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Snacking Increased among U.S. Adults between 1977 and 2006[1–3]

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Abstract

This study built on limited knowledge about patterns and trends of adult snacking in the US. We selected adults aged 19 y and older (*n* = 44,754) between 1977–1978 and 2003–2006 with results weighted and adjusted for sample design effects. Differences testing, by a Student's *t* test, used STATA 10 ($P \le 0.01$). We defined a snacking event as intake of foods over a 15-min period and excluded food defined as snacks but eaten at a meal. Dietary data were obtained from the first 2 d for the 1977–1978 Nationwide Food Consumption Survey (NFCS 77) and the 1989–1991 Continuing Survey of Food Intake by Individuals (CSFII 89); and 2-d dietary data from the 1994–1996 CSFII (CSFII 96) and the NHANES from 2 consecutive surveys: NHANES 2003–2004 and NHANES 2005–2006 (NHANES 03–06). Results showed that snacking prevalence increased significantly from 71 to 97% in 2003–2006 with increases in both the 1989–1994 and the 1994–2006 periods. In all adults, snacking occasions increased 0.97 events over this time period ($P < 0.01$) and the contribution of snacks to total energy intake increased from 18 to 24% ($P < 0.01$). The energy density of snacks (food plus beverages) also increased progressively over the time period studied. Important changes in snacking food sources were found among desserts, salty snacks, candies, and sweetened beverages. More research is needed to gain a better understanding of the implications for overall energy intake and energy imbalance. J. Nutr. 140: 325–332, 2010.

Introduction

Obesity among U.S. adults has increased markedly over the past few decades. Approximately 29% of 20- to 39-y olds, 37% of 40- to 59-y olds, and 31% of those aged >60 y are obese (1). Different dietary factors, including intake of energy beverages, away from home eating, portion sizing, and snacking have been related to the excess of energy intake and obesity at different life stages (2–18).

Meal and snack patterns, including the frequency of daily eating occasions, are suspected to affect health outcomes, including cardiovascular disease and glucose intolerance (19,20). However, the contribution of meal frequency and snacking to overeating and body weight remains unclear. Many studies in adults of all age groups have reported higher values of BMI related to lower eating frequency (4,11,21,22), whereas others have found no relation (23,24) or gender differences to BMI (25,26). Snacking, usually defined as eating occasions different from main meals (breakfast, lunch, dinner/supper), has been commonly regarded as contributing to excess weight (26,27). Late night eating, greater intake of energy-dense salty snacks and energy beverages, or increased portion sizes of snacks are among other behaviors noted (28–32). Other studies on snacking related to BMI have shown inconsistent results (21,33,34). These inconsistencies may be due to under-reporting (35) of energy-dense snack and dessert-type foods (36,37), especially among obese people. Recent research among adults has found a higher BMI is associated with a higher total daily energy intake and a higher energy intake at all eating occasions (38). Moreover, energy intake has been found to increase with snacking frequency in both males and females, irrespective of physical activity. This increase is markedly higher in obese individuals (26). According to these results, increased snacking may be associated with a greater risk of energy imbalance and increased overweight and obesity.

Previous studies among young adults and children reported large increases in snacking frequency and higher contribution of snacking to total energy intake between 1977 and 1994 (28,29). Among U.S. adults, only 1 paper examined this topic and did not find large increases in eating frequency or snacking from 1971 to 2002 (39). This previous study used very precise food- and meal-based measures of snacking and adjusted as much as possible for some measurement differences by linking foods and food composition tables over the full period studied. We examined systematically overall patterns of snacking, shifts in energy intake from snacking, snacking occasions, and energy intake per snacking event. We also examined the shifts in snacking food and beverage sources, in addition to the overall trends of the energy density of snacks and meals.

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[3] Supplemental Tables 1 and 2 are available with the online posting of this paper at jn.nutrition.org.
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Participants and Methods

Survey design and sample. We used data collected from 4 nationally representative surveys of food intake in the U.S. population. The sample

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selected for analysis consisted of 44,754 adults aged 19 y and older who reported 1 or 2 d of intake. The USDA data come from 17,464 respondents from the 1977–1978 Nationwide Food Consumption Survey (NFCS)[4] 77; 8340 from the 1989–1991 Continuing Survey of Food Intake by Individuals (CSFII) 89, and 9460 from the 1994–1996 CSFII (CSFII 96). From the NHANES, there were 9490 respondents from 2 consecutive surveys: NHANES 2003–2004 and NHANES 2005–2006 (NHANES 03–06). The USDA and NHANES surveys are based on a multistage, stratified area probability sample of noninstitutionalized U.S. households. Detailed information about each survey and its sampling design has been published previously (40–44). The major difference is that although the NHANES sampling system is nationally representative, it does not represent each region by season and is not randomly distributed over the days of the week as the earlier USDA surveys were (45). By utilizing secondary USDA and NHANES data, we were exempt from institutional review board concerns for this paper.

Dietary data. All dietary survey data utilized a comparable food composition table and collection methods developed by the USDA. The NFCS 77 and CSFII 89 surveys contain information on dietary intake that was collected over 3 consecutive days using a single interviewer-administered 24-h recall followed by a self-administered 2-d food record. Dietary data from NFCS 77 and CSFII 89 surveys consisted of all foods eaten at home and away from home during the previous day (24-h recall) and the records of the foods eaten on the day of the interview and the following day (2-d records). The CSFII 1994–96 (CSFII 96) survey collected interviewer-administered 24-h recalls on 2 nonconsecutive days (3–10 d apart). The NHANES 03–06 surveys (a survey integrating USDA dietary methodology into the NHANES system) included 2 nonconsecutive days of 24-h dietary recall data. The d 1 interview is conducted by trained dietary interviewers in the Mobile Examination Center and the d 2 interview is collected by telephone 3–10 d following the Mobile Examination Center interview. For NHANES 03–06, the USDA's Automated Multiple Pass Method, a 5-step computerized dietary recall instrument, was used for collecting 24-h dietary recalls, either in person or by telephone. For our purpose of studying snacking behavior over time, the first 2 d of dietary intake from each survey have been included in this analysis to provide fairly comparable measurement periods and protocols. In the cases where either d 1 or 2 results were not obtained, the individuals with only the other day were included.

