Appetite 112 (2017) 23–34

Contents lists available at ScienceDirect

Appetite

journal homepage: www.elsevier.com/locate/appet

Multicontextual correlates of energy-dense, nutrient-poor snack food consumption by adolescents

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ARTICLE INFO

Article history:
Received 1 July 2016
Received in revised form
7 December 2016
Accepted 8 January 2017
Available online 9 January 2017

Keywords:
Snack food
Adolescents
Home environment
Peers
School environment
Neighborhood
Media

ABSTRACT

Frequent consumption of energy-dense, nutrient-poor snack foods is an eating behavior of public health concern. This study was designed to inform strategies for reducing adolescent intake of energy-dense snack foods by identifying individual and environmental influences. Surveys were completed in 2009–2010 by 2540 adolescents (54% females, mean age = 14.5 ± 2.0, 80% nonwhite) in Minneapolis-St. Paul, Minnesota schools. Daily servings of energy-dense snack food was assessed using a food frequency questionnaire that asked about consumption of 21 common snack food items, such as potato chips, cookies, and candy. Data representing characteristics of adolescents' environments were collected from parents/caregivers, friends, school personnel, Geographic Information System sources, and a content analysis of favorite television shows. Linear regression was used to examine relationships between each individual or environmental characteristic and snack food consumption in separate models and also to examine relationships in a model including all of the characteristics simultaneously. The factors found to be significantly associated with higher energy-dense snack food intake represented individual attitudes/behaviors (e.g., snacking while watching television) and characteristics of home/family (e.g., home unhealthy food availability), peer (friends' energy-dense snack food consumption), and school (e.g., student snack consumption norms) environments. In total, 25.5% of the variance in adolescents' energy-dense snack food consumption was explained when factors from within each context were examined together. The results suggest that the design of interventions targeting improvement in the dietary quality of adolescents' snack food choices should address relevant individual factors (e.g., eating while watching television) along with characteristics of their home/family (e.g., limiting the availability of unhealthy foods), peer (e.g., guiding the efforts of a peer leader in making healthy choices), and school environments (e.g., establishing student norms for selecting nutrient-dense snack foods).

1. Introduction

Frequent consumption of energy-dense, nutrient-poor snack foods is an eating behavior of public health concern (Hess & Slavin, 2014; Larson & Story, 2013). Energy-dense, nutrient-poor snack foods may supplant recommended foods that supply shortfall nutrients or otherwise make important contributions to maintaining good health (2015 Dietary Guidelines Advisory Committee, 2015). If consumed in amounts that exceed caloric needs, energy-dense snack foods may also contribute to risk for obesity. Research has produced mixed evidence in regards to the relationship of energy-dense snack food consumption with weight gain and obesity (Larson & Story, 2013); however, studies in adult and adolescent populations that have accounted for underreporting suggest there

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http://dx.doi.org/10.1016/j.appet.2017.01.008
0195-6663/

Abbreviations

EAT 2010 study	Eating and Activity in Teens study
FFQ	food frequency questionnaires
GIS	Geographic Information System
SES	socioeconomic status
Project F-EAT study	Families and Eating and Activity among Teens study
Snack food	energy-dense, nutrient-poor snack foods

is a direct relationship (Larson, Miller, Watts, Story, & Neumark-Sztainer, 2016; Murakami & Livingstone, 2015). More information about energy-dense snack food consumption is needed to direct the refinement and development of strategies that target reduced consumption of these snack foods.

There is a particular need for information to direct the development of efforts to prevent obesity and reduce energy-dense snack food consumption among ethnic/racial minority and low-income adolescents (Larson, Story, Eisenberg, & Neumark-Sztainer, 2016; Ogden, Carroll, Kit, & Flegal, 2014). Despite ongoing efforts to limit the availability of energy-dense snack foods in schools and evidence of small secular decreases in U.S. adolescents' consumption of energy-dense snack foods (Bridging the Gap & Robert Wood Johnson Foundation, 2014; Gorski et al., 2016; Larson, Story et al., 2016), previous research by the authors found that consumption of these foods by adolescents has remained highest among those from black, Native American, and mixed/other ethnic/racial backgrounds and low-income families over the past decade (Larson, Story et al., 2016). The average daily intake of energy-dense snack foods was less than two servings among non-Hispanic white adolescents on a given day in 2010 while adolescents who identified their ethnicity/race as black or mixed/other reported an average intake of nearly three servings (Larson, Miller et al., 2016; Larson, Story et al., 2016).

Given the complexity of influences on adolescent eating behaviors, efforts to reduce consumption of energy-dense snack foods will likely be most successful if they address multiple contexts of influence (Hoelscher, Kirk, Ritchie, Cunningham-Sabo, & Academy Positions Committee, 2013; Huang, Drewnoski, Kumanyika, & Glass, 2009). Ecologic models have been developed to describe the range of potential influences on eating behavior (Story, Kaphingst, Robinson-O'Brien, & Glanz, 2008); however, most studies of influences on energy-dense snack food consumption have simultaneously assessed only a few contexts. Previous multicontextual studies have largely focused on a combination of potential home/family and peer influences with or without consideration of individual-level factors (Ball et al., 2009; De Bourdeaudhuij & van Oost, 2000; Gregori et al., 2011; Luszczynska et al., 2013; Martens, van Assema, & Brug, 2005; van Ansem, van Lenthe, Schrijvers, Rodenburg, & van de Mheen, 2014; van Ansem, Schrijvers, Rodenburg, & van de Mheen, 2015). Few, if any, studies have simultaneously assessed individual factors in combination with home/family, peer, school, and neighborhood environments and screen media exposure. It is further noteworthy that most studies of screen media exposure have focused on the influence of advertising without considering the content of television programs, which account for considerably more viewing time than relatively brief commercials (Boyland & Whalen, 2015; Boyland et al., 2016). As may be of particular significance in addressing identified disparities, there is also limited research addressing what multicontextual factors are of greatest relevance for energy-dense snack food consumption among ethnically/racially diverse and low-income populations of youth who are at risk for obesity. Most existing studies of influences on energy-dense snack food consumption have been conducted outside the U.S., and thus the findings may not be highly relevant to the diverse cultural groups of adolescents in this country.

The current multicontextual study was designed to build on previous research through a uniquely comprehensive examination of individual-level personal and behavioral factors; characteristics of home/family, peer, school, and neighborhood environments; and aspects of screen media exposure that are associated with energy-dense snack food consumption among ethnically/racially diverse U.S. adolescents. In addition, this study sought to determine the overall and relative contributions made by individual and environmental contexts for explaining energy-dense snack food consumption among a sample of low-income adolescents from diverse ethnic/racial groups. Ecological theory and social cognitive theory were used in combination with the existing literature to identify potential correlates of consumption with a focus on modifiable characteristics. Ecological models emphasize the importance of multiple environmental contexts of influence on health behaviors like energy-dense snack food consumption and social cognitive theory is particularly useful for illuminating socio-environmental, personal, and behavioral factors that determine behaviors as well as guiding the translation of findings to interventions (Bandura, 1986; Larson & Story, 2009; McAlister, Perry, & Parcel, 2008; Sallis, Owen, & Fisher, 2008). As an example of how these theories informed the selection of potential correlates, the existing evidence base of observational and intervention studies addressing linkages between characteristics of home food environments and eating behavior was reviewed with a focus on energy-dense food consumption and food intake between meals. The review resulted in the identification of environmental characteristics that have been consistently related to adolescent eating behavior (e.g., family meal frequency, parental attitudes about healthy foods) or found to be of particular relevance to snack food consumption (e.g., home food availability, parental restriction of high-calorie food) (Campbell et al., 2007; Cutler, Flood, Hannan, & Neumark-Sztainer, 2011; Fulkerson, Larson, Horning, & Neumark-Sztainer, 2014; Larson & Story, 2009; Loth, MacLehose, Larson, Berge, & Neumark-Sztainer, 2016). Results of the current multicontextual analysis are expected to provide preliminary data relevant to the design of interventions and development of policies that will help to ensure the foods and beverages consumed by young people at snack occasions contribute to meeting dietary recommendations and not to excess energy intake.

