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Symposium Review
Dairy Foods Symposium

Understanding the link between frequency of eating and cardiometabolic health outcomes in Americans who "snack"*

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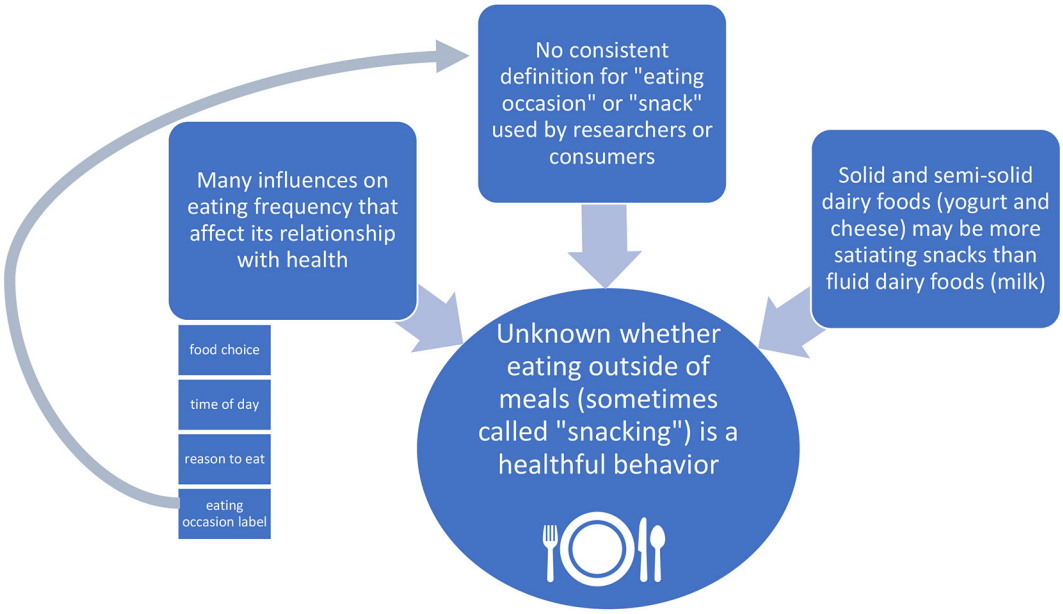
Graphical Abstract



Summary

While many factors influence the relationship between eating frequency and health, there is no consistent definition for either "eating occasion" or "snack." Therefore, it remains unknown whether eating outside of meals or "snacking" is a healthful behavior. Regarding dairy foods, current evidence indicates that solid and semi-solid dairy foods such as cheese and yogurt may be more satiating than fluid dairy foods such as milk.

Highlights

- Americans eat 5 or more times per day, on average.
- Little is known about the association between eating frequency and health.
- No consistent definition is used by researchers or consumers for "snacks."
- Solid and semi-solid dairy foods (yogurt, cheese) may be more filling than milk.

*Presented as part of the Dairy Foods Symposium: United States of Snacking: Is Snack Time Changing the Way America Eats? held at the ADSA Annual Meeting, June 2022.
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Understanding the link between frequency of eating and cardiometabolic health outcomes in Americans who "snack"*

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Abstract: On average, Americans ages 2 yr and older eat 5 or more times per day and consume nearly a quarter of their daily energy outside of breakfast, lunch, and dinner. Frequency of eating (FOE) has been identified by both the 2020 Dietary Guidelines for Americans Scientific Advisory Committee and the American Heart Association as an important area of study to improve the dietary patterns and overall health of the American public. However, the current evidence on FOE is conflicting; it does not indicate whether eating more frequently is a healthful behavior or not. Clinical and prospective studies have shown that FOE has an inverse relationship with some cardiometabolic health markers, including total cholesterol and low-density lipoprotein cholesterol concentrations, but the relationship between FOE and other health markers such as high-density lipoprotein cholesterol concentrations, blood pressure, obesity, and coronary heart disease incidence remains unclear. Several factors may affect the relationship between FOE and cardiometabolic health including the types of foods consumed, time of day, motivation to eat, cultural background, age, sex, and food security status. Another factor affecting both the relationship between FOE and health as well as the research on FOE and health is how eating occasions are labeled. Many definitions have been proposed and used in research to delineate between meals and snacks, but a consistent definition is not currently used for "snacks," even in official dietary guidance. With the current limitations in the body of research, conclusions about the healthfulness of frequent eating cannot be drawn. In addition, conclusions cannot be drawn on the healthfulness of eating snacks (as an eating occasion) or more than 3 meals per day. More directed research is required to understand the relationships between the labels used for an eating occasion and cardiometabolic health outcomes as well as the health impacts of frequent food and beverage consumption and how and why they may vary among different population groups.