Snack vs. meal definitions. The USDA and NHANES surveys collected information on eating occasions, such as snacks and meals. Each eating occasion was determined by the respondent in each survey. Respondents were asked to name the type of each eating occasion. The time when the eating or drinking event began was recorded for each food or beverage. The snack category included those eating occasions defined by the respondent as "snack," plus the occasions related to snacking, such as food and/or coffee/beverage breaks. Meals were defined by the respondent as breakfast/brunch, lunch, and dinner/supper. People often consume more than 1 food item when having a snack. Therefore, we combined all snack foods consumed within 15 min of each other as a single snacking occasion. To determine whether participants were snackers or not, we classified them as snackers if they snacked on any day of intake. For those individuals who snacked on d 1 and 2, we computed the contribution of snacking for each day and then averaged these contributions. Also, some people defined foods eaten at the same time as both snack and meal. We changed them all to meal if any were defined as a snack, as in all cases most of the foods were identified as 1 of 3 meals (e.g. eating chips with a lunch). In NCFS 77, CSFII 89, and CSFII 96, we found eating occasions defined as "other" or "no answer." If a person did not have 3 meals, the missing values were recoded as meals according to the eating time. The remaining eating occasions were assigned to meals if the person did not eat 3 meals. Finally, the remaining missing eating occasions were considered as snacks. In summary, we have set 3 principal meals, if possible, and then we have studied the snacking behavior outside them in all the years surveyed.

University of North Carolina at Chapel Hill food grouping system. To determine those food items contributing to energy intake, the University of North Carolina at Chapel Hill (UNC-CH) food grouping system was used. This food grouping system links all foods from 1965 to the present. Comparable food composition Latin names and nutrient compositions are used to link the same foods in each food group over time. All the foods reported in the USDA surveys were assigned to the 107 UNC-CH food groups. First, we assigned the major food groupings designated by the USDA and then further classified them according to fat and fiber content. The UNC-CH food grouping system has been previously described (46). For all individuals, the amount of snacking energy provided by each UNC-CH food group was calculated and then divided by the total energy from snacking of all individuals. Those food groups contributing the most to snacking energy intake are reported. Diet soft drinks and sweetened or unsweetened coffee/tea were excluded as snacks from analysis of shifts in energy in the food group analysis. These food items accounted for a very low percent of energy of the total snacking daily energy.

Water as a beverage was collected differently across the surveys. Because plain water was added as a food item in 2003, we determined that water accounted for up to 5% of all the reported foods in 2003–2006 compared to 0% in all the other previous surveys. Water was deleted as a food item in all the years studied.

Statistical analysis. Data are presented as means ± SE. Snacking trends were studied dividing the population into 3 groups: 19–39 y old, 40–59 y old, and 60 y and older. We used survey commands to account for survey design, weighting, and clustering (47,48). The proportion of adults (19 y and older) consuming 0–2 snacks/d, 3–5 snacks/d, and >6 snacks/d within each sociodemographic characteristic and classified by BMI was determined in NHANES 03–06. The proportion of snackers within each age group by key sociodemographic groups was also determined in NHANES 03–06 but varied little between all subpopulations (**Supplemental Table 1**). For each survey year, the percentage of individuals who reported snacking on d 1, 2, or both was determined. For snackers, we computed each survey year by age group. We used both the mean number of snacking occasions per day, mean energy intake (kJ and kcal), and g consumed per snacking occasion for this computation. The contribution of snacking to total energy intake was also determined. The energy density of snacks (food and beverages or both) and meals (food and beverages or both) was calculated dividing the total energetic content of each category by the total amount of g consumed from them. Differences testing, by a Student's *t* test, used STATA, version 10 (47), to weight the results and control SE for sample design effects. A P-value ≤ 0.01 was considered significant.

Results

Proportion of adults by snacking groups. Some sociodemographic characteristics were related to a higher snacking habit defined in terms of number of daily snacking events (**Table 1**). Males, non-Hispanic Whites, and people with higher income level and education were mainly included in the group with 3–5 snacks/d ($P < 0.01$). Other descriptive characteristics such as BMI classified a higher proportion of normal and obese individuals in the group of 3–5 snacks/d, although these proportions did not differ from the group of 0–2 snacks/d.

Dynamic increases in snacking behavior. The prevalence of snackers over a 2-d period increased over all adults (≥19 y) from 71% in 1977 to 97% in 2003–2006 (percent of snackers on d 1, 2, or both) (**Fig. 1**). For the same period and age group, the percentage of snacking on both d 1 and d 2 increased from 42 to 78% (data not shown).

[4] Abbreviations used: CSFII, Continuing Survey of Food Intake by Individuals; NFCS, Nationwide Food Consumption Survey; UNC-CH, University of North Carolina at Chapel Hill.