2. Methods

2.1. Study design and population

The EAT 2010 (Eating and Activity in Teens) study was designed to examine factors associated with weight-related outcomes in adolescents (Eisenberg, Carlson-McGuire, Gollust, & Neumark-Sztainer, 2015; Graham, Larson, & Neumark-Sztainer, 2014; Larson, Wall, Story, & Neumark-Sztainer, 2013; Neumark-Sztainer et al., 2012; Wall et al., 2012). Classroom-administered surveys, food frequency questionnaires (FFQ), and anthropometric measures were completed by adolescents from 20 public middle schools and high schools in the Minneapolis-St. Paul metropolitan area of Minnesota during the 2009–2010 academic year. Following the ecological framework that guided the overall study, data were additionally collected from parents/caregivers, friends, school personnel, Geographic Information System (GIS) sources, and content analysis of favored television shows accessed through online services (e.g. network websites, Netflix) as described in detail below. All study procedures were approved by the University of

Minnesota's Institutional Review Board Human Subjects Committee and by the research boards of participating school districts.

The analytic sample was limited to participants with both survey and FFQ data, and included 2540 adolescents with a mean age of 14.5 years (SD = 2.0); 44.8% were in middle school (6th–8th grades) and 55.2% were in high school (9th–12th grades). Participants were equally divided by gender (53.7% females) and 57.7% of participants qualified for free or reduced-price school meals. The ethnic/racial backgrounds of participants were as follows: 19.7% white, 27.9% African American or Black, 20.5% Asian American, 17.2% Hispanic, 3.6% Native American, and 11.1% mixed or other.

2.2. Adolescent assessments

Trained research staff administered surveys and FFQs during selected health, physical education, and science classes. Surveys were administered during two class periods that were typically 45–50 min. Adolescents were given the opportunity to assent only if their parent/guardian did not return a signed consent form indicating refusal to have their child participate. Among adolescents who were at school on the days of survey administration, 96.3% had parental consent and chose to participate.

2.2.1. Survey development and measures

Development of the EAT 2010 survey was guided by a review of previous Project EAT surveys to identify the most salient items; the study's theoretical framework; expert review by professionals from different disciplines; and extensive pilot testing with adolescents. The study's theoretical framework (available online at http://www.sphresearch.umn.edu/epi/project-eat/#2010) integrates social cognitive theory with an ecological perspective (Bandura, 1986; Sallis et al., 2008) to direct attention not only to individual-level personal (e.g., weight change intentions) and behavioral factors (e.g., frequency of snacking while viewing television), but also to the multiple physical and social environments that potentially influence behavior. Survey items and response options used to assess individual-level factors and adolescents' perceptions of home/family and friend characteristics are described in Table 1, which includes survey measure sources (Blumberg, Bialostosky, Hamilton, & Briefel, 1999; Godin & Shephard, 1985; Kandel & Davies, 1982; Kaur et al., 2006; Saelens, Sallis, Black, & Chen, 2003) and the psychometric properties for measures in the study population where appropriate. Socioeconomic status (SES) and other sociodemographic characteristics were also assessed on the EAT 2010 survey; SES was determined primarily using the higher education level of either parent (Sherwood, Wall, Neumark-Sztainer, & Story, 2009).

2.2.2. Youth and Adolescent FFQ

The Youth and Adolescent FFQ was designed to assess multi-vitamin use and usual intake of 127 foods over the past year and requires approximately 20–30 min to complete (Larson, Harnack, & Neumark-Sztainer, 2012; Rockett, Wolf, & Colditz, 1995). The validity and reliability of the Youth and Adolescent FFQ have been examined and found to be within acceptable ranges for dietary assessment (Rockett et al., 1995, 1997). Similar to previous research, responses to the FFQ were excluded for 121 participants that reported a biologically implausible level of total energy intake (<400 kcal/day or >7000 kcal/day) (Larson, Miller et al., 2016; Larson, Story et al., 2016; Neumark-Sztainer, Wall, Perry, & Story, 2003). As part of completing the FFQ, adolescents were asked to indicate how often they had consumed 21 energy-dense, nutrient poor food and drink items that are commonly consumed by young people at snack occasions (Field et al., 2004). The selected food items were characterized by high levels of saturated fat and added sugars, and low levels of micronutrients that are important for growth and development (potato chips; corn chips; nachos with cheese; fun fruit or fruit rollups; toaster pastries; cake; snack cakes; Danish, sweetrolls, or pastry; donuts; cookies; brownies; pie; chocolate bar or packet; other candy bars; other candy without chocolate; gelatin desserts; pudding; frozen yogurt; ice cream; milkshake or frappe; and popsicles) (Larson & Story, 2011). Servings were defined by easily distinguished units such as one small bag, one pack, and one slice as appropriate for the item.

2.3. Home/family environment: parent/caregiver survey

Parents/caregivers of adolescent participants were also asked to respond to a survey as part of Project F-EAT (Families and Eating and Activity among Teens) (Loth, MacLehose, Fulkerson, Crow, & Neumark-Sztainer, 2013). A total of 3424 parents of adolescents included in the analytic sample provided informed consent and responded; 2182 adolescents had at least one parent respond and 1242 adolescents had two parents respond. For the current analysis, only data from the adolescent's primary parent (n = 2,182, 91.4% female) were used in order to achieve independent data that best describe the usual home environment. When two parents responded, primary parent status was determined using an algorithm that accounted for the family living situation (preference to parents who lived with their child more than half the time), relationship to the adolescent (preference to biological/adoptive parents), and the parent's gender (preference to females).

Parents were given the options of responding to a written survey by mail or completing a telephone interview. The initial mailing included an invitation letter describing the Project F-EAT study and a telephone number to call if the parent preferred to complete their survey by telephone. Additional follow-up contact attempts were made to non-responders by mail and telephone as needed. The majority of respondents (77.8%) completed a paper survey by mail. Measures included on the written survey and telephone interview were reviewed by a panel of content-area experts and bi-cultural research staff to address cultural sensitivity, and pilot tested with parents of adolescents. Parent survey items and response options used to assess perceptions of home/family environment characteristics are described in Table 1.

