEM) of 6.9 (0.3) times to obtain data for 4 days, including 2 fast food days that satisfied both criteria.

Interstudy Comparison to Evaluate Underreporting

Underreporting of dietary intake is a well-recognized phenomenon, particularly among overweight adolescents, but little is known regarding differential underreporting among foods.23-25 This phenomenon could bias data in study 2 in either direction: against our primary hypothesis if energy intake from fast food were selectively underreported, or in favor of the hypothesis if energy intake from fast food were reported more completely than energy intake from other foods. To evaluate the potential for bias, we examined underreporting of total energy intake and energy intake from fast food in overweight and lean participants, using data from both studies. Recalled total daily energy intake (study 2), averaged across 2 fast food days and 2 non–fast food days, was expressed as a percentage of estimated total energy expenditure to assess the accuracy of self-report of total energy intake. Recalled energy intake from fast food (study 2), averaged across the 2 fast food days, was expressed as a percentage of observed energy intake during the fast food feeding (study 1) to assess the accuracy of self-report of fast food energy intake.

Statistical Methods

Statistical analyses were conducted using SAS statistical software (release 8.2, SAS Institute Inc, Cary, NC). For study 1, 2-sample t tests were used to compare energy intake during the meal between overweight and lean adolescents. For study 2, analysis of variance was performed using the mixed linear model procedure to evaluate whether the interaction between weight status (overweight vs lean) and type of day (fast food days vs non–fast food days) influenced total daily energy intake. In an additional model, we adjusted for self-reported relative amount of food intake. Preplanned contrasts were estimated from the fitted models for overweight and lean adolescents to determine the effects of fast food on total daily energy intake within groups. For the interstudy comparison, a mixed linear model was used to compare the accuracy of self-report between overweight and lean participants. The model for evaluating self-report of fast food intake was adjusted for the relative meal size rating in study 1. Using a 5%
type I error rate, we estimated that a sample of 50 participants (25 overweight, 25 lean) would provide 80% power to detect a between-group difference in energy intake of approximately 150 kcal in study 1 and a difference in effect of approximately 260 kcal between overweight and lean participants in study 2. All results are presented as mean (SEM). Statistical significance was defined as \( P < .05 \).

**RESULTS**

Participant characteristics are presented in Table 2. There were no significant differences in demographic variables (sex, race, age) or height between the overweight and lean participants. The overweight adolescents tended to be less physically active than their lean counterparts \( (P = .06) \) and tended to have a higher total energy expenditure \( (P = .07) \).

**Study 1**

When instructed to eat as much or little fast food as desired, the participants consumed 1652 (87) kcal, amounting to 61.6% (2.2%) of the estimated total energy expenditure. Overweight participants ate more than lean participants, whether energy intake was expressed in absolute terms or relative to estimated needs (Table 3). Relative meal size ratings did not differ between the overweight and lean adolescents \( (8.5 \ [0.4] \text{ vs } 7.8 \ [0.5], P = .22) \).

**Study 2**

There was a significant interaction between type of day (fast food vs non–fast food day) and weight status (overweight vs lean) for total daily energy intake \( (P = .05 \text{ unadjusted, } P = .04 \text{ after adjustment for self-reported relative amount of food intake}) \). Overweight participants consumed 409 (142) kcal/d more on fast food than non–fast food days. In contrast, energy intake was not significantly different on fast food and non–fast food days for the lean participants (Table 4). With regard to physical activity, there was no interaction between type of day and weight status \( (P = .46) \).

**Interstudy Comparison to Evaluate Underreporting**

We sought evidence for incomplete reporting of food intake by examining observed dietary intake data in study 1 and recalled intake data in study 2 (Table 5). Recalled total daily energy intake, expressed as a percentage of estimated total energy expenditure, tended to be lower for the overweight compared with lean participants \( (-15.3\% \ [8.9%], P = .09) \). Recalled energy intake from fast food in study 2, compared with observed intake in study 1, was also lower for the overweight compared with lean participants.
(−17.3% [8.7%], P = .05). Adjustment for relative meal size rating in study 1 did not materially affect this difference (−15.0% [8.6%], P = .09). Thus, as expected, overweight participants tended to underreport total energy intake compared with lean participants; however, the group difference in reporting accuracy was similar for total and fast food energy intake (−15.3% vs −17.3%, P = .84), providing evidence against the possibility of a false-positive result.

