Background: The design of dietary, metabolic, and intervention studies should reflect the meal patterning of free-living individuals, but this design has not been systematically reviewed recently.

Objective: Our objective was to examine meal-patterning trends [meals and snacks, termed eating occasions (EOs)] in a sample of US children and adults.

Design: This was a nationally representative cross-sectional study of US data sets from 1977 to 1978, 1994 to 1998, and 2003 to 2006 in 28,404 children (2–18 y of age) and 36,846 adults (≥19 y of age). The main outcomes of interest included the number and size (energy/d) of meal and snack EOs, the composition (food or beverage) of each EO, and the time interval between each EO.

Results: The number of EOs increased over the previous 30 y among all ages. For adults and children, the change in the number of EOs from 1977 to 2006 was greatest for those in the 75th and 90th percentiles, although the mean number increased across all percentiles. Energy intake, particularly from snacking, increased for both groups in all percentiles of the distribution. The time between EOs decreased by 1 h for adults and children (to 3.0 and 3.5 h in 2003–2006, respectively). Overwhelmingly, meals consisted of both food and beverages, but the percentage of snacking occasions that consisted of beverages only increased considerably among children.

Conclusions: US children and adults are consuming foods more frequently throughout the day than they did 30 y ago. Researchers undertaking future clinical, preload, and related food studies need to consider these marked shifts as they attempt to design their research to fit the reality of the eating patterns of free-living individuals.

INTRODUCTION

A large proportion of studies on the effects of food on metabolic change studies to full-day feeding studies and studies of nutrient composition and metabolic response (1–3). Even most longer-term food-pattern studies (4, 5) are based on promoting and following selected eating patterns. Food-patterning research has targeted the control of insulin concentrations, satiety, and energy intake in a limited number of studies (6–8).

The relation between meal frequency and energy intake, weight dynamics, insulin resistance, and lipid profile is complex, and only a few studies (4, 9–14) have addressed this area. From an epidemiologic perspective, the literature results are conflicting and often based a less than ideal study design (4, 9–14). There are related reports (7, 15) on fasting and caloric restriction, suggesting potentially important benefits in terms of health and longevity, and a few studies (7, 16, 17) suggest that frequent nibbling (defined as ≥5 times/d) has some health benefits, but these literature reports are too few, are conducted in diverse populations, and lack consensus. With respect to diabetes, there is an unofficial consensus in clinical care that consuming evenly spaced eating occasions (EOs) throughout the day is better than major binging episodes, but there are few formal research reports supporting these recommendations.

Recently, there has been an increased interest in examining recreational (or mindless) eating (18, 19). Evidence suggests that snacking (20, 21) and total energy intake (22, 23) have increased. However, a major gap exists in attempting to situate these snacking increases into broader meal patterning and examining how overall meal patterning has shifted over time in the United States. With the use of nationally representative survey data collected between 1977 and 2006 for adults and children (24, 25), we conducted a systematic examination in this study of the shifts in the frequency of meals and snacks over time with respect to the total number of daily events and the proportion of time spent eating. Although we did not directly examine how such changes influenced insulin sensitivity or other metabolic outcomes, our findings provided a perspective on this research and whether or not there is a basis for rethinking diet and metabolic-behavior study designs.
METHODS

Survey design and sample

We used data collected from 4 nationally representative surveys of food intake in the US population. The analysis sample consisted of 28,404 children (aged 2–18 y) and 36,846 adults (aged ≥19 y) come from these 4 surveys:


Having replaced the USDA and Department of Health and Human Services nutrition monitoring systems, the sample design, survey instruments, dietary collection procedures, and food composition tables used in NHANES matched the earlier USDA surveys. The USDA and NHANES surveys are based on a multistage, stratified area probability sample of noninstitutionalized US households. Detailed information about each survey and its sampling design was published previously (24, 25).

Dietary data

The Nationwide Food Consumption Survey 1977–1978 contained information on all foods eaten at and away from home over 3 consecutive days by using a single interviewer-administered 24-h recall followed by a self-administered 2-d food record of all foods consumed on the day of the 24-h interview and 1 d after the interview.

