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PEDIATRIC HIGHLIGHT

Snack food intake does not predict weight change among children and adolescents

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OBJECTIVE: To assess whether intake of snack foods was associated with weight change among children and adolescents.
METHODS: Prospective study of 8203 girls and 6774 boys, 9–14 y of age in 1996, in an ongoing cohort study who completed at least two questionnaires between 1996 and 1999. Intake of snack foods was assessed in 1996–1998 with a validated food frequency questionnaire designed specifically for children and adolescents. The outcome measure was change in age- and gender-specific *z*-score of body mass index (BMI).
RESULTS: Boys consumed more snack foods than girls during the entire study period. After controlling for Tanner stage of development, age, height change, activity, and inactivity, there was no relation between intake of snack foods and subsequent changes in BMI *z*-score among the boys ($\beta = -0.004$), but snack foods had a weak inverse association ($\beta = -0.007$, $P < 0.05$) with weight change among the girls. However, the results were confounded by dieting status, which had a significant positive independent association with BMI change. After controlling for dieting status and whether the mother was overweight, the association between servings per day of snack foods and subsequent changes in BMI *z*-score were not significant in either gender.
DISCUSSION: Our results suggest that although snack foods may have low nutritional value, they were not an important independent determinant of weight gain among children and adolescents.
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Introduction

During the past two decades, the prevalence of overweight has more than doubled among children and adolescents.[1] Currently, approximately 15% of children and adolescents in the United States are overweight. During the same time period that the prevalence of overweight has increased, the average number of calories per day from snack foods has increased.[2] Despite the ecological association, the relation between snack food intake and weight change is not well understood. In a cross-sectional study of 1562 children in the Bogalusa Heart Study, Nicklas *et al*[3] observed that consumption of sugar-sweetened beverages and sweets were associated with being overweight. The association of snack food intake and weight has also been investigated in two prospective studies. Francis *et al*[4] followed 173 Caucasian girls from age 5 to 9 y. They observed no relationship between intake of snacks and weight gain among children with lean parents; however, among the girls with at least one overweight parent, snack food intake was associated with greater weight gain. Unfortunately, Francis and colleagues did not control for caloric intake, thus it is unknown whether their results were confounded by differences in caloric intake. In another longitudinal study of snack food intake and weight change, 178 nonobese premenarcheal girls were followed annually over a 10-y period and no association was observed between consumption of snack foods and either body mass index (BMI) or percent body fat.[5] We are unaware of other longitudinal studies on snack food intake and weight change.

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Snack foods tend to be energy dense and of little nutritional value. The low fat and no fat snack foods, which were popular in the 1990s, often contained fewer grams of fat, but similar calories to the normal fat options of similar types of snack foods. Despite their lack of nutritional value, snack foods are readily available to children and adolescents in a variety of settings, including school.[6] Because snack foods are commonly consumed by children and adolescents, understanding their relationship to weight gain is important. To assess whether intake of snack foods, including reduced fat snack foods, are predictive of weight gain, we analyzed data from approximately 15 000 preadolescent and adolescent girls and boys in the Growing Up Today Study, a prospective cohort study of youth throughout the United States.

Methods

The Growing Up Today Study (GUTS) was established in 1996 by recruiting children, who were 9–14 y of age, of women participating in the Nurses' Health Study II (NHS II). Using the NHS II data, we identified mothers who had children aged 9–14 y. We wrote a detailed letter to the mothers, explaining that the purpose of GUTS was to study the predictors of weight change during adolescence and sought parental consent to enroll their children. Additional details have been reported previously.[7] Approximately 68% of the girls ($N = 9039$) and 58% of the boys ($N = 7843$) returned completed questionnaires, thereby assenting to participate in the cohort. The study was approved by the Human Subjects Committees at Brigham and Women's Hospital.

Measures

Maternal measures. Information on maternal weight, height, and BMI (kg/m^2) came from the questionnaires that the mothers completed as part of the NHS II. Height was assessed in 1989. Weight has been assessed on each of the biennial surveys. Weight in 1995 was used to calculate mother's BMI [wt(kg)/ht(m)^2] around the time that her child or children were enrolled in GUTS.