Frequency of eating (**FOE**) has increased in the United States since the 1970s (Duffey and Popkin, 2011). According to data from the National Health and Nutrition Examination Survey (**NHANES**) 2015–2016, 93% of Americans eat more than 3 times per day, consuming about a quarter of their daily calories outside of breakfast, lunch, and dinner (Dietary Guidelines Advisory Committee, 2020). Americans ages 2 yr and older average 5 or more eating occasions per day, including 2 to 4 meals and 0.5 to 3.5 snacks (Murakami and Livingstone, 2015; Dietary Guidelines Advisory Committee, 2020). Frequency of eating has been identified by both the 2020 Dietary Guidelines for Americans Scientific Advisory Committee (**DGAC**) Report and the American Heart Association as an important area of study to improve the dietary patterns and overall health of the American public (St-Onge et al., 2017; Dietary Guidelines Advisory Committee, 2020).

However, even though NHANES data indicate an increase in the frequency with which Americans eat, there is little scientific evidence or dietary guidance about FOE. For instance, the 2020 DGAC found insufficient evidence to make recommendations on whether or not a relationship exists between FOE and growth, size, body composition, and the risk of overweight and obesity (Dietary Guidelines Advisory Committee, 2020). One factor that continues to complicate our understanding of the relationship between eating frequency and health is the diversity of definitions for "eating occasion" and "snack" used by the scientific community. In addition, a variety of additional factors can also influence the health impacts of eating between meals, including how individuals label their eating occasions, their motivations to eat, food security status, socioeconomic background, and food choice (Hess et al., 2016). The interaction between these factors, FOE, and cardiometabolic health markers also remains poorly understood.

The objective of this review is to provide a brief overview of what we do know about how FOE, sometimes referred to as "snacking," affects health. This review will cover the literature on associations between snacking and cardiometabolic health outcomes, especially weight status, snacking, and diet quality, and factors that affect eating decisions, closing with a summary of research on snacking and health specific to dairy foods. Cardiometabolic health is correlated with dietary intake across the lifespan and contributes to rates of chronic health conditions including heart disease, the leading underlying cause of death in the United States in 2021 (Dietary Guidelines Advisory Committee, 2020; Ahmad et al., 2022).

Many of the studies that have been conducted on the cardiometabolic health impacts of frequent eating episodes report inconsistent results, and the evidence does not indicate clearly whether eating more frequently is a healthful behavior or not. Clinical and prospective studies have shown that FOE has an inverse relationship with some cardiometabolic health markers, including total and

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low-density lipoprotein cholesterol concentrations (Arnold et al., 1993; Titan et al., 2001), but the relationship between FOE and other health markers such as high-density lipoprotein cholesterol levels, systolic and diastolic blood pressure, as well as the relationship between FOE and coronary heart disease incidence remains unclear (Cahill et al., 2013; St-Onge et al., 2017; Leech et al., 2019).

