

Impact of the daily meal pattern on energy balance¹

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Abstract

The daily distribution of food intake can influence the regulation of energy balance and, in consequence, the control of body weight. Two aspects of this question must be considered: the daily number of eating occasions and their temporal distribution. Since the 1960s, epidemiological studies have reported an inverse relationship between frequency of eating and body weight, suggesting that a “nibbling” pattern could help to prevent obesity. This notion has later been put into question by the recognition of a high level of dietary underreporting in overweight individuals. In addition, no difference in total daily energy expenditure has been documented as a function of daily meal number. Weight loss is not facilitated by high meal frequency. Snacking in obese subjects is associated with higher energy and fat intake. By contrast, in normal-weight people, snacking does not necessarily lead to increased energy intake, while snacks often contain more carbohydrates and less fat than regular meals. Obese people tend to eat little in the morning and much in the afternoon and the evening. In extreme cases, a “night-eating syndrome” is observed. Understanding the relationship between the circadian distribution of intake and obesity (or resistance to weight loss) seems critical for theoretical as well as clinical reasons.

Keywords: *energy balance; meal pattern; snacking*

Introduction

In human societies, eating is a patterned activity. Social constraints usually determine how many meals are to be ingested daily, and when meals are or are not appropriate. The meal pattern is an important aspect of social interactions. Just a few years ago, in many European societies, it was difficult, if not impossible, and most often considered inappropriate, to have food at other times than the socially accepted mealtimes. A newborn child was trained early to shape his or her eating behaviour according to the socially appropriate pattern. Clearly, this situation has changed in recent years in developed societies, where food has become available constantly and in practically unlimited amounts.

The development of the obesity epidemic has coincided with the loosening of traditional meal patterns, and it seems legitimate to ask whether this had any impact on the energy balance of individuals, and on their ability to control body weight. A lot of research has been devoted to the relationships

between the daily meal pattern and the body's adiposity status (1). Two important aspects of the meal pattern have been investigated: the daily meal number and the circadian distribution of intake.

The daily meal number and body adiposity

Is there an optimal number of daily eating occasions to facilitate body weight control? This question has drawn much interest since the 1950s, when observational and intervention studies suggested an inverse relationship between the daily meal number and body adiposity: a nibbling pattern was thought to be more favourable to low body mass than a gorging pattern, for a given energy intake. Work by Pavel Fabry and colleagues (2, 3) popularized the notion that eating often was associated with lower body fatness in middle-aged men as well as in school-children. A number of observational studies produced congruent results in the following years (4–6).

Over the same period, investigators became increasingly suspicious of self-reported food intake data. Dietary underreporting by overweight people has been increasingly recognized as a strong confounding factor in epidemiological studies (7–9). Underreporting affects not only energy intake, but

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also the daily number of eating occasions, and snacks are particularly prone to underreporting (10–12). The development of the doubly labelled water technique to measure body energy expenditures made it clear to the scientific community that a certain level of underreporting of food intake occurred in the population at large (about 20%) and that underreporting was likely to be aggravated in overweight and obese subjects (some people underreported their energy intake by 50% or even more) (9, 13). Such observations cast doubt on the validity of data suggesting that heavy people eat fewer meals a day than their leaner peers. In a study by Kant (5), the results again suggested that lower body mass index (BMI) was associated with increasing daily meal number, but also made it clear that the heaviest subjects, who reported fewer meals, also reported total energy intakes that were totally incompatible with their minimal energy needs.

Later studies comparing nibbling and gorging meal patterns were more prudent about potential underreporting and found no significant differences in body adiposity as a function of daily meal number (14–17). A recent study even reported more daily meals in obese than in lean women (18). Recently, Ma et al. (19) found a significant decrease in the risk of obesity with increasing meal number, but again the potential impact of underreporting in this study could be important.

What mechanisms could allow a nibbling meal pattern to induce less body fat accumulation than a gorging pattern? Two types of effect have been investigated. Several studies assessed the postprandial energy expenditure (the thermic effect of feeding), using a ventilated hood technique (20–24). The results of these studies are inconsistent. While half find non-significant differences between one daily meal and two or four meals, others report either a higher thermic effect with gorging than with nibbling, or the opposite. Other studies have investigated the total daily energy expenditure on nibbling versus gorging patterns using whole-body calorimetry: all reported non-significant differences (25–28). One study used the doubly labelled water method and again reported no difference in total daily energy expenditure as a function of daily meal number (27).

The potential benefits of a nibbling versus a gorging meal pattern for body weight loss were investigated in obese patients. While one study suggested that weight loss induced by a low-calorie diet might be facilitated on seven rather than three

meals a day (29), several other studies failed to demonstrate any effects on the amount or rate of weight loss attributable to meal number, when energy intake was held constant (27, 30–33).

In conclusion, the early suggestion of an inverse relationship between daily meal number and body adiposity has not been confirmed. This notion probably resulted from underreporting of food intake by the heavier participants in observational studies. In addition, no mechanism has been found to account for any potential benefit of nibbling versus gorging on body fat accumulation: total daily energy expenditure is the same on both types of meal pattern. During a low-calorie diet, all other things being equal, meal number has no demonstrated effect on the amount or the rate of weight loss.

Under controlled laboratory or hospital conditions, it is possible to determine patients' or subjects' daily energy intake and to distribute it over a certain number of eating occasions. In free-living conditions, however, the daily energy intake is not limited by clinical or experimental control, and a higher daily meal number may be a potential cause of overeating in many obese individuals with satiety deficits, who experience great difficulty in terminating a meal once they have started eating.