Child measures. Dietary intake, physical activity, inactivity, Tanner stage of development, weight control strategies, weight, and height were assessed annually from 1996 through 1999 in GUTS. Height, weight, and Tanner stage were self-reported. We calculated BMI using self-reported weight and height information and calculated z-scores based on the CDC growth charts,[8] which are age- and gender-specific. Drawings of the five Tanner stages of development of pubic hair were used for assessing pubertal development.

Dietary intake was assessed with the Youth/Adolescent Questionnaire (YAQ), a validated self-administered semi-quantitative food frequency questionnaire assessing intake over the past year.[9,10] The YAQ was validated by comparing, in terms of ranking, the estimated intake from the YAQ to the average of three nonconsecutive 24-h recalls. The questionnaire asks participants how often, on average, they consumed each of the 131 foods listed (such as mixed vegetables, macaroni and cheese, and peanut butter sandwich). The food portion sizes were determined by a review of US Department of Agriculture Handbook No. 8 serving sizes,[11] NFCS Foods Commonly Eaten by Individuals (specifically for ages 9–18 y),[12] and the 'natural' serving size (eg bread slice; apple 1). Based on expert opinion, 24-h recalls, and write-ins on an earlier version of the YAQ used in a pilot study, a snack food section was developed for the YAQ. In 1996 and 1997, there were 27 questions on snack foods. In 1998, there were 25 questions assessing intake of snack foods (see Table 1 for snack foods assessed). Daily servings of snack foods were estimated by summing these items. Examples of serving sizes of snack foods include one pop tart, one snack cake, three cookies, and one small bag of popcorn. Sugar-sweetened beverages, such as soda, can be consumed as a snack or as part of a meal, thus they were not included as servings of snack foods. However, in secondary analyses, we assessed the association of servings per day of snack foods and sugar-sweetened beverages (soda—not diet, Hawaiian punch, lemonade, Kool-Aid, or other noncarbonated fruit drink).

In 1997 and 1998, the participants were asked 'think about the snack foods you eat like chips, cake, cookies, and ice

Table 1 Snack foods assessed on the 1996–1998 GUTS questionnaires

	1996	*1997*	*1998*
Potato chips	X	X	X
Corn chips/Doritos	X	X	X
Nachos	X	X	X
Popcorn	X	X	X
Pretzels	X	X	X
Peanuts, nuts	X	X	X
Fun fruit or fruit rollups	X	X	X
Graham crackers	X	X	X
Crackers, like Wheat Thins or Ritz	X	X	X
Poptarts	X	X	X
Cake	X	X	X
Snack cake, like Twinkies	X	X	X
Danish, sweet rolls, or pastry	X	X	X
Donuts	X	X	X
Cookies	X	X	X
Brownies	X	X	X
Pie	X	X	X
Chocolate, like Hershey's or M & Ms	X	X	X
Other candy bar	X	X	
Other candy without chocolate	X	X	X
Jello	X	X	
Pudding	X	X	X
Frozen yogurt	X	X	X
Ice cream	X	X	X
Milkshake or frappe	X	X	X
Popsicle	X	X	X
Seeds (sunflower or pumpkin)	X	X	
Frequency of eating low fat or no fat snacks		X	X
Energy bar (like Power or Cliff Bar)			X
High protein bar (like MetRx or Balance Bar)			

cream. When you have these snacks, do you ever eat the low fat or no fat kinds (like Snackwells or Health Choice)?'Participants who reported 'yes,'were then asked 'do you eat them: always (I eat snack foods *only* if they are low fat or no fat), sometimes (I eat some low fat or no fat snacks), or rarely (I usually don't eat low fat or no fat snacks).'

Physical activity was assessed with 18 questions on hours per week within each of the four seasons that a participant engaged in a specific activity (eg, volleyball, soccer). A summary score of average hours per week of physical activity was computed. Reports of an average of more than 40 h per week were considered implausible and therefore set to missing and not used in the analysis. Inactivity was estimated by asking participants the average number of hours per week spent watching TV; watching videos or VCR; reading/homework; or playing Nintendo/Sega/computer games. Reports of an average of more than 80 h per week of inactivity were considered implausible and therefore set to missing and not used in the analysis.