TABLE 1 Proportion of adults (≥19 y) over a 2-d period by sociodemographic characteristics in the NHANES, 2003–2006[1–2]

Sample characteristics	Snacks/d 0–2	3–5	≥6
		%	
Weighted sample	38.5	41.5	20.0[a,b]
Males	37.5	42.5[a]	19.9[a,b]
Females	39.4	40.5	20.1[a,b]
Ethnicity[3]			
White, non-Hispanic	35.8	43.0[a]	21.3[a,b]
Black, non-Hispanic	43.1	39.8	17.1[a,b]
Hispanic	48.1	35.8[a]	16.1[a,b]
Income level[4]			
<185% National poverty level	42.5	38.8	18.7[a,b]
185–350% National poverty level	38.3	42.2	19.5[a,b]
>350% National poverty level	36.2	42.4[a]	21.4[a,b]
Household's education			
<High school diploma	41.4	40.0	18.6[a,b]
≥High school diploma	36.3	42.4[a]	21.4[a,b]
BMI			
Normal	36.5	41.8	21.7[a,b]
Overweight	38.7	39.3	22.1[a,b]
Obese	40.2	43.4	16.5[a,b]

[1] Data are weighted to account for survey design effects and to be nationally representative. [a]Different from 0–2 snacks/d, $P < 0.01$; [b]different from 3–5 snacks/d, $P < 0.01$ (*t* test).

[2] The proportion of snackers over a 2-d period by sociodemographic characteristics in the NHANES 2003–2006 is in **Supplemental Table 1**.

[3] Mexican American and Other Hispanic were included in the Hispanic group.

[4] To more accurately represent income level, household income is expressed as a percentage of the federal poverty thresholds adjusted for inflation. Each household's income is expressed as a percentage of the of the poverty thresholds of the appropriate size. Poverty thresholds are provided by USDA and DHHS Surveys (41–44).

Behavioral changes in snacking habits. Snacking occasions increased in all adults from 1977–1978 to 2003–2006 (~1 snack more) ($P < 0.01$) (**Table 2**). The middle-aged group (40–59 y) accounted for the highest number of snacks per day in 2003–2006 (2.35 ± 0.03). The age group with >60 y experienced the highest increase in the number of snacks per day, around 1.12 occasions more over the 1977–2006 time period. Regarding the energy intake per snacking event, changes between 1977–1978 and 2003–2006 were significant and large ($P < 0.01$) (Table 2). We found the largest increase in the energy intake per snacking event in the younger group (19–39 y) between 1977–1978 and 2003–2006 (~416 kJ more). Moreover, people between 19 and 39 y had more energy per snack than the others in 2003–2006

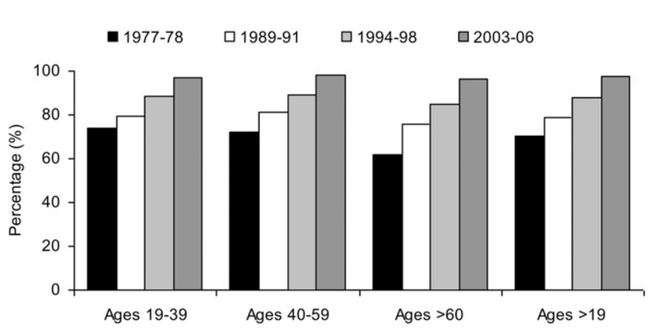

FIGURE 1 Percent of U.S. individuals consuming snacks over a 2-d period (% of snackers on d 1, 2, or both).

(1105 ± 20.60 kJ). The total g per snacking occasion increased across all age groups ($P < 0.01$) and participants aged 19–39 y had the highest amount of g per snacking occasion in 2003–2006 (374 ± 9.78). Finally, for total energy from snacks, the amount increased across all groups between each year (except 1994–2006 for those aged 19–30 y) ($P < 0.01$).

The increase in the total percentage of energy intake from snacking occasions in all age groups between 1977 and 2006 was significant ($P < 0.01$) (**Fig. 2**). There was also an increase between each time period in all age groups ($P < 0.01$), except for an insignificant change for young adults in the 1994–2006 time period. The percent of daily energy from snacks increased progressively in adults aged >19 y (~922 kJ/d more), contributing almost one-fourth of energy intake by 2006. Energy from snacks increased between 6 and 7 percentage points for all age groups over the 1977–2006 time period.

Snacking food and nutritional impact. **Table 3** presents the energy density of snacks and meals (foods, beverages, and both combined) in adults. Over the time period studied, we found a significant increasing trend for total snacking (food plus beverages) in all the age groups studied. The energy density of snacking beverages also increased in all the adults aged >19 y. Meals food also showed a significant increasing trend in all the adults for the studied periods.

The top 5 sources of energy were desserts, salty snacks, other snacks, sweetened beverages, and juices/fruit (**Fig. 3**). The major increase from 1997–1978 to 2003–2006 was found in low-fat and high-fat salty snacks, with small increases also in candies, nuts/seeds, alcoholic beverages, fruit drinks, and sport drinks. We found decreases for overall desserts (although low-fat desserts increased), milk/dairy, and juices/fruit.

Discussion

Over the past 2 decades, U.S. adults have steadily increased the number of daily snacking occasions. The percentage of energy intake from snacking occasions has increased to 24%. Interestingly, our results show significant shifts in snacking between the 1977–1978 period and the mid-1990s and again in the past decade. Not only do we find major increases in snacking behavior, but food sources of snacks have changed. Major shifts toward increased intake of salty snacks, chips, and nuts have occurred along with smaller shifts toward reduced amounts of desserts, dairy products, and fruit.

