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Adolescent Snacking Behaviors Are Associated with Dietary Intake and Weight Status[1–3]

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Abstract

Background: Most adolescents consume ≥1 snack/d; exploring the relevance of snacking patterns for overall diet and weight status is important to guide dietary counseling and public health strategies for obesity prevention.

Objective: This study examined intake of common energy-dense snack foods, total number of snacks consumed, frequency of consuming snacks prepared away from home, and frequency of snacking while watching television in adolescents and how these behaviors may be linked to diet and weight status. Relations were examined with attention to potential confounders that may help explain the mixed findings of previous research.

Methods: Survey measures of snacking behavior, a food-frequency questionnaire, and anthropometric measurements were completed by 2793 adolescents (53.2% girls, mean age = 14.4 y) in Minneapolis–St. Paul school classrooms in 2009–2010. Linear regression was used to examine associations with adjustment for sociodemographic characteristics and other potential confounding factors, such as meal skipping, underreporting energy intake, dieting to lose weight, and physical activity.

Results: Adolescents reported consuming a mean of 2.2 energy-dense snack food servings/d and 4.3 snacks/d and purchasing snacks prepared away from home on 3.2 occasions/wk. More than two-thirds of adolescents reported that they sometimes, usually, or always consumed a snack while watching television. The measures of snacking were directly associated ($P < 0.01$) with higher energy, lower fruit/vegetable, higher sugar-sweetened beverage, and more frequent fast-food intakes in all models except for one: energy-dense snack food servings were not related to sugar-sweetened beverage intake. A direct relation between daily servings of energy-dense snack foods and body mass index (BMI) *z* score was found; however, the snacking behaviors were inversely related to BMI *z* score ($P < 0.01$).

Conclusions: The observed cross-sectional associations suggest that snack consumption is a risk factor for poor diet, but unless energy-dense foods are consumed, snacking does not consistently contribute to overweight in US adolescents. *J Nutr* 2016;146:1348–55.

Keywords: adolescents, snacking, dietary quality, fast-food restaurants, weight status

Introduction

Poor dietary habits and weight-related problems have serious consequences for the health of young people in the United States and take a heavy economic toll on the nation (1–3). Because the foods and beverages consumed at snack occasions account for a large proportion of adolescents' overall diets (4), snacking behaviors are important to consider as a component of dietary counseling and public health strategies targeting these problems. National survey data indicate that the foods and beverages consumed at snack occasions contribute ~25% of total daily energy intake for boys and girls ages 12–19 y and that ~3 of 4 adolescents consume ≥2 snacks on a given day (4). It is critical that strategies and messages designed to address snacking behaviors are informed by a comprehensive understanding of the potentially complex relations between snacking behaviors and weight-related outcomes. Previously reported differences in snacking behaviors between population subgroups include a greater consumption of energy-dense, nutrient-poor snack foods by low-income, black, Native American, and mixed ethnicity/race adolescents (5). The reported differences suggest that it may be particularly important to build on knowledge of these relations among lower-income and ethnic/racial minority groups

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who experience the highest rates of poor nutrition and obesity (6–9).

Several studies have shown that frequent snacking is associated with higher total caloric intake (10–12); however, most previous research has found no evidence of a relation between snacking behavior and weight status or indicated that young people who consume more snacks are less likely to be overweight (13). Given these conflicting findings and the urgent need for effective strategies to improve adherence to dietary guidance and to limit excess weight gain among vulnerable populations (14), additional research is needed to address evidence gaps. Few studies, to our knowledge, have addressed the potential for bias as a result of weight-loss attempts or the underreporting of overall intake that occurs more often in overweight than in nonoverweight youth (13). Furthermore, there is a specific need for studies to examine the relation between snacking and weight-related outcomes within the context of meal and activity patterns (13). It is possible that frequent snacking may have little impact on overall daily energy intake or weight status for adolescents who typically consume snacks in place of meals. Time spent in moderate-to-vigorous physical activity also needs to be considered because more active adolescents may require the additional calories consumed as part of snacks to meet their energy needs.

