Less frequent eating predicts greater BMI and waist circumference in female adolescents

Lorrene D Ritchie

ABSTRACT
Background: Little is known about the effect of eating frequency on adiposity.
Objective: The study aim was to assess the prospective relation of an objective measure of eating frequency with adiposity in girls from ages 9–10 to 19–20 y.
Design: By using data from 3-d diet records collected from 2372 girls in the National Heart, Lung, and Blood Institute Growth and Health Study, meal, snack, and total eating frequencies aggregated over the first 2 study years were examined in relation to 10-y change in BMI and waist circumference (WC).
Results: Eating frequency was lower in black and older girls than in white and younger girls (P < 0.0001). In whites, lower initial snack and total eating frequencies were related to greater 10-y increases in BMI (P = 0.023 and 0.012, respectively) and WC (P = 0.030 and 0.015, respectively). In blacks, lower initial meal and snack frequencies were related to greater increases in BMI (P = 0.004 and 0.022, respectively) and WC (P = 0.052 and 0.005, respectively). Also, in blacks, lower initial total eating frequency was related to greater increases in WC (P = 0.010). After adjustment for baseline adiposity measure, race, parental education, physical activity, television and video viewing, total energy intake, and dieting for weight loss, lower initial total eating frequency remained related to greater 10-y increases in BMI (P = 0.013) and WC (P = 0.036).

INTRODUCTION
Nearly one-third of US adolescents are overweight or obese; among blacks, the prevalence is even higher, affecting nearly half of black adolescent females (1). In comparison with male and white adolescents, female and black adolescents experience more rapid increases in weight trajectory into young adulthood (2). Furthermore, most obese adolescents remain obese as adults (3). Therefore, prevention of excess weight gain during adolescence is critical to reversing obesity trends.

Eating more often has been related to an increased energy intake (4), suggesting frequency of eating may be a behavioral factor to target for obesity prevention. Recently the USDA and the Department of Health and Human Services conducted a comprehensive literature review to inform the 2010 Dietary Guidelines for Americans (5). Because of the lack of prospective studies, it was concluded that there was insufficient evidence to determine whether frequency of eating affects obesity. Other recent reviews have also called for additional research on this topic (6, 7).

Interpreting the literature on eating frequency is complicated by the fact that there is no consensus on what constitutes a snack, a meal, or an eating occasion. Many studies have relied on respondents’ self-identification of meals compared with snacks (8, 9), whereas others have used dietitians to differentiate between the two (10). Because of concerns over definitional differences, other researchers have attempted to use more objective criteria. In one study, an eating occasion was classified as any event that provided ≥50 kcal with a minimum time interval of ≥15 min between episodes (11). In another, a snacking occasion was defined as food eaten within a 15-min period (12). Snacks and meals have also been defined on the basis of the foods consumed rather than when or how often such items are eaten (13–15). Furthermore, some have equated “frequency of eating” or “nibbling” with snacking (16), whereas others have separated snacks from meals (10, 17).

In 2 nationally representative cross-sectional studies in children, no relation was observed between meal frequency and weight status (9, 18). Longitudinal studies that have examined snacking in children in relation to body weight have had mixed results, with studies variously showing a positive relation (19) or no relation (14, 20). In a biracial cohort of >2000 adolescent females, Franko et al (10) reported that a greater number of meals (≥3) was related to a lower concurrent BMI; snack frequency was not examined in this study.

To further our understanding of eating frequency and its relation to adiposity, the aims of this study were as follows: to use an objective definition to quantify eating frequency, to track eating frequency in girls across adolescence (from ages 9 or 10 y

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to 19 or 20 y), to assess the prospective relation of eating frequency with BMI and waist circumference (WC), and to examine differences in eating frequency and its relation to measures of adiposity between black and white girls.

