Overview Essay

Sorting Out the Dietary Impact of Snacks and Snacking

Introduction

Can snacking help people lose weight and maintain a healthy body weight? Or can snacking contribute to increased body weight? Can increased snacking by Americans over the past thirty years be associated with the U.S. epidemic of increased overweight and obesity?

Snacking is a complex behavior. Each of these contradictory questions may be answered yes, supported by sizeable bodies of research.

A number of issues may contribute to such contradictory findings. These issues range from the definition of snacking to the nutritional quality and timing of snacks, to individual characteristics of the snackers themselves.

This overview provides a concise review of the research on snacking with the goals of clarifying such issues and identifying practical strategies for healthful snacking that contribute to weight management and thus have real-life usefulness for individuals and the health professionals who work with them.

Definitions of Snacking

One of the difficulties in determining the potential impact of snacking on weight status may be the lack of a consensus definition of snacking in the research literature [1, 2, 3, 4].

In most population studies, such as the National Health and Nutrition Examination Survey (NHANES), snacking occasions are self-reported and to a large extent self-defined. In analyses of such epidemiological data, the most common definition has been “food eaten between meals” [5, 6, 7, 8]. Meals are typically defined as breakfast, lunch, and dinner. Some studies may refine this definition further. For example, one influential series of studies regards all foods eaten between meals within a 15 minute time frame as a single snacking occasion [5, 6, 7, 9]; another sets a time-of-day framework [10]. Clinical studies examining aspects of snacking also typically use a between-meals approach. The definition of snacks and snacking in this overview is consistent with this general “food eaten between meals” definition.
One potential problem, however, with this between-meals definition is that it does not allow for or account for the “multiple small meals” approach of some common diets used for weight management or for managing chronic diseases. Another potential problem that may cause invalid snacking assessment is this general problem of underreporting of snack intakes, particularly by overweight individuals [11, 12, 13].

A recent paper proposed a physiological (or metabolic) definition of snacking as a way of avoiding the seemingly contradictory evidence of the impact of snacking on weight status [3]. Didier Chapelot has proposed that snacking be used to describe only those eating occasions that occur in a usual satiety period and in the absence of hunger and that contribute negatively to energy balance [3]. Eating occasions no matter when they occur that don’t meet these metabolic requirements would be considered “meals.”

A major drawback to this approach is that it makes snacking negative by definition. In keeping with this negative view, “snack foods” are generally seen as energy dense, nutrient-poor foods. Also when it comes to communicating and influencing public health behaviors such a definition may lack commonsense and practical application, although it may help health professionals in thinking about developing strategies for healthful snacking.

Johnson and Anderson have proposed a broad description of a snack that could be tested to see if it might lead to a clearer and more consistent definition of snacking in research:

A snack is comprised of solid food(s), including those typically eaten with a utensil (with or without a beverage) that occurs between habitual meals for the individual, is not a substitute for a meal, and provides substantially fewer calories than would be consumed in a meal [2].

Patterns and Trends in Snacking in the United States

Analyses of national population-based survey data from 1977 to 2006 in both children and adults have shown an increase over time in snacking occasions and energy intake from foods eaten as snacks [14, 6, 7, 15].

Children

Among children (2-18y) the prevalence of eating at least one snack over 2 days increased from 74% in 1977 to 98% in 2005, according to a recent study based on data from four national surveys (1977-78 Nationwide Food Consumption Survey, 1989-1991 Continuing Survey of Food Intake by Individuals, 1994-96,1998 CSFII, and 2003-04, 2005-06 National Health and Nutrition Examination Surveys [7]. The prevalence of eating at least one snack each day increased from 48% to 78% [7]. The greatest increase was observed from 1989 on. Snacking occasions increased an average of 1.1 per day for all age groups, with the youngest children (2-6y) having the largest average increase of 1.41 snacks daily. By 2006 daily
Calories from snacking occasions equaled 27% of daily energy consumption among children and youth (2-18y) [7].