The CSFII 1994–1998 Survey collected interviewer-administered 24-h recalls on 2 nonconsecutive days (spaced 3–10 d apart). Similarly, NHANES 2003–2006 included 2 nonconsecutive days of 24-h dietary recall data. Day 1 interviews were conducted by trained dietary interviewers in a mobile examination center, whereas day-2 interviews were collected by telephone 3–10 d after the interview in the mobile examination center. For NHANES 2003–2006, the USDA’s Automated Multiple-Pass Method (25), a 5-step computerized dietary recall instrument, was used for collecting 24-h dietary recalls either in person or by telephone. For snacking behavior over time, the first 2 d of dietary intake from each survey were included in this analysis to provide fairly comparable measurement periods and protocols.

Meal and snack definitions

This set of surveys collected information on EOs, such as breakfast, lunch, dinner, and snacks. Respondents were asked to name the type of EO and the time when the EO began for each food that was recorded. Because people often consume more than one food item when having a snack, we combined all snack foods consumed within 15 min of each other as a single snacking occasion. Some individuals defined foods eaten at the same time as both a snack and meal. In these instances, we defined all foods reported at that EO as meal foods.

In the NHANES, respondents defined all foods as either 1 of 3 meals or as a snack. However, in the NCFS 1977–1978 and CSFII 1994–1998, EOs were defined as “other” or “no answer.” Foods consumed at these occasions were handled in the following manner. First, the EOs were recoded as meals if the respondent did not report having 3 meals, and the reported eating time was one that was normally associated with a major meal (breakfast, lunch, or dinner). The remaining EOs were assigned to meals if the person did not report 3 meals, regardless of the reported eating time (ie, even if the eating time was not one typically associated with a major meal). Finally, the remaining missing occasions were considered snacks only if the person had reported eating 3 meals. We feel that this approach was a very conservative way to define snacking. Henceforth, meals and snacks were combined and collectively referred to as EOs.

As dietary behavior has changed, the concepts of what is contained in a meal and in a snack were blurred for some respondents. We used the term increased EO to describe the overall shifts under way in all time periods where beverages or food were consumed as indicated by these dietary intake surveys.

Mean time interval between EOs

With the use of data from the start time of each EO, we calculated the mean number of minutes between EOs. We did not have information on the length of time spent eating, and estimates did not account for the time from the last EO of one day to the start of the first EO the next day.

Statistical analyses

All analyses were conducted with Stata 10 (Stata Corp, College Station, TX) by using survey commands to account for survey design effect and sampling weight. The number of EOs was measured for all instances where any kilocalorie of food or beverage was consumed. Separate water or diet beverage occasions with no calories were excluded, partially because the data on water intake were very inaccurate, and we could see no way to use the data collected. The total number of EOs was computed for each survey year by age grouping in years (2–18 and ≥19 y of age). Results were unadjusted for demographic shifts over time and thus represent the experience of the average American at each time period. Unreported data were examined for smaller age groupings (2–6, 7–12, 13–19, 20–59, and ≥60 y of age). In general, the trends were the same as those observed for the larger groupings, except higher amounts of snacking among the 2–6-y-olds and slightly lower among individuals aged ≥60 y. However, these differences were not significant (ie, between snacking in the 2–6-y-olds compared with the 2–18-y-olds), so only the larger age groupings were presented.

For each survey year, difference testing was based on the F test with the Stata TEST command after the SVY MEAN command (Stata Corp). $P \leq 0.05$ was set for statistical significance with Bonferroni correction. The mean number of people in each of the percentiles (lower 10th, 25th, and 50th and upper 50th,
25th, and 10th) was compared between each time period for the total number of EOs and the relative size (kcal) of meals and snacks.

RESULTS

Number of meals and snacks

We first examined the shifts in the total numbers of EOs between 1977 and 2006 (Figure 1). For both age groups, the median total number of EOs increased by a full EO between 1977 and 2006. Among children, this increase tended to occur in a stepwise fashion, increasing by one-half between 1977 and 1998 and one-half between 1998 and 2006. Among adults, the increase occurred primarily between 1998 and 2006. This same pattern was observed at all percentiles, and all shifts were significant at $P \leq 0.001$. For both age groupings, the 50th, 75th, and 90th percentiles had the largest increases in the total number of EOs. By 2006 the adults and children had equivalent numbers of eating and drinking occasions at each percentile.

