Characterizing eating patterns: a comparison of eating occasion definitions[1]

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ABSTRACT

Background: To date, many approaches have been used to define eating occasions (EOs). A standard definition for EOs is required to facilitate further research.

Objective: In this study, we examined the influence of differing definitions of EOs on the characterization of eating patterns.

Design: Cross-sectional dietary data from two 24-h recalls collected during the 2011–12 Australian National Nutrition and Physical Activity Survey (n = 5242 adults, aged ≥19 y) were analyzed. Eight definitions were applied: participant-identified, time-of-day, and 6 neutral definitions (individual EOs separated by different time intervals and/or an additional energy criterion of 210 kJ). Frequency of and total energy intake from meals, snacks, and all EOs were estimated, as appropriate. Differences were tested by using F tests, stratified by sex and age group. Agreement between different definitions of meal and snack frequencies was assessed by using intraclass correlation coefficients (ICCs). For each definition, linear regression was used to estimate the proportion of variance in total energy intake (kJ) and amount of food intake (g) predicted by frequency of EOs and meals and snacks.

Results: Among both sexes and across all age groups, mean frequencies of meals differed between the participant-identified and time-of-day definitions (mean difference range = 0.1–0.3; $P < 0.001$). There were statistically significant differences between mean frequencies of EOs across the 6 neutral definitions ($P < 0.001$). There was good agreement for snacks (men: ICC = 0.89; women: ICC = 0.87) but not meal frequencies (men: ICC = 0.38; women: ICC = 0.36) between the participant-identified and time-of-day definitions. The neutral definition (15-min time interval plus energy criterion) best predicted variance in total energy intake (R^2 range = 19.3–27.8).

Conclusions: Different approaches to the definition of EOs affect how eating patterns are characterized, with the neutral definition best predicting variance in total energy intake. Further research that examines how different EO definitions affect associations with health outcomes is needed to develop consensus on a standard EO definition. *Am J Clin Nutr* 2015;102:1229–37.

Keywords: eating frequency, eating occasions, eating patterns, meal frequency, snack frequency

INTRODUCTION

There is growing evidence suggesting that eating patterns are important determinants of diet quality, energy and nutrient intakes, and cardiometabolic health (1–3). However, although skipping breakfast has been inversely associated with diet quality (4–9) and prospectively associated with poor cardiometabolic health outcomes (10–13), evidence for other types of eating patterns has been less consistent (1, 2, 12–17). A possible reason for this inconsistency is the diversity of approaches used to define an eating occasion (EO) (18). This heterogeneity is a major impediment to the interpretation of findings across studies (1, 2, 18–20), because the definition of an EO, be it a meal, snack, or any occasion where food and/or beverage is consumed, may affect how eating patterns are characterized in terms of frequency, spacing, and timing. Differences in eating pattern characterization may affect the direction and magnitude of associations with diet quality and health outcomes. However, this issue has received little attention (1).

Some researchers have defined meals and snacks separately (21–26), whereas others have assessed individual EOs (16, 26–28), a neutral term that encompasses both meals and snacks. For example, a participant-identified approach (22, 24, 26) asks participants to identify each EO as a meal or snack, whereas the time-of-day approach (23, 29, 30) delineates meals and snacks according to the time of day in which the EO occurs. When defining EOs, there is a lack of consensus around what constitutes an individual EO, with different time intervals (e.g., 15, 30, 45, and 60 min) often used to separate EOs from the surrounding EOs (22, 25, 28, 31). In addition to a time interval, Gibney and Wolever (32) proposed that an EO should also contain a minimum energy content of 210 kJ (50 kcal), and this criterion has been adopted in many subsequent studies (14, 31, 33).

The importance of EO definition choice was highlighted in a recent study that examined associations between overall eating frequency and measures of adiposity (14). Murakami and Livingstone

[1] Supported by an Australian Postgraduate Award Scholarship (to RML), an Australian Research Council Future Fellowship (FT100100581; to SAM), and a National Heart Foundation Future Leader Fellowship (Award number: 100046; to AT).

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Received May 6, 2015. Accepted for publication September 10, 2015.

First published online October 7, 2015; doi: 10.3945/ajcn.115.114660.

(14) reported that applying a minimum energy criterion of 210 kJ, compared with no energy criterion, significantly reduced the number of reported EOs per day and strengthened associations between eating frequency and BMI and waist circumference. This suggests that methodologic differences in defining a single EO affect both eating pattern characterization and associations with health outcomes. A clear and objective definition of a "meal" and a "snack" is also crucial for understanding how different EO types affect diet quality and health outcomes. Methodologic differences in the definition of meals and/or snacks may result in classification differences (1). That is, time-of-day vs. participant-identified approaches may yield different eating patterns for persons who eat outside of conventional mealtimes. Although many definitions are available to characterize eating patterns, evidence to guide which definition to use is currently lacking (18). Therefore, the aim of this study was to compare different EO definitions with the characterization of eating patterns by using nationally representative data on Australian adults.

METHODS

Sample and study design

Data for this study were drawn from the 2011–12 Australian National Nutrition and Physical Activity Survey, a cross-sectional, nationally representative survey conducted by the Australian Bureau of Statistics. The survey, which used a multistage, stratified-area, probability sampling design, sampled householders in private dwellings in 8 states and territories of Australia. The final responding sample included 12,153 respondents aged ≥2 y (77% response rate), of whom 9341 were adults aged ≥19 y. Person-specific weights, adjusted for probability of selection and nonresponse, were used to provide estimates relating to the whole population. Detailed information on the method of the survey has been published previously (34). Ethics approval for the Australian Bureau of Statistics to conduct household interview components of health surveys was provided by the Census and Statistics Act of 1905 (34).