2.4. Peer environment: friendship nominations

Much of the existing literature regarding the influence of peers on eating behavior has been based on perceptions of friends' behaviors, which may be effected by one's own attitudes (Cutler et al., 2011; Gregori et al., 2011; Luszczynska et al., 2013; Martens et al., 2005; van der Horst et al., 2008). This limitation of previous studies was addressed by collecting friendship nominations to complement the survey measures of perceptions regarding friends' behavior. Adolescents were asked to nominate up to six of their closest friends (up to three males and three females) within their school by selecting friends' identification numbers from a comprehensive school list (Sirard et al., 2013). Adolescents were permitted to nominate fewer than six friends as well as to nominate friends outside of their school using a generic code number. Data provided by each nominated friend on his or her own EAT 2010 survey were linked back to the nominator, allowing for the creation of variables to describe peer environments (see Table 1). All nominated friend variables were calculated using data on all nominated friends, regardless of friendship reciprocity, to examine weight-related behaviors among peers of adolescent participants.

2.5. School environment: personnel surveys

At each participating school, surveys were completed by an

Table 1
Description of individual-level; home/family, peer, school, and neighborhood environment; and screen media exposure measures[a,b,c].

	Source[a]	Survey items or description
Individual-level factors		
Identity as a picky eater	A	*I am a picky eater.* Four responses ranging from *strongly disagree* to *strongly agree.* (Test-retest r = 0.75)
Perceived cost barriers to healthy eating	A	*Eating healthy just costs too much.* Four responses ranging from *strongly disagree* to *strongly agree.* (Test-retest r = 0.58)
Involvement in at-home food preparation	A	*In the past week, how many times did you help make dinner or supper for your family?* (Test-retest r = 0.61)
Meal skipping	A	*During the past week, how many days did you eat breakfast?* Two similar statements were used to separately ask about lunch and dinner. A dichotomous indicator of meal skipping was defined by reporting any meal was consumed on fewer than five days of the week. (Test-retest agreement = 84%)
Depressive symptoms	A	Kandel and Davies' six-item scale for adolescents (Kandel & Davies, 1982) was used to assess the frequency of symptoms during the past year. (Cronbach's α = 0.83, Test-retest r = 0.75)
Weight-related concerns	A	*How strongly do you agree with the following statements?* Two statements (e.g., *I think a lot about being thinner*). Four responses ranging from *strongly disagree* to *strongly agree.* (Cronbach's α = 0.83, Test-retest r = 0.77)
Weight change intentions	A	Adolescents were asked to indicate if they were currently trying to *lose weight, stay the same weight, gain weight, or not trying to do anything* about their weight. (Test-retest agreement = 82%)
Weight control behaviors		
Dieting in past year	A	*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.* Responses were dichotomized into non-dieters (responded never) and dieters (other responses). (Test-retest agreement = 82%)
Healthy diet and exercise behaviors	A	*How often have you done each of the following things in order to lose weight or keep from gaining weight during the past year?* Six behaviors were categorized as healthy (e.g., ate less high-fat foods, exercise, ate less sweets). Four responses ranging from *never* to *on a regular basis.* (Cronbach's α = 0.88, Test-retest r = 0.71).
Unhealthy diet and extreme behaviors	A	*Have you done any of the following things in order to lose weight or keep from gaining weight during the past year?* Nine behaviors were categorized as unhealthy (e.g., ate very little food, took diet pills, smoked more cigarettes) and responses were dichotomized according to the use of none or any behaviors. (Test-retest agreement = 85%)
Snacks prepared away from home frequency	A	*How many times each week do you usually eat after-school snacks or foods prepared away from home?* A similar statement was used to separately ask about late night snacks. Responses were summed to represent weekly frequency of consuming a snack prepared away from home.
Snacks while watching television frequency	A	*How often do you snack while watching TV?* Five responses ranging from *never* to *always*. (Test-retest r = 0.63)
Media use: television viewing hours, video gaming hours	A	Average weekly hours spent on television viewing and video gaming were calculated based on separate reports of free time use on an average weekday (Monday-Friday) and weekend day (Saturday or Sunday).Viewing television was described as *watching TV/DVDs/videos* and video gaming as *Xbox/Play-station/other electronic games that you play when siting.* (Test-retest r = 0.86)
Team sport involvement	A	*During the past 12 months, on how many sports teams did you play?* (Test-retest r = 0.86)
Sleep hours	A	Average hours of sleep per day was calculated based on reports of usual bedtimes and wake-up times for an average weekday (Monday-Friday) and separately for an average weekend day (Saturday or Sunday). Bedtime was defined as when you *go to bed (to go to sleep)* and wake-up time was defined as when you *get out of bed (to start your day)* (Pasch, Laska, Lytle, & Moe, 2010; Wolfson et al., 2003).
Home/family characteristics		
Home unhealthy food availability	A	*How often are the following true?* Four statements (e.g., *Potato chips or other salty snacks are available in my home*). Four responses ranging from *never* to *always*. (Cronbach's α = 0.79, Test-retest r = 0.65)
Household food security	P	Six-item short form of the U.S. Household Food Security Survey Module (Blumberg et al., 1999). (Test-retest r = 0.77)
Family meal frequency	P	*During the past week, how many times did all, or most, of your family living in your household eat a meal together?* (Test-retest r = 0.72)
Perceived encouragement to eat healthy foods	A	*My mother (father) encourages me to eat healthy foods.* Four responses ranging from *not at all* to *very much*. Average scores were determined based on responses for mother and father. (Test-retest r = 0.61)
Parental restriction of high-calorie food	P	Modified restriction subscale of the Child-Feeding Questionnaire (Kaur et al., 2006). *How much do you agree with the following statements?* Six statements (e.g., *If I did not guide or regulate my child's eating, he/she would eat too much of his/her favorite foods.*). Four responses ranging from *disagree* to *agree.* (Cronbach's α = 0.86, Test-retest r = 0.68).
Peer characteristics		
Perceived attitudes/behavior		
Think it is important to eat healthy foods	A	*Many of my friends think it is important to eat healthy foods like fruits and vegetables.* Four response options ranging from *not at all* to *very much*.
Diet to control weight	A	*Many of my friends diet to lose weight or keep from gaining weight.* Four response options ranging from *not at all* to *very much*.
Friends' weight-related behaviors		
Snack food intake	F	Daily servings were estimated by summing reported intake of 21 common energy-dense, nutrient-poor snack food items (salty snacks, baked sweets, candy, and frozen desserts). Average number of daily snack food servings among nominated friends was calculated.
Dieting	F	*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.* Responses were dichotomized into non-dieters (responded never) and dieters. The proportion of nominated friends who were dieters was calculated.
Meal skipping	F	*During the past week, how many days did you eat breakfast?* Two similar statements were used to separately ask about lunch and dinner. A dichotomous indicator of meal skipping was defined by reporting any meal was consumed on fewer than five days of the week and the proportion of nominated friends who were skipping meals was calculated.
School characteristics		
Presence of fast-food restaurant in 800 m	N	Commercial databases were used along with NAICS codes (722110, 722211, 722212, and 722213) to identify restaurants and both chain names and 18 key words (e.g., take out, fried, pizza) were used to identify fast-food restaurants within network buffers.
Presence of convenience store in 800 m	N	Commercial databases were used along with NAICS codes (44512, 44711, and 44719) to identify convenience stores, including gas stations, within network buffers.