Snacking occasions and snacking foods for this study are based on a definition that focuses on self-selected snacking events but removes as snacks the foods that were eaten at meals. We also utilize food groups based on foods that are linked over time so the same foods are in the same food groups (48). Nevertheless, we differ from other scholars. For example, one recent study reported across the 4 NHANES surveys [I (1971–1975), II (1976–1980), III (1988–1994), and 1999–2002)] a decline in snacking prevalence (39). That we used only surveys with 2 d of dietary data may have been one reason for the different interpretation. Another may be our exclusion of snack foods such as chips consumed at a meal. NHANES collected only 1 d of dietary intake data before the integration in 2003 with the USDA and a combination of 1 d of direct face-to-face recall with a subsequent telephone interview. Other earlier research, with slightly less restrictive definitions of snacking events, found increased snacking patterns and a higher contribution to total daily energy over the 1977–1996 period (28,29).

TABLE 2 Number of snacks consumed per day and amount and energy consumed per snacking occasion by U.S. individuals from the 1977–1978, 1989–1991, 1994–1996, and 2003–2006 surveys by age group[1]

	1977–1978	1989–1991	1994–1996	2003–2006
Age 19–39 y				
Snacks, *n/d*	1.38 ± 0.04	1.63 ± 0.08[a]	1.94 ± 0.05[ab]	2.22 ± 0.03[abc]
Energy per snack				
kJ	692 ± 15.60	877 ± 15.24[a]	1097 ± 32.15[ab]	1105 ± 20.60[ab]
kcal	165 ± 3.73	210 ± 3.64[a]	262 ± 7.68[ab]	264 ± 4.92[ab]
(% from food)[2]	(38)	(48)	(57)	(62)
Snack size				
g	235 ± 4.98	290 ± 3.71[a]	370 ± 9.92[ab]	374 ± 9.78[ab]
(% from food)[3]	(23)	(34)	(43)	(51)
Total energy from snacking				
kJ	1689 ± 29.4	2106 ± 35.4[a]	2701 ± 82.0[ab]	2841 ± 56.7[ab]
kcal	403 ± 7.0	503 ± 8.5[a]	645 ± 19.6[ab]	679 ± 13.5[ab]
Age 40–59 y				
Snacks, *n/d*	1.34 ± 0.04	1.81 ± 0.08[a]	1.99 ± 0.04[a]	2.35 ± 0.03[abc]
Energy per snack				
kJ	563 ± 14.71	698 ± 30.33[a]	854 ± 18.44[ab]	916 ± 20.72[ab]
kcal	134 ± 3.51	167 ± 7.24[a]	204 ± 4.40[ab]	219 ± 4.95[ab]
(% from food)[2]	(38)	(51)	(60)	(68)
Snack size				
g/snack	212 ± 5.46	286 ± 8.38[a]	322 ± 6.96[ab]	354 ± 12.45[ab]
(% from food)[3]	(22)	(33)	(43)	(54)
Total energy from snacking				
kJ	1397 ± 27.5	1704 ± 103.1[a]	2115 ± 37.6[ab]	2398 ± 42.8[abc]
kcal	334 ± 6.6	407 ± 24.6[a]	505 ± 9.0[ab]	573 ± 10.2[abc]
Age ≥60 y				
Snacks, *n/d*	0.93 ± 0.03	1.38 ± 0.04[a]	1.65 ± 0.04[ab]	2.05 ± 0.03[abc]
Energy per snack				
kJ	483 ± 18.16	572 ± 19.19[a]	699 ± 15.29[ab]	719 ± 14.74[ab]
kcal	115 ± 4.34	137 ± 4.58[a]	167 ± 3.65[ab]	172 ± 3.52[ab]
(% from food)[2]	(34)	(47)	(58)	(68)
Snack size				
g	154 ± 5.08	189 ± 5.22[a]	221 ± 4.40[ab]	236 ± 6.69[ab]
(% from food)[3]	(23)	(36)	(46)	(55)
Total energy from snacking				
kJ	1163 ± 27.7	1316 ± 50.7[a]	1552 ± 35.2[ab]	1692 ± 36.8[abc]
kcal	278 ± 6.6	314 ± 12.1[a]	371 ± 8.4[ab]	404 ± 8.8[abc]
Age ≥19 y				
Snacks, *n/d*	1.26 ± 0.04	1.62 ± 0.06[a]	1.89 ± 0.04[ab]	2.23 ± 0.02[abc]
Energy per snack				
kJ	604 ± 13.20	744 ± 15.40[a]	918 ± 15.77[ab]	946 ± 15.43[ab]
kcal	144 ± 3.15	178 ± 3.68[a]	219 ± 3.77[ab]	226 ± 3.68[ab]
(% from food)[2]	(37)	(49)	(58)	(66)
Snack size				
g	210 ± 4.49	263 ± 2.59[a]	318 ± 5.44[ab]	335 ± 7.51[ab]
(% from food)[3]	(23)	(34)	(44)	(53)
Total energy from snacking				
kJ	1493 ± 21.8	1785 ± 44.5[a]	2230 ± 41.5[ab]	2415 ± 37.2[abc]
kcal	357 ± 5.2	426 ± 10.6[a]	533 ± 8.5[ab]	579 ± 7.6[abc]

[1] All estimates are mean ± SE. Data were obtained from those individuals who reported any snack over a 2-d period (d1, 2, or both). [a]Different from 1977–1978, $P < 0.01$; [b]different from 1989–1991, $P < 0.01$; [c]different from 1994–1996, $P < 0.01$ (*t* test).

[2] % Energy from food was calculated dividing the energy from foods by the total energy (food plus beverages) × 100.

[3] % Grams from food was calculated dividing the grams from foods by the total grams (food plus beverages) × 100.

In a previous survey (mid-1990s) of U.S. individuals aged from 18 to 54 y, <1% reported no snacks (49). By focusing across all adults, utilizing the same food composition table, and using 2 da of dietary data in all time periods, we attempted to provide a more consistent measurement over time.