The current study was designed to build on existing literature by examining how snacking behavior may be related to dietary intake and weight status among a large and ethnically/racially diverse sample of adolescents. Because observed associations may depend on what aspects of snacking behavior are measured and there is little consistency in the existing research (15, 16), multiple aspects of snacking were examined here. On the basis of frequently used definitions of snacking in the existing literature, analyses focused on servings of common energy-dense snack foods (e.g., potato chips, candy bars), total number of snacks consumed per day, the frequency of consuming snacks prepared away from home, and the frequency of snacking while watching television. In addition, the existing literature was used to inform the selection of potentially important confounding factors (e.g., meal skipping, underreporting, intention to lose weight by dieting) that have not been adequately investigated together in studies of adolescent snacking behaviors (13). It was hypothesized that the overall number of snacks consumed would be unrelated to adolescent dietary intake or weight status but that a higher number of energy-dense snack food servings, frequent consumption of snacks prepared away from home, and frequently snacking while watching television would be directly related to markers of poor dietary quality and a higher BMI z score.

Methods

Study design and population

The EAT 2010 (Eating and Activity in Teens) study was designed to examine weight-related variables in a population-based sample of adolescents (17–19). Classroom-administered surveys, FFQs, and anthropometric measures were completed by 2793 adolescents during the 2009–2010 academic year. The study population included adolescents from 20 public middle schools and high schools in the Minneapolis–St. Paul metropolitan area of Minnesota, which serve socioeconomically and ethnically/racially diverse communities. The mean ± SD age of the study population was 14.4 ± 2.0 y. Participants were equally divided by sex (53.2% girls) and were similar in terms of free or reduced-price school meal eligibility status and ethnic/racial composition to the overall student population within each enrolled school district (20, 21). Approximately 71% of participants qualified for free or reduced-price school meals. The ethnic/racial backgrounds of the participants were as follows: 29.0% African American or black, 18.9% white, 19.9% Asian American, 16.9% Hispanic, 3.7% Native American, and 11.6% mixed or other.

All of the study procedures were approved by the University of Minnesota's Institutional Review Board Human Subjects Committee and by the research boards of the participating school districts. Adolescents were not given the opportunity to assent if their parent/guardian returned a signed letter indicating refusal to have their child participate. Among adolescents who were at school on the days of survey administration, 96.3% were given the opportunity to assent and chose to participate.

EAT survey measures

The EAT 2010 survey is a 235-item, self-report instrument assessing a range of factors of potential relevance to weight status and weight-related behaviors among adolescents (17, 22). The estimates of measure test-retest reliability reported below were determined for a 1-wk period in a diverse sample of 129 middle school and high school students. For the analysis described here, the EAT survey was used to assess the frequency of snacking while watching television, weekly hours of television viewing, physical activity, eating at fast-food restaurants, meal skipping, current intentions to lose weight, and sociodemographic characteristics.

Frequency of snacking while watching television. The pairing of snack consumption with television viewing was assessed with the question, "How often do you snack while watching TV?" Response categories were "always," "usually," "sometimes," "rarely," and "never"; these responses were scored 5, 4, 3, 2, and 1 to create a continuous variable, with a higher score representing more frequent snacking while watching television (test-retest reliability $r = 0.63$).

Television viewing. Adolescents were asked to indicate the typical number of leisure-time hours they spent watching television, DVDs, or videos for both weekdays and weekend days (23, 24). Response categories for each question were as follows: "0 h," "0.5 h," "1 h," "2 h," "3 h," "4 h," and "≥5 h". These responses were scored 0, 0.5, 1, 2, 3, 4, and 6, respectively. Average weekday hours were multiplied by 5, and average weekend hours were multiplied by 2 before summing to create continuous variables representing total weekly hours of use (test-retest reliability $r = 0.67$).

Physical activity. Weekly hours of moderate-to-vigorous physical activity (test-retest $r = 0.73$) were examined as a covariate. Items on the EAT 2010 survey individually assessed strenuous and moderate activity by using questions adapted from the widely used Godin Leisure-Time Exercise Questionnaire (25). Examples of specific activities were given after each question. Self-reported estimates of weekly physical activity hours were adjusted to correct for overestimation on the basis of the results of a validation substudy that used accelerometer data on 134 adolescent participants in EAT 2010.

