REVIEW

Snack Food, Satiety, and Weight[1–3]

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ABSTRACT

In today's society, snacking contributes close to one-third of daily energy intake, with many snacks consisting of energy-dense and nutrient-poor foods. Choices made with regard to snacking are affected by a multitude of factors on individual, social, and environmental levels. Social norms, for example, that emphasize healthful eating are likely to increase the intake of nutrient-rich snacks. In addition, satiety, the feeling of fullness that persists after eating, is an important factor in suppressing overconsumption, which can lead to overweight and obesity. Thus, eating snacks between meals has the potential to promote satiety and suppress overconsumption at the subsequent meal. Numerous studies have explored the relation between snack foods and satiety. These studies concluded that whole foods high in protein, fiber, and whole grains (e.g., nuts, yogurt, prunes, and popcorn) enhance satiety when consumed as snacks. Other foods that are processed to include protein, fiber, or complex carbohydrates might also facilitate satiety when consumed as snacks. However, studies that examined the effects of snack foods on obesity did not always account for satiety and the dietary quality and portion size of the snacks consumed. Thus, the evidence concerning the effects of snack foods on obesity has been mixed, with a number of interventional and observational studies not finding a link between snack foods and increased weight status. Although further prospective studies are warranted to conclusively determine the effects of snack foods on obesity risk, the consumption of healthful snacks likely affects satiety and promotes appetite control, which could reduce obesity. *Adv Nutr* 2016;7:866–78.

Keywords: snack food, satiety, energy density, nutrient density, overweight

Background

Snacking is often defined as consuming a food or drink between regular meals; however, this definition varies somewhat, with some studies defining specific periods of time after a meal (e.g., 15 min) and others specifying the amounts of food (e.g., portion sizes smaller than regular meals) or calories consumed (1–3). However, irrespective of the variations in the definition of snacking, it is important to differentiate between snacks and meals to examine their specific role in daily energy intake and their impact on health (1). In addition, categorization of the healthfulness of snacks has not been consistent across studies. Nevertheless, there is consensus that nutrient-poor and energy-dense snacks should be regarded as unhealthful (4, 5). The healthfulness of snacks can be determined on the basis of their contents being consistent with established dietary recommendations and guidelines (6, 7), which promote diets consisting of more fruit, vegetables, and whole grains and less total fat (especially solid fats), sodium, and refined sugars. Yet, despite a general interest in the idea of consuming more healthful foods and snacks among the population (8), ready-to-eat highly processed snacks are both increasingly available and consumed (6, 9, 10).

Indeed, snacking constitutes ~27% of children's daily caloric intake and there has been a significant increase in snacking habits over the past several decades (3, 11). Specifically, in 2006, children consumed 1.1 more snacks/d, with the amount of each snack increasing by ~50 g, in comparison to 1977, with a transition toward greater consumption of salty and candy-like snacks (3). Similarly, among US adults, the number of daily snacking occasions increased by ~1 snack/d from 1997 to 2006 (11). Thus, because snacks are pervasive in today's society, with energy-dense snacks and snacks of low dietary quality linked to increased risk of obesity and cardiovascular disease (3, 11), it is paramount to investigate factors contributing to snacking behaviors. Although previous research has assessed the literature on snacking and its effects on health (12), in the current review we aim to comprehensively examine particular aspects of the phenomenon of snacking by investigating factors that affect

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snacking behavior (including psychological and physiologic approaches) as well as the effects of various snack foods on weight. The current study aims to provide a comprehensive (although not systematic) review on the following 3 main topics: *1*) determinants of snacking, *2*) snack food and satiety, and *3*) snack food and body weight.

Determinants of Snacking

Food choices in general, and snacking in particular, are influenced by a multitude of factors. The National Heart, Lung, and Blood Institute describes a wide array of factors that affect individual health behavior on the basis of the socioecological model; these consist of factors on the personal, social and cultural, organizational, environmental, and policy levels (13). On the personal level, both biological and demographic (e.g., age, sex, genes) and psychological (e.g., emotions, self-efficacy, knowledge) factors affect eating behavior (13). For example, Wouters et al. (14) found that snacking and soft drink intake was more prevalent in boys and less-educated youth. In addition, emotional eaters and individuals under psychological stress have been found to consume higher amounts of energy-dense snacks, particularly sweet and fatty snacks (15). Moreover, knowledge about healthful snacks and self-efficacy in choosing the "right" snacks are important determinants of snacking behavior (16). Furthermore, variations in genes are responsible for an individual's taste receptors, which, in turn, affect taste perception and thus food and snack preferences (17). On the social and cultural level, factors such as modeling behaviors from the family and social norms are related to snacking behavior. Rhee et al. (18), for example, found that restrictive feeding practices by parents were related to decreased snack consumption among children (18), whereas Robinson et al. (19) observed that messages that emphasize that the social norm is to limit junk food significantly reduced the intake of high-calorie snacks (19). In addition, organizational factors and the physical environment also affect snacking behaviors (13). For example, lack of access to fresh fruit and vegetables in many low-income ethnic minority neighborhoods limits residents' ability to consume these healthful snacks (20). Conversely, the abundance of convenience stores in low-income neighborhoods, which often contain numerous unhealthful snacks, adversely affects the nutrition quality of ethnic minority populations (21).

In addition, specific properties of the snacks consumed as well as an individual's perception of these snacks are likely to affect snacking behavior and may lead to overeating. Specifically, over the years, package sizes of snacks have markedly increased (22–24). This increase in package size (11) has directly influenced total energy intake, regardless of the individual's state of hunger or the liking and palatability of the snack (22).

In addition, when distracted (e.g., by watching television or a movie), individuals often overconsume and are not necessarily cognizant of the dietary quality and quantity of the snacks eaten (25). Moreover, the energy density of snacks has also increased (11), which also affects total caloric intake and dietary quality (26). Although decreasing the package size can affect the quantity of unhealthful snacks consumed, increasing the portion size of less palatable healthful snacks (e.g., a larger bowl of raw vegetables) may actually facilitate healthful eating (25).