Dietary assessment

Dietary intake was assessed during two 24-h recalls via a computer-assisted personal interview and a computer-assisted telephone interview. The computer-assisted telephone interview was completed on a different day, approximately 9 d after the computer-assisted personal interview, by 65% (n = 6053) of the 9341 adult respondents. The dietary recalls were conducted across all days of the week and all months of the year and used the USDA Research Service 5-pass dietary recall method (35). Information on respondents' EOs were collected during each 24-h recall. Respondents were asked to name the type of EO and the time of day when the EO commenced. Response options for EO type included breakfast, brunch, lunch, dinner, supper, snack, morning tea, afternoon tea, drink/beverage, extended consumption, other, and don't know/not determined. Each food and beverage reported in the 24-h recall was uniquely coded, and energy intakes were calculated from the Australian Supplement and Nutrient Database 2011–13, developed by the Food Standards Australia New Zealand. Dietary information was averaged across the 2 d of recall to obtain mean estimates of energy intake and eating patterns.

EO definitions

Eight definitions, based on previously published definitions (14, 22, 23, 26, 29, 30, 32, 33), were applied and are summarized in **Table 1**. These approaches were broadly categorized as either *1*) definitions that delineate meals and snacks (participant identified and time of day) (22, 26, 29, 30) or *2*) definitions that only delineate individual EOs (neutral) (14, 28, 32, 33). For all EO definitions, beverages (except plain drinking water) consumed in the absence of food could also constitute an individual EO.

Classifying meals and snacks

For the participant-identified definition, EOs reported by respondents in the 24-h recall as breakfast, brunch, lunch, dinner, and supper were considered meals, and EOs reported as a snack, morning tea, afternoon tea, and beverage/break were considered snacks. EOs reported as "extended consumption" and "other" (including "other" and "don't know/not determined") were considered meals and snacks if they occurred ≤15 min after a meal or snack EO, respectively, because it was inferred that this EO was a continuation of the preceding EO. For the time-of-day definition, a meal was defined as the largest EO (in terms of energy, kJ) occurring between 0600 and 1000 h, 1200 and 1500 h,

TABLE 1
Summary of the 8 eating occasion definitions that were compared[1]

Definition applied	Description
Meals and snacks	
1) Participant identified	Meal: EOs reported by respondents as breakfast, brunch, lunch, dinner, and supper
	Snack: EOs reported by respondents as snack, morning/afternoon tea, and beverage break
2) Time of day	Meal: Largest EO (kJ) occurring between 0600 and 1000, 1200 and 1500, and 1700 and 2100
	Snack: All other EOs
EOs	
3) Neutral: 15-min time interval	An individual EO is separated in time from the preceding and succeeding EO by >15 min
4) Neutral: 15-min time interval plus 210-kJ energy criterion	An individual EO contains a minimum energy content of 210 kJ and is separated in time from the preceding and succeeding EO by >15 min
5) Neutral: 30-min time interval	An individual EO is separated in time from the preceding and succeeding EO by >30 min
6) Neutral: 30-min time interval plus 210-kJ energy criterion	An individual EO contains a minimum energy content of 210 kJ and is separated in time from the preceding and succeeding EO by >30 min
7) Neutral: 60-min time interval	An individual EO is separated in time from the preceding and succeeding EO by >60 min
8) Neutral: 60-min time interval plus 210-kJ energy criterion	An individual EO contains a minimum energy content of 210 kJ and is separated in time from the preceding and succeeding EO by >60 min

[1]EO, eating occasion.

and 1700 and 2100 h. All other EOs occurring within these times and any EOs occurring outside of these times were considered snacks.

During data cleaning, it was found that some respondents (n = 524) reported 2 different types of EOs at the same clock time (e.g., lunch and snack EOs were both reported at 1400 h). Therefore, a standardized and consistent approach to data cleaning, adapted from previous research, was applied to both the participant-identified and time-of-day definitions (26, 36). Where respondents reported a meal and a snack EO at the same clock time, all foods reported as the snack EO were recoded to the meal EO, unless the respondent had already reported that same meal EO earlier in the day, in which case the meal EO was recoded to the snack EO. Where foods/beverages consumed as extended consumption or other were reported at the same time as a meal or snack, all foods reported at this EO were recoded to the respective meal or snack EO. Where respondents also reported eating multiple snacks or multiple meals close together in time, all foods and beverages pertaining to the same EO type consumed ≤15 min of each other were combined, consistent with the published literature (22, 26).

Six variations of the neutral definition of an EO were applied (Table 1). For the first 3 variations, an EO was defined as any occasion where food and/or beverages were consumed with all EOs separated in time from the preceding and succeeding EO by 15, 30, and 60 min, respectively, classing as an individual or separate EO. Where multiple EOs occurred ≤15, ≤30, and ≤60 min of each other, respectively, these were also combined as a single EO. For the final 3 variations of the neutral definition, an energy criterion of 210 kJ [as per Gibney and Wolever (32)] was applied in addition to the time intervals of 15, 30, and 60 min. For example, an EO had to contain a minimum of 210 kJ and be separated in time from the preceding and succeeding EOs by at least 15, 30, and 60 min, respectively.

Eating pattern variables

For the participant-identified and time-of-day definitions, the mean total frequency of meals and snacks, the mean total energy intake (kJ) from meals and snacks, and the mean total energy intake per meal and snack were calculated. For the neutral definitions, the mean total frequency of all EOs, the mean total energy intake (kJ) from all EOs, and the mean total energy intake per EO were calculated. To estimate the mean total frequency and mean total energy intake from EOs containing beverages only, we grouped all items reported in the 24-h recalls into beverage and nonbeverage items by using the Food Standards Australia New Zealand 8-digit food grouping codes that uniquely identify each food. For respondents, where ≥2 foods/beverages were combined just before eating, a combination code from Food Standards Australia New Zealand was used to identify and group foods consumed as a beverage (e.g., sugar added to tea or coffee) or as food (e.g., milk added to breakfast cereal). The clock time of when each EO commenced was used to calculate the mean time (minutes) between EOs. Therefore, estimates of spacing between EOs did not account for the duration of the EO.