Small English snacking studies based on mid-1990s data found that adult snacking provided 17–29% of the total daily energy with younger and middle-aged adults consuming a larger proportion of energy from snacks (27,50). Our study, consistent with this last approach, states that the young adults (19–39 y

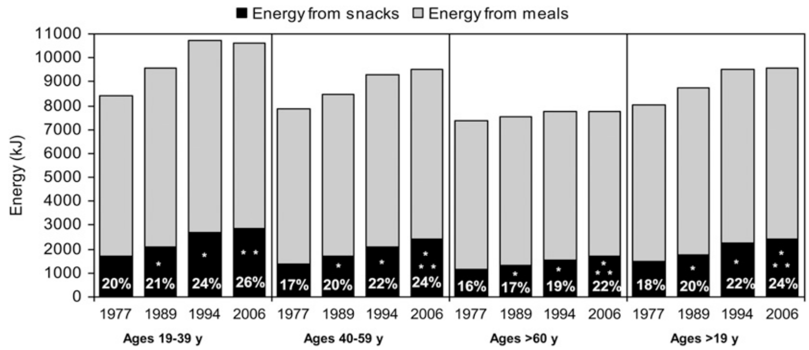

FIGURE 2 Contribution of snacking to total daily energy intake by year and age group. Numbers within solid dark bars in the bottom represent the mean percent of energy from snacks. *Different from the previous year, $P < 0.01$; **different between 1977–78 and 2003–06, $P < 0.01$ (t test).

old), and especially the middle-aged adults (40–59 y old), present critical snacking trends as was shown in the last periods (1989–1996 and 1996–2006).

This study is based on nationally representative data and found increased portion sizes in terms of both energy per snacking occasion and g per eating occasion. Our findings are consistent with others that reported increased portion sizes in U.S. surveys (13,14). Higher portion sizes might be linked to increased energy intake (51,52). Another component of possible sources of increased energy intake (along with number of occasions and portion sizes) is energy density, defined as the energy content per g of the eating event (snack or meal) that includes beverages, foods, and both combined (53–55). This study shows important trends toward higher energy density of snacks (meals plus beverages) and meals food over the 1977–2006 period.

TABLE 3 Trends in energy density of meals and snacking (food, beverages, or both) occasions in U.S. adults aged ≥19 y old

	1977–1978	1989–1991	1994–1996	2003–2006
Age 19–39 y		*kJ/g*[1]		
Total snacking	3.73	4.10[a]	4.15[a]	4.44[a]
Total meals	4.52	4.52	4.40	4.56[c]
Snacking food	12.06	12.35	11.85	12.31
Meals food	7.87	8.00	7.70[b]	8.21[ac]
Snacking beverages	1.26	1.21	1.30	1.47[abc]
Meals beverages	1.30	1.30	1.30	1.38[abc]
Age 40–59 y				
Total snacking	3.43	3.43	3.89[ab]	3.94[ab]
Total meals	4.06	4.06	3.98	4.06
Snacking food	11.39	12.10[a]	11.51[b]	11.81
Meals food	7.33	7.37	7.24	7.70[abc]
Snacking beverages	1.00	0.92	1.00	1.13[b]
Meals beverages	0.92	0.96	0.96	1.00[a]
Age ≥60 y				
Total snacking	4.23	4.23	4.52	4.73[a]
Total meals	3.98	3.77[a]	3.77[a]	3.85[ac]
Meals food	6.99	6.57[a]	6.49[a]	6.99[bc]
Snacking beverages	1.30	1.30	1.26	1.21
Meals beverages	0.88	0.96	0.88	0.92
Age ≥19 y				
Total snacking	3.73	3.89	4.15[a]	4.31[ab]
Total meals	4.23	4.19	4.10[a]	4.23[c]
Snacking food	11.60	11.77	11.35[b]	11.85[c]
Meals food	7.49	7.45	7.24[a]	7.75[abc]
Snacking beverages	1.17	1.13	1.21	1.30[ab]
Meals beverages	1.09	1.09	1.09	1.13

[1] Total snacking and meals energy density combines food plus beverages. [a]Different from 1977–1978, $P < 0.01$; [b]different from 1989–1991, $P < 0.01$; [c]different from 1994–1996, $P < 0.01$ (t test).

There are limitations to our analysis of snacking trends. Different methodologies were used in the dietary surveys, particularly the shift into the 1990s from the 1980s. Subsequent changes have been much smaller. To capture more accurately the total diet, both USDA and NHANES, and later the combined system of the 2003–2006 period, increased the number of passes through the day with repeated queries on what has been eaten in the 1990s. The most important subsequent change, a shift to a second day of dietary intake data for NHANES, started after the merger with the USDA survey system in the 2003–2006 period. The introduction of the multiple pass method in the 1990s may have added additional snacks in that period; however, the methodological changes between the 1990 and most recent data are smaller. Furthermore, the consequences of these methodological changes have not been measured with a bridging study as was done between shifts in methods in the 1970s to the1980s (56). Also, for NHANES in particular, different nutrient databases have been used for each survey. For both, shifts in the measurement and accuracy of data for foods and the changes in the food supply could affect the composition of these nutrient databases. We addressed these food composition table concerns by using the system developed by this UNC team. This allowed us to link food coded and collected in the last survey with foods consumed by respondents in earlier surveys and ensure consistently high-quality estimates of nutrient values over time (57). There were also a different number of days of data collection in each survey. While NFCS 77 and CSFII 89 collected 3 d of intake, in CSFII 96 and NHANES 2003–2006 only 2 d of intake were recorded. Using 3 d of data would create noncomparable information. Further, the record data for d 3 provides surprisingly distinct and less believable results (only 4% of participants reported snacking on d 3) (28). Selection of comparable 2-d periods seemed the best way to provide comparable data. Using 2 d is a closer approximation of usual intake, although it would be better if these days were always measured randomly many days apart.