Eating at fast-food restaurants. The frequency of eating at fast-food restaurants was assessed with the question, "In the past month, how often did you eat something from the following types of restaurants (include take-out and delivery)?" Types of restaurants included the following: traditional burger-and-fries, Mexican fast-food, fried chicken, sandwich or sub shop, and pizza place. Six response options ranged from "never/rarely" to "≥1 time/d" (test-retest $r = 0.49$). To prevent probable overreporting from influencing the results, responses indicating a frequency of >3 times/d were reassigned a value of 90 times/mo before dividing by 4 to generate weekly frequency values.

Meal skipping. The number of days that adolescents consumed meals during the past week was assessed with the use of 3 questions, which separately asked about breakfast, lunch, and dinner. Response categories for each item were "never," "1–2 d," "3–4 d," "5–6 d," and "every day" [test-retest r (breakfast) = 0.60, r (lunch) = 0.60, r (dinner) = 0.76]. A

dichotomous indicator of meal skipping was defined as one in which adolescents reported they ate any meal <5 d/wk.

Intention to lose weight by dieting. Adolescents were asked to report on changing their diet with the intention to lose weight in response to the question, "How often have you gone on a diet during the last year? By 'diet' we mean changing the way you eat so you can lose weight." Response categories included the following: "never," "1–4 times," "5– 10 times," ">10 times," and "I am always dieting." As in previous analyses, responses were dichotomized into nondieters (responded "never") and dieters (other responses) [test-retest agreement (nondieter compared with dieter) = 82%] (26, 27).

Sociodemographic characteristics. Sex, age in years, ethnicity/race, and socioeconomic status (SES) were assessed by self-report (28). The prime determinant of SES was the higher educational level of either parent, with adjustments made for student eligibility for free/reduced-price school meals, family public assistance receipt, and parent employment status (test-retest $r = 0.90$) (29, 30).

Youth and Adolescent FFQ

The Youth and Adolescent FFQ was used to assess usual daily servings of common energy-dense, nutrient-poor snack foods and drinks; how many snacks adolescents consumed on school days and vacation/weekend days; and how often adolescents consumed snacks prepared away from home. In addition, it was used to assess usual daily energy intake and markers of dietary quality (daily servings of fruit and vegetables, sugar-sweetened beverages). The validity and reliability of the Youth and Adolescent FFQ have been previously examined and found to be within acceptable ranges for dietary assessment (31, 32). Similar to previous research, responses to the FFQ were excluded for 123 participants who reported biologically implausible amounts of total energy intake (<400 or >7000 kcal/d) (5, 33).

Energy-dense, nutrient-poor snack foods (servings/d). Adolescents were asked to indicate how often they had consumed energy-dense, nutrient-poor food and drink items that are commonly consumed by youth at snack occasions (34). Snack food items (e.g., potato chips, cookies, candy, ice cream) were assessed as part of a section of the FFQ entitled "snack foods/desserts"; however, it is possible that adolescent participants consumed these food/drink items with meals. A serving of snack food was defined by units such as 1 small bag, 1 pack, and 1 slice, as appropriate for the item. Typical daily snack intake was estimated by summing the reported consumption of 21 items (5).

Total number of snacks (snacks/d). Adolescents were also asked to indicate the number of snacks (food or drinks) they usually consumed between breakfast and lunch, after lunch and before dinner, and after dinner separately for school days and vacation/weekend days. Response categories for each item were "none," "1," "2," "3," and "≥4." For analysis, the number of snacks consumed at each time of day was assigned a score of 0.0, 1.0, 2.0, 3.0, or 4.0 to correspond to the 5 possible responses before summing these scores to obtain totals for a school day and vacation/weekend day. The usual number of snacks on a school day was multiplied by 5 and the usual number of snacks on a vacation/weekend day was multiplied by 2 before summing the values and dividing by 7 to generate the average number of daily snacks.