Table 1 (*continued*)

	Source[a]	Survey items or description
Campus availability of competitive foods	SF	*Are there any vending machines in your school that are available to students before or during the school day? Does your school offer a la carte options at lunch?* Yes/no responses were combined to indicated 0 = not available, 1 = a la carte or vending available, or 3 = both a la carte and vending available.
Classroom food policies	SA	*Please indicate whether any of the following practices occur at your school.* Response options (*no; yes, it is up to the teacher; yes, but it is discouraged*) were dichotomized for two practices: 1) students are allowed to eat food during class (other than for parties or special events) and 2) food is used as a reward for good behavior and/or academic performance.
Schools' commitment to promotion of healthy eating	SA	*In your opinion, to what extent has your school made a serious/real effort to promote healthy food and beverage habits among students?* Five response options ranging from *not at all* to *a very great extent.*
Norms number of snacks during school day	A	*Fill in the number of snacks (food or drinks) eaten on school days.* Five responses ranging from *none* to *4 or more*. Responses for snacks consumed *1) between breakfast and lunch* and *2) after lunch, before dinner* were summed. The average number of daily snacks consumed among surveyed students at each school was calculated.
Neighborhood characteristics		
Presence of fast-food restaurant in 1200 m	N	Commercial databases were used along with NAICS codes (722110, 722211, 722212, and 722213) to identify restaurants and both chain names and 18 key words (e.g., take out, fried, pizza) were used to identify fast-food restaurants within network buffers (Forsyth et al., 2012).
High density of fast-food restaurants in 1600 m	N	A dichotomous indicator of high density of fast-food restaurants was defined by the presence of five or more fast-food restaurants (the sample median) accessible near the participant's home (Forsyth et al., 2012).
Presence of convenience store in 1200 m	N	Commercial databases were used along with NAICS codes (44512, 44711, and 44719) to identify convenience stores, including gas stations, within network buffers (Forsyth et al., 2012).
Screen media characteristics		
Snack incident frequency	O	Coders recorded any time a food was shown on screen during a popular television show and identified snack incidents based on time cues, the number of foods, dialogue, and other context (e.g., a meal eaten during school-day coded as lunch). Inter-coder reliability for identifying meal types (including snacks) was very high across the two waves of coding ($\kappa = 0.98–1.0$). The average number of snacks shown in participant's three favorite television shows was calculated (Mean = 5.5, SD = 4.0, Range = 0–18) (Eisenberg et al., 2016).
Unhealthy snack food incident percentage	O	The overall healthfulness of foods shown as part of each snack incident was coded as mostly healthy (i.e., well-balanced meals, fruit, vegetables, lean proteins, cheese, yogurt), mostly unhealthy (i.e., sweets such as baked desserts and candy, potato chips, snack foods, sugared cereal), or unclear. Inter-coder reliability for the healthfulness of food items was initially moderate ($\kappa = 0.51$) but improved after additional training and for the second wave of coding ($\kappa = 1.0$). The average proportion of snacks including unhealthy foods for a participant's three favorite television shows was calculated (Mean = 22.1%, SD = 30.2%, range = 0–100%) (Eisenberg et al., 2016).

[a] A, adolescent report; F, friend report; N, Geographic Information System data sources; O, measured; P, parent report; SA, school administrator; SF, school foodservice manager; ST, school physical activity teacher.
[b] SD, standard deviation.
[c] NAICS, North American Industrial Classification System.

administrator and food service professional. Administrators reported on policies and practices of relevance to weight-related health and their schools' commitment to promoting healthy eating. Food service professionals reported on school food availability and policies. All participating personnel were instructed to respond in regard to the 2009–2010 academic year and encouraged to confer with others at their school if they were unsure of policies or practices. School survey items and response options used in the current analysis are described in Table 1.

2.6. Residential and school neighborhood environments: GIS data sources

GIS data sources were used to examine food access within residential neighborhood environments and school neighborhoods. Network buffer distances of 1200 m–1600 m were selected for examining access to fast food restaurants and convenience stores in residential neighborhoods as prior research has found that adolescents perceive an easy walking distance to be about 15 min and the average participant in this study was not of driving age (Colabianchi et al., 2007). For the school neighborhood assessment, smaller network buffers of 800 m were selected to better capture food access within a distance that might be easily traveled by students during the school day. ArcGIS Version 9.3.1 (Esri, 2009, Redlands, CA, USA, 2009) was used for geocoding each adolescent's home address and school addresses, and GIS variables were defined following previously published protocols (D'Sousa et al., 2012; Forsyth et al., 2012). GIS data sources included land-use data, and commercial databases accessed through Esri Business Analyst. Additional details of the GIS variables are described in Table 1.

2.7. Screen media

Media environment data were collected by asking adolescents to write in the titles of their three favorite television shows. Favorite shows among the EAT 2010 sample were ranked by weighting each adolescent's first listed show more highly than the second show, which counted more than the third show. To be included among the set of favorite shows, the title had to be a program with a specific name and use a format with characters, scenes, dialogue, and plot, so entries that were broad topic areas (e.g. “sports,” “music videos”), networks (e.g. “MTV”), or sports or music events (e.g. “106 & Park”) were excluded. Closely related shows such as CSI, CSI-New York and CSI-Miami were combined and considered as the original version (Eisenberg et al., 2015; Eisenberg, Larson, Gollust, & Neumark-Sztainer, 2016). Over half (54.7%) of the adolescent sample for this analysis listed one or more of the top 25 shows.

The 25 most popular shows were content analyzed. Three episodes of each show were randomly selected from the 2010 season and were accessed via online services (e.g. network website, Netflix). Coding was done in two waves of three coders for the first 10 shows and then two coders for the remaining 15 shows, with one original coder training the two new coders to ensure consistency in applying the instrument. Training included at least four rounds of practice coding with earlier seasons of the top 25 shows. During the training period, coders analyzed shows independently; coders then met as a team to discuss their coding, reconcile any discrepancies, and clarify instructions in the codebook. In the final round of practice coding, two to three coders scored selected episodes and inter-coder reliability was calculated with Cohen's Kappa statistic (Landis & Koch, 1977). Additional details of the coding procedure have previously been described and media environment variables are described in Table 1 (Eisenberg et al., 2015, 2016).

2.8. Statistical analysis

Analyses were conducted in 2016 using version 9.4 of the Statistical Analysis System. In total, 38 independent variables representing individual-level factors and characteristics of adolescents' environments were examined in terms of their association with consumption of energy-dense, nutrient-poor snack foods (hereafter "snack food"). We used two different regression modeling strategies, which provided complementary information about the relationships between independent variables and snack food consumption. First, separate linear regression models were used to examine the relationship between each independent variable and snack food consumption (Model 1). Multiple markers of weight-related attitudes and behaviors were examined using this strategy to build understanding; given the consistent finding that weight concerns and efforts to lose weight were associated with lower consumption of snack food and the potential for multicollinearity to influence the results (Friedman & Wall, 2005), only one measure of weight change intentions was included in the second model. Model 2 simultaneously included all other independent variables in order to identify the strongest correlates of snack food consumption across the individual-level and ecological contexts based on *P* values.