Earlier population-based observational studies of snacking behaviors in children in general supported these trends [16, 17, 18].

Calories per snacking occasion also appear to have increased. Analysis of the same national survey data cited above determined that grams per snack occasion also increased to about 50 grams per occasion until 2003 and then leveled off although energy density per calorie remained essentially constant during these 30 years. Daily increase in calories consumed from snacking totaled an average of 168 calories. This increase in snacking calories probably contributed to the daily increased calorie consumption for all groups of 113 more calories in 2006 compared to 1977. The largest increase of total daily intake of 182 calories occurred in the youngest children (2-6y) [7, 19]. Figure 1 illustrates the increase over time in daily energy intake from snacking occasions.

The main sources in 2006 of snacking energy among children include dessert foods (cakes, cookies, ice cream, pies, gelatin), savory snacks (crackers, chips, pretzels, popcorn), sweetened beverages, candies, nuts, seeds, ready-to-eat cereal, fruit juice and fresh fruit, milk and dairy. Energy from dessert foods decreased but remained in first place. The largest increase was savory snacks which claimed second place. Sweetened beverages had a modest increase although consumption of regular soft drinks decreased. Intake of fruit juice increased but fresh fruit decreased. Consumption of candies increased while that of milk and dairy declined [7, 19]. Portion sizes of popular energy-dense foods also increased [14, 5].

Figure 1: Percentage of Children’s Energy Intake from Snacks on Any Given Day

![Figure 1](image_url)

Source of data for Figure 1: Table 6 NFCS-Continuing Survey of Food Intakes by Individuals, 1985; Table 7, CFSII 1994-96; Table 25, NHANES 2005-06.
**Adults**

Among adults (19y and over) the prevalence of eating at least one snack over 2 days increased from 71% in 1977 to 97% in 2005, according to a recent study based on data from four national surveys (1977-78 Nationwide Food Consumption Survey, 1989-1991 Continuing Survey of Food Intake by Individuals, 1994-96,1998 CSFII, and 2003-04, 2005-06 National Health and Nutrition Examination Surveys) [6]. The prevalence of eating at least one snack each day increased from 42% to 78% [6]. Adults ages 40-59 had the highest number of daily snacking occasions in 2006. From, 1977-2006, however, adults older than 60y had the greatest increase in number of snacks, about 1.12 per day [6]. Based on national survey data, Figure 2 illustrates the increases in daily snacks by adults from 1977-78 to 2007-08.

In contrast to this study, an earlier study that analyzed NHANES data from a slightly earlier time frame (1971-2002) found no significant increase in eating occasions including snacking among adults [15]. This earlier study, however, used data from only one day rather than two, included all eating occasions, and had a slightly different definition of snacking.

Another study among young adults (19-29y) using nationally representative data from 1977-78 to 1994-96 found that daily energy from snacks increased from 20% to 23% of total calories chiefly because energy consumed in each snacking occasion increased 26% and the number of daily snacks increased 24% [20].

All these population studies found an increase in the quantity and energy density of foods consumed.

As indicated by 2006 NHANES surveys, popular snack foods among adults include sweet dessert foods, savory/salty snacks, other snacks, sweetened beverages, juices/fruit [6]. Largest increases were in savory/salty snacks, both low fat and high fat, with small increases in candies, nuts/seeds, alcoholic drinks and fruit and sports drinks [6]. Although total dessert food intakes decreased they remained the top source of energy. Milk/dairy and juices/fruit intakes also declined [6].

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**Figure 2: Percentage of Adults, 20+ y, Eating Specific Numbers of Snacks on One Day**

![Bar chart showing percentage of adults eating specific numbers of snacks on one day from 1977-78 to 2007-2008.](image)

I. Association of Snacking with Weight Status and Body Mass Index (BMI)

The relationship of snacking patterns or behaviors to weight status and BMI remains unclear in spite of numerous observational and experimental studies. The mixed results indicate that the relationship between snacking and weight status is a complex issue. This complexity may be due to the large number of confounding factors that may be associated with snacking behaviors.