Snacks prepared away from home (snack occasions/wk). The number of times per week that adolescents consumed snacks prepared away from home was assessed with the use of 2 questions. The questions separately asked about after-school snacks and late-night snacks (including weekdays and weekends) but did not provide detailed instruction with regard to the sources of food and drink to include. Response categories for each item were "never or almost never," "1–2 times/wk," "3–4 times/wk," and "≥5 times/wk." For analysis, the number of times per week that snacks were prepared away from home was assigned a frequency of 0.0, 1.5, 3.5, or 5.0 to correspond to the 4 possible responses before summing these frequency scores to obtain a weekly total.

Dietary quality. Daily servings of fruit (excluding juice; 9 items) and vegetables (excluding potatoes; 18 items) were examined as markers of better dietary quality, and sugar-sweetened beverages (nondiet soda, fruit drinks) were examined as a marker of poorer dietary quality. A daily serving was defined as the equivalent of 0.5 cups for fruit and vegetables and the equivalent of 1 glass, bottle, or can for sugar-sweetened beverages.

Weight status

Research staff measured adolescents' height and weight following standardized procedures (17, 35). BMI values were calculated according to the following formula: weight (kg)/height (m^2) and converted to z scores, standardized for sex and age (36).

Statistical analysis

All of the analyses were conducted by using the Statistical Analysis System (SAS version 9.4, 2013; SAS Institute). Linear regression was used to separately model measures of adolescent dietary and weight outcomes (usual daily intakes of energy, fruit and vegetables, and sugar-sweetened beverages; eating at fast-food restaurants; BMI z score) on each of the 4 aspects of snacking behavior (total number of snacks per day, servings of common energy-dense snack foods, frequency of consuming snacks prepared away from home, frequency of snacking while watching television) examined here. Each model was adjusted for sex, age, ethnicity/race, SES, and lifestyle behaviors (i.e., weekly hours of moderate-to-vigorous physical activity, intention to lose weight by dieting). Servings of fruit and vegetables and sugar-sweetened beverages were used as markers of dietary quality, and models including these outcomes were accordingly adjusted for total reported energy intake. Models of snacking while watching television similarly included total weekly hours of television viewing as an additional covariate. Models of total number of snacks per day were examined with and without adjustment for meal skipping. A 99% confidence level was used to interpret the significance of probability tests, corresponding to a P value <0.01.

There were 253 students who did not complete an FFQ, and there was incomplete reporting on some of the items. All variables except for the total number of snacks per day had <15% of information that was missing, with total snacks having 26% of information that was missing. To decrease the risk of bias due to missing data, multiple imputation was used for all regression models (37, 38). Twenty iterations were used to generate data sets with missing data imputed on the basis of a multivariate normality and missing-at-random assumption. Results were combined by using PROC MINIANALYZE in SAS, which uses Rubin's rule (38). There were no meaningful differences between the presented results on the basis of analyses that used multiple imputation and results on the basis of complete-case analysis.

To ensure that associations of snacks per day or energy-dense, nutrient-poor snack food servings with weight status were not due solely to differential underreporting of food and drink consumption, additional analyses that adjusted for underreporting were completed. The method described by Murakami and Livingstone, adjusting for a continuous ratio of energy intake to estimated energy requirement, was used to account for probable underreporting in models (39). Energy intake was based on the Youth and Adolescent FFQ, and the estimated energy requirement was estimated with the use of sex- and age-specific equations (40). Height and weight measurements along with self-reported age and physical activity were inputs to these equations. Self-reported hours of light, moderate, and vigorous physical activity were used to estimate weekly metabolic equivalents of task expenditure and to assign each participant a multiplier according to the DRI definitions. Adjustment for underreporting reduced the estimated strength of the association between snacks per day and BMI z score and affected both the strength and direction of the association between servings of energy-dense, nutrient-poor snack foods and BMI z score; thus, adjustment for underreporting was retained for presentation.

Moderation by sex (male or female), ethnicity/race (non-Hispanic white or minority background), SES (low to low-middle or middle to high), and dieting (nondieter or dieter in past year) was also separately tested by examining statistical interactions for each of the models

investigated here. The results did not show a pattern to provide support for conducting stratified analyses. After applying the Bonferroni correction (significance set at $P = 0.0025$) for multiple tests, only 2 of 20 probability tests suggested the presence of a significant interaction. On the basis of these findings, detailed results of testing for moderation were not presented.