Overall models that controlled for gender were examined along with regression models stratified on gender as previous research has identified differences in the factors that explain the dietary behaviors of females and males (Larson, Neumark-Sztainer, Story, & Burgess-Champoux, 2010; Zabinski et al., 2006). All regression models controlled for adolescent age in years, SES, and ethnicity/race and a random school-level effect was included to ensure that standard errors would correctly account for the number of participating schools. Additionally, all variables were standardized to allow for relative comparisons of strength between observed associations. Adjusted R^2 values were examined for Model 2 to determine the total variance explained together by all individual and environmental variables. For Models 1 and 2, a *P* value of <0.05 was used to determine statistical significance. No explicit control for multiple comparisons was performed; all *P* values are instead presented to three decimal places and the results emphasize patterns and magnitudes of observed associations.

There was a varying amount of missing data for each environmental variable, due largely to the use of multiple sources of data (EAT 2010 survey: 0–11%, parent/caregiver survey: 15–21%, friendship nominations: 40–44%, school personnel surveys: 0–2%, GIS data sources: 2–10%, content analysis of TV shows: 45%). Taken together, these missing data would have led to the deletion of a substantial number of adolescents from analyses using listwise deletion and a small, biased analytic sample. To avoid dropping adolescent participants from the full analytical sample, multiple imputation for missing variables was implemented using Proc MI (Rubin, 1987; Yuan, 2005). All regressions for Models 1 and 2 were performed across 20 imputed datasets and results were combined and summarized using Proc MIANALYZE, which incorporates uncertainty due to the missing values. Simulation studies support the use of multiple imputation over other techniques for handling missing data in order to decrease bias and improve efficiency even when the missing fraction for some variables is as large as 50% (Fichman & Cummings, 2003; Little & Rubin, 2002).

3. Results

Adolescent males and females reported consuming an average of two daily servings of common snack foods (males: 2.1 servings, females: 2.2 servings); daily consumption ranged from no servings to a high of 18.3 servings. Regression analyses were used to examine how variables from each context (individual, home/family, peer, school, neighborhood, and screen media) were related to adolescents' consumption of snack foods. Results are presented first for variables that were significantly related to snack food consumption in individual regression analyses, not adjusting for the potential influence of other correlates except sociodemographics (Model 1); next, associations with snack food consumption are presented with adjustment for the influence of all other variables (Model 2).

3.1. Associations of snack food consumption with individual and environmental characteristics

In models controlling for sociodemographics (Table 2), the individual characteristics found to be significantly associated with higher consumption of snack foods were self-identification as a picky eater, more frequent involvement in at-home food preparation, intention to gain weight, more frequent consumption of snacks prepared away from home, more frequent snacking while watching television, spending more time watching television, and spending more time playing video games. Conversely, lower consumption of snack foods was associated with weight-related concerns, the intention to lose weight, dieting in the past year, engaging in more healthy weight control behaviors, and sleeping more hours at night. Associations between environmental characteristics and snack food consumption represented the home/family (i.e., higher home availability of unhealthy food, less parental encouragement to eat healthy foods), peer (i.e., greater average consumption of snack foods by friends), and school (i.e., greater average number of snacks consumed by other students within school on weekdays) contexts. Standardized beta coefficient estimates from these models indicated that consumption of snacks prepared away from home, snacking while watching television, and attending a school where other students consume a high average number of snack foods were among the strongest of individual and environmental correlates of adolescent snack food behavior. For example, the coefficient associated with snacking while watching television indicated that adolescents who always versus never had a snack while watching TV were consuming nearly three additional daily servings of snack foods.

Results from the gender-stratified models identified similar correlates of snack food consumption among adolescent males and females. Among males only, greater school commitment to the promotion of healthy eating was associated with lower snack food consumption. Among females, snack food consumption was not related to hours of sleep or parental encouragement to eat healthy foods; however, consumption was also directly associated with school policies allowing students to eat during class and inversely associated with the presence of fast food restaurants in one's neighborhood of residence.

3.2. Overall contribution of individual and environmental characteristics to explaining snack food consumption

All together, the 34 variables included in the mutually adjusted model explained 25.5% of the overall variance, 23.6% of the variance for males, and 27.4% of the variance for females in consumption of snack foods. Considering the variables within each context as a unique block of correlates, the total proportions of variance explained by each block were as follows: 18.3% individual (males: 17.5%, females: 19.5%), 7.1% demographic (males: 6.3%, females: 7.7%), 10.1% home/family (males: 7.9%, females: 11.5%), 4.4% peer (males: 3.8%, females: 4.7%), 1.2% school (males: 0.1%, females: 1.7%), 0.0% neighborhood (males: 0.0%, females 0.0%), and 0.0% screen media (males: 0.0%, females: 0.0%).

Table 2
Associations of specific individual, environmental, and screen media characteristics with adolescent energy-dense snack food intake.