Dieting was assessed with a question adapted from the Youth Risk Behavior Surveillance System questionnaire.[13] The question asks, 'During the past year, how often did you diet to lose weight or to keep from gaining weight?' The response categories for the frequency of dieting to control weight during the past year were: 'ever,' 'less than once a month,' '1–3 times a month,' 'once a week,' '2 to 6 times per week,' or 'every day.' Children who reported that they had dieted 'less than once a month,' '1–3 times a month,' or 'once a week,' were grouped together as infrequent dieters, whereas, children who reported dieting to lose or maintain weight '2 to 6 times per week' or 'every day' were labeled as frequent dieters.

Main outcomes

The outcome was annual (1996–1997, 1997–1998, and 1998–1999) weight change. Weight change was modeled as the differences in age- and gender-specific *z*-score of BMI (based on the CDC reference data) between questionnaires (approximately 1-y apart). *z*-Scores were used instead of raw BMI values because the former had a lower correlation with height (Spearman's $r = 0.1$ *vs* $r = 0.3$). As part of normal development both weights and heights are expected to increase during this age range, thus a *z*-score of 0 is not equivalent to no weight change. For example, girls with no change in *z*-score gained a mean of 11.6 lbs among the 10-y olds and a mean of 4.1 lbs among the 14-y olds. Girls with a *z*-score change of 0.28 (the 75th percentile) gained a mean of 16.4 lbs among the 10-y olds and a mean of 10.7 lbs among the 14-y olds.

Sample

Participants included 8203 girls and 6774 boys who were 9–14 y of age in 1996, completed at least two GUTS questionnaires between 1996 and 1999, and provided plausible information on height and weight on the questionnaires. There were 923 girls and 1087 boys who completed two, 1759 girls and 1736 boys who completed three, and 5521 girls and 3951 boys who completed all four questionnaires. Children who reported consuming less than 500 or greater than 5000 calories per day or were determined to be outliers in terms of snack food intake because they were 3 or more standard deviations above the mean, had their intake of snack foods set to missing and not used in the analysis of the particular time period (eg, 1996–1997, 1997–1998, etc).

Analysis

All analyses were stratified by gender and conducted with SAS software (SAS version 8.2, Cary, NC, USA). Mixed linear regression models were used for all multivariate analyses (SAS proc mixed). All models assessing the association between intake of snack foods and weight change over approximately a 1-y period controlled for age, age squared, Tanner stage of pubic hair development, activity, inactivity, age- and gender-specific *z*-score of BMI at the beginning of the 1-y interval, and height change over the 1-y interval. Age squared was included in the model because the relationship between age and change in BMI *z*-score was not linear. The following potential confounders were included in some of the statistical models: dieting status, mother's weight status, and race/ethnicity. Owing to a combination of genetic and shared environmental factors, the weight status of a child is frequently associated with the weight status of his or her parents. In our study, only information on one parent, the mother, was available. In addition, to assess whether mother's weight status was an effect modifier, a secondary analysis stratified on mother's weight status was run. To assess whether the effect of snack food intake was due to differences in intake of total calories, we reran the mixed linear regression models controlling for caloric intake. In addition to modeling snack intake as servings per day of snack foods, we also ran analyses, where we modeled intake as calories per day from snack foods or percent of calories per day from snack foods. Secondary analyses modeled snack intake as consumption of snack foods and sugar-sweetened beverages. Three time periods were assessed: 1996–1997, 1997–1998, and 1998–1999. In analyses assessing whether consumption of low fat or no fat snack foods was predictive of weight change, the analysis was limited to the time periods 1997–1998 and 1998–1999 because intake of low or no fat snack foods was not assessed in 1996. In analyses assessing whether change in snack food intake independently or jointly predicted weight change, the analysis was limited to the time periods 1996–1997 and 1997–1998 because the diet assessment in 1999 was brief and did not include a complete assessment of snack foods, so change could not be assessed between 1998 and 1999. Snack food intake and dieting to control weight were treated as time-dependent covariates. All *P*-values are two-sided, with $P < 0.05$ considered statistically significant.