Sociodemographics

Respondents' sex and age, the highest level of education, and country of birth were requested in the household survey. Age was categorized into the following age groups, consistent with the age groups outlined in the Nutrient Reference Values for Australian adults (37): 19–30, 31–50, 51–70, and ≥71 y. Educational level was categorized as low (completed some high school or less), medium (completed high school or completed some high school and/or certificate/diploma), or high (having a tertiary qualification). Country of birth was categorized by the Australian Bureau of Statistics as Australia, other main English-speaking countries, and all other countries.

Analytic sample

Adults aged ≥19 y who completed two 24-h recalls (n = 3288 excluded) and were not pregnant, breastfeeding, or undertaking shiftwork in the past 4 mo (n = 687 excluded) were eligible for inclusion in the present study (n = 5366). Eight participants reported consuming only water during one of the 24-h recalls and were excluded from the analysis. After the recoding of EO variables, 116 respondents who had remaining EOs that either were not identified as a meal/snack (e.g., individual EOs reported as other, don't know, or extended consumption) or were missing the time at which an EO commenced were also excluded from the analysis. After exclusions (n = 4099), the final analytic sample was 5242 adults (2402 men and 2840 women).

Statistical analyses

All analyses were conducted with Stata 13 (StataCorp LP) and were stratified by sex and age group. Point estimates were derived by using the appropriate person weights, and replicate weights were applied to compute jackknife SEs to account for the clustered survey design. Descriptive statistics for sociodemographic and meal pattern variables are presented as weighted proportions or weighted means ± SDs. The F test (TEST command) was used to determine differences between EO definitions, and the Bonferroni correction (with α set at 0.05) was used to account for multiple testing across >2 EO definitions. Intraclass correlation coefficients (ICCs) were used to assess the

TABLE 2
Sociodemographic characteristics of participants in the NNPAS 2011–12[1]

	Men (n = 2402)	Women (n = 2840)
Age group, y		
19–30	22	19
31–50	35	34
51–70	32	33
≥71[2]	11	14
Country of birth		
Australia	69	69
Other main English-speaking countries	12	12
All other countries	19	19
Educational level		
Low[2]	21	29
Medium[2]	53	42
High	26	28

[1]Results are presented as weighted percentages (%). NNPAS, National Nutrition and Physical Activity Survey.

[2]Indicates significant differences (F test, $P < 0.001$) between men and women.

TABLE 3
Total frequency of meals and snacks, total energy intake from meals and snacks, and total energy intake per meal and per snack for the participant-identified vs. time-of-day definitions

	n	Participant identified	Time of day	*P* value[1]
Frequency of meals, *n*				
Men				
19–30 y	370	2.8 ± 0.5[2]	2.5 ± 0.4	<0.001
31–50 y	877	2.9 ± 0.5	2.8 ± 0.3	<0.001
51–70 y	820	2.9 ± 0.5	2.8 ± 0.3	<0.001
≥71 y	335	3.1 ± 0.5	2.9 ± 0.3	<0.001
Women, *n*				
19–30 y	388	2.9 ± 0.4	2.7 ± 0.3	<0.001
31–50 y	963	3.0 ± 0.5	2.9 ± 0.3	<0.001
51–70 y	1013	3.1 ± 0.6	2.9 ± 0.3	<0.001
≥71 y	476	3.1 ± 0.5	2.9 ± 0.3	<0.001
Frequency of snacks, *n*				
Men				
19–30 y	370	2.1 ± 1.0	2.4 ± 1.0	<0.001
31–50 y	877	2.7 ± 1.4	2.8 ± 1.4	<0.001
51–70 y	820	2.6 ± 1.4	2.7 ± 1.4	<0.001
≥71 y	335	2.4 ± 1.4	2.6 ± 1.5	<0.001
Women				
19–30 y	388	2.3 ± 1.1	2.4 ± 1.1	<0.001
31–50 y	963	2.9 ± 1.5	3.0 ± 1.5	<0.001
51–70 y	1013	2.7 ± 1.6	2.9 ± 1.6	<0.001
≥71 y	476	2.5 ± 1.5	2.7 ± 1.6	<0.001
Total eating frequency, *n*				
Men				
19–30 y	370	4.9 ± 1.1	4.9 ± 1.1	—
31–50 y	877	5.6 ± 1.5	5.6 ± 1.5	—
51–70 y	820	5.5 ± 1.5	5.5 ± 1.5	—
≥71 y	335	5.5 ± 1.5	5.5 ± 1.5	—
Women				
19–30 y	388	5.2 ± 1.2	5.2 ± 1.2	—
31–50 y	963	5.9 ± 1.6	5.9 ± 1.6	—
51–70 y	1013	5.8 ± 1.7	5.8 ± 1.7	—
≥71 y	476	5.6 ± 1.6	5.6 ± 1.6	—
Total EI[3] from meals				
Men				
19–30 y	370	7723 ± 1974	7252 ± 2042	<0.001
31–50 y	877	7517 ± 2436	7403 ± 2409	0.041
51–70 y	820	6951 ± 2281	6872 ± 2234	0.051
≥71 y	335	6553 ± 2177	6244 ± 2086	<0.001
Women				
19–30 y	388	5857 ± 1790	5693 ± 1724	0.034
31–50 y	963	5615 ± 2068	5493 ± 2004	0.001
51–70 y	1013	5558 ± 1999	5425 ± 1952	<0.001
≥71 y	476	5327 ± 1976	5206 ± 2009	0.001
Total EI from snacks, kJ				
Men				
19–30 y	370	2467 ± 1665	2938 ± 1661	<0.001
31–50 y	877	2530 ± 1877	2644 ± 1851	0.041
51–70 y	820	2138 ± 1742	2217 ± 1625	0.051
≥71 y	335	1594 ± 1362	1904 ± 1590	<0.001
Women				
19–30 y	388	1816 ± 1188	1979 ± 1199	0.034
31–50 y	963	1851 ± 1349	1972 ± 1369	0.001
51–70 y	1013	1578 ± 1318	1712 ± 1369	<0.001
≥71 y	476	1337 ± 1178	1457 ± 1125	0.001

(Continued)

