British Journal of Nutrition (2023), 129, 1075–1085 doi:10.1017/S0007114522001970

Association of daily nutrient intake with breakfast and snack consumption among young Japanese adults aged 20–39 years: data from the 2012 National Health and Nutrition Survey

Mai Matsumoto[1], Emiko Okada[1], Ryoko Tajima[1], Aya Fujiwara[1,2] and Hidemi Takimoto[1]*

[1]*Department of Nutritional Epidemiology and Shokuiku, National Institutes of Biomedical Innovation, Health, and Nutrition, 1-23-1 Toyama, Shinjuku-ku, Tokyo 162-8636, Japan*

[2]*Department of Social and Preventive Epidemiology, School of Public Health, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan*

(Submitted 25 November 2021 – Final revision received 30 May 2022 – Accepted 20 June 2022 – First published online 4 July 2022)

Abstract

Eating frequency has been associated with nutrient intake and diet quality. The aim of this study was to examine the association between daily nutrient and food group intake and consumption of breakfast and/or snacks among young Japanese adults, as secondary analysis of the 2012 National Health and Nutrition Survey in Japan involved 1420 men and 1659 women aged 20–39 years. Dietary intake data were collected using a one-day semi-weighed household dietary record. Participants were classified into four groups based their breakfast and snack consumption, defined as the consumption of any food or beverage that contained energy based on participant-defined eating occasions; both breakfast and snack consumption (B+S+), breakfast consumption without snacking (B+S–), breakfast skipping and snack consumption (B–S+) and breakfast skipping without snacking (B–S–). The proportion of breakfast skippers among men and women was 11·8 % and 6·6 %, whereas that of snack consumers among men and women was 55·3 % and 68·2 %, respectively. Energy, Mg potassium (in both sexes), vitamin B_2, Ca, (only men) and folate and dietary fibre (only women) intakes were higher among breakfast and snack consumers than in the B+S– group. The nutrient intake level of the B+S– group was similar to that of the B–S+ group, whereas the B–S– group had lower energy (both sexes), Cu, dietary fibre and potassium (only women) intakes than the B+S– group. Snack consumption could supplement nutrients that may not be adequately consumed by three meals among young Japanese adults.

Key words: **Breakfast skipping: Snack: Young adults: Japan: National Health and Nutrition Survey**

Eating frequency, especially breakfast skipping and snack consumption, has been reported to be associated with nutrient intake and diet quality in epidemiological and experimental studies; however, the findings were not consistent[1–10]. For example, eating frequency is related to higher intake of carbohydrate, dietary fibre and some vitamins and minerals among adults in USA and Australia[1,3]. In USA adults, higher eating frequency has also been associated with better dietary quality, as indicated by the HEI-2010 score[2]. On the other hand, breakfast skipping is associated with a decrease in the daily intake of energy, dietary fibre, vitamin B_1, Ca and potassium among Japanese and Koreans adults under 50 years old both in epidemiological and interventional studies[4–6]. However, a study in the UK reported that daily energy intake of university students is not affected with or without breakfast consumption[7]. Furthermore, studies reported inconsistent results on the association between snack consumption and intake of nutrients and food groups. For example, snack consumption was associated with a higher consumption of nutrient-rich foods, such as fruit and milk, and a lower intake of meat and added sugars in USA adults[9]. Snack consumption was not associated with macro- and micronutrient intake and by itself does not lead to poor diet quality among female students aged 17–26 years in UK[10]. However, snack consumption was associated with a higher intake of daily energy and confectionaries and a lower micronutrient intake among British and Finland adults[8,11]. Inconsistent results may be that studies have focused only on the total number of eating frequency or on a specific meal (i.e. breakfast skipping or snack consumption).

The frequency of meal or snack consumption differs according to age. Among the elderly in USA, the percentage of those who skip breakfast or consume snacks is low[12]. In contrast, among young adults, the breakfast skipping rate was higher than other age groups[13], and the proportion of snack consumers was

Abbreviations: NHNS, National Health and Nutrition Survey.

* **Corresponding author:** Hidemi Takimoto, email thidemi@nibiohn.go.jp

also high[14]. Energy intake from meals or snacks also differs by age. Even among young adults who consume breakfast, the energy intake from breakfast (approximately 15 % of the daily energy intake) was less than that of the elderly (> 20 %)[15]. In addition, the energy intake from snacks (20 % of the daily energy intake) among young adults aged 19–29 years[13] was approximately the same as that from breakfast among the elderly[15]. Breakfast skippers were also likely to consume snacks daily among Japanese adults[16]. These results suggest that assessments of energy, nutrient and food group intake, especially in young adults, should consider their situation regarding breakfast and snack consumption, to identify targets for nutritional intervention. Although one study has investigated the association between specific meals, snack patterns (i.e. breakfast, dinner and twice snack consumption; breakfast, lunch, dinner and snack consumption and lunch, dinner and twice snack consumption) and overall dietary intake among American adults[1], no study has examined the association of breakfast and snack consumption with daily nutrient or food group intake, with a particular focus on young adults, who are more likely to breakfast skippers and snack consumers[13,14].