SUBJECTS AND METHODS

Sample

Data collected from 1213 black and 1166 white girls in the 10-y National Heart, Lung, and Blood Institute Growth and Health Study (NGHS) were used to examine eating frequency through adolescence. As previously reported (21), girls were recruited in 1987 by 3 clinical centers: Berkeley, CA; Cincinnati, OH; and Washington, DC. The University of California at Berkeley recruited a census sample of girls from all public and private schools in west Contra Costa County, an urban area north of Berkeley. The Children’s Hospital of Cincinnati recruited participants from public and parochial schools chosen to be representative of Hamilton County, which includes inner city, urban, and suburban areas. Westat (Washington, DC) participants were randomly drawn from the membership directory of families enrolled in Group Health Association, a large health maintenance organization. The institutional review boards of each participating site approved study protocols, and parental consent was obtained for all participants.

Inclusion criteria at study enrollment consisted of the following: age within 2 wk of 9 or 10 y at the time of the first study visit, black or white (by self-report), living with parents or guardians with racial concordance, and parent or guardian providing information on the demographic characteristics of the household. The NGHS instituted a comprehensive protocol to ensure high participation throughout the study. Retention in year 10 was at 88% of the original cohort.

Assessment of anthropometric measures and eating and physical activity behaviors

The cohort provided annual information on nutrition and physical activity patterns and anthropometric measurements. Anthropic measurements were performed by examiners who were trained and certified every year. At each study visit, measurements were made twice; a third measurement was performed if the first 2 differed by more than predetermined levels. With the use of standardized protocols as described previously, height and weight measurements (from which BMI was derived) were performed with participants wearing light clothing and without shoes; WC was measured at the umbilicus (21).

Methodologies for collecting dietary information were validated by using actual observed eating and activity behavior. The 3-d food record was found to be more accurate than a single 24-h recall or 5-d food-frequency methodologies, and multiple food records are considered the most reliable means of establishing meaningful dietary patterns (22). Girls were instructed in keeping 3-d food records consisting of 2 weekdays and 1 weekend day as previously described (23). Briefly, each girl was provided with measuring cups, spoons, rulers, and age-appropriate, written portion-size materials. Trained and certified nutritionists reviewed records with each girl promptly after they were completed, and in no case later than after 15 d. During these inter-

views, girls elaborated on food preparation, brand names, and portion sizes and were probed for forgotten items. Food records were collected at every annual visit except for years 6 and 9. To minimize any seasonal diet variations, annual assessments were scheduled at a similar time of year for each girl.

Definition of eating frequency variables

The following aspects of daily frequency of eating were investigated: number of meals, number of snacks, and total number of eating episodes (meals and snacks combined). An eating episode comprised all foods and beverages recorded at a single clock time, regardless of the amount or type of food or beverage reported. On the basis of national averages of the distribution of calories from meals compared with snacks (8, 24, 25), a meal was defined as any eating episode comprising ≥15% of total calories, regardless of the time of day or composition of foods or beverages consumed. All other eating episodes were classified as a snack. An objective measure of an eating episode was used in this study to extend a previous report of timing of eating patterns in the NGHS cohort, which based meals on the number of foods and time of day (10). To aggregate across all study years, the mean of the number of meals and snacks for each participant for each study visit was computed, then averaged by participant over all visits. To aggregate across the initial 2 study years, the mean of the number of meals and snacks for each participant for each study visit was computed, then averaged by participant over 2 visits. Eating frequency data from the initial 2 study years (ages 9–11 y) were aggregated to estimate usual eating frequency at baseline. The following distributions were examined: 1–2.5 meals/d; 0–1, 1.1–2, 2.1–3, and >3 meals/d; 1–3, 3.1–4, 4.1–6, and >6 meals/d. Frequency-of-eating variables were compared with change in BMI and WC from age 9 or 10 y (initial study visit) to age 19 or 20 y (final study visit). For 312 girls who were missing a BMI measurement and 324 girls who were missing a WC measurement at the final study visit, the second to last visit measurements were used.