Results

Description of adolescent snacking behaviors. Adolescents reported consuming a mean of 2.2 daily servings of common energy-dense snack foods, 4.3 snacks/d, and 3.2 snacks/wk prepared away from home. The frequencies of snacking while watching television were reported as follows: 5.9%, never; 24.8%, rarely; 43.9%, sometimes; 17.0%, usually; and 8.4%, always. Previously reported sociodemographic patterns of snacking behavior were confirmed (5). Descriptive statistics additionally suggested that girls were more likely than boys ($\beta = 0.14$, SEE = 0.04, $P < 0.001$) to snack while watching television. In comparison to adolescents who reported their ethnic/racial background as white, black adolescents were more likely ($\beta = 0.23$, SEE = 0.04, $P < 0.001$) and Asians adolescents were less likely ($\beta = -0.29$, SEE = 0.05, $P < 0.001$) to snack while watching television. There was no association between snacking while watching television and SES.

The total number of snacks per week reported by adolescents was modestly correlated with a higher intake of energy-dense snack foods, greater frequency of consuming snacks that were prepared away from home, and more frequent snacking while watching television. Similar modest correlations were observed between the other measures of adolescent snacking behavior (**Table 1**).

Measures of adolescent snacking behavior were also related to lifestyle behaviors. Measures of snacking were inversely associated with the intention to lose weight by dieting and directly associated with hours of moderate-to-vigorous physical activity. For example, dieters consumed a mean of 3.7 snacks/d compared with a mean of 4.6 snacks/d among adolescents who did not report dieting ($P < 0.001$). Dieters also reported fewer daily servings of common energy-dense snack foods than did adolescents who did not report dieting (1.9 compared with 2.3 servings; $P < 0.001$) and fewer weekly occasions of purchasing snacks prepared away from home (2.8 compared with 3.4 times; $P < 0.001$).

Associations of adolescent snacking behaviors and dietary intake. Most models that accounted for sociodemographic characteristics and lifestyle behaviors showed consistent associations between each measure of adolescent snacking behavior and measures of dietary intake (**Table 2**). The measures of snacking behavior were directly associated with higher total energy intake, lower energy-adjusted fruit and vegetable intake, and more frequent eating at fast-food restaurants. Three of the 4 measures of snacking behavior were also directly associated with higher energy-adjusted sugar-sweetened beverage intake; however, daily servings of energy-dense snack foods were not associated with daily servings of sugar-sweetened beverages. For example, models specifying frequency of snacking while watching television as the independent variable showed that adolescents who always had a snack compared with those who never had a snack while watching television consumed 1.3 fewer daily servings of fruit and vegetables and 0.4 additional daily servings of sugar-sweetened beverages.

Associations of adolescent snacking behaviors and weight status. Models that accounted for sociodemographic characteristics, lifestyle behaviors, and underreporting showed that daily servings of energy-dense snack foods were directly related to adolescent BMI *z* scores; however, in contrast, the total number of snacks consumed per day was inversely related to BMI *z* scores (**Table 3**). For example, the mean increase in BMI *z* score associated with 1 additional daily serving of an energy-dense snack food was 0.05 units. Similar models accounting for sociodemographic characteristics and lifestyle behaviors showed that BMI *z* score was inversely related to the frequency of consuming snacks prepared away from home and the frequency of snacking while watching television.

Discussion

This study described snacking behaviors in a population-based sample of adolescents and investigated relations with dietary intake and weight status with attention given to several potential confounding factors and moderators. Findings indicated that it is typical for adolescents to consume a total of 4 snacks/d, >2 daily servings of energy-dense snack foods, and snacks prepared away from home on 3 occasions/wk. The results also suggest that the majority of adolescents (69%) sometimes, usually, or always consume snacks while watching television. The frequency of these snacking behaviors may be important to address as part of interventions designed to promote health and to prevent disease because the results showed mostly consistent associations with higher total daily energy intake and indicators of a poor diet, including lower fruit and vegetable intake, higher sugar-sweetened beverage intake, and more frequent consumption of food purchased from a fast-food restaurant. A direct relation between daily servings of energy-dense snack foods and BMI *z* score was also observed (i.e., the consumption of more snacks was linked to a higher BMI *z* score); however, in contradiction to the study's hypothesis, each of the other observed snacking behaviors was inversely related to BMI *z* score. The observed relations were