Snacking

Until recently, many European societies maintained a traditional meal pattern and it was inappropriate for adults to consume foods at other times than socially accepted mealtimes. Some tolerance was granted for children, but they were strongly encouraged to adopt the adult meal pattern as early as possible. This situation has changed enormously in recent years. Adults and children can obtain food at any time and usually do not even question the appropriateness of snacking between meals. Such trends have been revealed by recent epidemiological studies in France (34) and Sweden (18), for example.

In France, a recent study of adults showed that most people snack at least once almost every day (35). Snacking can occur at any time of day (morning, afternoon, evening). In these healthy, non-obese subjects, days without snacks resulted in the same amount of energy as days with snacks, suggesting some form of energy compensation. This observation agrees with numerous reports from other countries (36–38). It has often been reported that in healthy individuals, snacks contain a higher proportion of carbohydrates and a smaller proportion of fats than

meals (35, 39–41). Thus, snacking in healthy people apparently improves the nutrient content of the diet without adding energy to it. Could the influence of snacking be different in obese people?

Snacking is generally held to exert a deleterious influence on the development and/or maintenance of obesity. In 1988, Booth stated that the “growing trend for ‘grazing’ rather than of the traditional pattern of three proper meals a day is a major factor in the aetiology of obesity” (42). Many studies have lent support for this notion. For example, Bertéus Forslund et al. (18) showed that obese Swedish women snack more often and have higher energy intake than lean peers. In obese French women, snackers have a higher energy intake than non-snackers (43).

Snacking thus appears to have more complex effects than was thought just a few years ago. Snacking may not always be the deleterious, unhealthy behaviour that it has often been considered to be. Indeed, very active people (children as well as adults) snack often but are leaner than less active peers. Very active children (44) often snack on healthy carbohydrate- or protein-rich foods. Therefore, snacking can contribute to improve the nutrient balance in some people, but may be deleterious in others (people with weight-control problems or satiety deficit, lovers of high-fat, high-sugar foods, etc.).

Circadian distribution of intake

In spite of years of dedicated research, it has never been possible to identify a single behavioural characteristic that would be specific to the obese population as a whole. There is, however, one very consistent finding that has been reported in several comparisons of obese and normal weight peers: obese people tend to eat less in the morning than lean controls, and to eat more in the afternoon and evening. In other words, the circadian distribution of daily intake consistently appears different in obese versus non-obese individuals. This has been reported in children (45), adolescents (46) and adults (18, 47). One exception to this general finding was that Andersson and Rössner (17) did not report any difference in the daily distribution of intake events between normal-weight and obese Swedish men.

A dietary survey showed that the body weight status in French children was associated with a different distribution of daily energy over the various daily eating occasions: a higher percentage of daily energy was ingested at breakfast in lean and

medium-weight French children, while dinner brought a higher proportion of daily energy in overweight and obese children (45). A recent study of Swedish women showed that all types of eating event (meals and snacks) were more numerous in obese than in control women (18), an effect accounted for by the more frequent eating occasions reported in the afternoon and evening, between traditional mealtimes.

It is not known whether this peculiar daily distribution of eating is a cause or a consequence of the obese status. How could eating late in the day contribute to obesity? It may be easier to adjust intake to needs if intake is more evenly distributed over the waking hours, so that intense sensations of hunger are not allowed to develop between intakes. In addition, it has been shown that the ingestion of breakfast is associated with better nutrient content of the diet and less snacking later in the day, which again may help to limit total energy intake. Conversely, skipping breakfast has been associated with unplanned overeating later in the day, due to intense hunger, more precisely with the ingestion of high-fat, high-sugar snacks (48). In extreme cases, the tendency to eat late in the day may lead to the “night-eating syndrome”, originally described by Stunkard et al (49). This cluster of obesity-linked behaviours (although it can also be found in non-obese patients) includes night eating, insomnia and morning anorexia (50).

A recent study of 867 healthy adults (36.3-year-old, BMI 24.5 on average) who filled out 7 day diet diaries established that the proportion of daily intake ingested in the morning correlates negatively with total daily energy intake, while the proportion ingested late in the day correlates positively with overall energy intake (51). In other words, people who eat early eat less, while people who eat late eat more. The larger total intake of late eaters could contribute to the development of obesity.

During a 9 month weight-loss programme, carried out over a school year, massively obese adolescents were exposed to a low-fat reducing diet distributed over three daily meals (including breakfast) plus one afternoon snack (52). The diet breakfast brought 20% of the daily energy. After the end of the diet and a substantial weight loss, the participants returned to their homes and usual activities. Follow-up investigations carried out 1 and 2 years after the end of the weight-loss programme showed that while body weight was

being regained progressively, the daily meal pattern had altered: breakfast tended to return to prediet energy content and extraprandial snacking increased, especially in the afternoon and evening. So, independently of actual daily energy intake, meal pattern changed during the weight regain period and this change was in the direction of a return to the pretreatment obese meal pattern. Such resistance to behavioural change suggests that a strong mechanism is working to reinstate the "obese meal pattern", independently of energy intake. The obese meal pattern could be causally related to the development or maintenance of obesity; however, the exact nature of the underlying mechanism remains unknown.

Conclusion

There is no clear, consistent evidence linking daily number of eating occasions and body adiposity. While traditional eating patterns are likely to change as a result of to present-day living conditions, the presence of snacking in the diet should be evaluated in terms of both energy and nutrient contributions. Understanding the relationship between the circadian distribution of daily intake and body adiposity status appears to be a critical issue for the prevention and treatment of obesity.

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