Results

In 1996, when the study began, the mean BMI and BMI *z*-score of the girls was similar to that of the boys (19.0 *vs* 19.1 kg/m^2 and 0.1 *vs* 0.2, respectively), but the girls ate fewer servings of snack foods per day than the boys (3.0 *vs* 3.2, respectively) (Table 2). Girls consumed a mean of 365 calories per day from snacks, whereas boys consumed a mean of 420 calories per day from snacks; however, in both genders calories from snack foods accounted for approximately 18% of total caloric intake. The majority of the participants at least occasionally consumed reduced fat snack foods, but the females consumed them more frequently than the males (Table 2). In 1997, when we first assessed the consumption of low or no fat snack foods, 55.2% consumed them occasionally and 5.2% ate only the reduced fat versions of snack foods. Among the boys, 43.1% consumed reduced fat snack foods occasionally and 2.5% only ate the reduced fat versions of snack foods. The prevalence of consuming low or no fat snack foods was similar in 1997 and 1998. During 3 y of follow-up, the intake of snack foods declined slightly for both girls and boys, but the intake was higher among the boys throughout the study period.

Table 2 Mean (s.d.) of age, body mass index (BMI), and daily intake of snack foods in 1996 among preadolescents and adolescents in the Growing Up Today Study

	Girls (n = *8203*)	*Boys* (n = *6774*)
Age (y)	12.0 (1.6)	11.9 (1.5)
BMI (kg/m^2)	19.0 (3.3)	19.1 (3.3)
z-Score of BMI	0.1 (1.0)	0.2 (1.1)
Servings per day of snack food	3.0 (1.6)	3.2 (1.7)
Intake of low of no fat snack foods[a]		
Never	26.9%	40.7%
Rarely	12.7%	13.7%
Sometimes	55.2%	43.1%
Always	5.2%	2.5%
Prevalence of maternal overweight (BMI ≥ 25 kg/m^2)[b]	38.9%	38.6%

[a]Assessed in 1997. [b]Assessed in 1995 as part of the Nurses' Health Study II.

Among the girls, after controlling for Tanner stage of development, age, height change, activity, and inactivity, which are known or suspected predictors of weight change, snack food intake was a significant, but weak, inverse predictor of annual changes in BMI *z*-score ($\beta = -0.007$ per serving, $P < 0.05$) (Table 3). There was no association between snack food intake and BMI change among the boys (Table 3).

We assessed whether mother's weight status (ie, overweight *vs* not overweight) was related to weight change and whether it modified the relationship between servings per day of snack foods and subsequent weight change. The changes in BMI *z*-scores were greater for the approximately 39% of participants whose mothers were overweight ($\beta = 0.047$ and 0.059 for girls and boys, respectively) than they were among their same-sex peers with leaner mothers (Table 3). In pounds these translate to the girls on average

Table 3 Prospective association between intake of snack foods and annual change in BMI *z*-score between 1996 and 1999 (Growing Up Today Study)

	Model 1: partially adjusted[a] β	*Model 1+mother's weight status* β	*Model 1+mother's weight and interaction with snack foods* β	*Model 1+mother's weight status and dieting* β	*Model 1+mother's weight status, dieting, and total calories* β (95% confidence interval)
(a) Among preadolescent and adolescent girls					
Snack food intake	−0.007*	−0.006*	−0.005	−0.005	−0.006 (−0.013, 0.001)
Mother is overweight		0.047[§]	0.051[§]	0.047[§]	0.047 (0.032, 0.061)
Interaction between snack food intake and mother being overweight			−0.002		
Dieting to control weight					
Infrequent dieting				0.026[¶]	0.026 (0.010, 0.043)
Frequent dieting				0.047[¶]	0.061 (0.030, 0.093)
(b) Among preadolescent and adolescent boys					
Snack food intake	−0.003	−0.004	−0.008	−0.002	−0.004 (−0.014, 0.007)
Mother is overweight		0.059[§]	0.026	0.059[§]	0.059 (0.036, 0.082)
Interaction between snack food intake and mother being overweight			0.012		
Dieting to control weight					
Infrequent dieting				0.112[§]	0.112 (0.063, 0.162)
Frequent dieting				0.117*	0.117 (0.021, 0.214)