Furthermore, the variety of available snacks influences how much people consume. From an evolutionary perspective, humans historically consumed a wide variety of foods in relatively small quantities to obtain a diversity of required nutrients, vitamins, and minerals while limiting the amount of toxins in the foods (27, 28). However, in today's society, increased variety has been shown to increase food consumption both during an eating occasion (e.g., at a birthday party or wedding) and across meals (29, 30). Remick et al. (27) referred to this as the "variety effect," which is regulated by sensory-specific satiety (i.e., the palatability of a specific food gradually declines as the food is eaten) (26) and monotony (i.e., the liking of a food decreases in response to food repetition across meals). Thus the "variety effect" reflects human reaction to the sensory aspects of foods rather than their nutritional properties (i.e., energy density, volume, and macronutrient composition). For example, Raynor and Epstein (31) found that when participants ate a highly palatable snack 4 times/wk for 8 wk, their hedonic ratings (i.e., the extent to which the snack tasted pleasant) decreased. This poses a particular challenge to consumers when exposed to the ubiquity and overabundance of highly processed snacks that offer variety on the basis of added fat, sugar, salt, and spices (28).

Snack Foods and Satiety

Satiety, the feeling of fullness that persists after eating, is an important factor in suppressing overconsumption, which can lead to overweight and obesity (32). Identifying eating patterns and foods that promote satiety without considerably increasing overall energy intake is important for promoting more healthful eating behaviors (32, 33). Eating snacks between meals can potentially promote satiety and suppress overconsumption at the next meal, although the literature has explored this phenomenon in certain foods and nutrients and, to our knowledge, has not yet examined the collective findings (34). A 2011 study developed a biobehavioral approach to assess whether objective criteria for eating a meal and snacking could be determined through multiple small substudies and found that, although snacks in general exerted a weak satiety effect, snacks higher in protein, compared with those with a higher carbohydrate or higher fat content, had the strongest satiety effect (1). Although it is important to consider the findings from this particular study, multiple studies have found satiating effects of a variety of foods and nutrients consumed as snacks.

Protein content of snack foods. The majority of studies that considered snacking satiety examined the protein content of foods, especially protein-rich foods, such as nuts, dairy, yogurt, and soy. Some studies considered the protein compared with the carbohydrate content of snacks. Specifically, Marmonier et al. (35) examined the effects of the nutrient composition of an afternoon snack consumed while not hungry on how soon the next meal was consumed. The sample of young men were given a high-fat, high-protein, or high-carbohydrate snack to be consumed 4 h after the beginning of lunch. The consumption of the high-protein snack delayed the request for dinner by the greatest length of time, followed by the high-carbohydrate, and then the high-fat snack. Findings from this study support the notion that a high-protein snack has the highest satiety compared with snacks high in other nutrients. Another study assessed the behavioral consequences of a high-protein snack compared with a high-carbohydrate snack consumed just under 4 h after lunch to investigate whether snacking when not hungry could contribute to obesity (35). Compared with a session in which no snack was consumed, the high-protein snack delayed the dinner request, but the high-carbohydrate snack did not, which also supports the notion that high-protein snacks may have the strongest ability to influence satiety. In contrast, another study explored how replacing wheat flour in a soft pretzel with soy ingredients could affect satiety, as well as other outcomes, but found that the soy addition did not affect satiety (36).

Although it is interesting to look simply at comparisons of nutrient content in snacks, multiple studies have considered how whole foods (e.g., nuts and yogurt) affect satiety. A review by Tan and Mattes (37) found that tree nuts and peanuts have high satiety values, as well as many other positive energy-balance attributes, when consumed as snacks (38). A different review article concluded that pistachios also have satiety and satiation effects when consumed as a snack (39). A 4-wk randomized parallel-arm study found that, when consumed as snacks, almonds reduced hunger and desire to eat during an acute-feeding session, leading the authors to suggest that almonds may be a healthful snack option (37). However, Alper and Mattes (38) found that, despite being energy-dense, peanuts have a high satiety value and chronic ingestion evokes strong dietary compensation and little change in energy balance (38). A different study compared almonds with a more conventional snack (cereal bars) on hunger rating (40). Compared with the control (who were not provided with snacks and were asked to continue with their habitual eating pattern) and cereal bar groups, the almond snack group had a significantly higher eating frequency, although this did not result in higher energy intake, body weight, or percentage of body fat. However, there was no difference in hunger ratings across the 3 groups. For the most part, results indicated that nuts appear to promote satiety when eaten as a snack.

The satiating effect of yogurt as a snack has also been explored in multiple studies. One recent study in women sought to determine whether a high-protein afternoon yogurt snack improved satiety, among other outcomes (41). The authors found that, compared with high-fat snacks, the consumption of yogurt significantly improved satiety among a sample of healthy women. Another study also conducted in women used an acute randomized crossover-design study in which participants were given a low-protein or high-protein yogurt 3 h after lunch (41). Perceived hunger and fullness were assessed throughout the afternoon until dinner was voluntarily requested. Snacking led to reduced hunger and increased fullness, although no differences in postsnack perceived hunger or fullness were observed between the low-protein and high-protein yogurt snacks (41). A third study found that an afternoon snack of Greek yogurt containing 24 g protein led to significantly reduced hunger, increased fullness, and delayed subsequent eating than did lower-protein snacks in healthy women (42). A fourth study observed that compared with other dairy products (e.g., milk and cheese), yogurt had a significantly greater effect on suppressing subjective appetite ratings but did not affect subsequent food intake (43). Overall, results indicate that yogurt also appears to promote satiety when eaten as a snack.

Fiber content of snack foods. Many studies that have investigated the satiety effects of snacking have done so by examining the fiber content of foods. However, like protein, some explored the effect of adding fiber to processed food products, whereas other studies looked at whole foods. Almiron-Roig et al. (44) considered the addition of fiber to a yogurt drink and found that it tended to be more satiating than the other foods. In another study in which fiber was added to a food, 20 healthy adolescents were selected and randomly assigned to receive a preload of barley enriched with β-glucan or control biscuits as a midmorning snack (45). A decrease in the desire to eat and an increase in fullness and satiety were experienced with the barley β-glucan–enriched biscuits compared with the control biscuits. Another study looked at the effect of psyllium and oat bran on postprandial glycemia and in vitro digestibility (46). The authors of this study found that the addition of psyllium fiber to extruded snack products reduced glycemic responses compared with a control snack. They also observed that the inclusion of oat bran in the snack products appeared to extend the glycemic response compared with the control snack, which suggested the possibility of prolonged glucose release that potentially affected satiety responses.