Therefore, the current study aimed to evaluate the association of breakfast and snack consumption with daily intake of nutrients and food groups, applying breakfast consumers without snack consumption as the reference group, among Japanese young adults aged 20–39 years who participated in the 2012 National Health and Nutrition Survey (NHNS).

Methods

Data source and study population

The NHNS is a nationally representative cross-sectional annual survey conducted by local public health centres under the supervision of the Ministry of Health, Labour, and Welfare. The present study was based on data from the 2012 NHNS conducted between 25 October and 7 December 2012. The reason for using the 2012 data in the present study is the larger sample size of 2012 and 2016 survey, but the survey was not conducted in several regions in 2016 due to the earthquake and Typhoon[17,18]. The details of the 2012 NHNS have been described elsewhere[17,19]. Briefly, the participants, who included households and their family members (aged > 1 year as of 1 November 2012) in 475 areas, were randomly selected by single-stage clusters from the general census areas in the 2010 National Census[20]. The 2012 NHNS consisted of a physical examination, dietary survey and lifestyle questionnaire. A total of 12 750 out of 24 555 eligible households (51·9 %) and 32 228 people participated in the dietary survey[17]. The current study included 5905 adults aged 20–39 years. We excluded lactating or pregnant women who may have changed their usual dietary habits (*n* 344)[21]. We also excluded participants with missing data required for analysis in the present study, such as body height and/or body weight, waist circumference, smoking status, habitual alcohol consumption and daily step counts (*n* 2707). Additionally, we excluded those who skipped lunch and/or dinner (*n* 119). Thus, the final sample consisted of 3079 Japanese adults aged 20–39 years (1420 men and 1659 women) (Fig. 1).

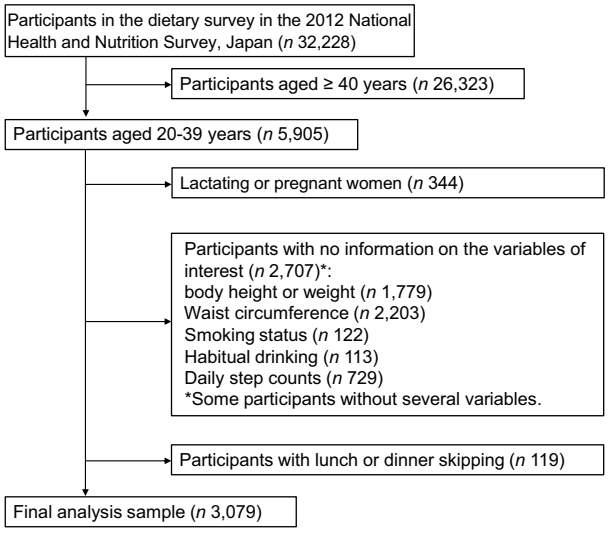

Fig. 1. Flow chart of participant inclusion.

This survey was conducted according to the guidelines laid down in the Declaration of Helsinki, all participants gave informed consent to the local government based on the Health Promotion Act[22]. Permission to use the 2012 NHNS data was obtained from the Ministry of Health, Labour, and Welfare, under Article 33 of the Statistics Act, and only anonymised information was available for this study. In accordance with the Ethical Guidelines of Epidemiological Research, our study was exempted from the application of these guidelines as only anonymised data were used.

Dietary assessment

Dietary intake data were collected using a one-day semi-weighed household dietary record, excluding Sundays and public holidays. Prior to completing the survey, trained fieldworkers (mainly registered dieticians) provided an outline of the survey and explained to the participants, especially the main record-keepers (members who are usually responsible for preparing meals), how to complete the dietary record. The main record-keepers in the household were instructed to weigh all foods and beverages consumed by the household members and the amount of food waste and leftovers. When the main record-keepers ate with the household members, then they recorded their names and weights on recording forms. Additionally, the main record-keepers recorded the approximate proportions of food consumed by each household member when members shared foods from the same dish to enable estimation of individual intake. If weighing was not possible because the meal was consumed away from home, the portion size consumed, or quantity of food, and details of any leftovers were estimated by the main record-keepers. When individual household members were not with the main record-keeper at the meal, the individual reported the amount of food or beverage to the main record-keeper. Participants, who were unable to report food or beverage intake on the survey day, were regarded as non-respondents.

