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Snacking: A cause for concern

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ABSTRACT

Snacking, like any dietary behavior, can be practiced in a manner that is healthful or not. The case presented in this critical review of the literature is that snacking is problematic, primarily due to its contribution to positive energy balance and promotion of overweight/obesity. There is strong evidence that snacking is associated with greater energy intake. How this translates to body weight is less clear, largely due to limitations of experimental measurement tools and research designs. Correction for these shortcomings reveals evidence implicating snacking in the high prevalence of overweight/obesity supported by multiple plausible mechanisms. Given the popularity of snacking and its potential to positively contribute to diet quality, it is recommended that efforts be made to better understand and harness snacking to a better purpose.

The fast and increasing pace of life is facilitated by the wide availability of convenience foods. Items that are palatable, nutritious, affordable, capable of being consumed quickly and preferably while engaged in other activities, are desired by consumers. Snacks can meet all of these criteria, but often emphasize only a sub-set of characteristics resulting in questions about their role in a healthful diet. Assigning positive or negative attributes to snacking is difficult when there is no agreed upon definition of the ingestive event. The implications of varying eating frequency, timing of ingestive events and/or dietary properties (e.g., sensory stimulation, nutrient contribution) that may stem from snacking can be antithetical and will differ between individuals. For example, snacking-related improvements in diet quality may be accompanied by increased energy intake and the consequences will differ if one has a diet that is nutrient rich or poor and is already contributing to positive or negative energy balance. Nevertheless, the position of this review is that in local and global environments where overweight and obesity are prevalent, snacking poses a cause for concern.

Total energy intake is determined by the balance between eating frequency and portion size. Under a regulated homeostatic model, there is a reciprocal relationship whereby a healthful body weight can be maintained with changes in either component. Increased frequency of energy intake can be offset by reduced portion sizes and vice versa. However, precise compensation is the exception rather than the rule as evidenced by the high global prevalence of overweight/obesity [1,2]. Snacking is not synonymous with increased eating frequency due to meal (also not clearly defined) skipping, but generally leads to increased ingestive events. If three meals per day is normative, there has been a marked change in dietary pattern. Globally, sales of snack foods are expected to exceed US$630 billion by 2020 [3]. Europe is the largest market. A recent review of 27 centers in 10 European countries revealed all had eating frequencies in the range of 4.9 to 7.0 occasions per day [4]. In the Mediterranean, Nordic and Central European countries, snacks contributed 14%, 29% and 31% of daily energy, respectively. For the Mediterranean countries, snack energy equaled energy contributed by breakfast and in the Nordic and Central European countries, snacking provided more energy than either breakfast or lunch. In 2012, Mexicans consumed 1.6 snacks per day which contributed 343 kcal/d or approximately 17% of total energy [5]. In the United States, analyses of National Health and Nutrition Examination Survey (NHANES) data between 1971–1974 and 2007–2010 revealed energy from main meals increased by 63 kcal/d and 112 kcal/d in males and females, respectively whereas energy from snacks increased by 132 kcal/d and 142 kcal/d in males and females [6]. As a percent of daily energy intake, energy from snacks increased by 3% in males and by 5% in females over this time period. Approximately 9% of the US population derives > 50% of their daily energy from snacks. This percentage is slightly lower than the peak in the 1999–2002 survey, but is still markedly higher than the approximately 5% reported in 1971–1974. Though smaller in absolute terms than western nations, the growth of snack sales is greater in developing countries (e.g., Asia-Pacific, Latin America, Middle East/Africa) [7]. In summary, snacking has increased in frequency, is highly prevalent and contributes 15–30% of daily energy in the US, European countries and elsewhere.

If total daily energy intake is rising and is disproportionately due to increased energy intake from snacking, it might be expected that there

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would be a robust association between snacking and BMI. There are surprisingly limited data on this issue prompting a call for increased research on the topic by the 2010 Dietary Guidelines Advisory Committee [8]. Nevertheless, there are data to this effect (e.g., [9–16]). Findings from the Adventist Health Study 2 is a notable example [16]. These data are particularly strong because they draw from a large sample of individuals (N = 50,660) with generally healthy lifestyles (e.g., low alcohol intake, higher physical activity, high prevalence of vegetarianism) who were studied longitudinally (7 years). They show a significant linear association between number of eating occasions and increase in BMI. However, there are also multiple studies reporting no [17–19] or an equivocal [20] association, an inverse relationship [21–25], a link only when snacks are of high energy density [26,27] or only in individuals with high BMI [26,28,29]. A recent meta-analysis reported an inverse association between eating frequency and fat mass and percent body fat in children, but noted this was attributable to just a single study [30].