Association of snacking or meal frequency with weight status

Reviews of cross-sectional [21, 22, 11, 12] and experimental [22, 23] studies determined that a majority of studies of snacking or eating frequency in children and adults found an inverse association or no significant association with weight status and/or BMI. Fewer studies found that snacking or greater eating frequency was associated with a higher BMI or risk of obesity [21, 22, 11]. A 2007 review of longitudinal studies in children found no correlation between increased risk of being overweight in childhood and snacking; it did find a relationship between this risk and consumption of sugar-sweetened beverages [24].

The variety of studies and cohorts examined in observational studies and their conclusions with regard to snacking or eating frequency are summarized at the end of this paper in Table 1: Cross-sectional studies in Children and Adolescents, Table 2: Longitudinal studies in Children and Adolescents, and Table 3: Observational Studies in Adults.

The authors of reviews and individual studies attribute the mixed results and varied findings of the studies to the complex nature of snacking and eating pattern behaviors, the difficulty of accounting for the many potentially confounding factors associated with eating behaviors, and the difficulty of designing population studies that control for these variables.

A review of experimental controlled studies found that eating frequency generally had no effect on energy expenditure and found some evidence for better appetite control with 6 eating occasions daily, rather than 3 [23].

Helping to maintain weight loss. Studies in individuals who have maintained a significant weight loss have found that an eating pattern that includes snacks (most typically 3 meals, 2 snacks) is associated with maintaining weight loss [25, 26].

Contributing to nutrient intakes in older adults. In older adults, snacking and more frequent meals may be associated with better intakes of energy and important nutrients in the daily diet [27, 28, 29, 30]. However, many such snacks may be more energy dense and less nutrient dense [30].

Potential confounding factors associated with snacking and weight status

A number of factors related to snacking may be variables associated with weight status:

- Under-reporting of food and energy intakes by overweight or obese subjects
  One hypothesis that seeks to explain why increased intakes of energy and energy-dense snacks are not associated with increased BMI, particularly in earlier studies, argues that under-reporting of food and energy intakes by overweight participants may contribute to this finding [31, 32, 11, 12, 33]. Such under-reporting is a well-established methodological problem in self-reported data in cross-sectional studies. However, at least one reviewer found that when the lack of an
association between snacking and weight status was adjusted for, the inverse relationship remained in this studies [21].

- **Physical activity status**
  Lower levels of physical activity have been associated with higher prevalence of overweight and obesity [34, 35, 36]. Some researchers suggest that the predominance of inverse or insignificant association found between eating frequency or snacking and BMI in population studies may result in part from the confounding influence of physical activity status, particularly in earlier studies [37, 38]. A number of studies, however, that have adjusted for physical activity levels have still found an independent inverse or insignificant association between eating frequency and BMI in adults [38, 39, 40, 10, 41, 42] and in children and adolescents [43, 44, 45, 46, 47, 48].

- **Portion sizes**
  Analyses of national survey data indicate that portion sizes of snacks and daily energy from snacks have increased over the last thirty to forty years in adults [6, 16, 49] and in children and adolescents [50, 7, 16, 49]. When not compensated for at other eating occasions (and total percentage of energy from meals has declined overall), larger portions of snack foods appear to contribute to greater total daily energy intake.

- **Timing of snacking**
  Some evidence suggests that snacking in the evening after dinner or later at night has greater association with increased or higher BMI than snacking at other times of the day [51, 52, 32, 53]. Other studies find no association [54]. In a weight loss trial mid-morning snackers lost less weight than afternoon and evening snackers [55].

- **Skipping meals, especially breakfast**
  Considerable cross-sectional evidence suggests that skipping breakfast is associated with greater BMI in children [56, 57, 58, 59] and adults [60, 41]. Greater meal skipping, including breakfast, is also associated with greater prevalence of snacking in some studies [61, 60] but not all [57].