[a]From mixed linear regression models controlling for age, age squared, Tanner stage, height change, baseline weight (modeled as age- and gender-specific *z*-score of BMI), activity, and inactivity. *$P < 0.05$. [¶]$P < 0.01$. [§]$P < 0.001$.

gaining slightly less (8.8 lbs) and the boys slightly more (14.0 lbs) than 10 lbs/y more than their peers with leaner mothers. Mother's weight status (ie, overweight *vs* not overweight), however, did not modify the association between snack food intake and changes in *z*-scores (Table 3). Moreover, in analysis stratified on mother's weight status, snacking was not a significant predictor of change in BMI *z*-score among offspring of mothers of healthy weight (BMI $<25\,kg/m^2$) or offspring of overweight (BMI $\geq$ 25 kg/m^2) mothers (data not shown). Dieting status and mother's weight status were significant independent predictors of change in BMI *z*-score (Table 3). After adjusting for them in the statistical model, servings per day of snack food was no longer a significant predictor. The results were consistent when snack food intake was modeled as calories per day from snack food or percent of daily calories from snack foods instead of servings per day of snack foods. When servings per day of sugar-sweetened beverages were included as snack foods the association between snack food intake and change in BMI *z*-score was similar to the main findings ($\beta=-0.004$ *vs* -0.006 for the girls and $\beta=-0.003$ *vs* -0.004 for the boys). Compared to girls who consumed less than one serving per day of snack foods or beverages, girls consuming three to five servings or five or more servings a day did not make significantly larger changes in BMI *z*-score (data not shown).

Because the 1999 diet assessment was brief and did not include many snack foods, the analysis assessing the association between change in servings per day of snack foods and weight change was limited to changes between 1996 and 1998. We observed that annual changes in snack food intake were unrelated to changes in BMI *z*-scores among both females ($\beta=0.006$, $P=0.2$) and males ($\beta=-0.008$, $P=0.1$). Moreover, there was no evidence of an interaction between initial snack food intake and change in snack food intake (data not shown).

To assess the association between intake of reduced fat snack foods and weight change, the analysis was limited to 1997 (when reduced fat items were first assessed) and 1999. Among the boys, but not the girls, consumption of reduced fat snack foods was associated with less weight gain. Compared to boys who never ate low or no fat snack foods, those who ate them at least occasionally during the past year gained approximately 0.041 *z*-scores less than their peers ($P<0.03$). Despite the higher prevalence of consumption of reduced fat products, among the girls there was no association between intake of reduced fat snacks and changes in BMI *z*-score ($\beta=0.0003$, $P=0.8$). There was no evidence that the association between intake of reduced fat snacks and changes in BMI *z*-score varied according to servings per day of snack foods (data not shown).

Discussion

In a large cohort of preadolescents and adolescents living throughout the United States, we observed that offspring of overweight mothers had larger increases in their BMI *z*-score than did their peers with leaner mothers. We did not, however, observe a meaningful independent association between intake of snack foods and subsequent increases in BMI *z*-scores. Our results are consistent with Phillips *et al*'s findings, but not entirely consistent with those of Francis *et al*.[4] Both our study and Francis' study observed a lack of association between snack food intake and weight change among children with lean mothers, but Francis *et al*[4] observed that among the girls with at least one overweight parent, snack food intake was associated with greater weight gain. We found that snack food intake was not a meaningful predictor of change in BMI *z*-score among children from lean or overweight mothers. Unlike the present study, Francis *et al* had information on the father's weight status, which might explain the difference in results. However, it is possible that Francis *et al*'s approach to statistically modeling the data, which imposed more structure than our approach, may explain the difference in the results regarding the offspring of overweight parents.