TABLE 1 Correlation coefficients for measures of adolescent snack consumption[1]

	Energy-dense and nutrient-poor snack foods	Snacks	Snacks prepared away from home	Snacking while watching television
Energy-dense and nutrient-poor snack foods, servings/d	1.00			
Snacks, *n*/d	0.39***	1.00		
Snacks prepared away from home, *n*/wk	0.31***	0.37***	1.00	
Snacking while watching television[2]	0.33***	0.42***	0.32***	1.00

[1] Values are unadjusted Pearson correlation coefficients. ***$P < 0.001$.

[2] Response options were assigned scores of 5 = always, 4 = usually, 3 = sometimes, 2 = rarely, and 1 = never.

TABLE 2 Associations of adolescent snack consumption with dietary intake[1]

	β (SE)	*P*
Associations with total energy intake		
Energy-dense and nutrient-poor snack foods, servings/d	339 (5.90)	<0.001
Snacks, *n*/d	138 (7.86)	<0.001
Snacks prepared away from home, *n*/wk	117 (7.72)	<0.001
Frequency of snacking while watching television[2]	309 (21.6)	<0.001
Associations with fruit and vegetable intake[3]		
Energy-dense and nutrient-poor snack foods, servings/d	−0.204 (0.022)	<0.001
Snacks, *n*/d	−0.098 (0.016)	<0.001
Snacks prepared away from home, *n*/wk	−0.112 (0.013)	<0.001
Frequency of snacking while watching television[2]	−0.306 (0.036)	<0.001
Associations with sugar-sweetened beverage intake[3]		
Energy-dense and nutrient-poor snack foods, servings/d	0.007 (0.011)	0.50
Snacks, *n*/d	0.047 (0.007)	<0.001
Snacks prepared away from home, *n*/wk	0.042 (0.006)	<0.001
Frequency of snacking while watching television[2]	0.102 (0.017)	<0.001
Associations with frequency of eating at a fast-food restaurant		
Energy-dense and nutrient-poor snack foods, servings/d	0.566 (0.037)	<0.001
Snacks, *n*/d	0.397 (0.034)	<0.001
Snacks prepared away from home, *n*/wk	0.398 (0.032)	<0.001
Frequency of snacking while watching television[2]	1.087 (0.081)	<0.001

[1] Model estimates are from a linear regression of the outcome on specific snacking patterns adjusted for socioeconomic status, age, sex, ethnicity/race, moderate-to-vigorous physical activity, and dieting behavior. The model estimates presented here do not include meal skipping because adjustment for this covariate did not change the observed associations.
[2] Response options were assigned scores of scores of 5 = always, 4 = usually, 3 = sometimes, 2 = rarely, and 1 = never. Model estimates were also adjusted for total weekly hours of television viewing.
[3] Model estimates were also adjusted for total energy intake.

found to be applicable to adolescents across sociodemographic subgroups.

The current study was designed to directly build on previous investigations of the relation between snacking behavior and weight status in adolescent populations. Most previous investigations similarly produced results that conflicted with the evidence that frequent snacking is associated with higher total caloric intake; it is logical to expect that a behavior associated with increased energy consumption would also be associated with higher BMI *z* score and risk of overweight and obesity, but this relation is not often observed (13, 41–43). For example, in a national sample of 5811 adolescents, Keast et al. (12) found that snacking frequency and the percentage of energy from snacks were inversely related to prevalences of overweight and obesity. The efforts described here to further investigate the relation by using multiple definitions of snacking and addressing often ignored but potentially important confounders (e.g., intention to lose weight by dieting) together in the same study population did not consistently lead to evidence of the expected relation. Only with regard to daily servings of energy-dense snack foods did the results show the expected direct relation and only after rigorously controlling for underreporting by using the novel energy intake:estimated energy requirement method proposed by Murakami and Livingstone (39). In combination with previous research, the results of the current study reflect the challenges of capturing all relevant aspects of snacking behavior and comprehensively assessing dietary intake (13). It is evident that the relation between snacking behavior and adolescent weight outcomes is complex and that underreporting may explain some of the unexpected findings reported in the literature. More detailed studies are needed to fully understand all aspects of how the relation between snacking behavior and weight outcomes depends on the nutritional composition and portions of food and beverages consumed for snacks.