Statistical analysis

Initial eating frequency (meal, snack, or total) was the independent measure; 10-y change in BMI and WC were the dependent measures. Analyses comparing eating frequency measures by race were performed by t test. Prospective analyses by race were performed by using ANOVA followed by Tukey’s honestly significant difference multiple-comparison tests. Levene’s test was used to check that the assumption of homogeneity was not violated, and plots of the residuals for deviations were created to ensure that the assumptions of independence and normality were not violated. Models examining the relation between eating frequency and adiposity were performed by complex ANOVA followed by Tukey’s honestly significant difference multiple-comparison tests. Analyses were conducted by using SAS (version 9.2, 2008; SAS Institute Inc) and R (version 2.8.1, 2008; R Development Core Team), a software designed for statistical computing. Differences were considered significant at P < 0.05 (2-tailed). Control variables included in models were selected on the basis of being potentially related to both independent and dependent measures in this (data not shown) and other (9, 25, 27)
Control variables included the following: baseline adiposity measure (BMI or WC), maximum years of school completed by either parent (categorized as 0–6, 7–9, or >10 y), physical activity [categorized as 1) never/almost never, 2) sometimes, or 3) usually/always in response to a survey question on frequency of being physically active], average television/video watching, total energy intake, dieting for weight loss (dichotomized as “never/almost never” or “sometimes/usually/always” in response to a survey question on current adherence to a diet to lose weight), and overweight status at baseline (BMI $\geq$85th percentile for age 9 or 10 y on the basis of CDC growth charts [26]). Control variables measured more than once over the course of the study were aggregated as follows: physical activity responses were averaged over measurement years and then reclassified as to whether closer to categories 1, 2, or 3 described above; television/video watching responses were averaged over all measurement years and then categorized as 0–20, 20.1–40, or >40 h/wk; total energy intake (kcal/d) was averaged from 3-d diet records and then averaged over all measurement years; and dieting to lose weight was dichotomized as “no” (never reported over the course of the study) or “yes” (reported at least once over the course of the study). In the adjusted models, 233 participants were excluded from the analysis due to missing data on one or more control variables, resulting in a usable sample of 2146.

RESULTS

Baseline values for eating frequency, BMI, WC, and control variables of interest were significantly different between black and white girls (Table 1). The aggregate mean $\pm$ SD values across the 10 y of study for all subjects was 4.23 $\pm$ 1.01 total eating episodes/d (2.56 $\pm$ 0.26 meals/d and 1.67 $\pm$ 1.06 snacks/d) (Table 2). For all subjects, total eating episodes averaged 479 $\pm$ 118 kcal/episode, with meals contributing 641 $\pm$ 135 kcal/episode and snacks contributing 150 $\pm$ 48 kcal/episode. Eating frequency (meals, snacks, and total episodes) was greater in white girls than in black girls and greater in younger girls than in older girls (Figure 1). The change in meal frequency as girls got older, however, was relatively small; most of the decrease in eating frequency was attributable to a reduction in snacking. Eating frequency also varied as a function of day of the week; by paired t tests, weekdays were characterized by more meal (P $< 0.0001$) and more snack (P $< 0.0001$) eating episodes than were weekends (averaging 2.58 $\pm$ 0.29 meals/d and 1.71 $\pm$ 0.109 snacks/d on weekdays compared with 2.53 $\pm$ 0.35 meals/d and 1.59 $\pm$ 1.25 snacks/d on weekends). Black girls ate fewer meals and snacks than did white girls on both weekends and weekdays (data not shown).

Aggregating intake data across all study years, the meal pattern followed by the majority (56%) of study participants was 2.5–3 times/d [a pattern followed by more whites (62%) than blacks (49%), P $< 0.0001$]. The most prevalent frequency of snacking was 1.1–2 times/d [followed by 43% of all participants and more whites (45%) than blacks (40%), P $< 0.05$]. The most prevalent frequency for total eating episodes was 4.1–6 times/d [followed by 47% of all participants and more whites (54%) than blacks (40%), P $< 0.001$].

Relations between the frequency of eating (meals, snacks, and total) aggregated over the initial 2 y of the study in relation to change in BMI or WC from baseline to the final measurement were examined separately for whites and blacks. Among white girls, lower initial snack and total eating frequencies were related to greater 10-y increases in BMI (P = 0.023 and 0.012, respectively) and WC (P = 0.030 and 0.015, respectively). Among black girls, lower initial meal and snack frequencies were related to greater increases in BMI (P = 0.004 and 0.022, respectively) and WC (P = 0.052 and 0.005, respectively). Also, in blacks, lower initial total eating frequency was related to greater increases in WC (P = 0.010).