Two studies considered how fibrous whole foods may relate to satiety when consumed as snacks. One study examined prunes consumed as a snack before a meal compared with an isoenergetic bread product of equal weight (33). Participants' feeling of hunger, desire, and motivation to eat were lower at all time points between snack and meals. Because the macronutrient content of both foods was similar in this study, the satiating power of prunes could be due to their relatively high fiber content. The authors concluded that prunes as a snack appeared to promote satiety and contributed valuable nutrients. In another study, the effects of different snack foods, including dried plums, on satiety and plasma glucose and hormone responses were assessed (47). In this study, 19 women, after fasting, consumed test foods including dried plums, low-fat cookies, white bread, and water only, which (with the exception of water) provided 238 kcal and were similar in total carbohydrate, fat, and protein content but differed in fiber and sugar content. They found that among these women, the consumption of dried plums as a snack suppressed hunger relative to a low-fat cookie as evidenced by lower glucose and/or satiety-regulating hormone concentrations. Overall, the addition of fiber to foods, as well as foods naturally high in fiber, appeared to promote satiety.

Other nutrient contents and factors in snack foods. Other studies that have considered the satiating effects of snacks examined the types of fat and carbohydrates. One dietary fat–based study explored the consumption of high–oleic acid and regular peanuts compared with chips and found no observed differences in perceived satiety (48). Another study examined the effects of replacement of fat by nonabsorbable fat on energy intake and on feelings of hunger and satiety (49). The authors concluded that fat replacement in meals or in snacks did not result in changes in hunger and satiety ratings throughout the day. On the basis of these studies, the type of fat in snacks may not have differing effects on satiety, although these findings are relatively limited and further studies should explore fat content in snacks.

The types of carbohydrates in snacks and their potential effect on satiety have also been explored. One study examined the impact of 2 different cookies on satiety and cardiovascular risk factors. A fructo-oligosaccharide–enriched cookie produced greater ratings of satiety than a control cookie, which showed the potential contribution of fructo-oligosaccharides to satiety (50). Another study compared short-term satiety from low-fat popcorn with potato chips, without making any alterations to their nutrient composition (51). Participants expressed less hunger, more satisfaction, and lower estimates of prospective food consumption after 6 cups of popcorn than after consumption of the potato chips. These studies suggest that certain carbohydrates, such as whole grains, may promote satiety when consumed as snacks.

Overall, these studies suggest that some whole foods high in protein, fiber, and/or whole grains, such as nuts, yogurt, dried plums or prunes, and popcorn, may promote satiety when consumed as snacks. Other foods that are processed to include protein, fiber, or complex carbohydrates may also promote satiety when consumed as snacks. Promoting these foods as snacks may contribute to satiety and suppress overconsumption at the next meal. **Table 1** provides a summary of this evidence.

Snack Foods and Body Weight

The imbalance between energy expenditure and energy intake that results in a positive energy balance is a contributing factor to the development of obesity. However, the impact of specific dietary factors has not been sufficiently examined, with the contribution of specific types of snacks subject to controversy (53). To date, observational and interventional studies have not sufficiently shown a causal relation between snack food and obesity. In fact, results have been quite mixed, with various and inconsistent exposures (e.g., types of snack food) and outcome measures (e.g., BMI compared with waist circumference) and variations in intervention periods, study populations, and the quality of the methodology used in the studies.

Nutrient-dense snack foods and body weight. A randomized clinical trial that examined the impact of including either a daily dark-chocolate or a nonchocolate snack on weight and anthropometric measurements in premenopausal women observed that both groups showed decreased body weight, hip and waist circumference, and fat mass (54). In comparison, a different randomized trial, over a 12-wk period, examined the effects of daily consumption of either cereal or an almond snack in healthy overweight or obese men (44). Study results showed no increase in energy intake, body weight, or percentage of body fat in either group (40). An additional study that focused on lean men examined the effects of eating isoenergetically dense snacks high in protein, fat, or carbohydrates, which comprised 30% of daily energy requirements, in the setting of an ad libitum diet of fixed nutrient composition (55). In this study, snack composition did not differentially affect total daily food intake or energy intake, nor did snacking lead to increased body weight (56). Another intervention study in normal-weight adults also suggested the ability to maintain a normal body weight through accurate compensation after snack consumption (57). Specifically, after 8 wk of a daily mandatory snack that provided 25% of energy requirements, there were no differences in energy intakes or body composition across groups who were assigned snacks either with or between meals and snacks having either a low or high energy density (58). A recent study by Njike et al. (59) found that the consumption of nut-based snack bars for 12 wk (compared with conventional snack bars) did not result in any weight change; however, they did observe reductions in percentage of body fat and visceral fat in overweight participants. In addition, an observational longitudinal study in school-aged children found that there was no increased risk to move into the overweight category on the basis of "snacking" or "junk or convenient" eating patterns (60). However, children who adhered to dietary guidelines, including intakes of vegetables, fruit, and unrefined cereal products, had a lower risk of remaining overweight over time (61).

Energy-dense snack foods and body weight. In the Monitoring Project on Risk Factors for Chronic Diseases (MORGEN)-EPIC (European Investigation into Cancer and Nutrition) population-based cohort study, there was some evidence, albeit inconsistent, that the consumption of energy-dense snacks (e.g., sweets, cakes, pastries, and savory snacks) was positively associated with an annual increase in weight among normal- to overweight adults (53). This relation also held true for children. In another cross-sectional study, the total amount of foods consumed, specifically from snacks, was positively associated with overweight status in children; yet, the odds of being overweight were very small (55). This may stem from an interaction effect of response inhibition and implicit preference for snack foods. One study in a group of predominantly normal-weight women found that those with strong implicit preferences for snack foods and low inhibitory capacity gained the most weight (57). Another mechanism for