TABLE 3 (*Continued*)

	n	Participant identified	Time of day	*P* value[1]
Total EI, kJ				
Men				
19–30 y	370	10,190 ± 2270	10,190 ± 2270	—
31–50 y	877	10,047 ± 3104	10,047 ± 3104	—
51–70 y	820	9089 ± 2872	9089 ± 2872	—
≥71 y	335	8147 ± 2539	8147 ± 2539	—
Women				
19–30 y	388	7672 ± 2208	7672 ± 2208	—
31–50 y	963	7465 ± 2453	7465 ± 2453	—
51–70 y	1013	7137 ± 2485	7137 ± 2485	—
≥71 y	476	6663 ± 2364	6663 ± 2364	—
Total EI per meal, kJ				
Men				
19–30 y	370	2839 ± 727	2879 ± 754	0.347
31–50 y	877	2626 ± 898	2642 ± 873	0.489
51–70 y	820	2389 ± 743	2420 ± 752	0.121
≥71 y	335	2131 ± 666	2152 ± 685	0.334
Women				
19–30 y	388	2071 ± 616	2093 ± 618	0.405
31–50 y	963	1898 ± 682	1921 ± 679	0.135
51–70 y	1013	1818 ± 635	1868 ± 634	0.003
≥71 y	476	1727 ± 620	1784 ± 637	<0.001
EI per snack, kJ				
Men				
19–30 y	370	1223 ± 947	1277 ± 591	0.412
31–50 y	877	974 ± 664	978 ± 592	0.846
51–70 y	820	825 ± 545	828 ± 497	0.846
≥71 y	335	669 ± 467	739 ± 463	0.004
Women				
19–30 y	388	870 ± 698	864 ± 536	0.898
31–50 y	963	656 ± 446	680 ± 446	0.043
51–70 y	1013	585 ± 427	593 ± 411	0.438
≥71 y	476	554 ± 432	561 ± 399	0.625

[1]*F* test of significant differences ($P < 0.01$) between definitions.
[2]Mean ± SD (all such values).
[3]EI, energy intake.

agreement between the absolute frequency of meal and snack EOs between the participant-identified and time-of-day definitions. Separate multiple linear regression models were used to determine the proportion of variance (model-adjusted R^2 value) in total energy intake (kJ) and total amount of food/beverage intake (g) predicted by the total meal and snack (both variables entered simultaneously in the model) and total EO frequency, calculated for each definition. The total energy intake and amount of food/beverage intake outcome variables were log-transformed before the regression analysis because they were positively skewed. For all analyses, $P < 0.01$ was considered statistically significant.

RESULTS

The sociodemographic characteristics of National Nutrition and Physical Activity Survey participants who completed two 24-h recalls, by sex, are presented in **Table 2**. Men were more highly represented than women in the medium education level category ($P < 0.001$), and a higher proportion of women were in the >70-y age group ($P < 0.001$) and the low–educational level category ($P < 0.001$).

The mean frequency of meals and snacks differed significantly ($P < 0.001$) after applying the participant-identified vs. the time-of-day definition among both men and women, across all age groups (**Table 3**). There were small but significant differences in total energy intake from meals and from snacks when applying the participant-identified definition vs. the time-of-day definition (Table 3). When applying the participant-identified approach, total energy intake was higher from meals and lower from snacks, but this difference was not significant across all age groups ($P > 0.01$). There were also few significant differences in the mean total energy intake per meal and per snack between these 2 definitions. There was good agreement in the frequency of snacks (men: ICC = 0.89; women: ICC = 0.87) between the participant-identified and time-of-day definitions. Results remained the same after stratification by age group (men: ICC range = 0.85–0.90; women: ICC range = 0.87–0.90). However, there was poor agreement between definitions in the frequency of meals (men: ICC = 0.38, women: ICC = 0.36; men: ICC range = 0.33–0.40; women: ICC range = 0.32–0.38).

The total EO frequency, total beverage-only EO frequency, mean time between EOs, total energy intake per EO, and total energy intake from beverage-only EOs for the 6 variations of the neutral definitions are presented in **Table 4**. In general, EO

TABLE 4

Total EO frequency, time (minutes) between EOs across 6 neutral definitions, total EI (kJ) per EO, total beverage-only EO frequency, and total EI (kJ) from beverage-only EOs, by sex and age group[1]