We developed a restrictive approach to the definition of snacking. We combined all the snacks consumed within 15 min of each other and we recoded those foods defined as snacks, but eaten as part of a meal, as a meal only. There have been different considerations of snacking, based on the name occasions reported by the participants, and/or counting each snack food eaten at a unique time interval as 1 snacking occasion (39,58). Others defined snacks according to the time of day or type of foods consumed (49,50,59,60). To date, there is no consensus about the snack foods or meal foods definitions. However, we think self-identification of a snacking occasion provides some

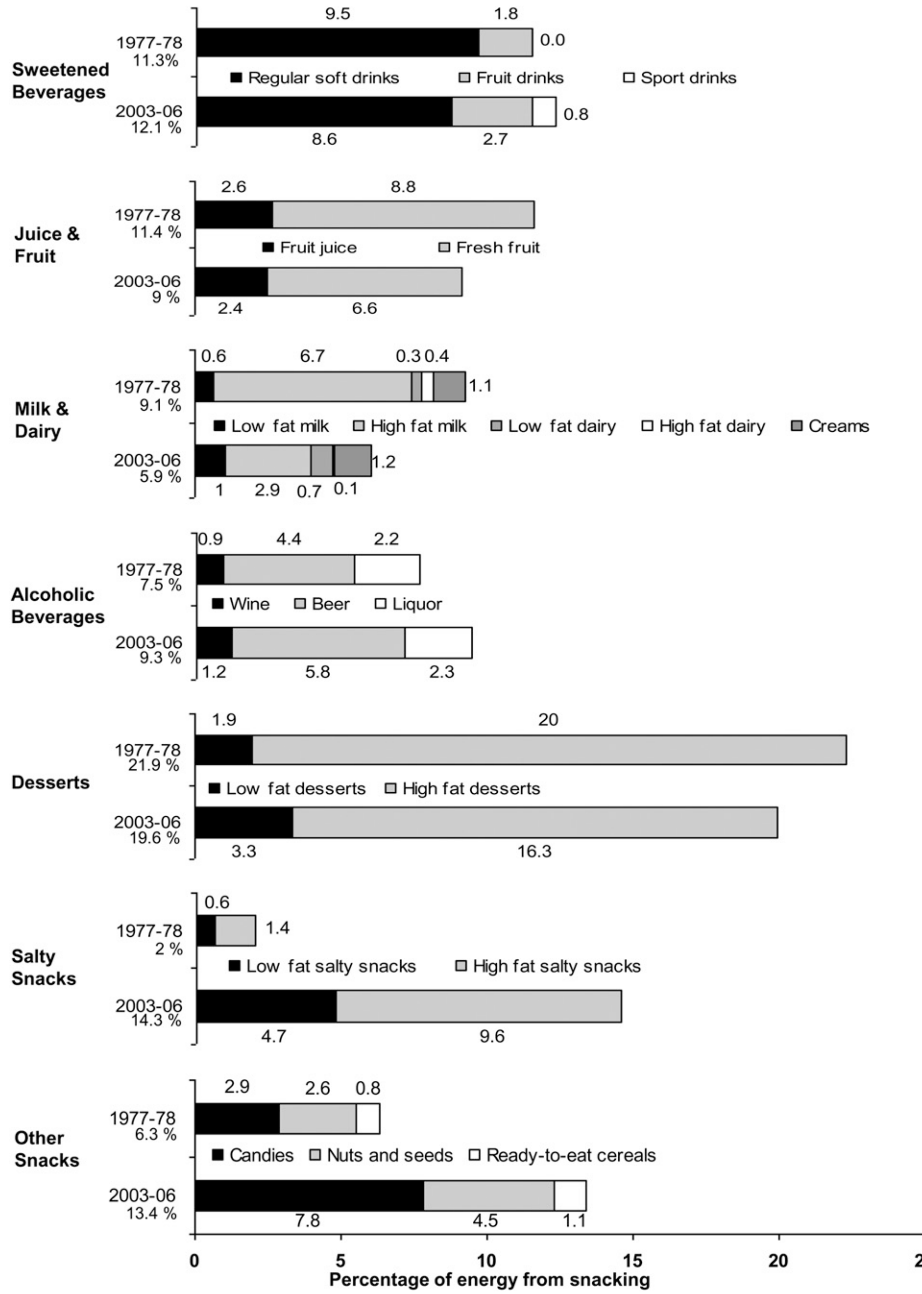

FIGURE 3 The proportion of snacking energy from food groups in U.S. adults aged 19 y and older. Colored bars represent percents of energy from snacking energy intake. The UNC-CH Food Grouping System was used to select the main food groups. Desserts include cakes, cookies, pies, bars, ice cream, and gelatin desserts. High-fat desserts were defined as those with >5 g fat/100 g of food. Salty snacks include crackers, chips, popcorn, and pretzels. High-fat salty snacks were defined as those with >5 g fat/100 g of food.

consistency over time, particularly with the large variance in time at which identified meals are consumed over time and across our age groups.

This study shows important shifts in the number of snacking occasions, foods consumed, and total contribution of snacks to overall energy intake across 3 age groupings of U.S. adults. The implications of these changes for overall energy intake, energy imbalance, and metabolic functioning need to be understood.