In a model adjusted for baseline adiposity measure (BMI or WC), race, parental education, physical activity, television/video viewing, and total energy intake (model 2), a lower frequency of eating snacks and total eating episodes aggregated across the initial 2 study years was associated with greater increases in BMI (P = 0.026 for meals, P = 0.039 for snacks, P = 0.006 for total eating episodes) and WC (P = 0.028 for snacks, P = 0.020 for total eating episodes) between initial (ages 9 or 10 y) and the final follow-up (ages 19 or 20 y) time point (Table 3). When dieting for weight loss was also added into the model (model 3), the relation between initial total eating frequency and 10-y increase in BMI (P = 0.013) and in WC (P = 0.036) remained significant.

### Table 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>All</th>
<th>White</th>
<th>Black</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meals (times/d)</td>
<td>2.59 $\pm$ 0.47</td>
<td>2.61 $\pm$ 0.46</td>
<td>2.57 $\pm$ 0.49</td>
<td>0.053</td>
</tr>
<tr>
<td>Snacks (times/d)</td>
<td>2.37 $\pm$ 2.14</td>
<td>2.63 $\pm$ 2.14</td>
<td>2.11 $\pm$ 2.11</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Total eating (times/d)</td>
<td>4.96 $\pm$ 2.01</td>
<td>5.24 $\pm$ 1.99</td>
<td>4.68 $\pm$ 1.99</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Parental education (y)$^2$</td>
<td>8.59 $\pm$ 3.43</td>
<td>9.53 $\pm$ 3.42</td>
<td>7.72 $\pm$ 3.20</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Physical activity$^2$</td>
<td>2.35 $\pm$ 0.69</td>
<td>2.43 $\pm$ 0.64</td>
<td>2.27 $\pm$ 0.72</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Television/video viewing (h/d)</td>
<td>4.41 $\pm$ 2.45</td>
<td>3.59 $\pm$ 2.04</td>
<td>5.20 $\pm$ 2.55</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Dieting for weight loss$^4$</td>
<td>1.29 $\pm$ 0.46</td>
<td>1.26 $\pm$ 0.44</td>
<td>1.33 $\pm$ 0.47</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>BMI (kg/m$^2$)</td>
<td>18.38 $\pm$ 3.84</td>
<td>17.94 $\pm$ 3.29</td>
<td>19.19 $\pm$ 4.20</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>65.19 $\pm$ 9.24</td>
<td>63.59 $\pm$ 8.28</td>
<td>66.69 $\pm$ 9.82</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

$^1$ All values are means $\pm$ SDs. Significant differences between whites and blacks were determined by $t$ test.

$^2$ Parental education was the maximum years of education completed by either parent.

$^3$ In response to a survey question on frequency of being physically active, physical activity was categorized as 1 = never/almost never, 2 = sometimes, or 3 = usually/always.

$^4$ Dieting for weight loss was categorized as 1 = never/almost never or 2 = sometimes/usually/always in response to a survey question on current adherence to a diet to lose weight.
DISCUSSION