- **Television viewing and snacking**
  Television viewing is associated with snacking in children and adolescents [62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 61, 73, 74] and adults [75, 76, 77, 78]. Typically, the more time spent watching television, usually greater than 2 hours daily, the greater the prevalence of and energy intake from snacking and the more positive the association with BMI or overweight [71, 65]. But snacking has not always been found to be a mediator of TV watching and BMI [65, 64].

- **Impact of advertising of foods, including snack foods**
  Some studies indicate that food advertising on television and in other media may promote the consumption of advertised snacks [68, 79, 80, 73, 78]. Some evidence suggests that advertising of healthful snack foods may increase consumption in some individuals [80, 81].

- **Food pricing**
  Some evidence suggests that the lower price of some energy dense foods such as savory/salty snacks and bulk packaging of the same results in cheaper volume costs for certain snack foods. Cheaper prices per serving for larger sizes of products (sodas, for example, in restaurants or
stores) may also contribute to greater intake of energy-dense but nutrient-poor calories [82, 83].

- **Type of snack food, particularly caloric sweetened beverages**
  In some studies [84, 24, 85, 64] but not others [36, 86, 87, 88] intake of caloric sweetened beverages in particular and other sweet snacks [84] has been associated with risk of overweight or higher BMI. Intakes of caloric sweetened beverages have increased over the last 30 to 40 years [89, 90, 91].

- **Weight status of snacker**
  In some studies, overweight or obese subjects tended to have greater energy intakes from snacking than normal weight subjects [92, 93, 94, 32]. But in other studies, overweight subjects consumed snacks and typical energy-dense snack foods less frequently [95, 96, 57].

- **State of hunger or satiety**
  Some experimental studies suggest that snacks consumed in a state of satiety may not be compensated for at the next meal and thus contribute to increased total energy intake [97, 98, 3]. Other experimental studies, however, found that between-meal snacks were compensated for and participants’ weight did not change during the study [99, 23].

- **Status of stress**
  Daily psychological hassles or stress, such as those related to interpersonal or work relationships, have been associated in some studies with a higher prevalence of snacking [100, 101, 102, 103, 104, 105, 106] or higher selection of energy dense (“unhealthy”) snacks [107].

- **Sleep patterns or sleep deprivation**
  Short sleep duration has been associated with greater prevalence of overweight in children [108, 109] and adults [92]. Shorter sleep duration was also associated with greater levels of snacking in some studies [108, 92, 110, 111, 112, 113] but not all [109].

- **Family food environment**
  The prevalence of snacking in mothers or parents has been positively associated with snacking in children [114]. Parental television viewing has also been associated with sweet snack association by children [66].

- **Energy eaten away from home**
  A cross-sectional study in children found a major increase in energy intake was associated with a major increase in energy eaten away from home, primarily from quick serve restaurants [8]. Snacks and meals were not differentiated. However, according to NHANES 2005 – 2008 data, schools were the location for only about 7% of daily energy intake for children (2 -19y) [195]. See Figure 3 for food intakes by location for children in 2005-08. In a study based on national survey data, over the 30 years energy intake from vending machines remained constant at only a fraction of one percentage point [8]. A study in high school girls found that in a week they ate more snacks (3.5) at a home other than their own than from retail outlets (3) [115].
II. Strategies for Incorporating Healthful Snacking in Weight Management

Most American adults and children enjoy one or two snacks daily. When foods for snacking are chosen wisely, these eating occasions provide opportunities to add important foods and nutrients to individual diets and to reduce consumption of nutrient-poor, energy-dense calories. Such strategies may contribute to better weight management and may be incorporated into effective weight loss plans.

These strategies can be important tools for families and individuals as they choose and prepare snacks to be eaten at home and away. The majority of daily food energy is consumed at home; only an average of 33% of food energy (for ages 2-70+) is consumed away from home [116]. Although up to 40% of school children may consume energy dense competitive foods on any given school day [117], it’s important to remember that in the total diet, children consume only an average of about 7% of their energy at school [196]. As a result, analysis of the same data indicates that the highest amounts of energy-dense foods with low nutrient value were consumed at home [118]. Consequently, the greatest influence on what and when snacks are consumed may reside in the home where parents may influence intakes of their children and where adults are responsible for their own choices.