TABLE 1 Overview of studies that assessed snack foods and satiety

Study	Target population	Study design	Intervention type	Comparison group	Results
Almiron-Roig et al. (44)	30 participants, 9 men and 21 women; mean age: 36.6 ± 9.1 y	Randomized crossover trial	Participants were given 5 preloads (a fiber-enriched drinking yogurt, a regular drinking yogurt, plain crackers, fresh banana, or an isovolumetric serving of water) over 5 sessions (with a minimum of 2 d between sessions).	Water served as the comparison.	Fiber-enriched yogurt was more satiating than regular yogurt, banana, crackers, and water. A trend was suggested, with fiber-enriched yogurt having the highest satiating effect followed by regular yogurt, then banana and crackers.
Alper and Mattes (38)	15 participants, 7 women and 8 men; mean age: 33 ± 9 y	Crossover intervention study	Participants were provided peanuts that equaled ∼505 ± 118 kcal/d for 8 wk with no dietary guidance, 3 wk with instructions to add peanuts to their customary diet, and 8 wk in which peanuts replaced an equal amount of other fats in the diet.	The period of time when peanuts that equaled ∼ 505 ± 118 kcal/d were provided for 8 wk with no dietary guidance served as the control.	There were no significant differences in the mean desire to eat, mean prospective consumption, and mean fullness ratings with regard to the intervention. However, peanuts had a high satiety value overall.
Barbour et al. (48)	24 participants, 11 women and 13 men; mean age: 61 ± 1 y	Triple crossover study	Participants consumed isoenergetic amounts of high-oleic or regular peanuts (56–84 g) or potato crisps (60–90 g) over 3 d after an overnight fast.	Unsalted potato crisps served as the control food.	No differences in perceived satiety were observed.
Brennan et al. (46)	12 participants	—	Participants consumed either a standard 25-g glucose drink in which psyllium and oat bran were incorporated at a 15% replacement concentration to flour or a control product.	The control product served as the comparison.	The inclusion of oat bran into the snack products extended the glycemic response of individuals compared with the control snack, potentially affecting satiety responses.
de Luis et al. (50)	38 participants, 9 men and 27 women; mean ages: 45.3 ± 16.1 and 50.8 ± 16.2 y, depending on the subgroup	Double-blind randomized clinical trial	Participants were randomly assigned to a test group that received cookies enriched with fructo-oligosaccharides or to a control group that received cookies with no fructo-oligosaccharides.	Control cookies served as the comparison.	After the test meal, the baseline AUC of the satiety score was higher with the satiety cookie than with the control cookie. Results were similar at follow-up.
Dougkas et al. (43)	40 men; mean age: 32 ± 9 y	Randomized crossover trial	Participants attended 4 sessions that were 1 wk apart. They received 3 isoenergetic (841 kJ) and isovolumetric (410 mL) servings of dairy snacks or water (control) 120 min after breakfast.	Water served as the comparison.	All dairy snacks tested reduced appetite compared with water. Hunger ratings were 8%, 10%, and 24% lower after the intake of yogurt than after cheese, milk, and water, respectively.

(Continued)

TABLE 1 (*Continued*)

Study	Target population	Study design	Intervention type	Comparison group	Results
Douglas et al. (42)	15 women; mean age: 26 ± 2 y	Randomized crossover study	Participants consumed afternoon snacks of yogurt with 5, 14, or 24 g protein, or no snack, for 3 d. On the fourth day, participants consumed a standardized lunch, and consumed their yogurt snack 3 h later or did not consume any snack.	The afternoons of "no snack" served as the comparison.	The yogurt snack led to reduced hunger and increased fullness compared with no snack. Among the types of snacks, hunger was lower and fullness was higher throughout the postsnack period after the higher-protein yogurt vs. the lower-protein yogurt.
Furchner-Evanson et al. (47)	19 women; mean age: 39.2 ± 0.7 y	Randomized, balanced crossover study	Participants consumed test foods (dried plums, low-fat cookies, white bread, and water only) on separate days. The test foods (except water) provided 238 kcal and were similar in total carbohydrate, fat, and protein content, but differed in fiber and sugar content.	A snack of 220 mL water served as the comparison.	The satiety index AUC was greater for the dried plum trial vs. the low-fat cookie trial.
Marmonier et al. (35)	11 men; mean age: 22.5 ± 0.5 y	Within-subject study	Participants were given a high-fat, a high-protein, or a high-carbohydrate snack that they were to consume 240 min after the beginning of lunch.	There was no control group.	Consumption of the high-protein snack delayed the request for dinner by 60 min, the high-carbohydrate snack delayed the dinner request by 34 min, and the high-fat snack delayed the dinner request by 25 min.
Marmonier et al. (35)	8 men; mean age: 22.6 ± 0.7 y	Within-subject study	Participants attended 3 sessions: *1*) a basal session, *2*) a session in which they consumed a high-protein snack, or *3*) a session in which they consumed a high-carbohydrate snack 215 min after lunch.	Each participant was his own control.	Compared with the basal (no snack) session, the high-protein snack delayed the spontaneous dinner request by 38 ± 16 min, but the high carbohydrate snack did not.
Nguyen et al. (51)	35 participants, 17 men and 18 women; mean age: 33 ± 11 y	Counterbalanced within-subject study	Across 4 trials in a laboratory setting, participants consumed a standardized breakfast. They then were either given a snack of 1 cup (4 g, 15 kcal) popcorn, 6 cups (27 g, 100 kcal) 94% fat-free microwave popcorn, or 1 cup (28 g, 150 kcal) potato chips, each with 200 mL water, or they received the control (200 mL water).	Water (200 mL) served as the comparison.	Participants expressed less hunger, more satisfaction, and lower estimates of prospective food consumption after 6 cups of popcorn than after all other treatments. Popcorn exerted a stronger effect on short-term satiety than did potato chips.

(*Continued*)

TABLE 1 (*Continued*)

Study	Target population	Study design	Intervention type	Comparison group	Results
Ortinau et al. (41)	20 women; mean age: 27 ± 2 y	Randomized crossover design study	Participants participated in three 8-h testing days comparing three 160-kcal afternoon snacks: high-protein yogurt, high-fat crackers, and high-fat chocolate.	The high-fat snacks served as the comparison.	The consumption of the yogurt snack led to greater reductions in afternoon hunger, but not fullness, vs. chocolate. The yogurt snack also delayed the request of dinner by 30 min compared with the chocolate snack.
Ortinau et al. (52)	32 women; mean age: 27 ± 2 y	Acute randomized crossover study	Participants consumed yogurt with either 5 or 14 g protein 3 h after consuming a standardized lunch. They then reported perceived hunger and fullness throughout the afternoon until dinner was voluntarily requested.	The yogurt with 5 g protein served as the comparison.	Snacking led to reductions in hunger and increases in fullness, although there were no differences in postsnack-perceived hunger or fullness between the 2 types of yogurt.
Simmons et al. (36)	20 participants, 8 men and 12 women; mean age: 25.3 ± 6.4 y	Randomized, counterbalanced, crossover study	Participants ate either a soy pretzel or wheat pretzel.	The wheat pretzel served as the comparison group.	The mean satiety score was 306.2 ± 215.0 cm × min for wheat vs. 311.3 ± 201.0 cm × min for the soy pretzel (P = 0.92). Soy did not have any effect on satiety in this study.
Tan and Mattes (37)	137 participants, 48 men and 89 women; mean ages ranged from 27.8 ± 10.7 to 32.9 ± 11.5 y, depending on the subgroup	Randomized, controlled, parallel-arm study	Participants were assigned to 1 of 5 groups: control, breakfast, lunch, morning snack, afternoon snack. Participants in the morning snack group were instructed to consume 43 g almonds as a morning snack for 4 wk. Participants in the afternoon snack group were instructed to consume 43 g almonds between lunch and dinner, with ≥2 h before and after these meals.	Participants in the control group were asked to avoid all nuts and seeds during the study period.	Postprandial "hunger" and "desire to eat" ratings were significantly less for the combined snack groups than for the combined meal and control groups (P = 0.026 and P = 0.023, respectively).
Vitaglione et al. (45)	20 participants, 10 men and 10 women; mean age: 18 ± 0.5 y	—	Participants received a 628-kJ or a 1884-kJ preload of barley β-glucan–enriched or control biscuits as a midmorning snack.	The control biscuits served as the comparison.	A decrease in the AUC of the desire to eat and an increase in the AUC of fullness and satiety were recorded with a small preload of barley β-glucan–enriched biscuit compared with a small preload of control biscuit.