The frequency of eating in the United States has increased over the time period that obesity rates have risen most dramatically, causing concern that more frequent eating—in particular snacking—may be a risk factor for excessive weight gain (25, 27). On the basis of dietary intake data from the Continuing Food Intake from Individuals surveys, between 1977–1978 and 1994–1996 the frequency of daily eating episodes (meals and snacks self-defined) increased from 3.92 to 4.53 in men and from 3.86 to 4.44 in women. These increases were largely due to a 60% increase in daily snacks (4). Children’s intake data from the Continuing Food Intake from Individuals surveys during the same time period indicate a similar trend: the prevalence of snacking increased in all age groups between 2 and 18 y of age (25). Following self-defined patterns in the NHANES, the prevalence of snacking increased from 74% of children in 1977–1978 to 98% in 2003–2006, with an average increase of 1.11 snacks/d (27). On the basis of dietary intake data from the Continuing Food Intake from Individuals surveys during the time period that obesity rates have risen most dramatically, the frequency of daily eating episodes (meals and snacks self-defined) increased from 3.92 to 4.53 in men and from 3.86 to 4.44 in women. These increases were largely due to a 60% increase in daily snacks (4). Children’s intake data from the Continuing Food Intake from Individuals surveys during the same time period indicate a similar trend: the prevalence of snacking increased in all age groups between 2 and 18 y of age (25). Following self-defined patterns in the NHANES, the prevalence of snacking increased from 74% of children in 1977–1978 to 98% in 2003–2006, with an average increase of 1.11 snacks/d (27). On the basis of dietary intake data from the Continuing Food Intake from Individuals surveys during the time period that obesity rates have risen most dramatically, the frequency of daily eating episodes (meals and snacks self-defined) increased from 3.92 to 4.53 in men and from 3.86 to 4.44 in women. These increases were largely due to a 60% increase in daily snacks (4). Children’s intake data from the Continuing Food Intake from Individuals surveys during the same time period indicate a similar trend: the prevalence of snacking increased in all age groups between 2 and 18 y of age (25). Following self-defined patterns in the NHANES, the prevalence of snacking increased from 74% of children in 1977–1978 to 98% in 2003–2006, with an average increase of 1.11 snacks/d (27). On the basis of dietary intake data from the Continuing Food Intake from Individuals surveys during the same time period indicate a similar trend: the prevalence of snacking increased in all age groups between 2 and 18 y of age (25). Following self-defined patterns in the NHANES, the prevalence of snacking increased from 74% of children in 1977–1978 to 98% in 2003–2006, with an average increase of 1.11 snacks/d (27).

The effect size in terms of the observed difference in BMI (in kg/m²) between the lowest and highest snacking-frequency groups was 1.29 (calculated from the fully adjusted model in Table 3). To translate the magnitude of this effect into practical terms, it is informative to compare this difference to changes achieved in successful pediatric obesity prevention interventions. The Shape Up Somerville Study, for example, achieved changes in BMI on the order of 0.2 in elementary school children as a result of a community-based initiative during one school year (28). Other interventions have achieved BMI changes in children of a similar magnitude (29–32).

This appears to be the first cohort study to examine snacking frequency in adolescents in relation to adiposity. Prior cohort studies of adolescent snacking have focused on the frequency of consumption of snack foods, as quantified by food-frequency questionnaire, rather than the frequency of snacking episodes. In the Massachusetts Institute of Technology Growth and Development Study, no relation was observed between the frequency of consuming energy-dense snack foods (baked goods, ice cream, chips, soda, and candy) by 196 premenarchial girls at ages 8–12 y and BMI z scores up to 10 y later (14). In the Growing Up Today Study in nearly 15,000 boys and girls aged 9–14 y at baseline, there was no relation between intake of snack foods and changes in BMI z score in boys after age, height change, Tanner stage, physical activity, and inactivity were controlled for. Among girls, there was a significant inverse association, but this association disappeared when dieting status was added to the model (20). In contrast, on the basis of data from 1148 boys and girls in the Quebec Heart Health

![TABLE 2](image)

Comparison between white (n = 1162) and black (n = 1210) female adolescents on frequency and caloric content of total eating episodes, meals, and snacks aggregated over the 10 study years.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>Mean ± SD</th>
<th>P value</th>
<th>Group</th>
<th>Mean ± SD</th>
<th>P value</th>
<th>Group</th>
<th>Mean ± SD</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency (times/d)</td>
<td>Whites</td>
<td>2.60 ± 0.25</td>
<td>&lt;0.0001</td>
<td>Blacks</td>
<td>2.55 ± 0.27</td>
<td>1.51 ± 1.03</td>
<td>0.40 ± 1.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy consumed (kcal/episode)</td>
<td>Whites</td>
<td>595 ± 113</td>
<td>&lt;0.0001</td>
<td>Blacks</td>
<td>686 ± 139</td>
<td>158 ± 55</td>
<td>525 ± 121</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Significant differences between whites and blacks were determined by t test.