Trained fieldworkers visited each household and checked for missing information and errors. In accordance with the survey manual of the NHNS[17], for the weights of foods and beverages that were not measured, the trained fieldworkers converted these estimates of portion sizes or quantity of foods into weights of foods. Then, the trained fieldworkers coded each food item according to the NHNS food number lists based on the 2010 Standard Tables of Food Composition in Japan[23] to calculate the intake of energy and nutrients. The trained fieldworkers inputted collected dietary intake data using software specifically developed for the NHNS; then, the data were compiled by trained investigators at the central office to create an overall dietary data set[17].

Energy and nutrients were calculated based on the 2010 standard tables of food composition in Japan. Food items were classified into nineteen groups based on standard tables[23]. The percentage of daily energy intake using reported values for each macronutrient was also calculated for protein, total fat (fat), SFA and carbohydrates.

Additionally, inadequate intake of each nutrient was determined by comparing nutrient levels with the relevant dietary reference value according to the Japanese dietary reference intakes, 2020[24], using a previously reported method[25–27]. In the Japanese dietary reference intakes, different types of dietary reference values were established according to their purpose. The estimated average requirement is set to prevent insufficient intake of nutrients, whereas the tentative dietary goal to prevent lifestyle-related diseases is set to prevent non-communicable diseases. Nutrient intake inadequacy was defined as follows: intake level below estimated average requirement was considered inadequate using the cut-point method for the following thirteen nutrients: vitamin A (as retinol activity equivalents), vitamin B_1, vitamin B_2, niacin (as niacin equivalent), vitamin B_6, vitamin B_{12}, folate, vitamin C, Ca, Mg, Fe, Zn and Cu. Regarding Fe intake, we applied the value $< 9{\cdot}3$ mg/d as recommended by the WHO (probability of inadequacy as 50 % by assuming bioavailability of Fe as 15 %)[28] for women aged 20–49 years according to the previous studies[26,29]. For the following seven nutrients outside the range of dietary goal values was considered inadequate; the dietary goal values used were the percentage of protein energy intake in (13–20 % energy), fat (20–30 % energy), SFA (≤ 7 % energy) and carbohydrate (50–65 % energy) and the intake level for total dietary fibre (men: ≥ 21 g/d, women: ≥ 18 g/d), Na (as salt-equivalent, men: $< 7{\cdot}5$ g/d; women: $< 6{\cdot}5$ g/d) and potassium (men: ≥ 3000 mg/d; women: ≥ 2600 mg/d). In the present study, crude values were used instead of the density values for all nutrients, except for macro nutrients, because it is not appropriate to underestimate the influence of breakfast and snack skipping although reporting errors could not be taken into account.

The definition of meal and snack consumption was based on the participant's identification; if any foods or beverages that contain energy and were listed in the meal (i.e., breakfast, lunch and dinner) or snack section of the self-reported dietary record, they were categorised as meals or snacks[4]. Participants were classified into four groups according to with or without breakfast and snack consumption (both breakfast and snack consumption (B+S+), breakfast consumption without snacking (B+S–), breakfast skipping and snack consumption (B–S+) and breakfast skipping without snacking (B–S–)).

Other variables

Body height (to the nearest 0·1 cm) and weight (to the nearest 0·1 kg) were measured for approximately 90 % of the participants by trained field workers according to standardised procedures. For the remaining participants, height and weight were measured either by other household members at home or self-reported. BMI was calculated as weight (kg) divided by height (m) squared. Additionally, participants wore a pedometer around their waist and measured the number of steps on a single day and then recorded the number in the dietary intake questionnaire. Information on smoking status (current smoker or not (those who quit smoking or never smoked)) and alcohol drinking habits during the preceding month (yes (drinking ≥ 20 g of pure alcohol at least three times a week) or not), occupation (professional/manager, sales/service/clerical, security/transportation/labour and others including student, housekeeper and not in paid employment) and living alone (yes or no) were collected using a self-administered questionnaire.