(*Continued*)

TABLE 1 (*Continued*)

Study	Target population	Study design	Intervention type	Comparison group	Results
Westerterp-Plantenga et al. (49)	48 women; mean ages ranged from 21.0 ± 0.7 to 33.4 ± 9.5 y, depending on the subgroup	Experimental design study	Participants received snacks that they could consume ad libitum and recorded food intake for 2 wk. In the first week, all snacks were full fat, and in the second week only half were full fat whereas the others were in reduced-fat reduced-energy form, and labeled as such.	—	Fat replacement in meals or in snacks did not result in changes in hunger and satiety ratings throughout the day. These results suggest short-term beneficial effects of fat replacement on energy and fat intake.
Zaveri and Drummond (40)	36 men; mean age: 39.6 ± 6.9 y	Randomized controlled trial	Participants were given 2 packets of cereal bars (30 g and high in carbohydrates) or almonds (28 g and high in protein) for 12 wk. They were free to eat the snacks at any time.	The control group did not receive the cereal bar or almonds and were asked to continue their habitual eating pattern.	Hunger did not significantly differ at baseline, 6 wk, or 12 wk between almond, cereal bar, and control groups.

this effect might stem from increased portion size, because increasing portions by 50% was found to increase daily energy intake by 16% and increasing portion size by 100% increased energy intake by 26% (60). Given the results as a whole, it is hard to conclude that snacking leads to increased energy intake or compensation. Another longitudinal study, which followed nonobese premenarchal girls, found that energy-dense snacks did not influence weight-status change over the adolescent period; specifically, soda was the only energy-dense snack that was significantly related to BMI *z* score over the 10-y study period (62). In a prospective study of both girls and boys, snack foods considered to be of low nutritional value were not an important independent determinant of weight gain among children and adolescents (5). Specifically, a null relation between the number of snack servings per day and subsequent changes in BMI *z* score was observed (5). Interestingly, another cross-sectional study in overweight and normal-weight adolescents observed that although overweight adolescents had more irregular meals, which may play a role in developing excess weight, they snacked significantly less often than did adolescents with a normal BMI (63). Other longitudinal studies have not found a clear and positive association between childhood obesity development and the behavior of snacking but did find an association with sugar-sweetened beverage consumption (63).

Snack foods, energy intake, and body weight. Although some findings suggest that the relation of eating frequency with BMI *z* score differs from that of changes in BMI (65), obesity-related eating behaviors, such as the number of eating occasions, have been considered for their contribution to higher energy intake. In a cross-sectional study, however, no association was found between the number of obesity-related eating behaviors and food portion size or the number of eating occasions but the number of obesity-related eating behaviors was associated with higher consumption of sugary and alcoholic beverages (66). Thus, these studies suggest that there may not be a link between snacking and overweight status in adults or adolescents and that the type of snack consumed is an important determinant that should be taken into account. In comparison, other studies suggested that some snack foods may indeed lead to increased energy intake and weight gain. In a crossover trial, participants partially compensated for energy when supplemented with commercial snack products over 14-d periods, but this compensation was insufficient to prevent some increase in energy balance, resulting in body-weight gain (49, 57).

On the basis of these studies, the effects of snack foods on body weight are mixed. Studies that used nutrient-dense snack foods were associated with weight loss or weight maintenance, whereas those that used energy-dense snack foods were associated with weight gain or had no effects on body weight. **Table 2** summarizes the evidence on the impact of snack foods on body weight.

TABLE 2 Overview of studies that assessed snack foods and body weight[1]

Study	Target population	Study design	Intervention type	Comparison group	Results
Evans et al. (65)	Urban schoolchildren, ages 9–15 y	Cross-sectional and prospective study	Eating frequency, the average number of reported daily eating occasions, was assessed by using 2 weekday 24-h diet recalls.	Normal BMI *z* score	From baseline to 6 mo, BMIz increased by 0.03 units for each additional reported eating occasion. This relation was no longer significant at 1 y.
Field et al. (5)	Boys and girls between ages 9 and 14 y	Prospective cohort study	Intake of snack foods was assessed in 1996–1998 with a validated FFQ designed specifically for children and adolescents.	No control group	There was no relation between intake of snack foods and weight gain.
Hendriksen et al. (53)	Normal-weight and overweight Dutch adults	Prospective cohort study	Intake of EDS foods (sweets, cakes, and pastries and savory snacks) was assessed at baseline by using a validated FFQ.	Lowest tertile of EDS food consumption	Inconsistent evidence of an association of EDS food consumption with annual weight change.
Jodkowska et al. (63)	Polish overweight and normal-weight adolescents, aged 13–15 y, of whom 953 were overweight and 953 had normal body mass	Cross-sectional analysis	Self-reported questionnaire containing questions regarding how often selected food products were usually consumed during the week, how regularly basic meals (breakfast, lunch, supper) were eaten, and data on snacking.	"Selection in pairs," each overweight pupil was paired with a pupil with normal body weight	Overweight adolescents consumed unhealthy products such as sweets and crisps significantly less often than their peers with appropriate body mass. Overweight girls ate dark bread significantly more often, and consumed soft drinks less often, than their peers with normal weight. Nevertheless, overweight teenagers snacked significantly less often than young people with normal body mass.
Johnstone et al. (56)	8 British men with ad libitum access to a diet of fixed composition	Randomized controlled crossover design	*1*) Mandatory snacks compared with snacks and *2*) the composition of isoenergetically dense snacks high in protein, fat, or carbohydrate on food and energy intakes.	No snack group	Body weight was not affected by snacking.
Moreno and Rodriguez (64)	Children and adolescents	Review	Dietary aspects influencing obesity development	Review	Longitudinal studies have only found a clear and positive association between obesity development and sugar-sweetened beverage consumption; this is not the case with snacking, fast food, or food portion sizes.