The mode and distribution of the frequency of daily EOs also shifted (Figure 2). In 1977, the mode number of EOs/d was 3, but this value shifted dramatically for children (Figure 2A) and adults (Figure 2B) to roughly 5 EOs/d in 2006. Although the distribution among adults was more highly skewed in 1977 (1977 range: 1–22 EOs/d; 2003–2006 range: 1–13.5 meals/d), a greater proportion of the sample in 2003–2006 consumed a larger number of EOs per day (upper 50th percentile in 1977: mean of 4.9 meals/d; upper 50th percentile in 2003–2006: mean of 6.6 meals/d).

Overall, meals consisted of both food and beverages, although small increases from 1977 to 1978 to 2003–2006 were noted in meals [consisting of only food (no beverage)] for children and adults (with a slight downward proportion for adults in 2003–2006 than in 1994–1998) (Table 1). In contrast, snacking occasions were increasingly dominated by beverages only, particularly among children between 1994 and 2006. Among adults, the percentage of snacks that consisted of beverages only increased between 1977 and 2006 (4% increase) but not as much as the percentage of snacks that was food only (11% increase).

Size of meals and snacks

The relative size of meals and snacks increased dramatically for children and adults (Table 2). Between 1977 and 2006, children consumed an average of 62 [(1524–1586)/1586 = 4%] fewer calories, whereas adults consumed $\approx 123 [(1692–1569)/1569 \approx 8\%]$ more calories at meals, from food and beverage combined. The energy from snacking occasions, on the other hand, increased dramatically for children and adults. Food-only snacks increased by $\approx 180$ calories for both children and adults, and adults consumed $\approx 100$ calories more from beverages alone between 1977 and 2006 (Table 2). Among adults, the energy from beverages alone (for combined meal and snack occasions) increased from 290 to 422 kcal, an increase of 45.5%.

Mean time interval between EOs

There was a 23% decrease in the amount of time (min) between EOs for children and adults from 1977 to 1978 and 2003–2006 (Figure 3). In 2003–2006, the mean amount of time between EOs was $\approx 3$ h for children (Figure 3A) and $\approx 3.5$ h for adults (Figure 3B), which is a 1-h decrease for children and adults from the mean amount of time between EOs in 1977 to 1978.

DISCUSSION

The purpose of this article was to use dietary patterns and trends to promote research on the question, “Do hunger and satiety still affect eating or has recreational (or mindless) eating taken over?” With the use of data spanning $\approx 30$ y, our results show a considerable shift in the number of daily EOs, with US adults reporting an average of 5 EOs/d. In related research, we showed that the number of separate snacking episodes increased significantly and that the change in food type and amount resulted in the average snack providing 100–300 kcal per snacking episode (22). Taken together, US children and adults in 2006.
consumed more food and beverages in total and ate more often than they did 30 y ago. During 2003–2006, the average energy intake for all Americans was 2533 kcal/d, which is an increase from 2090 kcal/d in 1977–1978, 2297 kcal/d in 1989–1991, and 2403 kcal/d in 1994–1998.

Although not directly addressed by our article, a greater number of meals per day has been associated with greater health benefits (metabolic outcomes, weight, and fat mass) in some (17, 26) but not all studies (27). Although these differences may be attributable to differences in the populations studied, such discrepancies indicate a need to further investigate these relations. Food reinforcement (the motivation to obtain food) also appears to differ between obese and nonobese individuals (28, 29), suggesting that regular snacking may decrease the reinforcing value of snack foods and could be antagonistic to reducing energy intake and promoting weight loss (30).

We also asked the question, “In the context of more constant eating, do we need to rethink our diet behavior and metabolic study designs?” Most studies of the dietary or metabolic effects of frequent eating (ie, snacks before meals) use preload designs and are not necessarily representative of the experience of the free-living individual. These studies are limited by their focus on a single macronutrient (31), a single food type (32), or the provision of preloads (foods/beverages used) or amount of time between preload and test meals that are not representative of an individual’s intake pattern (33). We estimated the average time between EOs to be 3.5 h in adults and 3.1 h in children in 2006 (down from 4.5 and 4.1 h in 1977 in adults and children, respectively). This time is considerably longer than the time used in the average preload study.

Studies examining the effects of preloads on gastric emptying and appetitive responses, specifically, are also limited by their focus on single dietary macronutrients (34–36) or a food’s physical state (37, 38). Further complicating these associations is the fact that increasing the time between the preload and meal resulted in less precise compensation (90 and 180 min compared with 30 min) in one study (39). Because these time intervals are similar to those observed between EOs in this study, frequent eaters could be at greater risk of over consumption. In total, current studies of the health and metabolic consequences of total meal patterns do not appear to be realistic and should be rethought.