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Literature Cited

1. Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM. Prevalence of overweight and obesity in the United States, 1999–2004. JAMA. 2006;295:1549–55.
2. Kant AK, Schatzkin A, Graubard BI, Ballard-Barbash R. Frequency of eating occasions and weight change in the NHANES I Epidemiologic Follow-up Study. Int J Obes Relat Metab Disord. 1995;19:468–74.
3. Rolland-Cachera MF, Deheeger M, Bellisle F. Nutrient balance and body composition. Reprod Nutr Dev. 1997;37:727–34.
4. Bellisle F, McDevitt R, Prentice AM. Meal frequency and energy balance. Br J Nutr. 1997;77 Suppl 1:S57–70.
5. Kant AK, Schatzkin A, Ballard-Barbash R. Evening eating and subsequent long-term weight change in a national cohort. Int J Obes Relat Metab Disord. 1997;21:407–12.

6. Roberts SB. High-glycemic index foods, hunger, and obesity: is there a connection? Nutr Rev. 2000;58:163–9.
7. Roberts SB, Williamson DF. Causes of adult weight gain. J Nutr. 2002;132:S3824–5.
8. Roberts SB, McCrory MA, Saltzman E. The influence of dietary composition on energy intake and body weight. J Am Coll Nutr. 2002;21:S140–5.
9. McCrory MA, Suen VM, Roberts SB. Biobehavioral influences on energy intake and adult weight gain. J Nutr. 2002;132:S3830–4.
10. Hays NP, Bathalon GP, McCrory MA, Roubenoff R, Lipman R, Roberts SB. Eating behavior correlates of adult weight gain and obesity in healthy women aged 55–65 y. Am J Clin Nutr. 2002;75:476–83.
11. Ma Y, Bertone ER, Stanek EJ III, Reed GW, Hebert JR, Cohen NL, Merriam PA, Ockene IS. Association between eating patterns and obesity in a free-living US adult population. Am J Epidemiol. 2003;158: 85–92.
12. Guthrie JF, Lin BH, Frazao E. Role of food prepared away from home in the American diet, 1977–78 versus 1994–96: changes and consequences. J Nutr Educ Behav. 2002;34:140–50.
13. Nielsen SJ, Popkin BM. Patterns and trends in food portion sizes, 1977–1998. JAMA. 2003;289:450–3.
14. Smiciklas-Wright H, Mitchell DC, Mickle SJ, Goldman JD, Cook A. Foods commonly eaten in the United States, 1989–1991 and 1994–1996: are portion sizes changing? J Am Diet Assoc. 2003;103:41–7.
15. Bray GA, Paeratakul S, Popkin BM. Dietary fat and obesity: a review of animal, clinical and epidemiological studies. Physiol Behav. 2004;83: 549–55.
16. Kant AK, Graubard BI. Eating out in America, 1987–2000: trends and nutritional correlates. Prev Med. 2004;38:243–9.
17. Popkin BM. Global nutrition dynamics: the world is shifting rapidly toward a diet linked with noncommunicable diseases. Am J Clin Nutr. 2006;84:289–98.
18. Popkin BM. The world is fat: the fads, trends, policies, and products that are fattening the human race. New York: Avery; 2009.
19. Fabry P, Fodor J, Hejl Z, Geizerova H, Balcarova O. Meal frequency and ischaemic heart-disease. Lancet. 1968;2:190–1.
20. Jenkins DJ, Wolever TM, Vuksan V, Brighenti F, Cunnane SC, Rao AV, Jenkins AL, Buckley G, Patten R, et al. Nibbling versus gorging: metabolic advantages of increased meal frequency. N Engl J Med. 1989;321:929–34.
21. Summerbell CD, Moody RC, Shanks J, Stock MJ, Geissler C. Relationship between feeding pattern and body mass index in 220 free-living people in four age groups. Eur J Clin Nutr. 1996;50:513–9.
22. Metzner HL, Lamphiear DE, Wheeler NC, Larkin FA. The relationship between frequency of eating and adiposity in adult men and women in the Tecumseh Community Health Study. Am J Clin Nutr. 1977;30: 712–5.
23. Edelstein SL, Barrett-Connor EL, Wingard DL, Cohn BA. Increased meal frequency associated with decreased cholesterol concentrations; Rancho Bernardo, CA, 1984–1987. Am J Clin Nutr. 1992;55:664–9.
24. Hampl JS, Heaton CL, Taylor CA. Snacking patterns influence energy and nutrient intakes but not body mass index. J Hum Nutr Diet. 2003;16:3–11.
25. Drummond SE, Crombie NE, Cursiter MC, Kirk TR. Evidence that eating frequency is inversely related to body weight status in male, but not female, non-obese adults reporting valid dietary intakes. Int J Obes Relat Metab Disord. 1998;22:105–12.
26. Berteus Forslund H, Torgerson JS, Sjostrom L, Lindroos AK. Snacking frequency in relation to energy intake and food choices in obese men and women compared to a reference population. Int J Obes (Lond). 2005;29:711–9.
27. Drummond S, Crombie N, Kirk T. A critique of the effects of snacking on body weight status. Eur J Clin Nutr. 1996;50:779–83.
28. Jahns L, Siega-Riz AM, Popkin BM. The increasing prevalence of snacking among US children from 1977 to 1996. J Pediatr. 2001;138: 493–8.
29. Zizza C, Siega-Riz AM, Popkin BM. Significant increase in young adults' snacking between 1977–1978 and 1994–1996 represents a cause for concern! Prev Med. 2001;32:303–10.
30. Wansink B. "Snack attack? Don't be tricked by low fat labels. It's easy to overeat when you think treats are 'good' for you." 2007 Mar 9. Available from: http://www.msnbc.msn.com/id/17469445/.