(Continued)

TABLE 2 (*Continued*)

Study	Target population	Study design	Intervention type	Comparison group	Results
Muñoz-Pareja et al. (66)	10,791 persons representative of the Spanish population who were ≥18 y old in 2008–2010	Cross-sectional study	Self-reported information was collected on 12 OREBs	Participants with ≤1 OREB	OREBs were associated with higher food energy density and higher consumption of sugary and alcoholic beverages.
Nederkoorn et al. (57)	Normal-weight undergraduate female students over a 1-y period	Longitudinal prospective cohort study	Implicit preference for food, response inhibition and BMI were measured.	Low implicit food preference	Participants with strong implicit preferences for snack foods and low inhibitory capacity gained the most weight.
Nicklas et al. (55)	1562 children aged 10 y (65% EA, 35% AA) over a 21-y period	Cross-sectional analysis	No intervention was delivered.	No comparison group	Food consumed from snacks was positively associated with overweight status.
Njike et al. (59)	34 overweight adult participants	Randomized controlled trial	Participants were provided nut-based snack bars to consume daily for 12 wk.	Conventional snack bar, specifically empty-calorie snack bar	Body fat and visceral fat were reduced and there were no adverse effects on weight, blood pressure, lipid profile, satiety, or quality of life.
Oellingrath et al. (61)	Primary-school children from Norway; middle childhood (fourth grade, 9–10 y old) to early adolescence (seventh grade, 12–13 y old).	Prospective cohort, cross-sectional, and longitudinal analysis	Categorization into 4 eating patterns: snacking, junk or convenient, varied Norwegian, and dieting	Unchanged normal-weight child	Children with stable or increased "varied Norwegian" pattern scores had a lower risk of remaining overweight over time than children with decreased scores for this pattern.
Piehowski et al. (54)	Premenopausal overweight women with BMIs (in kg/m^2) of 25–43	Randomized controlled trial, 18 wk	Reduced-calorie diet including either a daily dark-chocolate snack or a nonchocolate snack	Nonchocolate snack group	Women in both the dark-chocolate snack and nonchocolate snack groups experienced decreases in body weight (−5.1 vs. −5.1 kg), hip circumference (−5.8 vs. −5.4 cm), waist circumference (−5.7 vs. −3.5 cm), fat mass (−3.9 vs. −3.6 kg), and body fat percentage (−3.4% vs. −3.1%), respectively, with no change in lean mass.
Phillips et al. (62)	Nonobese premenarchal girls 8–12 y old were enrolled between 1990 and 1993 and followed until 4 y after menarche	Prospective cohort study	Relation between EDS foods and relative weight change	No control group	There was no relation between BMIz or %BF and total EDS food consumption. Soda was the only EDS food that was significantly related to BMIz over the 10-y study period.

(Continued)

TABLE 2 (*Continued*)

Study	Target population	Study design	Intervention type	Comparison group	Results
Viskaal-van Dongen et al. (58)	16 men and 66 women (mean age: 21.9 y), mean BMI (in kg/m^2): 20.7	Randomized controlled trial, 8 wk	Randomly assigned to 1 of 4 parallel groups in a 2 × 2 design: snacks consumed with or between meals and snacks having a low (<4 kJ/g) or high (>12 kJ/g) energy density. For 8 wk, subjects consumed mandatory snacks that provided 25% of energy requirements on each day.	High energy–density snack food	No differences in changes in body weight between the 4 groups. Similarly, there were no differences in changes in body composition, PAL, and energy intake between the 4 groups.

[1] AA, African American; BMIz, standardized BMI z score; EA, Euro-American; EDS, energy-dense snack; OREB, obesity-related eating behavior; PAL, physical activity level; %BF, percentage of body fat.

Summary and Conclusions

Although efforts have been put forth to examine the effects of snack foods on satiety and weight status, to our knowledge the association between snack foods and body weight has not been sufficiently summarized to date. In addition, studies on the topic used various study designs (ranging from cross-sectional to randomized controlled trials) and often had methodologic limitations. For the intervention studies, the intervention duration as well as the timing of the introduction of the snack food varied; specifically, some studies advised participants to consume the snack food between meals whereas others advised participants to snack as needed. The intervention studies included in this review were primarily short term. The type of snack foods that were used in the various studies also varied; some studies used snack foods that were high in protein and/or fiber, whereas others used snacks that were high in fat and/or sugar. In addition, the sample sizes of participants in the included studies were small, and the composition of the control groups was inconsistent across studies, with some studies lacking a control group altogether. In addition, the variation in the dietary patterns of participants makes it difficult to interpret the findings. Yet, this inherent variation in dietary patterns in the study participants is also a strength because it is similar to a real-world scenario, in which dietary patterns and habits vary. Although the findings of the studies that evaluated the impact of nutrient-dense snacks that are higher in protein and fiber showed weight reduction or weight maintenance, the findings of the studies that assessed the impact of low-nutritional-value snacks (e.g., sugar-sweetened beverages, sweets, cakes, pastries, pizza, and savory foods) were conflicting. Specifically, some studies showed weight gain, whereas others found no weight gain.

In summary, this review suggests that the judicious selection of snack foods has the potential to contribute valuable nutrients to the daily diet. Furthermore, snack foods have the potential to contribute to satiety, with higher-protein snack foods having the strongest effect. For example, the consumption of high-protein, high-fiber snack foods can lead to reduced caloric intake at a subsequent meal when compared with high-fat, high-sugar snack foods. Consequently, thoughtful selection of snack foods may contribute to body-weight maintenance or reduction. However, when considering all of the aforementioned methodologic limitations in these studies and the conflicting results it is hard to reach a decisive conclusion on the impact on snack foods on weight status. Larger long-term multisite intervention trials that take into consideration the time of consumption of the snack foods are warranted to elucidate the impact of snack foods on both satiety and body weight. In addition, mechanistic studies are warranted to understand the underpinning mechanism or mechanisms through which the various snack foods affect body weight.