Despite evidence linking frequent snacking to higher total energy intake and a higher proportion of energy provided by added and total sugars (10–12, 44), the nutritional composition of snacks consumed by US adolescents is varied. National survey data indicate that snacks also make several positive contributions to meeting nutrient requirements. In 2011–2012, NHANES data for school-aged boys and girls showed that across age and sex groups the foods and beverages consumed at self-defined snack occasions contributed ~25% of total daily energy, 34–39% of total sugar, and 21–26% of saturated fat intake on a given day (4). The proportion of nutrient intake provided by foods and beverages consumed at snack occasions was similar to the contribution of total energy for fiber (22–25%), vitamin C (27–39%), potassium (20–23%), calcium (19–27%), and magnesium (23–29%). Snacks additionally made smaller but substantial contributions to intakes of protein (13–16%), vitamin A (13–21%), vitamin B-6 (15–22%), folate (15–17%), vitamin D (13–22%), iron (18–20%), and zinc (15–18%). Thus, the quality of foods and beverages consumed at snack occasions is meaningful and snacks consisting of healthy options may represent an important opportunity for addressing nutrient needs that are not fully met at meals.

The results of the current study also make a particular contribution in adding to a relatively small set of studies that examined relations between consuming snacks while watching television and weight-related outcomes. A review of the existing literature identified only a limited number of studies in preschoolers (45), children (46–48), or adolescents (49–51) that reported on associations with various measures of snacking behaviors linked to television and produced mixed results. At least 4 of the 7 published studies reported finding that in ≥1 subgroups of the population sample the behavior of frequent snacking was linked to a higher BMI or odds of overweight (45–48), 1 study showed no relation (50), and 2 studies showed inverse relations (49, 51). For example, a study in Texas asked nearly 12,000 students to report on how often they consumed snacks and 5 groups of foods commonly advertised on television (e.g., sodas and soft drinks, frozen desserts) (49). Among the adolescent students, daily consumption of ≥2 snacks and ≥4 foods advertised on television was associated with reduced odds

TABLE 3 Associations of adolescent snack consumption with BMI *z* score[1]

	β (SE)	*P*
Energy-dense and nutrient-poor snack foods,[2] servings/d	0.059 (0.011)	<0.001
Snacks,[2] *n*/d	−0.032 (0.008)	<0.001
Snacks prepared away from home, *n*/wk	−0.029 (0.007)	<0.001
Frequency of snacking while watching television[3]	−0.174 (0.019)	<0.001

[1] Model estimates are from a linear regression of BMI *z* scores on specific snacking patterns adjusted for socioeconomic status, age, sex, ethnicity/race, moderate-to-vigorous physical activity, and dieting behavior. The model estimates presented here do not include meal skipping because adjustment for this covariate did not change the observed associations.
[2] Model estimates were also adjusted for continuous underreporting on the basis of the ratio of energy intake to estimated energy requirement.
[3] Response options were assigned scores of scores of 5 = always, 4 = usually, 3 = sometimes, 2 = rarely, and 1 = never. Model estimates were also adjusted for total weekly hours of television viewing.

of overweight regardless of the amount of television watched. Differences in the measurement of snacking behaviors linked to television and adjustment for potential confounders have likely contributed to contradictory findings in the literature along with inattention to relevant aspects of media use other than advertising, such as the messages about snacking embedded within the content of favored television programs and the pairing of snacking with time spent using other forms of screen media. The current study assessed the frequency of snacking while watching television without making assumptions with regard to the types of food or beverage consumed and controlled for not only hours of television viewing but also physical activity and dieting behavior. Together with previous research linking television viewing to higher energy-dense snack consumption and BMI, it is evident that the relation between snacking while watching television and adolescent weight outcomes is complex and deserves future research (13).