	Overall		Males		Females	
	β (SE)[a,b]	*P*	β (SE)[a,c]	*P*	β (SE)[a,c]	*P*
Individual characteristics						
Identity as a picky eater	**0.16 (0.05)**	**<0.001**	**0.25 (0.07)**	**<0.001**	**0.09 (0.06)**	**0.168**
Perceived cost barriers to healthy eating	−0.05 (0.05)	0.312	−0.02 (0.07)	0.772	−0.07 (0.06)	0.286
Involvement in at-home food preparation frequency	**0.14 (0.05)**	**0.002**	**0.16 (0.08)**	**0.041**	**0.13 (0.06)**	**0.045**
Meal skipping	−0.07 (0.05)	0.137	−0.07 (0.07)	0.284	−0.06 (0.06)	0.329
Depressive symptoms	0.08 (0.05)	0.115	0.10 (0.07)	0.169	0.07 (0.06)	0.249
Weight-related concerns	**−0.15 (0.05)**	**0.001**	−0.13 (0.07)	0.075	**−0.15 (0.06)**	**0.015**
Weight change intentions						
Maintain weight	−0.05 (0.05)	0.366	−0.11 (0.08)	0.147	0.02 (0.07)	0.752
Gain weight	**0.19 (0.05)**	**<0.001**	0.09 (0.07)	0.185	**0.33 (0.09)**	**<0.001**
Lose weight	**−0.18 (0.05)**	**0.001**	**−0.26 (0.08)**	**0.002**	−0.08 (0.07)	0.264
No intentions	Reference		Reference		Reference	
Weight control behaviors						
Dieting in past year	**−0.16 (0.05)**	**<0.001**	**−0.18 (0.07)**	**0.015**	**−0.15 (0.06)**	**0.019**
Healthy behavior frequency	**−0.29 (0.05)**	**<0.001**	**−0.20 (0.07)**	**0.003**	**−0.35 (0.06)**	**<0.001**
Unhealthy behaviors	−0.04 (0.05)	0.418	0.00 (0.07)	0.948	−0.05 (0.06)	0.471
Snacks prepared away from home frequency	**0.65 (0.05)**	**<0.001**	**0.57 (0.07)**	**<0.001**	**0.72 (0.06)**	**<0.001**
Snacks while watching television frequency	**0.73 (0.05)**	**<0.001**	**0.79 (0.07)**	**<0.001**	**0.42 (0.06)**	**<0.001**
Television viewing hours	**0.34 (0.05)**	**<0.001**	**0.24 (0.07)**	**<0.001**	**0.42 (0.06)**	**<0.001**
Video gaming hours	**0.35 (0.05)**	**<0.001**	**0.28 (0.06)**	**<0.001**	**0.56 (0.10)**	**<0.001**
Team sport involvement	0.07 (0.05)	0.135	0.11 (0.07)	0.108	0.05 (0.071)	0.449
Sleep hours	**−0.12 (0.05)**	**0.019**	**−0.24 (0.07)**	**0.001**	−0.03 (0.07)	0.675
Home/family characteristics						
Home unhealthy food availability	**0.69 (0.04)**	**<0.001**	**0.64 (0.07)**	**<0.001**	**0.74 (0.06)**	**<0.001**
Household food security	0.07 (0.05)	0.189	0.00 (0.08)	0.978	0.13 (0.07)	0.068
Family meal frequency	0.05 (0.05)	0.350	0.04 (0.08)	0.603	0.05 (0.07)	0.426
Perceived encouragement to eat healthy foods	**−0.11 (0.05)**	**0.018**	**−0.15 (0.07)**	**0.037**	−0.09 (0.06)	0.135
Parental restriction of high-calorie food	0.09 (0.05)	0.068	0.14 (0.08)	0.081	0.05 (0.07)	0.462
Peer characteristics						
Perceived attitudes/behavior						
Think it is important to eat healthy foods	−0.00 (0.05)	0.991	0.08 (0.07)	0.220	−0.08 (0.06)	0.202
Diet to control weight	−0.02 (0.05)	0.746	0.06 (0.07)	0.395	−0.06 (0.06)	0.304
Friends' weight-related behaviors						
Snack food intake	**0.33 (0.05)**	**<0.001**	**0.33 (0.08)**	**<0.001**	**0.37 (0.07)**	**<0.001**
Dieting	0.05 (0.05)	0.31	0.10 (0.07)	0.179	0.01 (0.07)	0.874
Meal skipping	0.05 (0.05)	0.29	−0.04 (0.07)	0.622	0.14 (0.08)	0.070
School characteristics						
Presence of fast-food restaurant in 800 m	0.14 (0.09)	0.107	0.09 (0.09)	0.325	0.20 (0.11)	0.081
Presence of convenience store in 800 m	0.02 (0.10)	0.798	0.07 (0.09)	0.404	0.01 (0.12)	0.960
Campus availability of competitive foods						
Not available	Reference		Reference		Reference	
A la carte or vending	0.10 (0.08)	0.218	−0.03 (0.09)	0.727	−0.15 (0.10)	0.161
A la carte and vending	0.20 (0.08)	0.218	−0.06 (0.09)	0.727	−0.30 (0.10)	0.161
Classroom food policies						
Allowed to eat in class	0.18 (0.10)	0.083	0.09 (0.10)	0.379	**0.25 (0.13)**	**0.047**
Food is used as reward	0.10 (0.10)	0.341	0.16 (0.10)	0.101	0.04 (0.13)	0.762
Schools' commitment to promotion of healthy eating	−0.13 (0.09)	0.160	−0.18 (0.08)	0.021	−0.09 (0.12)	0.482
Norm number of snacks during school day	**0.25 (0.06)**	**<0.001**	**0.24 (0.08)**	**0.003**	**0.27 (0.09)**	**0.003**
Neighborhood characteristics						
Presence of fast-food restaurant in 1200 m	−0.05 (0.05)	0.343	0.07 (0.07)	0.340	−0.15 (0.06)	0.020
High density of fast-food restaurants (≥5) in 1600 m	−0.08 (0.05)	0.086	0.03 (0.07)	0.699	**−0.19 (0.06)**	**0.003**
Presence of convenience store in 1200 m	0.04 (0.05)	0.403	0.07 (0.07)	0.339	0.01 (0.06)	0.924
Screen media characteristics						
Snack incident frequency	−0.03 (0.06)	0.649	0.13 (0.09)	0.163	−0.15 (0.09)	0.108
Unhealthy snack food incident percentage	−0.03 (0.05)	0.575	0.05 (0.09)	0.596	−0.11 (0.07)	0.130

SE = standard error.
[a] β coefficients are standardized and are interpreted as the amount of standard deviation (SD) change in energy-dense snack food servings associated with a 1 SD change in the individual or environmental characteristic.
[b] Model 1 estimates are from separate linear regressions of energy-dense snack food servings on specific individual and environmental characteristics along with adolescent age, gender, ethnicity/race, and socioeconomic status and a random school-level effect. Statistically significant associations ($P < 0.05$) are shown in bold.
[c] Model 1 estimates are from separate, gender-stratified linear regressions of energy-dense snack food servings on specific individual and environmental characteristics along with adolescent age, ethnicity/race, and socioeconomic status and a random school-level effect. Statistically significant associations ($P < 0.05$) are shown in bold.

The overall results observed for specific characteristics in this model that mutually adjusted for all other individual and environmental characteristics were comparable to the results from the initial models that controlled only for sociodemographics; however, fewer associations were statistically significant (Table 3). The individual characteristics found to be significantly associated with greater consumption of snack foods were lower perceived cost barriers to healthy eating, more frequent involvement in at-home

food preparation, more frequent consumption of snacks prepared away from home, more frequent snacking while watching television, and spending more time playing video games. Conversely, lower consumption of snack foods was associated with intention to lose weight. Associations between environmental characteristics and snack food consumption represented only the home/family (i.e., higher home availability of unhealthy food, more frequent family meals, parental restriction of high-calorie food) and peer (i.e., greater average consumption of energy-dense snack foods by friends) contexts.

Results from the gender-stratified models were similar to the overall mutually adjusted model despite some differences in the statistical significance of associations for males and females. Some factors identified as relevant to consumption in the overall model were not significantly associated with intake among males (such as involvement in at-home food preparation) or females (such as parental restriction of high-calorie food). Among males, snack food consumption was also directly associated with self-identification as a picky eater and inversely associated with more parental encouragement to eat healthy foods. Among females, snack food

Table 3
Mutually-adjusted associations of individual, environmental, and screen media characteristics with adolescent energy-dense snack food intake.