![FIGURE 1](image)

Mean (±SD) frequency of meals (A) and snacks (B) by age and race. **The daily numbers of meals, snacks, and eating episodes were significantly different between blacks and whites by t test: *P < 0.001, **P < 0.0001, ***P < 0.0001. n = 1162 for whites, and n = 1210 for blacks. Although any given participant had a maximum of 8 annual measurements beginning at ages 9 or 10 y and ending at ages 19 or 20 y, continuous yearly age intervals are represented when data from all participants are combined. Error bars represent ±1 SD for whites (dark bars) and ±1 SD for blacks (light bars).
TABLE 3
Changes in adiposity measures according to frequency of meals, snacks, and total eating episodes

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Sample size</th>
<th>Change in BMI Mean ± SE</th>
<th>Change in WC Mean ± SE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Model 1</td>
<td>Model 2</td>
</tr>
<tr>
<td>Meals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1–2.5 times/d</td>
<td>1066 (50)</td>
<td>6.68 ± 0.15a</td>
<td>7.18 ± 0.23a</td>
</tr>
<tr>
<td>&gt;2.5 times/d</td>
<td>1080 (50)</td>
<td>7.13 ± 0.14a</td>
<td>7.63 ± 0.22b</td>
</tr>
<tr>
<td><strong>P</strong> value</td>
<td></td>
<td>0.026</td>
<td>0.026</td>
</tr>
<tr>
<td>Snacks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–1 time/d</td>
<td>603 (28)</td>
<td>7.30 ± 0.20a</td>
<td>7.66 ± 0.26a</td>
</tr>
<tr>
<td>1.1–2 times/d</td>
<td>618 (29)</td>
<td>7.03 ± 0.19a</td>
<td>7.62 ± 0.26a</td>
</tr>
<tr>
<td>2.1–3 times/d</td>
<td>414 (19)</td>
<td>6.90 ± 0.23abc</td>
<td>7.45 ± 0.29a</td>
</tr>
<tr>
<td>&gt;3 times/d</td>
<td>511 (24)</td>
<td>6.36 ± 0.21bc</td>
<td>6.89 ± 0.28a</td>
</tr>
<tr>
<td><strong>P</strong> value</td>
<td></td>
<td>0.009</td>
<td>0.039</td>
</tr>
<tr>
<td>Total eating episodes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1–3 times/d</td>
<td>236 (11)</td>
<td>7.75 ± 0.32a</td>
<td>8.05 ± 0.37a</td>
</tr>
<tr>
<td>3.1–4 times/d</td>
<td>619 (28)</td>
<td>7.10 ± 0.19b</td>
<td>7.59 ± 0.26a</td>
</tr>
<tr>
<td>4.1–6 times/d</td>
<td>908 (42)</td>
<td>6.88 ± 0.16b</td>
<td>7.44 ± 0.24a</td>
</tr>
<tr>
<td>&gt;6 times/d</td>
<td>383 (18)</td>
<td>6.23 ± 0.24b</td>
<td>6.68 ± 0.31b</td>
</tr>
<tr>
<td><strong>P</strong> value</td>
<td></td>
<td>0.001</td>
<td>0.006</td>
</tr>
</tbody>
</table>

1 The frequencies of meal, snack, and total eating episodes were aggregated across the first 2 y of the study (ages 9–11 y). Change in adiposity measure was calculated as the difference between the measures at the final and initial study visits. ANCOVA was used to test overall model significance for meals, snacks, or total eating episodes. Means within a column that do not share a common letter are significantly different (P < 0.05) by Tukey’s honestly significant difference test. Due to the protection against multiple comparisons, means may not be declared different, even though the overall effect was significant. Model 1 adjusted for baseline adiposity values (BMI or WC). Model 2 adjusted for baseline adiposity values (BMI or WC), race, parental education, physical activity, television/video viewing, and total energy intake. Race was classified as either white or black. Parental education was the maximum years of education completed by either parent. Physical activity was assessed as the frequency of being physically active over the first 2 y. Television/video viewing (h/wk) and total energy intake (kcal/d) were averaged for the first 2 y. Model 3 adjusted for factors included in model 2 plus dieting for weight loss, which was dichotomized as never reporting this behavior or reporting it at least once over the 10 study years. WC, waist circumference.

2 Percentages may not add up to 100% due to rounding. In the models, 226 participants were excluded from the analysis due to missing data on one or more control variables, resulting in an analytic sample of 2146.