Two reviews, published less than a year apart, had different conclusions regarding the relationship between FOE and weight status. According to one review of cross-sectional studies in the United States, a greater FOE was associated with higher energy intake, but there was insufficient evidence to determine the effect of greater FOE on BW over time (Cowan et al., 2020). In contrast, a second review of both observational and intervention studies indicated that the relationship between FOE and BW varied by life stage. In children, FOE had an inverse relationship with BW as well as body mass index (**BMI**) and abdominal obesity (Garcidueñas-Fimbres et al., 2021). However, in adolescents, every additional eating occasion was associated with an increase in BMI z-score and, in adults, a greater FOE was associated with lower body weight, lower BMI, and smaller waist circumferences compared with lower FOE (Garcidueñas-Fimbres et al., 2021). Garcidueñas-Fimbres et al. (2021) present differences in the relationship between FOE and weight status depending on age. However, there are also many endogenous and exogenous factors that affect development and growth at each life stage that may also affect the association between FOE and weight status. Additional intervention studies are needed to understand how and why FOE affects adiposity at different ages.

Cross-sectional studies from the United States, South Korea, and Australia also report inconsistent associations between eating frequency and weight status. After adjusting for the ratio of energy intake to estimated energy requirements, Murakami and Livingstone (2015) reported a positive association between FOE and both overweight/obesity and central adiposity among American adults. An Australian study found no association between FOE and overweight/obesity and BMI after adjusting for total energy intake and removing energy misreporters (Leech et al., 2017). Data from the Korean NHANES indicated that greater FOE was inversely associated with indicators of obesity (body fat percentage, BMI, and waist circumference) (Kim et al., 2018). However, diet quality mitigated these relationships. If diet quality was high, eating frequency was inversely associated with obesity indicators, but if diet quality was low, eating frequency was positively associated with indicators of obesity (Kim et al., 2018). Overall diet quality may be a stronger determinant of how FOE affects cardiometabolic health than weight status alone. As with the associations between FOE and weight status by age, however, more directed research is still needed to fully characterize this relationship.

Other studies have addressed the relationship between FOE and diet quality as well, with varying results. Greater FOE was positively associated with diet quality in one review article (Garcidueñas-Fimbres et al., 2021), whereas a cross-sectional study by Leech et al. found that adults with the greatest FOE had the lowest diet quality scores (Leech et al., 2017). A previous publication from Leech et al. reported more nuance in the association between FOE and diet quality, finding that the frequency of meals was associated with greater overall diet quality among both males and females. However, the relationship between snack frequency (eating outside of meals) and diet quality was inconsistent (Leech et al., 2016). A cross-sectional study of Japanese adults also compared the interaction between diet quality and eating frequency by meals versus snacks (Murakami et al., 2020). Greater meal frequency increased diet quality scores, regardless of whether the "meal" determination was made by participant definition or by time of day. Whether snacks affected diet quality depended on how "snack" was defined. Participant-defined snacks were associated with increased dietary quality, whereas "time-of-day"-defined snacks tended to be associated with decreased dietary quality (Murakami et al., 2020). Eating occasions defined as meals seem to be associated with increased dietary quality, whereas snacking and diet quality do not have a consistent relationship.

Diet quality has also been assessed by time of day of eating occasions. Zeballos and Chelius (2021) used NHANES 2007–2018 data to compare dietary quality among participants who ate more than 3 times on one day of dietary recalls but not on a second day. Americans eating more than 3 times per day increased energy intake by about 200 kcal and the Healthy Eating Index (**HEI**) score by 0.59 points (Zeballos and Chelius, 2021). Divided into "morning grazing" and "evening grazing" groups, Americans who ate more than twice between 0300 and 1459 h had higher HEI scores than participants eating more than once between 1500 and 0259 h. Most participants grazed in the "evening" hours (Zeballos and Chelius, 2021). The lower HEI scores among the "evening grazers" may be due to the foods selected as a snack among people who eat more after 1500 h. Barrington and Beresford (2019) indeed found that foods selected as a snack tend to vary by time of day. While morning snacks (consumed between midnight and 1100 h) increased fruit and vegetable consumption, evening snacks (consumed between 1630 h and midnight) were associated with fast food intake as well as higher BMI and a greater rate of eating while distracted. Evening snacking was more detrimental to healthy weight maintenance than snacking at other times of the day (Barrington and Beresford, 2019). In both of these studies, evening snacking was associated with lower diet quality and consumption of less nutrient-dense foods.