	Overall		Males		Females	
	β (SE)[a,b]	*P*	β (SE)[a,c]	*P*	β (SE)[a,c]	*P*
Individual characteristics						
Identity as a picky eater	0.08 (0.04)	0.068	**0.14 (0.07)**	**0.041**	0.02 (0.06)	0.708
Perceived cost barriers to healthy eating	**−0.10 (0.04)**	**0.022**	−0.07 (0.06)	0.269	−0.12 (0.06)	0.050
Involvement in at-home food preparation frequency	**0.14 (0.04)**	**0.002**	0.13 (0.07)	0.066	**0.13 (0.06)**	**0.029**
Meal skipping	−0.05 (0.04)	0.281	−0.09 (0.06)	0.177	−0.01 (0.06)	0.847
Depressive symptoms	0.03 (0.05)	0.538	0.05 (0.07)	0.495	0.02 (0.06)	0.699
Weight change intentions						
Maintain weight	−0.04 (0.05)	0.470	−0.10 (0.08)	0.172	0.04 (0.07)	0.554
Gain weight	0.08 (0.05)	0.091	0.01 (0.06)	0.853	0.14 (0.08)	0.075
Lose weight	**−0.11 (0.12)**	**0.046**	**−0.18 (0.08)**	**0.022**	−0.02 (0.07)	0.774
No intentions	Reference		Reference		Reference	
Snacks prepared away from home frequency	**0.36 (0.05)**	**<0.001**	**0.29 (0.07)**	**<0.001**	**0.40 (0.07)**	**<0.001**
Snacks while watching television frequency	**0.41 (0.05)**	**<0.001**	**0.52 (0.07)**	**<0.001**	**0.33 (0.07)**	**<0.001**
Television viewing hours	0.07 (0.05)	0.117	−0.01 (0.07)	0.861	0.12 (0.06)	0.058
Video gaming hours	**0.13 (0.05)**	**0.005**	0.12 (0.06)	0.053	**0.26 (0.09)**	**0.006**
Team sport involvement	0.03 (0.05)	0.474	0.08 (0.06)	0.210	0.00 (0.06)	0.989
Sleep hours	−0.07 (0.05)	0.136	−0.13 (0.07)	0.064	−0.02 (0.06)	0.806
Home/family characteristics						
Home unhealthy food availability	**0.39 (0.05)**	**<0.001**	**0.31 (0.07)**	**<0.001**	**0.44 (0.07)**	**<0.001**
Household food security	0.01 (0.05)	0.789	−0.04 (0.07)	0.622	0.05 (0.06)	0.461
Family meal frequency	**0.10 (0.05)**	**0.037**	0.11 (0.07)	0.145	0.10 (0.06)	0.097
Perceived encouragement to eat healthy foods	−0.04 (0.05)	0.354	**−0.15 (0.07)**	**0.034**	0.04 (0.06)	0.552
Parental restriction of high-calorie food	**0.13 (0.05)**	**0.006**	**0.16 (0.07)**	**0.025**	0.11 (0.06)	0.084
Peer characteristics						
Perceived attitudes/behavior						
Think it is important to eat healthy foods	0.08 (0.05)	0.126	0.14 (0.08)	0.078	0.02 (0.07)	0.74
Diet to control weight	0.01 (0.05)	0.874	0.06 (0.08)	0.486	−0.02 (0.06)	0.71
Friends' weight-related behaviors						
Snack food intake	**0.24 (0.05)**	**<0.001**	**0.25 (0.07)**	**<0.001**	**0.21 (0.07)**	**0.003**
Dieting	0.06 (0.05)	0.247	0.12 (0.08)	0.137	0.01 (0.07)	0.864
Meal skipping	0.02 (0.05)	0.695	−0.04 (0.07)	0.604	0.07 (0.07)	0.323
School characteristics						
Presence of fast-food restaurant in 800 m	0.12 (0.09)	0.151	−0.01 (0.14)	0.943	**0.27 (0.13)**	**0.041**
Presence of convenience store in 800 m	−0.10 (0.07)	0.170	0.02 (0.11)	0.87	−0.19 (0.11)	0.076
Campus availability of competitive foods						
Not available	Reference		Reference		Reference	
A la carte or vending	−0.06 (0.06)	0.277	−0.10 (0.09)	0.272	−0.02 (0.09)	0.821
A la carte and vending	−0.12 (0.06)	0.277	−0.20 (0.09)	0.272	−0.04 (0.09)	0.821
Classroom food policies						
Allowed to eat in class	0.06 (0.06)	0.369	−0.04 (0.10)	0.657	0.14 (0.10)	0.150
Food is used as reward	0.00 (0.07)	0.990	0.08 (0.11)	0.506	−0.02 (0.12)	0.848
Schools' commitment to promotion of healthy eating	−0.08 (0.08)	0.344	−0.08 (0.12)	0.526	−0.02 (0.12)	0.870
Norm number of snacks during school day	0.04 (0.05)	0.474	0.04 (0.09)	0.682	0.04 (0.08)	0.649
Neighborhood characteristics						
Presence of fast-food restaurant in 1200 m	−0.06 (0.05)	0.206	−0.01 (0.08)	0.887	−0.12 (0.07)	0.075
High density of fast-food restaurants (≥5) in 1600 m	−0.04 (0.05)	0.466	0.01 (0.07)	0.904	−0.08 (0.06)	0.204
Presence of convenience store in 1200 m	0.07 (0.05)	0.115	0.07 (0.07)	0.313	0.09 (0.06)	0.172
Screen media characteristics						
Snack incident frequency	−0.04 (0.07)	0.546	0.01 (0.10)	0.893	0.09 (0.10)	0.363
Unhealthy snack food incident percentage	−0.01 (0.07)	0.849	0.00 (0.10)	0.964	−0.04 (0.09)	0.664

SE = standard error.

[a] β coefficients are standardized and are interpreted as the amount of standard deviation (SD) change in energy-dense snack food servings associated with a 1 SD change in the individual or environmental characteristic.

[b] Model 2 estimates are from a linear regression of energy-dense snack food servings that simultaneously included all named individual and environmental characteristics along with adolescent age, gender, ethnicity/race, and socioeconomic status and a random school-level effect. Statistically significant associations ($P < 0.05$) are shown in bold.

[c] Model 2 estimates are from a gender-stratified linear regression of energy-dense snack food servings that simultaneously included all named individual and environmental characteristics along with adolescent age, ethnicity/race, and socioeconomic status and a random school-level effect. Statistically significant associations ($P < 0.05$) are shown in bold.

consumption was additionally associated with the presence of at least one fast food restaurant nearby one's school.

4. Discussion

This study was guided by ecological theory and social cognitive theory in examining potential correlates of adolescents' energy-dense snack food consumption. The study was designed to inform targets for intervention and policy development by focusing on potentially modifiable individual-level personal and behavioral factors; characteristics of home/family, peer, school, and neighborhood environments; and aspects of screen media exposure. Study findings provided support for multiple principles of social cognitive theory; factors within multiple contexts were related to snack food consumption, and factors more proximal to the individual explained the most variance in consumption. Just over one quarter of the variance in adolescents' snack food consumption was explained when 34 multicontextual factors were examined together and, when examined as a unique set of correlates, the 12 individual factors alone explained approximately 18% of the variance. Despite the particular relevance of individual factors, associations between environmental factors and adolescents' snack food consumption represented three contexts. The results suggest that the design of interventions targeting improvement in the dietary quality of adolescents' snack food choices should additionally consider addressing characteristics of their home/family (e.g., limiting the availability of unhealthy foods), peer (e.g., guiding the efforts of a peer leader in making healthy choices), and school environments (e.g., establishing student norms for selecting nutrient-dense snack foods). As few gender differences were identified, the results further suggest that tailoring separate interventions for male and female adolescents may be of limited value.