Not uncommonly, null or inverse associations between snacking frequency and BMI are noted in observational studies where there is a positive association between snacking and energy intake (e.g., [27,31]). Given that body weight can be measured quite accurately and reliably, but the same cannot be said for food intake in free-living individuals [32,33], this raises the question as to whether the variability in epidemiological studies stems from under-reporting. There is considerable evidence to indicate this is the case. One of the first and most influential reports of an inverse association between eating frequency and BMI was a cross-sectional assessment of Hungarian men [21]. There was a sharp monotonic decline of BMI with reported eating frequency ranging from < 2X/d to > 7X/d. However, as noted by Bellisle et al. [34], there was also step-wise under-reporting of energy intake with the error greatest for those claiming to eat < 2X/d. This suggests those claiming to eat least frequently either failed to report eating events or actually skipped eating events as a way to moderate their energy intake. In either case, it would challenge the claim of an inverse association between eating frequency and BMI. Under-reporting is also evident in nationally representative data sets of the US population. Using the full Continuing Survey of Food Intake in Individuals (CSFII) data set (N ~ 6500), no association was observed between reported energy intake or eating frequency and BMI [35]. However, with exclusion of implausible reporters, a significant positive association is observed for both energy intake and eating frequency. Even more striking are the findings using NHANES data. Using the unadjusted sample, there was a null or inverse association between overall eating frequency or snacking frequency (defined by energy or eating occasions per day) and risk for overweight/obesity in males (N = 9397; ≥20 y/o) and females (N = 9568; ≥20 y/o) [36]. However, when excluding under-reporters, the associations were positive. The same phenomenon holds for analyses with children (N = 4346; 6–11 y/o) and adolescents (N = 6338; 12–19 y/o). Every negative association switched to positive or was attenuated and positive associations strengthened when corrected for intake plausibility. Similar results were reported with data from the National Diet and Nutrition Survey involving 1487 British adults (19–64 y/o). The definition of snacking can also lead to discrepant findings. The INTRERMAP study involving 2696 men and women 40–59 y/o between 1996 and 1999 reported an inverse association between number of eating occasions per day and BMI, but excluded all ingestive events comprised of beverages alone [25]. Given the high level of energy beverages provide and the fact that they are commonly ingested alone [37] this undermines the findings. Thus, when critically assessed, the apparent inconsistency between snacking and BMI is due, to a large degree, to biases introduced by under-reporting energy intake and questionable definitions of snacks. When corrected, a positive association is observed more consistently.

Inconsistencies are also reported in clinical trials and warrant critical assessment. A recent review of clinical trials evaluating the effect of varying eating frequency on body weight concluded eating frequency exerted little impact on appetite and BMI [38]. However, with respect to appetite, none of the 12 studies summarized had a sample size > 20 and in six of the trials, it was < 10. Additionally, in nine of the 12 studies, the duration of observation was less than one day. Given the high variability in appetitive sensation, it is not clear that studies of such limited power and short duration yield reliable findings. The findings related to BMI are equally suspect. In eleven of the eighteen studies summarized, the duration of study was < 4 weeks and for sixteen of the eighteen studies, the duration of study was less than ≤8 weeks. This is a very short time to monitor body weight changes in response to dietary interventions. In the one study of one year's duration [39], there was an attrition rate of 34% and the three meal plus three snack group only increased snack intake by 0.4 snacks per day. The finding was no effect of snacking on body weight. In summary, it is argued that due to their lower statistical power and perhaps poor compliance to intervention, published randomized controlled trials provide an inadequate basis for drawing conclusions about the effects of snacking on BMI.

To further aid evaluation of the potential contribution of snacking to positive energy balance and weight gain, mechanistic studies should be considered. Why should snacking be especially problematic for weight gain? First, the food industry has been especially responsive to consumer demands for products that are palatable, convenient and reasonably priced. This has been coupled with a shift in culture where eating at non-traditional times and in non-traditional locations has gained social acceptability. The American Time Use Survey reveals men and women engage in primary eating (eating is the main focus of their activity) for just over one hour per day, but secondary eating (eating while engaged in other activities) occurs for another 20 min per day. Moreover, secondary drinking occurs for an additional 57 min per day in males and 69 min in females [40]. Secondary drinking is significantly, positively associated with BMI. Additionally, snacking is associated with higher food reward sensitivity impulsivity [41]. Thus, the high palatability and convenience of snacks may predispose selected individuals to snacking and in these individuals, snacking is associated with BMI. This may be especially problematic when snacking is initiated in the absence of hunger [41,42].

Second, snacks exert limited effects on hunger, desire to eat and fullness. Indeed, they may actually enhance these sensations. Given that snacks are generally lower in energy and smaller in volume than meals, it is not surprising that the reduction of hunger before and after each eating occasion is smaller for snacks [43]. However, when holding energy and volume constant and just varying eating events, similar findings are obtained. In a standard preload design trial, individuals were provided a single meal on one occasion or the same meal divided into 4 equal portions provided over a 180-minute period and were then given access to an ad libitum test meal at 240 min [44]. All appetitive indices were less modified (e.g., less reduction of hunger or enhancement of fullness) by the higher eating frequency intervention over the initial 180 min. This was reversed at the 240-minute time point, but this had no effect on energy intake at the test meal. In another trial, participants were acclimated to eating either three times per day or eight times per day for 3 weeks prior to testing [45]. The low frequency eaters were provided a single meal and the high frequency eaters were provided the same meal divided into two and were presented 2.5 h apart. The composite appetite score was higher in the high frequency eaters indicating this eating pattern is not superior at moderating the sensations that drive feeding. In yet another trial, providing participants common meals divided into three or six eating occasions resulted in higher 24-hr hunger and desire to eat AUC values compared to the three eating occasion intervention. This was due to lesser reductions of these two sensations following each eating occasion with higher eating frequency and comparable rebound sensation levels [46]. This response pattern has been described previously [47].

Third, snacks tend to elicit weak energy compensation (i.e., adjustments to later intake to offset the contribution of energy by the