	n	15 min	15 min + 210 kJ	30 min	30 min + 210 kJ	60 min	60 min + 210 kJ
EO frequency, *n*							
Men							
19–30 y	370	4.8 ± 1.0[a,2]	4.5 ± 1.0[b]	4.5 ± 0.9[b]	4.3 ± 0.8[c]	4.1 ± 0.7[d]	3.9 ± 0.7[e]
31–50 y	877	5.5 ± 1.5[a]	5.0 ± 1.3[b]	5.1 ± 1.2[c]	4.7 ± 1.1[d]	4.6 ± 0.9[e]	4.2 ± 0.9[f]
51–70 y	820	5.4 ± 1.4[a]	4.7 ± 1.2[b]	5.0 ± 1.2[c]	4.5 ± 1.1[d]	4.5 ± 1.0[d]	4.1 ± 1.0[e]
≥71 y	335	5.4 ± 1.4[a]	4.8 ± 1.2[b]	5.0 ± 1.3[c]	4.5 ± 1.1[d]	4.5 ± 1.0[d]	4.2 ± 0.9[e]
Women							
19–30 y	388	5.1 ± 1.2[a]	4.6 ± 1.0[b]	4.8 ± 1.0[c]	4.4 ± 0.9[d]	4.3 ± 0.8[d]	4.0 ± 0.8[e]
31–50 y	963	5.8 ± 1.5[a]	4.9 ± 1.3[b]	5.4 ± 1.3[c]	4.7 ± 1.1[d]	4.8 ± 1.0[d]	4.3 ± 0.9[e]
51–70 y	1013	5.7 ± 1.6[a]	4.7 ± 1.3[b]	5.3 ± 1.3[c]	4.5 ± 1.1[d]	4.7 ± 1.0[b]	4.2 ± 0.9[e]
≥71 y	476	5.5 ± 1.6[a]	4.6 ± 1.3[b]	5.2 ± 1.3[c]	4.4 ± 1.2[d]	4.7 ± 1.1[b]	4.2 ± 1.0[e]
Time between EOs, min							
Men							
19–30 y	370	215 ± 58[a]	225 ± 59[b]	227 ± 56[b]	235 ± 57[c]	253 ± 64[d]	259 ± 65[d]
31–50 y	877	190 ± 56[a]	208 ± 63[b]	202 ± 55[c]	220 ± 61[d]	228 ± 57[e]	241 ± 62[f]
51–70 y	820	194 ± 69[a]	215 ± 74[b]	209 ± 69[b]	230 ± 75[c]	232 ± 70[c]	250 ± 74[d]
≥71 y	335	183 ± 63[a]	204 ± 66[b]	196 ± 62[c]	216 ± 65[d]	215 ± 61[d]	232 ± 65[e]
Women							
19–30 y	388	192 ± 57[a]	211 ± 58[b]	205 ± 58[b]	221 ± 61[c]	227 ± 57[c]	241 ± 60[d]
31–50 y	963	173 ± 55[a]	199 ± 65[b]	187 ± 57[c]	211 ± 66[d]	210 ± 57[d]	231 ± 66[e]
51–70 y	1013	176 ± 58[a]	207 ± 68[b]	188 ± 56[c]	216 ± 67[d]	210 ± 56[bd]	233 ± 66[e]
≥71 y	476	177 ± 65[a]	206 ± 72[b]	188 ± 63[c]	216 ± 71[d]	206 ± 62[b]	230 ± 70[e]
EI per EO, kJ							
Men							
19–30 y	370	2211 ± 552[a]	2361 ± 579[b]	2330 ± 555[b]	2470 ± 580[c]	2563 ± 608[c]	2687 ± 623[d]
31–50 y	877	1890 ± 628[a]	2082 ± 636[b]	2024 ± 667[c]	2208 ± 675[d]	2266 ± 745[e]	2417 ± 742[f]
51–70 y	820	1730 ± 558[a]	1974 ± 621[b]	1857 ± 594[c]	2097 ± 677[d]	2065 ± 674[d]	2291 ± 752[e]
≥71 y	335	1573 ± 540[a]	1756 ± 530[b]	1682 ± 566[c]	1858 ± 564[d]	1843 ± 618[d]	1995 ± 633[e]
Women							
19–30 y	388	1558 ± 479[a]	1705 ± 471[b]	1656 ± 508[c]	1789 ± 502[d]	1828 ± 568[d]	1948 ± 585[e]
31–50 y	963	1329 ± 470[a]	1554 ± 511[b]	1427 ± 497[c]	1638 ± 542[d]	1608 ± 577[d]	1788 ± 624[e]
51–70 y	1013	1292 ± 472[a]	1543 ± 510[b]	1379 ± 497[c]	1604 ± 524[d]	1535 ± 542[b]	1733 ± 561[e]
≥71 y	476	1251 ± 473[a]	1463 ± 474[b]	1325 ± 487[c]	1525 ± 496[d]	1443 ± 513[b]	1627 ± 524[e]
Beverage-only EO frequency, *n*							
Men							
19–30 y	370	0.8 ± 0.7[a]	0.6 ± 0.6[b]	0.7 ± 0.6[c]	0.5 ± 0.5[d]	0.5 ± 0.5[bd]	0.4 ± 0.4[e]
31–50 y	877	1.2 ± 1.0[a]	0.7 ± 0.8[b]	1.0 ± 0.8[c]	0.6 ± 0.7[d]	0.7 ± 0.7[b]	0.5 ± 0.6[e]
51–71 y	820	1.1 ± 0.9[a]	0.5 ± 0.7[b]	0.9 ± 0.8[c]	0.4 ± 0.6[d]	0.7 ± 0.7[e]	0.3 ± 0.5[f]
≥71 y	335	0.9 ± 0.9[a]	0.4 ± 0.6[b]	0.8 ± 0.8[c]	0.3 ± 0.5[d]	0.6 ± 0.6[e]	0.2 ± 0.5[f]
Women							
19–30 y	388	0.9 ± 0.7[a]	0.6 ± 0.5[b]	0.8 ± 0.6[c]	0.5 ± 0.5[d]	0.6 ± 0.5[b]	0.4 ± 0.5[e]
31–50 y	963	1.3 ± 1.1[a]	0.6 ± 0.8[b]	1.1 ± 0.9[c]	0.5 ± 0.7[d]	0.7 ± 0.7[e]	0.4 ± 0.6[f]
51–70 y	1013	1.2 ± 1.2[a]	0.4 ± 0.7[b]	1.0 ± 1.0[c]	0.4 ± 0.6[d]	0.7 ± 0.8[e]	0.3 ± 0.5[f]
≥71 y	476	1.0 ± 1.2[a]	0.4 ± 0.7[b]	0.9 ± 1.0[c]	0.3 ± 0.6[d]	0.7 ± 0.8[e]	0.2 ± 0.5[f]
EI from beverage-only EOs, kJ							
Men							
19–30 y	370	556 ± 679[a]	540 ± 674[b]	484 ± 627[c]	472 ± 625[d]	377 ± 530[e]	367 ± 530[f]
31–50 y	877	677 ± 919[a]	642 ± 919[b]	570 ± 841[c]	541 ± 841[d]	432 ± 721[e]	412 ± 720[f]
51–70 y	820	425 ± 732[a]	384 ± 731[b]	356 ± 684[b]	323 ± 684[c]	261 ± 583[d]	235 ± 582[e]
≥71 y	335	289 ± 444[a]	244 ± 436[b]	230 ± 392[b]	192 ± 390[c]	182 ± 353[d]	154 ± 353[e]
Women							
19–30 y	388	484 ± 529[a]	462 ± 530[b]	439 ± 521[c]	421 ± 523[d]	332 ± 483[e]	319 ± 483[f]
31–50 y	963	488 ± 692[a]	436 ± 692[b]	395 ± 624[c]	353 ± 624[d]	287 ± 499[e]	258 ± 502[f]
51–70 y	1013	354 ± 610[a]	296 ± 590[b]	301 ± 572[b]	255 ± 560[c]	226 ± 499[d]	193 ± 493[e]
≥71 y	476	314 ± 625[a]	271 ± 610[b]	246 ± 438[b]	211 ± 433[c]	187 ± 359[c]	159 ± 355[d]

[1]Different superscript letters indicate significant differences (*F* test with Bonferroni correction, $P < 0.01$) between definitions. EI, energy intake; EO, eating occasion.