**COMMENT**

In 1989, a published statement warned that a lifetime of fast food consumption may place children at increased risk for obesity.26 However, until recently, the potentially adverse effects of fast food in youth have received limited attention in the medical literature.27 With increasing recognition that excess adiposity confers serious health risks and that environmental factors may be driving the obesity epidemic,28 the role of fast food in promoting obesity has emerged as a topic of great interest and debate. Some nutrition professionals argue that fast food is contributing to the obesity epidemic,29 whereas others support industry claims that fast food can be part of a healthful diet.29

Herein, we present the first investigation, to our knowledge, designed to evaluate the effects of fast food on energy intake in overweight vs lean adolescents. Assuming a dietary pattern of 3 meals and 1 or 2 snacks per day, average meal size to maintain energy balance should not exceed approximately 30% of daily energy requirements or approximately 790 kcal in our study sample. Compared with this figure, the participants in study 1 massively overate (1652 kcal or 61.6% of estimated total energy expenditure) in the naturalistic setting of a food court. Overeating, observed in both groups of participants, was especially pronounced among the overweight. Moreover, the overweight participants consumed more total energy on days with than without fast food, in contrast to the lean participants, who consumed virtually the same amount on both days. This observation suggests that overweight individuals do not compensate completely for the massive portion sizes characteristic of fast food today.

There are several ways that an individual could maintain energy balance throughout a day that included large portions of fast food: by decreasing food intake subsequent to a fast food meal, by decreasing food intake in anticipation of a fast food meal, or by adjusting the size of a fast food meal based on how much of other foods have been or will be consumed. Our study does not allow us to determine in which of these ways the lean and overweight participants differed. We also cannot determine whether the failure to compensate fully for energy from large fast food meals is an inherent trait, causing obesity in susceptible individuals, or a secondary event that occurs after development of obesity. Nevertheless, these findings suggest that, at least, fast food consumption serves to maintain or exacerbate obesity in susceptible individuals.

Although excess energy intake in response to large portions is not unique to fast food,7,10–12 we focused on this dietary pattern because of its dominant position in adolescents’ diets and the possibility of a causal link to the obesity epidemic. Indeed, fast food is designed to promote consumption of a maximum of energy in a minimum of time, a precept of not only the business model but also the very name. Other dietary scenarios (eg, a buffet) might also provoke overeating and incomplete energy compensation if they resembled fast food in critical respects, including high energy density, low fiber content, extensive food processing (facilitating rapid swallowing with minimal chewing), and low satiating value. In those scenarios, however, the distinction with fast food may be more one of terminology or marketing than physiology. By contrast, overeating to the magnitude observed in study 1 would be virtually impossible with satiating, low-energy-density, high-fiber foods that require much chewing before swallowing (eg, fruits, vegetables, legumes, whole grain products).

Several issues that pertain to study design should be noted. Strengths include evaluation of energy intake in a naturalistic setting in study 1 and within-subject comparisons in study 2, reducing the possibility of confounding by demographic and behavioral factors. Limitations include a relatively small sample size, restricted generalizability, and reliance on self-report for assessment of energy intake in study 2 (a methodologic issue common to all studies that aim to assess diet under free-living conditions).

Consistent with previous studies23,24 that show that overweight participants have a particularly strong tendency to underreport what they eat, self-reported energy intake on non-fast food days in study 2 was lower for the overweight compared with the lean adolescents. However, owing to the within-subject design, underreporting would lead to a false-positive result only if energy intake from fast food were reported more completely (ie, less underreporting) than total energy intake by the overweight vs lean adolescents. The interstudy comparison suggests that this was not the case. Total daily energy intake in study 2, expressed as a percentage of total energy expenditure, was lower for the overweight than the lean adolescents. Recalled energy intake from the fast food meals in study 2, expressed as a percentage of intake observed in study 1, was also lower for the overweight adolescents. However, the magnitude of underreporting of energy intake from fast food compared with total daily energy intake by the overweight vs lean participants was similar, even after adjustment for meal size rating, suggesting that fast food was not reported more completely than other foods. Moreover, prior studies23-35 suggest that the opposite is likely to occur: overweight individuals may report high-calorie foods perceived as “fattening” (eg, fast food) less, rather than more, completely than other foods. This effect, if present, would bias the study toward the null hypothesis.
In conclusion, our investigation suggests that overweight adolescents are less likely to compensate for the energy in large portions of fast food than their lean counterparts. These findings do not imply that fast food is without detrimental effect in lean adolescents. Previous research has shown that fast food consumption among children in a nationally representative sample affects diet quality in ways that would plausibly increase risk for obesity, regardless of baseline body weight. Although the causes of obesity are multifaceted (as emphasized by the fast food industry), public health measures to limit fast food consumption in children may be warranted. Such measures could include nutrition education campaigns, legislation to regulate marketing of fast food to children, and elimination of fast food from schools.

Author Contributions: As principal investigator, Dr Ludwig had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Ebbeling, Sinclair, Pereira, Garcia-Lago, Ludwig.

Acquisition of data: Ebbeling, Sinclair, Garcia-Lago.

Analysis and interpretation of data: Ebbeling, Pereira, Feldman, Ludwig.

Drafting of the manuscript: Ebbeling, Ludwig. Critical revision of the manuscript for important intellectual content: Pereira, Garcia-Lago, Feldman, Ludwig.


Administrative, technical, or material support: Sinclair, Garcia-Lago.

Supervision: Ebbeling, Ludwig.

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