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References

1. Chapelot D. The role of snacking in energy balance: a biobehavioral approach. J Nutr 2011;141:158–62.
2. Chapli K, Smith AP. Definitions and perceptions of snacking. Curr Top Nutraceutical Res 2011;9:53–9.
3. Piernas C, Popkin BM. Trends in snacking among U.S. children. Health Aff (Millwood) 2010;29:398–404.
4. Larson N, Story M. A review of snacking patterns among children and adolescents: what are the implications of snacking for weight status? Child Obes 2013;9:104–15.
5. Field AE, Austin SB, Gillman MW, Rosner B, Rockett HR, Colditz GA. Snack food intake does not predict weight change among children and adolescents. Int J Obes Relat Metab Disord 2004;28:1210–6.
6. Lucan SC, Karpyn A, Sherman S. Storing empty calories and chronic disease risk: snack-food products, nutritive content, and manufacturers in Philadelphia corner stores. J Urban Health 2010;87:394–409.
7. USDA. Dietary guidelines for Americans, 2010 [cited 2013 Jul 28]. Available from: http://www.cnpp.usda.gov/DGAs2010-PolicyDocument.htm.
8. Armstrong G, Farley H, Gray J, Durkin M. Marketing health-enhancing foods: implications from the dairy sector. Mark Intell Plann 2005;23:32–57.
9. Farley TA, Baker ET, Futrell L, Rice JC. The ubiquity of energy-dense snack foods: a national multicity study. Am J Public Health 2010;100:306–11.
10. Brennan MA, Derbyshire E, Tiwari BK, Brennan CS. Ready-to-eat snack products: the role of extrusion technology in developing consumer acceptable and nutritious snacks. Int J Food Sci Technol 2013;48:893–902.
11. Piernas C, Popkin BM. Snacking increased among U.S. adults between 1977 and 2006. J Nutr 2010;140:325–32.
12. Miller R, Benelam B, Stanner SA, Buttriss JL. Is snacking good or bad for health: an overview. Nutr Bull 2013;38:302–22.
13. National Heart Lung and Blood Institute. An ecological model of diet, physical activity, and obesity. Predictors of obesity, weight gain, diet, and physical activity workshop; 2004 Aug 4-5; Bethesda, MD. http://www.nhlbi.nih.gov/research/reports/2004-obesity.
14. Wouters EJ, Larsen JK, Kremers SP, Dagnelie PC, Geenen R. Peer influence on snacking behavior in adolescence. Appetite 2010;55:11–7.
15. Camilleri GM, Caroline M, Kesse-guyot E, Andreeva VA, Bellisle F, Hercberg S, Péneau. The associations between emotional eating and consumption of energy-dense snack foods are modified by sex and depressive symptomology. J Nutr 2014;144:1264–73.
16. Schunk JM, McArthur LH, Maahs-Fladung CA. Correlates for healthful snacking among middle-income midwestern women. J Nutr Educ Behav 2009;41:274–80.
17. Grimm ER, Steinle NI. Genetics of eating behavior: established and emerging concepts. [cited 2016 Jul 28]. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3052625/
18. Rhee KE, Boutelle K, Jelalian E, Barnes R, Dickstein S, Wing R. Firm maternal parenting associated with decreased risk of excessive snacking in overweight children. Eat Weight Disord 2015;20:195–203.
19. Robinson E, Harris E, Thomas J, Aveyard P, Higgs S. Reducing high calorie snack food in young adults: a role for social norms and health based messages. Int J Behav Nutr Phys Act 2013;10:73.
20. Shuval K, Leonard T, Nguyen B, Ngo TH, Yaroch AL. Behavioral economics and fruit and vegetable intake: the Fair Park Study. Health Behav Policy Rev. 2015;2(2):92–9.
21. Freeman A. Fast food oppression through poor nutrition. Calif Law Rev. 31 December 2007 [cited 2015 Mar 7]. Available from: http://scholarship.law.berkeley.edu/cgi/viewcontent.cgi?article=1198&context=californialawreview.
22. Wansink B, van Ittersum K. Portion size me: downsizing our consumption norms. J Am Diet Assoc 2007;107:1103–6.
23. Rolls BJ, Roe LS, Meengs JS, Wall DE. Increasing the portion size of a sandwich increases energy intake. J Am Diet Assoc 2004;104:367–72.
24. Nielsen SJ, Popkin BM. Patterns and trends in food portion sizes: 1977–1998. JAMA 2003;289:450–3.
25. Wansink B, Kim J. Bad popcorn in big buckets: portion size can influence intake as much as taste. J Nutr Educ Behav 2005;37:242–5.
26. Kral TVE, Rolls BJ. Energy density and portion size: their independent and combined effects on energy intake. Physiol Behav 2004;82:131–8.
27. Remick AK, Polivy J, Pliner P. Internal and external moderators of the effect of variety on food intake. Psychol Bull 2009;135:434–51.
28. Armelagos GJ. Brain evolution, the determinates of food choice, and the omnivore's dilemma. Crit Rev Food Sci Nutr 2014;54:1330–41.
29. Meiselman HL, deGraaf C, Lesher LL. The effects of variety and monotony on food acceptance and intake at a midday meal. Physiol Behav 2000;70:119–25.
30. Zandstra EH, deGraaf C, van Trijp HC. Effects of variety and repeated in-home consumption on product acceptance. Appetite 2000;35:113–9.
31. Raynor HA, Epstein LH. Dietary variety, energy regulation, and obesity. Psychol Bull 2001;127:325–41.
32. Benelam B. Satiation, satiety and their effects on eating behaviour. Nutr Bull 2009;34:126–73.
33. Farajian P, Katsagani M, Zampelas A. Short-term effects of a snack including dried prunes on energy intake and satiety in normal-weight individuals. Eat Behav 2010;11:201–3.
34. Drummond S, Crombie N, Kirk T. A critique of the effects of snacking on body weight status. Eur J Clin Nutr 1996;50:779–83.
35. Marmonier C, Chapelot D, Louis-Sylvestre J. Effects of macronutrient content and energy density of snacks consumed in a satiety state on the onset of the next meal. Appetite 2000;34:161–8.
36. Simmons AL, Miller CK, Clinton SK, Vodovotz Y. A comparison of satiety, glycemic index, and insulinemic index of wheat-derived soft pretzels with or without soy. Food Funct 2011;2:678–83.
37. Tan SY, Mattes RD. Appetitive, dietary and health effects of almonds consumed with meals or as snacks: a randomized, controlled trial. Eur J Clin Nutr 2013;67:1205–14.
38. Alper CM, Mattes RD. Effects of chronic peanut consumption on energy balance and hedonics. Int J Obes Relat Metab Disord 2002;26:1129–37.
39. Dreher ML. Pistachio nuts: composition and potential health benefits. Nutr Rev 2012;70:234–40.
40. Zaveri S, Drummond S. The effect of including a conventional snack (cereal bar) and a nonconventional snack (almonds) on hunger, eating frequency, dietary intake and body weight. J Hum Nutr Diet 2009;22:461–8.
41. Ortinau LC, Hoertel HA, Douglas SM, Leidy HJ. Effects of high-protein vs. high- fat snacks on appetite control, satiety, and eating initiation in healthy women. Nutr J 2014;13:97.
42. Douglas SM, Ortinau LC, Hoertel HA, Leidy HJ. Low, moderate, or high protein yogurt snacks on appetite control and subsequent eating in healthy women. Appetite 2013;60:117–22.
43. Dougkas A, Minhane AM, Givens DI, Reynolds CK, Yaqoob P. Differential effects of dairy snacks on appetite, but not overall energy intake. Br J Nutr 2012;108:2274–85.
44. Almiron-Roig E, Grathwohl D, Green H, Erkner A. Impact of some isoenergetic snacks on satiety and next meal intake in healthy adults. J Hum Nutr Diet 2009;22:469–74.
45. Vitaglione P, Lumaga RB, Montagnese C, Messia MC, Marconi E, Scalfi L. Satiating effect of a barley beta-glucan-enriched snack. 2010. J Am Coll Nutr 2010;29:113–21.
46. Brennan MA, Derbyshire EJ, Brennan CS, Tiwari BK. Impact of dietary fibre-enriched ready-to-eat extruded snacks on the postprandial glycaemic response of non-diabetic patients. Mol Nutr Food Res 2012;56:834–7.
47. Furchner-Evanson A, Petrisko Y, Howarth L, Nemoseck T, Kern M. Type of snack influences satiety responses in adult women. Appetite 2010;54:564–9.
48. Barbour JA, Howe P, Buckley JD, Wright GC, Bryan J, Coates AM. Lower energy intake following consumption of Hi-oleic and regular peanuts compared with iso-energetic consumption of potato crisps. Appetite 2014;82:124–30.
49. Westerterp-Plantenga MS, Wijckmans-Duijsens NE, ten Hoor F, Weststrate JA. Effect of replacement of fat by nonabsorbable fat (sucrose polyester) in meals or snacks as a function of dietary restraint. Physiol Behav 1997;61:939–47.
50. de Luis DA, de la Fuente B, Izaola O, Aller R, Gutiérrez S, Morillo M. Double blind randomized clinical trial controlled by placebo with a fos enriched cookie on satiety and cardiovascular risk factors in obese patients. Nutr Hosp 2013;28:78–85.