There is no widely accepted definition of snack food, thus the definitions used by Francis *et al*[4] and Phillips *et al*[5] are slightly different from one another in that the latter included intake of sugar-sweetened beverages. Ludwig *et al*[14] observed a prospective association between intake of sugar-sweetened beverages and the development of obesity; however, despite including beverages in their definition of snack intake, Phillips *et al* did not observe an association between snacking and weight gain. In our study, the inclusion of sugar-sweetened beverages in the snack food category did not meaningfully change the results. Regardless of the definition of snack food, there was not a strong association between intake of snack foods and weight gain. Although certain snack foods, such as donuts and cookies might be generally accepted as unhealthy snacks, there is no consensus on what constitutes a healthy snack. Some low or lower fat snack foods, such as pretzels and graham crackers, may have relatively high glycemic loads, thus they would be considered as unhealthy by some nutritional researchers.

Although the magnitude of the effect of mother's weight status and dieting status were slightly stronger among the boys than the girls, overall, the results were similar across gender. The one exception would be that among the boys, intake of low or no fat snack foods was associated with smaller changes in BMI *z*-score, but the magnitude of the association was small. It is unclear why the association was only seen in males. It is possible that determinants and correlates of consuming reduced fat snack items vary by gender and that these factors were not controlled for in the statistical analysis (ie, there were unmeasured confounders). More research is needed to understand the gender-specific determinants of snacking.

There are a variety of reasons that intake of snack foods might promote weight gain. First, snack foods may be consumed in addition to, not instead of, regular meals.

Snack foods may contribute as much as 140–300 calories per item, thus the consumption of several snack food items per day (the mean in the present study) would result in a nontrivial addition of calories. Second, many snack foods derive a substantial number of their calories from fat. Although dietary fat was observed to be predictive of weight gain in the CARDIA study,[15] we have not observed an association between intake of dietary fat and weight gain in this cohort.[16] Nevertheless, the role of fat in weight gain remains an active area of research and therefore it is possible that snack food intake could promote weight gain through a dietary fat effect. Third, there are some data to suggest that intake of high glycemic foods may promote hunger and increase food intake, which could lead to greater weight gain.[17] However, in our study, we did not observe any consistent evidence that intake of snack foods promoted weight gain relative to height gain. Moreover, reduced fat foods frequently have higher sugar (and similar calories) than their full fat versions. Thus, if a high glycemic diet promoted weight gain, one would expect to see a positive, not inverse, association between intake of low or no fat snack foods and weight gain.

Although our information on weight and height is based on self-report, we do not view this as a serious limitation since the validity of self-reported weight and height among preadolescents and adolescents has been investigated by several groups of researchers and the results suggest that preadolescents and adolescents provide valid information.[18–20] For example, among 1657 adolescents, aged 12–16 y, in the NHANES III study, Strauss observed high correlations between self-reported weight and actual weight ($r=0.87$–0.94, depending on gender or race) and self–reported height and actual height (ranged from $r=0.82$–0.91).[19] In addition, in a nationally representative sample of youth from the National Longitudinal Study of Adolescent Health, Goodman *et al*[20] observed that the correlation between BMI calculated from self-report *vs* measured height and weight was 0.92.

Our study has several limitations: it does not represent a random sample of all US adolescent males and females. Because the participants are children of nurses, we have relatively few children of low socioeconomic status in the sample. Therefore, the results of the sample may not be readily generalizable to economically disadvantaged populations. Moreover, we did not have information on the father's weight status, thus we had incomplete information on parental weight status. Another limitation is that we were able to assess snack foods, but not snacking occasions. Therefore, we could not assess snacking on other foods, such as cereal and sandwiches, which may contribute an equal number of calories as snack foods. Since our definitions of snacking were based on types of foods eaten, not eating occasion, we may have misclassified some youth in terms of snacking patterns. It is possible that our results are therefore biased towards the null, which could explain the lack of positive association.

In conclusion, our data did not offer support for the hypothesis that snacking promotes weight gain. Future studies are needed which assess snacking patterns, including snacking on items other than 'snack foods,' and the role snack foods play in overall dietary intake and weight changes. Moreover, it would be advisable for future studies to assess snacking context, such as snacking while watching television. Most snack food items are of poor diet quality, thus regardless of the lack of association between intake of snack foods and subsequent weight gain, it would be prudent to recommend consuming snack foods only in moderation.

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