[2]Mean ± SD (all such values).

frequency (including beverage-only EO frequency) decreased, and time between EOs, total energy intake per EO, and total energy intake from beverage-only EOs increased with increasing time interval used to delineate EOs ($P < 0.01$). Within each time interval, applying a minimum energy criterion also had a similar effect.

Among both sexes and across all age groups, the highest proportion of variance of total energy intake was predicted by the 15-min plus minimum 210-kJ neutral definition (R^2 range = 19.3–27.8; **Table 5**). The results were less consistent for total amount of food/beverage intake. The highest R^2 values were observed for the 15-min plus minimum 210-kJ neutral definition among men aged 31–50 y (R^2 = 18.8) and 51–70 y (R^2 = 15.9) and among men (R^2 = 22.8) and women (R^2 = 24.3) aged >70 y. The participant-identified definition best predicted amount of food intake among men and women aged 19–30 y (men: R^2 = 21.4; women: R^2 = 20.1), whereas the time-of-day approach best predicted amount of food intake among women aged 31–50 y (R^2 = 25.0) and 51–70 y (R^2 = 28.4).

DISCUSSION

This study objectively examined the influence of 8 different EO definitions, based on previously published definitions, on the characterization of eating patterns among a nationally representative sample of Australian adults. To our knowledge, this is the first methodologic study among adults to objectively examine multiple definitions on the characterization of a variety of different eating patterns and examining the extent to which they predict the proportion of variance in total energy intake and total amount of food consumed.

There were small but significant differences in the characterization (e.g., frequency, spacing, and total energy intake) of eating patterns between the participant-identified and the time-of-day definition and across the 6 variations of the neutral definition. Among both sexes and across all age groups, the neutral definition with a 15-min time interval plus a 210-kJ energy criterion best predicted variance in total energy intake. The findings were less consistent when total amount of food/beverage intake was predicted, but both the 15-min time interval plus a 210-kJ energy criterion definition and the participant-identified definition performed well. In support of these findings, Murakami and Livingstone (14) observed that, among British men and women, the correlation between overall eating frequency and total energy intake was strongest for a neutral definition with a 15-min time interval and a 210-kJ energy criterion. The second strongest correlation was observed for a neutral definition that included all energy-containing EOs followed by a neutral definition that included all EOs, with both definitions similarly employing a 15-min time interval (14). Moreover, in the same study, EO frequency determined by the 15-min time interval plus 210-kJ definition showed the strongest association with BMI and waist circumference (14). Together, this suggests that a 15-min time interval plus an energy criterion definition may be an appropriate choice for use in eating patterns research. This neutral definition, however, would require additional criteria to delineate meals from snacks and is an area for future research (18).

In the present study, the frequency of snacks determined using the time-of-day definition (range: 2.4–3.0) is higher than the frequency reported in a nationally representative sample of Brazilian adults (range: 1.4–1.5). Although the study by Duffey et al. (30) also adopted a similar time-of-day definition, differences between the reported frequency may be due to cultural differences in snacking behaviors between Australia and Brazil. Indeed, in a study of US older adults (aged ≥65 y) that applied a similar participant-identified approach, mean ± SD snacking frequency was 2.54 ± 0.13, within the range (2.3–2.9) of the present study (38).

These findings are consistent with a previous study of British adults that observed a lower overall EO frequency (men: 7.2–5.6; women: 6.7–4.8) after applying a 210-kJ energy criterion (14). In a study of US adults, de Castro (39) also noted differences in the total energy intake from macronutrients at different times of the day when applying 5 different definitions that employed time intervals of 15, 45, and 90 min plus an energy criterion of 209 kJ, 418 kJ, or 837 kJ. Although this observation was noted in the method of that study, only results for the 45-min plus 209-kJ definition were reported because the patterns of results did not differ in terms of the energy distribution across the day. However, quantitative differences in eating pattern variables such as overall EO frequency and meal and/or snack frequency that result from differences in EO definition approaches may

TABLE 5
Proportion of variance (%) of total energy intake (kJ) and total weight (g) of food/beverage intake (g) predicted by each definition[1]

		Participant identified, %		Time of day, %		15 min, %		15 min + 210 kJ, %		30 min, %		30 min + 210 kJ, %		60 min, %		60 min + 210 kJ, %	
	n	EI	Wgt	EI	Wgt	EI	Wgt	EI	Wgt	EI	Wgt	EI	Wgt	EI	Wgt	EI	Wgt
Men																	
19–30 y	370	15.1	21.4[2]	15.4	19.7	15.4	20.5	19.3[2]	19.7	14.4	19.1	17.6	17.1	13.7	16.2	16.2	14.4
31–50 y	877	12.3	18.5	12.3	18.2	13.1	18.7	23.1[2]	18.8[2]	11.7	17.1	20.9	16.6	8.8	14.3	18.6	14.8
51–70 y	820	18.7	15.7	17.9	15.7	16.5	15.4	26.5[2]	15.9[2]	14.6	15.2	23.0	14.5	10.6	10.6	16.8	10.1
≥71 y	335	18.9	21.2	16.2	21.7	15.9	20.9	27.4[2]	22.8[2]	15.0	18.5	24.1	19.2	9.9	16.0	15.7	15.1
Women																	
19–30 y	388	16.9	20.1[2]	15.4	20.1[2]	15.0	18.7	25.2[2]	17.8	11.6	16.3	21.0	15.3	10.0	14.1	16.1	11.5
31–50 y	963	17.4	24.8	16.2	25.0[2]	14.8	23.9	23.3[2]	18.6	13.5	22.3	21.0	16.9	8.9	15.2	15.1	11.9
51–70 y	1013	18.1	27.4	17.2	28.4[2]	15.6	27.9	27.8[2]	23.1	15.1	25.6	26.9	22.3	12.6	21.1	24.7	19.9
≥71 y	476	14.2	19.4	17.4	22.1	13.1	20.3	26.9[2]	24.3[2]	11.8	19.1	24.5	23.4	12.2	20.4	23.7	21.2

[1]EI, energy intake; Wgt, weight.
[2]Highest value.

help explain the difference in the strength and significance of associations between eating patterns, diet quality, and health outcomes across studies.