Social milieu and motivation to eat, among others, also affect the associations between FOE and health (Hess et al., 2016). Social pressure can affect FOE, food choice, and diet quality. A research team in the United Kingdom recently studied the impact of eating outside of meals as a social act in the office environment by evaluating "office cake" consumption, where a cake is shared among colleagues to celebrate milestones and recognize employee accomplishments (Walker and Flannery, 2020). Nearly 60% of respondents in a cross-sectional study of 940 office-based employees in England ate "office cake" at least once a week, and "office cake" was available up to 5 times a week in most workplaces (Walker and Flannery, 2020). In this case, consuming a slice of cake as an additional eating occasion was perceived by both female employees and younger employees (18–29 yr of age) as a social necessity, with social retributions in case of refusal (Walker and Flannery, 2020). As Walker and Flannery conclude, "social modeling" affects eating behaviors in the workplace and among socially connected people. An earlier study concluded that eating outside of meals—both "healthy" and "unhealthy" choices—was more common in a workplace environment than at home and that consumption differed in the context of location as well as social environment (Liu et al., 2015). Previous studies have also found that social modeling affects food intake, especially with packaged

highly palatable foods (Prinsen et al., 2013; Cruwys et al., 2015). While the social modeling of food intake has been well established with regard to packaged highly palatable foods such as cookies and crackers, the social modeling of more nutrient-dense foods has not been well characterized and could be an important area for future research to improve public health.

One factor that continues to complicate consensus on the health impacts of eating frequency is that, on a global scale, there is a lack of consensus for definitions of "snack," "snacking," or "snack food." Aligning on a single definition would improve the quality and consistency of research on the topic (Potter et al., 2018). A 2021 survey of Americans conducted by the International Food Information Council (**IFIC**) indicated that snacks are typically defined by time of day versus by type of food, though there are Americans who define "snacks" in both ways (IFIC, 2021). There are also Americans who identify snacks (compared with meals) by social setting, defining "meals" as eating occasions with family or friends and "snacks" as occasions where one eats alone (IFIC, 2021). Yet, even though IFIC reports these definitions as the ones most commonly used by the US public, the studies cited in this review alone use several different definitions for both "snacks" and for "eating occasions" in general. Leech et al. defined eating occasions as intakes providing at least 50 kcal and separated in time from other eating occasions by at least 15 min (Leech et al., 2017, 2019). In the Leech et al. studies, labels for eating occasions ("snacks" versus "meals") were determined by participants (Leech et al., 2019). St-Onge et al. (2017) used a 50 kcal threshold to define an eating occasion. In contrast, Zeballos and Chelius (2021, p. 3) defined eating occasions as "any occasion in which food or drink was consumed and calories ingested were greater than 9 kcal." Murakami et al. (2020) evaluated eating occasions as meals and snacks based on both participant definitions and time of day definitions. For the time of day definitions, meals were defined as eating occasions within certain time frames (e.g., breakfast between 0600 and 1000 h, lunch between 1200 and 1500 h, dinner between 1800 and 2100 h). All other eating occasions were categorized as "snacks." An earlier study categorized eating occasions that provided at least 50 kcal as either meals or snacks based on their percentage contributions to total energy intake (i.e., >15% or less than or equal to 15%), participant self-report, and time of day (Murakami and Livingstone, 2015). In their review article, Garcidueñas-Fimbres et al. (2021, p. 3) relied on researcher determination of eating frequency, which they state is "often assessed by self-report" but is sometimes divided into "meal" or "snack" categories, "according to the energy percentage contribution (% energy) or based on the hour (clock time)." Other research teams relied entirely on participant self-report, provided lists of specific foods that counted as "snacks," or provided no definition at all. Kim et al. (2018) relied entirely on self-report in their study. Eating frequency was "defined as the sum of the number of meals and snacks" according to self-report, where meals were defined as breakfast, lunch, and dinner, and snack intake was determined by participant answer to the question "how many times do you eat snacks a day?" (Kim et al., 2018). Barrington and Beresford (2019) defined snacks by food type, listing the following items as examples: cookie, slice of cake/pie, energy bar, fruit, candy, and ice cream.