51. Nguyen V, Cooper L, Lowndes J, Melanson K, Angelopoulos TJ, Rippe JM, Reimers K. Popcorn is more satiating than potato chips in normal-weight adults. Nutr J 2012;11:71.
52. Ortinau LC, Hoertel HA, Douglas SM, Leidy HJ. The effects of increased dietary protein yogurt snack in the afternoon on appetite control and eating initiation in healthy women. Nutr J 2013;12:71.
53. Hendriksen MA, Boer JM, Du H, Feskens EJ, van der A DL. No consistent association between consumption of energy-dense snack foods and annual weight and waist circumference changes in Dutch adults. Am J Clin Nutr 2011;94:19–25.
54. Piehowski KE, Preston AG, Miller DL, Nickols-Richardson SM. A reduced-calorie dietary pattern including a daily sweet snack promotes body weight reduction and body composition improvements in premenopausal women who are overweight and obese: a pilot study. J Am Diet Assoc 2011;111:1198–203.
55. Nicklas TA, Yang SJ, Baranowski T, Zakeri I, Berenson G. Eating patterns and obesity in children: the Bogalusa Heart Study. Am J Prev Med 2003;25:9–16.
56. Johnstone AM, Shannon E, Whybrow S, Reid CA, Stubbs RJ. Altering the temporal distribution of energy intake with isoenergetically dense foods given as snacks does not affect total daily energy intake in normal-weight men. Br J Nutr 2000;83:7–14.
57. Nederkoorn C, Houben K, Hofmann W, Roefs A, Jansen A. Control yourself or just eat what you like? Weight gain over a year is predicted by an interactive effect of response inhibition and implicit preference for snack foods. Health Psychol 2010;29:389–93.
58. Viskaal-van Dongen M, Kok FJ, de Graaf C. Effects of snack consumption for 8 weeks on energy intake and body weight. Int J Obes (Lond) 2010;34:319–26.
59. Njike VY, Kavak Y, Treu JA, Doughty K, Katz DL. Snacking, satiety, and weight: a randomized, controlled trial. Am J Health Promot 2015 Nov 11 (Epub ahead of print; DOI:10.4278/ajhp.150120-QUAN-676).
60. Rolls BJ, Roe L, Meengs JS. Larger portion sizes lead to a sustained increase in energy intake over 2 days. J Am Diet Assoc 2006;106:543–9.
61. Oellingrath IM, Svendsen MV, Brantsaeter AL. Tracking of eating patterns and overweight: A follow-up study of Norwegian schoolchildren from middle childhood to early adolescence. Nutr J 2011;10:106–17.
62. Phillips SM, Bandini L, Naumova EN, Cyr H, Colclough S, Dietz WH, Must A. Energy-dense snack food intake in adolescence: longitudinal relationship to weight and fatness. Obes Res 2004;12:461–72.
63. Jodkowska M, Oblacinska A, Tabak I, Radiukiewicz K. Differences in dietary patterns between overweight and normal-weight adolescents. Med Wieku Rozwoj 2011;15:266–73.
64. Moreno LA, Rodriguez G. Dietary risk factors for development of childhood obesity. Curr Opin Clin Nutr Metab Care 2007;10:336–41.
65. Evans EW, Jacques PF, Dallal GE, Sacheck J, Must A. The role of eating frequency on relative weight in urban school-age children. Pediatr Obes 2015;10:442–7.
66. Muñoz-Pareja M, Guallar-Castillon P, Mesas AE, López-García E, Rodríguez-Artalejo F. Obesity-related eating behaviors are associated with higher food energy density and higher consumption of sugary and alcoholic beverages: a cross-sectional study. PLoS One 2013;8:e77137.