**TABLE 1**

<table>
<thead>
<tr>
<th></th>
<th>Children 2–18 y old</th>
<th>Adults ≥19 y old</th>
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</thead>
<tbody>
<tr>
<td><strong>Meals</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food alone</td>
<td>14 ± 35.1</td>
<td>23 ± 42.2</td>
</tr>
<tr>
<td>Beverage alone</td>
<td>1 ± 11.6</td>
<td>2 ± 13.5</td>
</tr>
<tr>
<td>Food and beverage</td>
<td>84 ± 36.5</td>
<td>75 ± 43.3</td>
</tr>
<tr>
<td><strong>Snacks</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food alone</td>
<td>45 ± 49.8</td>
<td>54 ± 49.8</td>
</tr>
<tr>
<td>Beverage alone</td>
<td>19 ± 38.9</td>
<td>19 ± 39.5</td>
</tr>
<tr>
<td>Food and beverage</td>
<td>36 ± 48.0</td>
<td>27 ± 44.1</td>
</tr>
</tbody>
</table>

1 All values are mean percentages ± SEs. Data are nationally representative US dietary data from the Nationwide Food Consumption Survey 1977–1978 (24), the Continuing Survey of Food Intake by Individuals 1994–1998 (25), and the National Health and Nutrition Examination Survey 2003–2006 (25). Meals were defined as breakfast, lunch, or dinner as self-reported by participants. Snacks were defined as any food consumed within 15 min of a participant’s self-reported snacking episode.
This study is not without limitations. First, dietary intake was self-reported on the basis of two 24-h recalls and thus may not be entirely representative of an individual’s usual intake. In particular, there is evidence of increased underreporting, particularly of foods felt to be linked with obesity such as higher fat and sugar items (40–43). Second, our method of defining EOs is somewhat subjective on the basis of limited data including the starting time and subject-defined type of EO (ie, meal or snack). We included any food consumed within 15 min of a subject-defined snack as part of that same snacking occasion and any food consumed within 30 min of a meal as part of that meal occasion (even if the individual called that item a snack); thus, we may underestimate the number of separate EOs. Together both of these points probably mean that our measures of the number of EOs and kilocalories from each EO in more recent time periods are not entirely representative of an individual’s usual intake. In particular, there is evidence of increased underreporting, particularly of foods felt to be linked with obesity such as higher fat and sugar items (40–43). Second, our method of defining EOs is somewhat subjective on the basis of limited data including the starting time and subject-defined type of EO (ie, meal or snack). We included any food consumed within 15 min of a subject-defined snack as part of that same snacking occasion and any food consumed within 30 min of a meal as part of that meal occasion (even if the individual called that item a snack); thus, we may underestimate the number of separate EOs. Together both of these points probably mean that our measures of the number of EOs and kilocalories from each EO in more recent time periods are not entirely representative of an individual’s usual intake. In particular, there is evidence of increased underreporting, particularly of foods felt to be linked with obesity such as higher fat and sugar items (40–43). Second, our method of defining EOs is somewhat subjective on the basis of limited data including the starting time and subject-defined type of EO (ie, meal or snack). We included any food consumed within 15 min of a subject-defined snack as part of that same snacking occasion and any food consumed within 30 min of a meal as part of that meal occasion (even if the individual called that item a snack); thus, we may underestimate the number of separate EOs. Together both of these points probably mean that our measures of the number of EOs and kilocalories from each EO in more recent time periods are not entirely representative of an individual’s usual intake. In particular, there is evidence of increased underreporting, particularly of foods felt to be linked with obesity such as higher fat and sugar items (40–43). Second, our method of defining EOs is somewhat subjective on the basis of limited data including the starting time and subject-defined type of EO (ie, meal or snack). We included any food consumed within 15 min of a subject-defined snack as part of that same snacking occasion and any food consumed within 30 min of a meal as part of that meal occasion (even if the individual called that item a snack); thus, we may underestimate the number of separate EOs. Together both of these points probably mean that our measures of the number of EOs and kilocalories from each EO in more recent time periods are not entirely representative of an individual’s usual intake.

### REFERENCES