Select Nutrient-Dense Snacks and Limit Energy-Dense Snacks

- **Fruits, vegetables, and low fat dairy or other protein**
  - These foods provide important vitamins, minerals, antioxidants.
  - High-protein, moderate energy snacks may increase satiety and energy intake may be compensated at the next meal [119].
  - Individuals who eat more than five servings of fruits and vegetables daily have been more successful at weight loss [120, 121].
  - Increasing fruit, vegetable, and low-fat dairy intakes has been associated with better weight loss and maintenance [122].
  - Controlled portions of dried fruits and fruit and nut bars, for example, can provide increased fiber and nutrients when replacing energy-dense snacks without affecting energy-intake or weight status [123, 124].
• **Nuts**
  o Studies show that inclusion of limited servings of nuts (1 to 2 daily) does not typically lead to weight gain while providing health benefits, such as better cholesterol levels [125, 126, 127, 128, 124, 129, 130, 131, 132, 133].
  o Peanuts, almonds, pistachios and other tree nuts make healthful snacks.
  o One nut serving is one ounce, about 1/4 cup. Calorie count ranges from 160 to 200.
  o Nuts are a source of antioxidants and heart-healthy fats as well as vitamins and minerals [134].

• **Whole grain snack foods**
  o Higher consumption of whole grains has been linked to lower body weight [135, 136] and greater maintenance of weight loss [121, 137].
  
  o Popcorn offers high-fiber crunch at 3 cups for under 100 calories.
    ▪ It has also been shown to be more satiating than potato chips [138, 139] and to improve dietary quality [140].
    ▪ Low fat popcorn snacks may also contribute positively to a weight loss diet [141].
    ▪ Popcorn also may increase whole grain consumption [142]. In NHANES 1999-2002, popcorn consumers had a 250% higher intake of whole grains and a 22% higher intake of fiber [143].
    ▪ Popcorn leads to higher whole grain intake when it replaces refined grain snacks [144].

**Practice Portion Control**

• **Use single-serve snack foods**
  o There is some evidence that serving snacks in smaller portions may help control energy intake from snacks [145, 146] and may help in weight management [147, 148]. Placing portions in smaller serving containers may also influence decreased consumption [149].
  o Single-service packaging such as fruit and nut bars or 100-calorie packs of savory or sweet snacks may help control intakes [150, 146, 151, 152].
  o Increasingly, single-serving convenience packs of fruits (e.g. fresh mixed fruit, grapes, apple slices) and vegetables (e.g., carrots) are available in supermarkets and convenience outlets.

• **Reduce bite size of occasional energy-dense snacks**
  o Experimental trials suggest that cutting energy dense snacks such as cookies or candies into smaller bites reduces calorie intake. Snackers tend to eat the same number of certain snacks regardless of size [153, 152].

• **Make your own single-serve snack packs**
  o Divide large packages of snacks, such as whole grain crackers, into smaller, single-serve packages. Do it right after purchase.
Use snack or sandwich baggies or small reusable containers.

**Drink Water and Non-Caloric Beverages**

- *Drinking water instead of caloric sweetened drinks appears to decrease energy intake and support weight loss*
  - Replacing caloric sweetened beverages with water has been associated with decreased energy intake in children and adults [154, 155, 156].
  - Drinking water has been associated with more effective weight loss in adults [157, 158] and children [159].
  - Drinking diet beverages in one RCT had no influence on intakes of sweet snack foods [160].

- *Decreasing consumption of caloric sweetened beverages may help maintain weight loss*
  - Reduced caloric sweetened beverage consumption was one strategy enabling a young adult cohort to maintain weight loss for over 5 years [161].
  - Substituting water for caloric sweetened beverages has been associated with lower weight gain in several adult populations [162, 163, 155].