The results emphasizing the role of individual-level and home/family-level influences on snack food consumption are mostly in alignment with previous studies among school-age children that have considered the role of multiple contexts; however, some counter-intuitive associations were identified. Despite some inconsistencies across studies, previous research has similarly identified television viewing (Campbell, Crawford, & Ball, 2006; Grenard et al., 2013; Snoek, van Strien, Janssens, & Engels, 2006), lower scores for restrained eating (Snoek et al., 2006), higher home availability of unhealthy foods (Campbell et al., 2007; Cutler et al., 2011; Luszczynska et al., 2013; Martens et al., 2005; Pearson, Ball, & Crawford, 2011), and overtly restrictive feeding practices (Loth et al., 2016) as correlates of greater snack food consumption. The observation that eating more snacks prepared away from home was associated with snack food consumption is also in agreement with the broader literature that has linked eating away from home to eating more calories and fat and less fruits and vegetables (Rosenheck, 2008; Sebastian, Wilkinson, & Goldman, 2009). In contrast, the results for involvement in at-home food preparation and having family meals do not align with the broader literature that has linked these behaviors to markers of a better diet quality (Chu et al., 2012; Fulkerson et al., 2014; Larson, Story, Eisenberg, & Neumark-Sztainer, 2006). It is possible the cross-sectional nature of the study design influenced these findings if parents who were concerned about their adolescent's snack food consumption were more likely to involve them in preparing food for family meals and eating meals as a household.

The current study also makes unique contributions to the existing literature on the characteristics of peers and the school environment that may influence adolescents' snack food consumption (Ball et al., 2009; De Bourdeaudhuij & van Oost, 2000; Gregori et al., 2011; Luszczynska et al., 2013; Martens et al., 2005; Pearson et al., 2011; Wouters, Larsen, Kremers, Dagnelie, & Geenen, 2010; van Ansem et al., 2014; van Ansem et al., 2015; van der Horst et al., 2008). The findings provided little additional support for the role of school food availability but help to confirm previous studies that have similarly identified norms for eating snacks (Gregori et al., 2011; van der Horst et al., 2008; Wouters et al., 2010), sensitivity to peer influence (van Ansem et al., 2015), and less peer pressure to limit snacks (Luszczynska et al., 2013) as correlates of greater energy-dense snack food consumption. In particular, only three previous studies could be identified that have investigated norms as an influence on snacking behavior among school-age children and only one of these studies directly collected peer reports of their own snacking behavior (Gregori et al., 2011; Wouters et al., 2010; van der Horst et al., 2008). The current and first U.S.-based study added strength and specificity to this evidence in assessing norms at the school-level by combining the separate, direct reports of individual students specifically about their snacking behaviors between breakfast and dinner on school days. Although evidence for an association between adolescents' snack food consumption and their friends' weight control behaviors was not found, the examination of this possible association as part of the current study is another important addition to the literature. A related study among the EAT 2010 population found that weight-control behaviors of friends are linked (Eisenberg et al., 2012) and, given other evidence that dieting is associated with less energy-dense snack food consumption (Larson, Miller et al., 2016), this potentially complex relationship should be further investigated.

There are both strengths and limitations of importance to consider in drawing conclusions from this study. The concurrent assessment of individual characteristics; home/family, peer, school, and neighborhood environments; and screen media exposures is a unique strength which allowed for a comprehensive, multicontextual examination of potential influences on energy-dense snack food consumption. Previous studies have similarly examined multiple contexts of influence on snack food consumption; however, to the best of the authors' knowledge, this study represents the most comprehensive examination to date. Direct collection of information on several characteristics of environments from parents/caregivers, friends, school personnel, and GIS data sources combined with content analysis of favored television shows is a particularly unique aspect of the design that limited the potential for self-report bias. Other strengths that merit consideration include the large size and ethnic/racial diversity of the population-based sample, the previously validated measure of dietary intake, and theory-informed efforts undertaken to identify the relative strength of factors within multiple contexts both in the absence and presence of other hypothesized correlates.

Certain limitations of the measures and design are also important to consider given their potential impact on study findings. The measure of energy-dense snack food consumption focused on sweets/desserts and did not allow for distinguishing how often these foods were consumed along with meals versus in between meals. Additionally, the use of school environment data reported by school personnel and the potential for classification and address errors in the GIS data may have weakened observed associations with characteristics of school and neighborhood environments (Boone, Gordon-Larsen, Stewart, & Popkin, 2008; Powell et al., 2011). As all participants were drawn from just 20 schools within two metropolitan districts, lack of variability between schools and neighborhoods may have limited our ability to detect associations. Finally, in regards to screen media exposures, certain types of entertainment programming (e.g., sports shows, music video shows) could not be meaningfully coded but might have included portrayals of food and related behaviors. It is also of concern that less popular shows were not included in this analysis and might

have portrayed content of greater relevance to energy-dense snack food consumption patterns.

4.1. Conclusions and implications

Future research efforts to investigate influences on energy-dense snack food consumption should incorporate longitudinal, multicontextual designs to help clarify the temporal nature of relationships and allow for exploring in greater depth how the nature of influences may be different across the course of development. Even though this study examined 34 individual and contextual characteristics in combination, future research will need to consider other potentially relevant attitudes, behaviors, and environmental exposures in order to more fully explain variance in adolescent snack food consumption and changes in consumption over time. For example, there is a particular need to investigate in combination a variety of relevant exposures that may occur earlier in development (e.g., feeding for reasons other than hunger), exposure to multiple forms of snack food marketing, the content of other forms of media such as electronic games, online videos, and social networking sites (Institute of Medicine, 2006), and personality traits such as impulsivity. There is growing evidence linking impulsivity to unhealthy eating behaviors such as overeating and thus it will be important for future studies to address this trait as part of multicontextual models (Kakoschke, Kemps, & Tiggemann, 2015). Additionally, studies that include geographically disbursed adolescents in both urban and rural areas are needed to better examine the roles of school policies and practices and neighborhood food retail access. Direct observations in schools and neighborhoods may further provide informative, unbiased details regarding the presence (e.g., number of snacks in vending machines) and marketing (e.g. placement near registers, signage) of energy-dense snack food and healthier alternatives. Finally, research can build on the results reported here by examining potential interactions among individual and environmental characteristics to better inform the design of nutrition interventions and refinement of policies.

Although additional research is needed to expand on and clarify the results reported here, the relationships observed do provide some important direction for interventions and policies targeting improvement in the dietary quality of adolescents' snack choices. Results of the current study suggest that interventions should address the individual characteristics of young people through strategies such as providing opportunities to taste a variety of healthy foods; supporting the preparation of low-cost, nutrient-dense snacks at home; recommending limits on overall screen time; and recommending limits on the consumption of snacks while watching television. Interventions for parents should discourage the use of common, overtly restrictive feeding practices and instead encourage limits on how often energy-dense snack foods are purchased for the household (Loth et al., 2013). Few characteristics of peer or school environments were related to energy-dense snack food consumption; however, school-based interventions should consider targeting peer norms to encourage the selection of nutrient-dense choices. Likewise, despite the largely null results for the role of neighborhood influences, observed findings in females suggest community-based interventions should consider addressing access to fast food restaurants near schools.

Funding

This study was supported by Grant Number R01HL084064 (PI: Dianne Neumark-Sztainer) from the National Heart, Lung, and Blood Institute and by Grant Number R03HD079504 (PI: Nicole Larson) from the National Institute of Child Health and Human Development. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Heart, Lung, and Blood Institute, the National Institute of Child Health and Human Development, or the National Institutes of Health.

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