In this study, mean frequency of meals and mean total energy intakes from meals were significantly higher for the participant-identified definition than for the time-of-day definition. Snack frequency and total energy intake from snacks were also lower for the participant-identified definition. There was also good agreement for snack but not meal frequency between the time-of-day definition and the participant-identified definition. Possible explanations for the poor agreement for meals could be that the fixed time frames employed by the time-of-day definition constrain the total number of meals to 3 and may not cater to persons who consume meals outside of conventional mealtimes. These time frames are also researcher driven and may introduce researcher bias, limiting comparison across studies (particularly across different countries or cultural groups). For the participant-identified definition, the researcher must also decide how to treat EOs that are not clearly defined as a meal or a snack (e.g., extended consumption) and whether meals or snacks occurring close together in time should be combined by using additional time criteria. These issues highlight the need for a standardized EO definition.

After applying 6 variations of the neutral definition, this study found significant differences in the characterization of all eating pattern variables examined (EO frequency, beverage-only EO frequency, spacing between EOs, total energy intake per EO, and total energy intake from beverage-only EOs). Irrespective of the time interval employed, applying a minimum energy criterion of 210 kJ reduced the total number of all EOs, total number of beverage-only EOs, and time between EOs and increased the reported energy intake per EO. This might be expected because application of an energy criterion of this amount would exclude any EOs containing only beverages or foods with very low or no kJ content (e.g., tea with milk). However, it is unclear how a 210-kJ energy criterion was established (32) and whether this value is the most appropriate choice for defining EOs.

One limitation of this study was that eating patterns were derived from two 24-h recalls. More recall days may be needed to better understand the variability in adults' eating patterns. Eating patterns are also shaped by age and cultural factors (40, 41), and although eating patterns may vary, the definitions used in this study may or may not be applicable despite different ages and cultures. Therefore, research in children and populations with different ethnic backgrounds is required. It is also unclear whether total energy intake and total amount of food/beverage intake are adequate performance indicators of EO definitions. However, how well an EO definition captures these indicators is also likely to affect how well it captures people's dietary and energy-balance profiles (42). A major strength of the present study was that it objectively compared 8 EO definitions, based on previously published works, among a nationally representative sample of Australian adults, stratified by sex and age group. An important next step will be to examine associations with indicators of diet quality and health.

In conclusion, the choice of EO definition significantly influences how eating patterns are characterized, with a 15-min time interval plus 210-kJ energy criterion definition best predicting variance in total energy intake and total amount of food/beverage consumed, suggesting that this definition may be an appropriate choice for use in eating patterns research. For research that differentiates meals from snacks, consensus is needed on whether a participant-identified approach or a time-of-day approach is more appropriate. This study found significant differences in some aspects of eating patterns (frequency of and total energy intake from meals and snacks) between these 2 approaches but little difference in their prediction of variance in total energy intake and amount of food/beverage consumed. Future research that examines how different EO definitions affect associations with outcomes such as diet quality and cardiometabolic health is required.

The authors' responsibilities were as follows—RML, AW, AT, and SAM: designed the research and read and approved the final manuscript; and RML: analyzed the data, wrote the manuscript, and had primary responsibility for the final content. The authors declared no potential conflicts of interest. The funding bodies had no role in the analysis or preparation of the manuscript.

REFERENCES

1. Leech RM, Worsley A, Timperio A, McNaughton SA. Understanding meal patterns: definitions, methodology and impact on nutrient intake and diet quality. Nutr Res Rev 2015;28:1–21.
2. Mesas AE, Munoz-Pareja M, Lopez-Garcia E, Rodriguez-Artalejo F. Selected eating behaviours and excess body weight: a systematic review. Obes Rev 2012;13:106–35.
3. Nicklas TA, O'Neil CE, Fulgoni VL 3rd. Snacking patterns, diet quality, and cardiovascular risk factors in adults. BMC Public Health 2014;14:388.
4. Deshmukh-Taskar PR, Radcliffe JD, Liu Y, Nicklas TA. Do breakfast skipping and breakfast type affect energy intake, nutrient intake, nutrient adequacy, and diet quality in young adults? NHANES 1999–2002. J Am Coll Nutr 2010;29:407–18.
5. Min C, Noh H, Kang YS, Sim HJ, Baik HW, Song WO, Yoon J, Park YH, Joung H. Skipping breakfast is associated with diet quality and metabolic syndrome risk factors of adults. Nutr Res Pract 2011;5:455–63.
6. Barr SI, DiFrancesco L, Fulgoni VL 3rd. Consumption of breakfast and the type of breakfast consumed are positively associated with nutrient intakes and adequacy of Canadian adults. J Nutr 2013;143:86–92.
7. Nicklas TA, Myers L, Reger C, Beech B, Berenson GS. Impact of breakfast consumption on nutritional adequacy of the diets of young adults in Bogalusa, Louisiana: ethnic and gender contrasts. J Am Diet Assoc 1998;98:1432–8.
8. Smith KJ, McNaughton SA, Cleland VJ, Crawford D, Ball K. Health, behavioral, cognitive, and social correlates of breakfast skipping among women living in socioeconomically disadvantaged neighborhoods. J Nutr 2013;143:1774–84.
9. Azadbakht L, Haghighatdoost F, Feizi A, Esmaillzadeh A. Breakfast eating pattern and its association with dietary quality indices and anthropometric measurements in young women in Isfahan. Nutrition 2013;29:420–5.
10. Mekary RA, Giovannucci E, Willett WC, van Dam RM, Hu FB. Eating patterns and type 2 diabetes risk in men: breakfast omission, eating frequency, and snacking. Am J Clin Nutr 2012;95:1182–9.
11. Smith KJ, Gall SL, McNaughton SA, Blizzard L, Dwyer T, Venn AJ. Skipping breakfast: longitudinal associations with cardiometabolic risk factors in the Childhood Determinants of Adult Health Study. Am J Clin Nutr 2010;92:1316–25.
12. Mekary RA, Giovannucci E, Cahill L, Willett WC, van Dam RM, Hu FB. Eating patterns and type 2 diabetes risk in older women: breakfast consumption and eating frequency. Am J Clin Nutr 2013;98:436–43.
13. Cahill LE, Chiuve SE, Mekary RA, Jensen MK, Flint AJ, Hu FB, Rimm EB. Prospective study of breakfast eating and incident coronary heart disease in a cohort of male US health professionals. Circulation 2013;128:337–43.
14. Murakami K, Livingstone MB. Eating frequency in relation to body mass index and waist circumference in British adults. Int J Obes (Lond) 2014;38:1200–6.
15. Titan SM, Bingham S, Welch A, Luben R, Oakes S, Day N, Khaw KT. Frequency of eating and concentrations of serum cholesterol in the Norfolk population of the European Prospective Investigation into Cancer (EPIC-Norfolk): cross sectional study. BMJ 2001;323:1286–8.