This study has several strengths and limitations of relevance to the interpretation of results. Strengths include the large size and ethnic/racial diversity of the population-based sample, the breadth of data examined with regard to different aspects of adolescents' snacking behavior, collection of measured heights and weights, and extensive statistical analyses conducted to examine factors that may confound or moderate relations. The combined assessment of multiple aspects of snacking behavior is a particularly important contribution. Available data allowed us to examine the relations of adolescent outcomes with daily servings of common energy-dense, nutrient-poor snack foods; the typical number of snacks consumed per day; the frequency of consuming snacks prepared away from home; and the frequency of snacking while watching television in the same population sample. In addition, to our knowledge, few other studies have had the opportunity to examine the scope of potential confounders of relations between snacking behavior and adolescent weight-related outcomes that were considered together here.

Despite the breadth of data examined, the measures used to assess multiple aspects of snacking behavior were brief to minimize respondent burden, some measures of confounders did not fully align with measures of snacking behavior in terms of the reference period, and other likely important aspects of snacking behavior and dietary quality were not explored. For example, the number of snacks consumed per day was assessed in reference to usual behavior over the past year, whereas the measure of meal skipping was specific to behavior during the past week, and it was not possible to assess whether adolescents who reported dieting during the past year had reported on snacking behavior during a period in which they were intending to lose weight. Other theoretically relevant aspects of snacking behavior that were not possible to explore include the contribution of snacking to overall energy intake, portion sizes of the foods consumed at snack occasions, the consumption of sugar-sweetened beverages at snack occasions, and contexts other than television viewing in which snacks were consumed (e.g., after exercise, at a restaurant with friends). Markers of dietary intake were selected for exploration on the basis of their particular relevance to current public health concerns because it was not feasible to comprehensively examine dietary quality. Furthermore, the information collected on the consumption of common energy-dense snack foods focused on sweets/desserts and did not allow for distinguishing how often these foods were consumed along with meals compared with between meals. Finally, particular caution should be used with regard to drawing conclusions about the directionality of relations because the design was cross-sectional.

In conclusion, the results described here suggest that there is a need for interventions to address the nutritional contributions of snacking occasions to overall adolescent dietary intake. The results were in agreement with national data (10) that indicate that adolescents frequently consume snacks, and it is consequently important to ensure that the foods and beverages consumed as snacks contribute to meeting dietary recommendations for the prevention of chronic disease and support of healthy growth and development (52). Providers of health services for adolescents can provide guidance to help young people make healthy food and beverage choices between meals and advocate in line with growing evidence that it is imperative for policies to support these choices in schools and other environments (53). Efforts are also needed to advocate that food and beverage marketing targeted to adolescents should promote only healthy foods and portions.

It will be important for future research to prospectively confirm these findings, expand the assessment of diet to other markers of nutritional quality, investigate additional contexts in which snacks are consumed (e.g., paired with video gaming, online networking, use of other electronic devices), and further build on knowledge with regard to key factors that influence the nutritional quality and amounts of foods and beverages that adolescents select to consume between meals. Although the results of this cross-sectional study linked 3 of the 4 snacking behaviors observed to less risk for overweight or obesity, additional prospective studies that carefully address the issue of underreporting and other confounding factors are needed to evaluate the potential impact of reverse causality on these relations above and beyond the confounding factors that were addressed here. Skipping meals was not found to be an important confounder in the current study, but in-depth studies of compensation for the food and beverage energy consumed at snack occasions could help to resolve inconsistencies in the literature on relations between snacking and weight-related health (13). For example, it is possible that some young people do not skip meals on days they consume more energy at snack occasions but instead reduce the amount of energy consumed at meals. Because observed associations between snacking and weight-related outcomes may depend on what aspects of snacking behavior are measured and there is little consistency in the existing research, it will be important for future studies to repeat the effort made in this study to examine multiple aspects of snacking.

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NIL conceived of the analyses performed for this study, coordinated data collection for the overall EAT 2010 study, and drafted the manuscript; JMM performed the statistical analysis; AWW and MTS contributed to the interpretation of results; and DRN-S conceived of the overall EAT 2010 study and provided oversight. All authors critically reviewed and approved the final manuscript.

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