Statistical analysis

All statistical analyses were stratified according to sex. The differences in characteristics among the four groups based on with or without breakfast and snack consumption were compared using the χ^2 test for categorical variables and ANOVA for continuous variables. Differences in daily intake of energy, nutrients and food groups based on with or without breakfast and snack consumption were assessed using the Dunnett test referenced to the B+S– group. The nutritional inadequacy of each nutrient intake was represented as the proportion of participants whose intake was below the estimated average requirement or outside the range of the dietary goal. Logistic regression analysis was used to examine the difference in the prevalence of meeting dietary reference intakes in the other groups compared to the B+S– group. The confounding factors considered were age group (20–29 and 30–39 years), occupation (professional/manager, sales/service/clerical, security/transportation/labour and others), living alone (yes or no), current smoker (yes or no), habitual alcohol drinking (yes or no) and energy intake (except for the analysis of energy itself and nutrients provided as % energy (protein, fat, saturated fatty acids and carbohydrate)). These variables have been reported as factors that affect breakfast skipping or snack consumption[4,30,31]. All statistical analyses were performed using SAS statistical software (version 9.4; SAS Institute Inc.). All reported P values were two-tailed. $P < 0{\cdot}05$ was considered statistically significant in the χ^2 and ANOVA, and $P < 0{\cdot}001$ was considered statistically significant in the Dunnett test to minimise of Type 1 error with reference to a previous study[32,33]. This study was limited to participants aged 20–39 years, and analyses were performed according to sex. The proportion of participants who were in the same group from the same household was approximately 2·5 % in the present study. Therefore, households were not included as the clusters, although the NHNS is a household survey.

Results

The basic characteristics of the participants stratified by breakfast and snack consumption are shown in Table 1. The proportions of breakfast skippers in men and women were 11·8 % and 6·6 %, respectively, whereas those for snack consumers were 55·3 % and 68·2 %, respectively. Men in the B–S– group (mean age: 29·1 years, SD: 6·2) and women in the B–S+ group (mean age: 27·9 years, SD: 5·7) were the youngest. The proportion of participants within the normal BMI range was approximately 70 % in both men and women. The proportion of underweight in men was the highest in the B–S– group, whereas no significant difference in terms of BMI was observed in women. There was a significant difference in terms of occupation among the four groups, in both men and women. The proportion of men working in sales, services or clerical was the highest in the B–S– group, whereas that in security, transportation or manual labour was the highest in the other three groups. In all four groups, women mostly worked in sales, services or clerical, especially those in the B–S– group. Both men and women participants living alone were more likely to be breakfast skippers, irrespective of snack consumption. The number of daily steps in the B–S– group was significantly the lowest among men but not among women. The highest proportion of current smokers and habitual alcohol drinkers among women were in the B–S+ and B–S– groups, respectively. However, waist circumference did not significantly differ based on breakfast and snack consumption in both sexes.

Table 2 shows the daily energy and nutrient intake based on the dietary record stratified by breakfast and snack consumption. Men who consumed both breakfast and snacks (B+S+) had higher intake of energy, vitamin B_2, Ca, Mg and potassium but lower intakes of protein (as % energy) and Zn than men who consumed breakfast but not snacks (B+S–). On the other hand, for only energy intake, the breakfast and snack skippers group (B–S–) had lower energy intake than the B+S– group. Women who consumed breakfast and snacks (B+S+) had higher intakes of energy, folate, Mg, dietary fibre and potassium but lower intake of protein (as % energy) than women who are non-snack consumers (B+S–). While women in the B–S– group had higher saturated fatty acid intake (as % energy) and lower energy, Cu, dietary fibre and potassium intake than those in B+S- group. No difference was observed in the intake between breakfast skippers with snack consumption (B–S+) and those in the B+S– group among both men and women.

The multivariate-adjusted OR for nutritional inadequacy based on with or without breakfast and snack consumption are shown in Table 3. Among men who consumed breakfast, those who also consumed snacks (B+S+) were less likely to have inadequate intake for vitamin B_2, vitamin C, Ca, Mg and potassium but a higher prevalence of inadequate intake of Zn and saturated fatty acid than non-snack consumers (B+S–). On the other hand, only the prevalence of inadequate folate intake was higher in the B–S– group than in the B+S– group. Among women, breakfast and snack consumers (B+S+) were more likely to have a lower prevalence of inadequate intake of vitamins A, B_2, B_6 and C, folate, Mg, dietary fibre and potassium than the B+S– group. A lower prevalence of inadequate protein intake and a higher prevalence of inadequate niacin intake were observed in the B–S+ group than in the B+S– group. The B–S– group was more likely to have a higher prevalence of inadequate folate and Cu intake than the B+S– group.

Food group intake based on breakfast and snack consumption is shown in Table 4. Men in the B+S+ group had higher intakes of grain, fruits, dairy products, confectionaries, tea, coffee, cocoa and soft drinks than men in the B+S− group. While women who consumed breakfast and snacks (B+S+) had higher intakes of fruits, confectionaries, tea, coffee, cocoa and soft drinks than those consume breakfast but not snacks (B+S–). Participants in the B–S+ group had higher intakes of confectionaries than those in the B+S– group among both men and women. Additionally, food group intake did not significantly differ between the B+S– and B–S– groups in both men and women.