Results of a study from Cowan et al. (2020) illustrate the impact that this range of definitions can have on the literature. Cowan et al. (2020) assessed snacking frequency and weight status using NHANES 2013–2016 data, looking at associations by snack definitions (participant-defined, eating events outside of meals, or eating occasions with greater than 50 cal as the definitions for snacks). Women with obesity consumed more energy from snacks than women without obesity when a snack was defined as eating outside of typical mealtimes, regardless of its energy contribution (Cowan et al., 2020). Snack frequency was highest (approximately 3 snacks per day) when snacking was defined as any eating occasion outside of a typical meal time, but snack frequency was halved (to 1.5 snacks per day) when based on participant definitions (Cowan et al., 2020). When defined as an eating occasion where ≥50 kcal was consumed, snack frequency decreased further to 1.3 snacks per day (Cowan et al., 2020). Until the nutrition science and public health communities can align on a definition of snacks, eating occasions, and eating frequency, it will remain difficult to determine the effect of snack consumption or FOE on weight, energy intake, blood pressure, or any other markers.

Yet, FOE continues to be an important consideration for dietary guidance. The 2020 DGAC Report states that FOE will be an important consideration for future Dietary Guidelines for Americans (**DGA**) cycles. Proposed topics and questions for the 2025 DGA Scientific Advisory Committee to review include one on the relationship between timing of eating occasions, including snacking, and either dietary quality or growth, size, body composition, weight status, and weight loss or maintenance (USDA and HHS, 2022). While little is understood about the health impacts of eating frequency, dietary guidance still recommends choosing nutrient-dense foods at any eating occasion, including "snacks." The World Health Organization recommends limiting sugar-containing beverages and snacks but encourages fresh or dried fruits and vegetables, whole-grain-based snacks, and nutritious snacks (Potter et al., 2018). In a review of how 86 food-based dietary guidelines addressed snacking, the most commonly recommended snack items included vegetables, fruit, low-fat and fat-free dairy foods, and starchy foods (Potter et al., 2018).

Like vegetables and fruit, low-fat and fat-free dairy foods tend to be underconsumed by Americans relative to dietary recommendations (USDA and HHS, 2020). Much of the recent research on dairy foods as snacks focuses on their impact on subsequent food and energy intake (satiety) (Dougkas et al., 2012; Douglas et al., 2013; Ortinau et al., 2013, 2014; Green et al., 2017; Gheller et al., 2019, 2021). In several of these studies, yogurt or cheese (or both) had a greater suppressive effect on appetite compared with milk or water (Dougkas et al., 2012; Ortinau et al., 2014; Law et al., 2017; Gheller et al., 2021), leading some researchers to conclude that solid and semi-solid dairy snacks were more effective than fluid dairy products in reducing subjectively measured appetite (Tsuchiya et al., 2006; Gheller et al., 2021). In other studies, including one study of children ages 9 to 14 yr, there were no differences in subjective appetite or food intake after eating a nondairy carbohydrate snack compared with a dairy snack (Gheller et al., 2019). Consuming yogurt, even high-protein yogurt, as a snack did not always lead to lower energy intake at a subsequent meal (Douglas et al., 2013). When juice and milk were compared as mid-morning snacks, drinking milk led to lower energy intake at a subsequent ad libitum pasta meal (Green et al., 2017). While American consumption of dairy foods does not meet current recommendations, cheese, yogurt, and other solid and semi-solid dairy foods recom-

mended in the DGA (soy yogurt, cottage cheese, kefir) may be more beneficial snack choices than fluid dairy choices because they are more satiating and, therefore, may contribute to lower energy intake at subsequent eating occasions. Yet more research is needed to differentiate the satiating impact of milk from other beverages and also to determine how less commonly consumed dairy options in the DGA such as soy milk, kefir, buttermilk, and frozen yogurt may affect satiety and energy intake.

Overall, increasing consumption of low-fat and fat-free dairy foods as well as other underconsumed food groups (whole grains, vegetables, and fruits) at eating occasions outside of meals would increase the nutrient density of these eating occasions and bring Americans closer to meeting nutrient needs and following eating patterns recommended in the DGA.

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Notes

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