**Avoid Mindless Snacking**

- *Prepare a portion controlled snack before settling down to read, watch TV, or do homework*
  - The longer individuals watch television the greater their snack intake. Planning ahead can limit snacks to appropriate portions.

- *Avoid eating straight out of large packages or containers*
  - A number of studies show that individuals eating out of larger packagers or containers typically consume greater amounts of food [164, 165, 166].

**Manage School Environments for Better Snack Choices**

There is some evidence that restricting sales of energy-dense snacks in school cafeterias, shops and vending machines and promoting more nutritious snacks and beverages may reduce consumption of such foods as caloric sweetened beverages and increase intakes of fruits and vegetables [167, 168, 169, 170]. School campaigns to educate students about healthful food choices may also have a positive effect [167, 171, 172, 173, 174].

However, school-age children and adolescents typically consume the greatest proportion of snacks outside of school, often in the home [8]. It is important, therefore, for parents to take steps to manage snacking at home such as other strategies suggested in this section.
Track Food Intakes to Assess Your Snacking Patterns

One strategy associated with successful weight loss by individuals who have lost significant amounts of weight and maintained it is that they tracked their food intakes and weighed themselves regularly (usually daily) [26, 175]. Although we located no studies of the potential benefits of tracking snacking alone, tracking daily food intakes for 3 to 7 days could help individuals identify the type of snacks they regularly consume and their snacking patterns. Such a record could provide a base for adopting strategies to incorporate healthful snacks into weight loss and weight maintenance plans.

III. Summary

This review of the current state of scientific research on snacking suggests several major points in summary:

- Population and experimental studies suggest that within a balanced diet healthful snacks can play a positive role in both weight loss and weight management.
  - Typical average snack frequency for this result is 2 daily.
  - Food type selected, such as nutrient-rich fruits, vegetables, whole grains, nuts, and low fat dairy, and controlled portions are also important.
- Healthful snacking strategies that positively affect weight control must still feature snack foods that are convenient, tasty, and cost effective to meet consumer preferences.
- Research findings on the impact of snacking on weight management are not yet definitive or conclusive. Continued research on this important aspect of U.S. eating behaviors is needed. Arriving at a consensus definition of what constitutes a "snack" and "snacking" may be a prerequisite to more conclusive research.
<table>
<thead>
<tr>
<th>Study (date)</th>
<th>Study name or cohort</th>
<th>Number of Subjects</th>
<th>Association of snacking patterns with BMI or weight</th>
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<tbody>
<tr>
<td>Barba (2006) [48]</td>
<td>ARCA study group; Italy</td>
<td>3668 (6-11 Y)</td>
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<td>NS</td>
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<td>748 (3-11 y)</td>
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<td>Sun (2009) [53]</td>
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<td>5753 (12-13y)</td>
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<td>Survey of Sugar Intake among Children, Scotland</td>
<td>1233 (5-17 y)</td>
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<td>Mercille (2010) [178]</td>
<td>1994,1998,2002 Mohawk community cohorts, Canada</td>
<td>449 (grades 4-6)</td>
<td>positive higher energy intake from snacks for children at risk of obesity; NS for normal weight and overweight children</td>
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<td>appx 1000 (13-15 y)</td>
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<td>Jodkowska (2011) [57]</td>
<td>Polish</td>
<td>953 normal wgt; 953 OW (13-15y)</td>
<td>NS for normal weight; obese snacked less often</td>
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<td>Guo (2012) [96]</td>
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<td>NS for normal weight; obese more likely to be nonsnackers</td>
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<td>HEIA, Norwegian</td>
<td>1103 (11y)</td>
<td>NS</td>
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<td>Jennings (2012) [46]</td>
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<td>inverse for normal weight but not centrally obese</td>
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<td>68 (college freshmen)</td>
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<td>Reilly (2005) [180]</td>
<td>UK ALSPAC/ 3-4y</td>
<td>909 (3-7 y)</td>
<td>Not conclusive for assn of dietary patterns at 3 with obesity at age 7. Energy dense food pattern barely significant positive after adjustment.</td>
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<td>Oellingrath (2011) [181]</td>
<td>Norwegian/ 3 y</td>
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<td>Ireland</td>
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<td>Dutch/ 3 y</td>
<td>2074, (5y)</td>
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<td>Ritchie (2012) [47]</td>
<td>NHLBI Growth and Health Study, US/10 y</td>
<td>2372 girls (9-10y to 19-20y)</td>
<td>inverse (after adjustment lower eating frequency associated with greater BMI and waist circumference</td>
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<td>Deliens (2013) [184]</td>
<td>Belgian/ 4 months</td>
<td>101 first year univ. students</td>
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<td>Study (date)</td>
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<td><strong>Cross-sectional Studies</strong></td>
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<td>Metzner (1977) [185]</td>
<td>Tecumseh Community Health Study</td>
<td>2000 (35-69 y)</td>
<td>inverse (meal frequency and adiposity)</td>
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<td>Dreon (1988) [186]</td>
<td>Stanford</td>
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<td>Edelstein (1992) [187]</td>
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<td>2034 (914 m, 1120 w, 50-89 y)</td>
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<td>NHANES I Epidemiologic Follow-up Study</td>
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<td>inverse baseline; NS adjusted</td>
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<td>Summerbell (1996) [188]</td>
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<td>inverse for middle-aged; NS overall</td>
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<td>95 (20-55 y)</td>
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<td>Ortega (1998) [189]</td>
<td>Spain</td>
<td>Elderly (58 institutionalized; 98 free living)</td>
<td>inverse</td>
</tr>
<tr>
<td>Wahlqvist (1999) [190]</td>
<td>International Union of Nutritional Sciences (IUNS) study, Greece</td>
<td>293; elderly</td>
<td>inverse</td>
</tr>
<tr>
<td>Titan (2001) [39]</td>
<td>EPI-COS study, UK</td>
<td>14,666 (45-75y)</td>
<td>inverse</td>
</tr>
<tr>
<td>Berteus Forslund (2002) [191]</td>
<td>SOS study, Sweden</td>
<td>83 obese women 94 normal wgt reference women</td>
<td>positive (obese women had greater eating frequency; but snacks contributed to greater energy intake for both groups)</td>
</tr>
<tr>
<td>Ruidavets (2002) [40]</td>
<td>French</td>
<td>330 men (45-64 y)</td>
<td>inverse</td>
</tr>
<tr>
<td>Berteus Forslund (2005) [94]</td>
<td>XENDOS study; SOS study, Sweden</td>
<td>4259 obese 1092 reference</td>
<td>positive</td>
</tr>
<tr>
<td>Huang (2005) [33]</td>
<td>CSFII 1994-96, US</td>
<td>6499 total sample 2685 “plausible” subsample</td>
<td>NS total sample; positive for “plausible” sample</td>
</tr>
<tr>
<td>Howarth (2007) [123]</td>
<td>CSFII 1994-96</td>
<td>1792 (20-59y) 893 (60-90 y)</td>
<td>positive for both groups</td>
</tr>
<tr>
<td>Yannakoulia (2007) [193]</td>
<td>Greece</td>
<td>200 women</td>
<td>NS premenopausal; positive postmenopausal</td>
</tr>
<tr>
<td>Mills (2011) [54]</td>
<td>US</td>
<td>1099 women (mean-49.7 y)</td>
<td>NS</td>
</tr>
<tr>
<td><strong>Longitudinal Studies</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bes-Rastrollo (2010) [194]</td>
<td>SUN Project, Spain/4.6 years</td>
<td>10,162 (mean-39 y)</td>
<td>positive</td>
</tr>
</tbody>
</table>

NS = not significant
References


142. Reimers, K; Lv, N; Lowndes, J; Angelopoulos, T; Nguyen, V; Rippe, J. A Daily Popcorn Snack Increases Whole Grain Intake Without Changing Consumption of Other Food Groups. 2012. Abstract/Poster presented to FNCE 2012, Academy of Nutrition and Dietetics.