16. 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.
17. Smith KJ, Blizzard L, McNaughton SA, Gall SL, Dwyer T, Venn AJ. Daily eating frequency and cardiometabolic risk factors in young Australian adults: cross-sectional analyses. Br J Nutr 2012;108:1086–94.
18. USDA, US Department of Health and Human Services. Scientific report of the 2015 Dietary Guidelines Advisory Committee. Washington (DC): US Government Printing Office; 2015.
19. Gatenby SJ. Eating frequency: methodological and dietary aspects. Br J Nutr 1997;77(Suppl 1):S7–20.
20. Johnson GH, Anderson GH. Snacking definitions: impact on interpretation of the literature and dietary recommendations. Crit Rev Food Sci Nutr 2010;50:848–71.
21. Bertéus Forslund H, Lindroos AK, Sjostrom L, Lissner L. Meal patterns and obesity in Swedish women-a simple instrument describing usual meal types, frequency and temporal distribution. Eur J Clin Nutr 2002;56:740–7.
22. Zizza CA, Xu B. Snacking is associated with overall diet quality among adults. J Acad Nutr Diet 2012;112:291–6.
23. 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.
24. Bellisle F. Meals and snacking, diet quality and energy balance. Physiol Behav 2014;134:38–43.
25. Ovaskainen ML, Tapanainen H, Pakkala H. Changes in the contribution of snacks to the daily energy intake of Finnish adults. Appetite 2010;54:623–6.
26. Popkin BM, Duffey KJ. Does hunger and satiety drive eating anymore? Increasing eating occasions and decreasing time between eating occasions in the United States. Am J Clin Nutr 2010;91:1342–7.
27. Duval K, Strychar I, Cyr MJ, Prud'homme D, Rabasa-Lhoret R, Doucet E. Physical activity is a confounding factor of the relation between eating frequency and body composition. Am J Clin Nutr 2008; 88:1200–5.
28. Riley MD, Baird DL, Hendrie GA. Dairy food at the first occasion of eating is important for total dairy food intake for Australian children. Nutrients 2014;6:3878–94.
29. Almoosawi S, Winter J, Prynne CJ, Hardy R, Stephen AM. Daily profiles of energy and nutrient intakes: are eating profiles changing over time? Eur J Clin Nutr 2012;66:678–86.
30. Duffey KJ, Pereira RA, Popkin BM. Prevalence and energy intake from snacking in Brazil: analysis of the first nationwide individual survey. Eur J Clin Nutr 2013;67:868–74.
31. Bellisle F, Dalix AM, Mennen L, Galan P, Hercberg S, de Castro JM, Gausseres N. Contribution of snacks and meals in the diet of French adults: a diet-diary study. Physiol Behav 2003;79:183–9.
32. Gibney MJ, Wolever TM. Periodicity of eating and human health: present perspective and future directions. Br J Nutr 1997;77(Suppl 1): S3–5.
33. Ma Y, Bertone ER, Stanek EJ 3rd, 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.
34. Australian Bureau of Statistics. Australian Health Survey: users' guide, 2011–13. Canberra (Australia): Australian Bureau of Statistics; 2013.
35. Blanton CA, Moshfegh AJ, Baer DJ, Kretsch MJ. The USDA Automated Multiple-Pass Method accurately estimates group total energy and nutrient intake. J Nutr 2006;136:2594–9.
36. Kant AK, Graubard BI, Mattes RD. Association of food form with self-reported 24-h energy intake and meal patterns in US adults: NHANES 2003–2008. Am J Clin Nutr 2012;96:1369–78.
37. National Health and Medical Research Council. Nutrient Reference Values for Australia and New Zealand [Internet]. [cited 2015 Jan 30]. Canberra (Australia): National Health and Medical Research Council; 2015. Available from: https://www.nrv.gov.au.
38. Zizza CA, Tayie FA, Lino M. Benefits of snacking in older Americans. J Am Diet Assoc 2007;107:800–6.
39. de Castro JM. The time of day of food intake influences overall intake in humans. J Nutr 2004;134:104–11.
40. Bisogni CA, Falk LW, Madore E, Blake CE, Jastran M, Sobal J, Devine CM. Dimensions of everyday eating and drinking episodes. Appetite 2007;48:218–31.
41. Jastran MM, Bisogni CA, Sobal J, Blake C, Devine CM. Eating routines: embedded, value based, modifiable, and reflective. Appetite 2009;52:127–36.
42. Livingstone MB, Black AE. Markers of the validity of reported energy intake. J Nutr 2003;133(Suppl 3):895S–920S.

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