31. Tholin S, Lindroos A, Tynelius P, Akerstedt T, Stunkard AJ, Bulik CM, Rasmussen F. Prevalence of night eating in obese and nonobese twins. Obesity (Silver Spring). 2009;17:1050–5.
32. Stunkard AJ, Allison KC, O'Reardon JP. The night eating syndrome: a progress report. Appetite. 2005;45:182–6.
33. Basdevant A, Craplet C, Guy-Grand B. Snacking patterns in obese French women. Appetite. 1993;21:17–23.
34. Andersson I, Rossner S. Meal patterns in obese and normal weight men: the 'Gustaf' study. Eur J Clin Nutr. 1996;50:639–46.
35. Schoeller DA. Limitations in the assessment of dietary energy intake by self-report. Metabolism. 1995;44:18–22.
36. Heitmann BL, Lissner L, Osler M. Do we eat less fat, or just report so? Int J Obes Relat Metab Disord. 2000;24:435–42.
37. Poppitt SD, Swann D, Black AE, Prentice AM. Assessment of selective under-reporting of food intake by both obese and non-obese women in a metabolic facility. Int J Obes Relat Metab Disord. 1998;22:303–11.
38. Howarth NC, Huang TT, Roberts SB, Lin BH, McCrory MA. Eating patterns and dietary composition in relation to BMI in younger and older adults. Int J Obes (Lond). 2007;31:675–84.
39. Kant AK, Graubard BI. Secular trends in patterns of self-reported food consumption of adult Americans: NHANES 1971–1975 to NHANES 1999–2002. Am J Clin Nutr. 2006;84:1215–23.
40. Rizek R. The 1977–78 Nationwide Food Consumption Survey. Fam Econ Rev. 1978;4:3–7.
41. USDA ARS, Beltsville Human Nutrition Research Center, Group FSR. Continuing Survey of Food Intakes by Individuals 1989–91 and Diet and Health Knowledge Survey 1989–91: documentation (csfii8991_documentation.pdf). Beltsville, MD [cited 2009 May 6]. Available from: http://www.ars.usda.gov/Services/docs.htm?docid=14541.
42. USDA ARS, Beltsville Human Nutrition Research Center, Group FSR. Continuing Survey of Food Intakes by Individuals 1994–96, 1998 and Diet and Health Knowledge Survey 1994–96: documentation (csfii9498_documentationupdated.pdf). Beltsville, MD [cited 2009 May 6]. Available from: http://www.ars.usda.gov/Services/docs.htm?docid=14521.
43. USDA ARS, Beltsville Human Nutrition Research Center, Group FSR. What We Eat in America, NHANES 2003–2004. Beltsville, MD. [cited 2009 May 15]. Available from: http://www.cdc.gov/nchs/about/major/nhanes/nhanes2003–2004/dr1tot_c.xpt.
44. USDA ARS, Beltsville Human Nutrition Research Center, Food Surveys Research Group. U.S. Department of Health and Human Services CfDCaP, National Center for Health Statistics (Hyattsville, MD). What We Eat in America, NHANES 2005–2006. [cited 2009 May 15]. Available from: http://www.cdc.gov/nchs/about/major/nhanes/nhanes2005–2006/dr1tot_c.xpt. 2005.
45. Haines PS, Hama MY, Guilkey DK, Popkin BM. Weekend eating in the United States is linked with greater energy, fat, and alcohol intake. Obes Res. 2003;11:945–9.
46. Duffey KJ, Gordon-Larsen P, Ayala GX, Popkin BM. Birthplace is associated with more adverse dietary profiles for US-born than for foreign-born Latino adults. J Nutr. 2008;138:2428–35.
47. Stata Corp. STATA V.X. College Station (TX): Stata Corp.; 2009.
48. Popkin BM, Haines PS, Siega-Riz AM. Dietary patterns and trends in the United States: the UNC-CH approach. Appetite. 1999;32:8–14.
49. Cross AT, Babicz D, Cushman LF. Snacking patterns among 1,800 adults and children. J Am Diet Assoc. 1994;94:1398–403.
50. Summerbell CD, Moody RC, Shanks J, Stock MJ, Geissler C. Sources of energy from meals versus snacks in 220 people in four age groups. Eur J Clin Nutr. 1995;49:33–41.
51. Rolls BJ, Roe LS, Meengs JS. Reductions in portion size and energy density of foods are additive and lead to sustained decreases in energy intake. Am J Clin Nutr. 2006;83:11–7.
52. Rolls BJ, Morris EL, Roe LS. Portion size of food affects energy intake in normal-weight and overweight men and women. Am J Clin Nutr. 2002;76:1207–13.
53. Rolls BJ, Drewnowski A, Ledikwe JH. Changing the energy density of the diet as a strategy for weight management. J Am Diet Assoc. 2005;105:S98–103.
54. Drewnowski A. The role of energy density. Lipids. 2003;38:109–15.
55. Stubbs RJ, Whybrow S. Energy density, diet composition and palatability: influences on overall food energy intake in humans. Physiol Behav. 2004;81:755–64.

56. Guenther P, Perloff B. Effects of procedural differences between 1977 and 1987 in the nationwide food consumption survey on estimates of food and nutrient intakes: results of the USDA 1988 Bridging Study. Washington, DC: USDA, Human Nutrition Information Service; 1990.
57. Popkin BM, Haines PS, Reidy KC. Food consumption trends of US women: patterns and determinants between 1977 and 1985. Am J Clin Nutr. 1989;49:1307–19.
58. Bigler-Doughten S, Jenkins RM. Adolescent snacks: nutrient density and nutritional contribution to total intake. J Am Diet Assoc. 1987;87: 1678–9.
59. Devaney BL, Gordon AR, Burghardt JA. Dietary intakes of students. Am J Clin Nutr. 1995;61:S205–12.
60. Ezell JM, Skinner JD, Penfield MP. Appalachian adolescents' snack patterns: morning, afternoon, and evening snacks. J Am Diet Assoc. 1985;85:1450–4.