3 Mean ± SE (all such values).

Demonstration project, adolescents who were of normal weight at follow-up (grade 9) had increased their intake of snack foods (doughnuts, cakes or pastries, chips, and candy) over the course of the prior 5 y, whereas those who were overweight or obese at baseline had not changed their snack food intake (13). Cross-sectional studies have likewise had inconsistent findings. For example, among 1562 black and white 10-y-olds in the Bogalusa Heart Study, the amount of food consumed as snacks was positively related to overweight (33). In contrast, in a US nationally representative study in 5811 adolescents aged 12–18 y, snacking frequency and percentage of energy intake from snacks were inversely associated with adiposity measures (34).

Only one intervention study (with nonrandom assignment) has examined the impact of changing eating frequency on obesity prevention. In this study in hearing impaired children in boarding schools in Czechoslovakia, an increased eating frequency (7 or 5 compared with 3 times/d) resulted in less gain in weight and skinfold thickness in older children (aged 10–16 y) but not in younger children (aged 6–11 y) (35). The authors hypothesized that puberty may be a critical period for the influence of eating frequency on weight, a contention that warrants further investigation.

Studies of adult adiposity have also examined snacking; as with studies of children, the results have been inconsistent (8, 17, 36, 37). Furthermore, whereas epidemiologic studies in adults have consistently shown a more favorable lipid profile associated with greater daily eating episodes (38–40), short-term clinical trials have had more mixed findings (41–46). A comparison of findings from various studies is complicated by methodologic differences, including varying definitions and methods of quantifying eating episodes.

Important strengths of this study include the prospective design with a long period of follow-up (10 y), a large sample size, the inclusion of multiple food records, and the use of measured (as opposed to self-reported) height and weight. However, several study limitations merit acknowledgment. First, this study included only black and white female adolescents, limiting the generalizability of findings to boys and other race-ethnicity groups. Because dietary intakes were collected by self-report, it is possible that girls who were more prone to weight gain were more likely to underreport the number of times they ate and/or ate less to avoid additional weight gain. Underreporting of food intake has been widely reported (47–49), and this is particularly evident for snacks (48) and for individuals who are overweight (49). Although control for baseline overweight did not alter the findings in this study, baseline overweight status may not have been an adequate indicator of propensity to underreport or undereat. Furthermore, whereas 2 y of diet measurements were aggregated to better quantify usual eating frequency at baseline, it is not known if the way in which eating frequency was reported by participants changed over this time.

Reverse causality is another plausible explanation for the observed relation between eating frequency and adiposity: individuals may skip meals and omit snacks in an attempt to lose weight or to prevent additional weight gain. One study found that...
when dieting boys and weight-conscious girls were eliminated from the analytic sample, the inverse relation between meal frequency and BMI no longer existed among adolescents (6, 50). The inclusion of dieting for weight loss in the analytic model attenuated, but did not eliminate, the relation observed in the present study. It is possible, however, that not all reverse causality was identified by self-reported dieting.

Although a standardized and objective means of classifying meals, snacks, and eating episodes was used to avoid discrepancies in how different individuals might categorize eating occasions and how the same individual might differentially categorize eating occasions through adolescence, other definitions have been reported in the literature and could influence study findings. By convention, the terms meal and snack were used; however, larger and smaller eating episodes are equally applicable. Values for frequency of eating, however, are comparable to those reported elsewhere. For example, on the basis of nationally representative data on 12–18-y-olds’ self-reported eating occasions collected during a similar time period as the NGHS study, Jahn et al (25) reported that snacking frequency averaged 1.62 times/d in 1989 and 1.97 times/d in 1996. Regardless, further research is warranted to identify how best to quantify eating frequency. Although it is unlikely that a single definition will be applicable to all age, sex, and cultural groups, and that different categories may be appropriate depending on the study objectives, the nutrition field would benefit from a refined list of selection options to facilitate comparisons across studies (15).

In conclusion, additional prospective and longitudinal analyses and intervention trials are warranted, with careful consideration of how eating frequency is defined. If it is confirmed that a greater number of daily eating times is beneficial, increasing the frequency of eating may be recommended as one strategy for preventing overweight in youth.

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