Discussion

To our knowledge, this is the first study to investigate daily nutrient intake by focusing on breakfast and snack consumption among young Japanese adults. We found that breakfast and snack consumers (B+S+) had higher levels of several vitamins and minerals than those who consumed only three meals a day (B+S–). Furthermore, the nutrient intake level of breakfast consumers without snack consumption (B+S–) was similar to that of breakfast skippers who consumed snacks (B–S+).

The proportion of breakfast skippers in the present study (men; 11·8 % and women; 6·6 %) was similar to that of a previous Japanese study (men; 10·6 % and women; 6·4 %)[34]. Additionally, the proportions of snack consumers in this study (men; 55·3 % and women; 68·2 %) were lower than that of previous studies for USA adults (approximately 80–90 %)[1,9]. This difference may be attributed to the higher proportion of lunch (approximately 25 %) and dinner (10 %) skippers in the USA[1] than Japanese in this study (5 %). The characteristics of breakfast skippers in this study were consistent with previous studies which reported that breakfast skippers were younger, living alone and smokers[30,34–37].

In the current study, breakfast and snack consumption was positively associated with energy intake similar to a previous study[3]. The higher energy intake in B+S+ groups could be explained by energy intake from confectionaries and soft drinks because snack consumers had more intakes of these food groups than non-snack consumers as previous studies, irrespective of dietary survey methods such as 24-h dietary recall and dietary record[11,13,38,39].

In contrast, the highest prevalence of underweight was observed in men but not in women in the B–S– group as well as a previous study which reported that eating frequency was positively associated with BMI only in USA men[2]. Underreporting is more common among young Japanese women[40], especially those who are overweight[41]. In fact, 20 % of the women in the B–S– group were overweight, although their energy intake was the lowest on the dietary record day. In addition, differences in social desirability by gender, such as underreporting of energy intake among women, have been

British Journal of Nutrition

Table 1. Characteristics of study participants stratified by breakfast and snack consumption among 1420 Japanese men and 1659 Japanese women aged 20–39 years from the NHNS 2012 data

	Breakfast consumers				Breakfast skippers				
	Non-snack consumers (B+S–)		Snack consumers (B+S+)		Snack consumers (B–S+)		Non-snack consumers (B–S–)		*P**
Men, *n* (%)	555	(39·1)	698	(49·2)	87	(6·1)	80	(5·6)	
Age, years, mean (SD)	31·8	(5·6)	31·8	(5·6)	30·5	(5·5)	29·1	(6·2)	<0·001
Body height, cm, mean (SD)	171·3	(5·9)	171·3	(5·9)	170·2	(5·9)	170·5	(6·2)	0·277
Body weight, kg, mean (SD)	69·0	(12·9)	68·8	(12·2)	68·4	(13·2)	66·5	(13·1)	0·418
Waist circumference, cm, mean (SD)	82·6	(9·8)	82·7	(10·1)	83·1	(11·5)	80·7	(11·1)	0·383
BMI category, *n* (%)									0·006
Underweight < 18·5)	25	(4·5)	30	(4·3)	4	(4·6)	12	(15·0)	
Normal (18·5–25)	379	(68·3)	483	(69·2)	61	(70·1)	49	(61·3)	
Overweight (≥ 25)	151	(27·2)	185	(26·5)	22	(25·3)	19	(23·8)	
Occupation, *n* (%)									0·009
Professional/manager	148	(26·7)	162	(23·2)	16	(18·4)	15	(18·8)	
Sales/service/clerical	157	(28·3)	215	(30·8)	24	(27·6)	31	(38·8)	
Security/transportation/manual labour	193	(34·8)	244	(35·0)	29	(33·3)	18	(22·5)	
Others	57	(10·3)	77	(11·0)	18	(20·7)	16	(20·0)	
Living alone, *n* (%)	42	(7·6)	75	(10·7)	21	(24·1)	19	(23·8)	<0·0001
Current smoker, *n* (%)	205	(36·9)	265	(38·0)	41	(47·1)	39	(48·8)	0·075
Habitual alcohol drinker, *n* (%)	164	(29·6)	177	(25·4)	15	(17·2)	19	(23·8)	0·064
Step counts, mean (SD)	8079	(4387)	8219	(4706)	7434	(4943)	6731	(4774)	0·029
Women, *n* (%)	489	(29·5)	1060	(63·9)	71	(4·3)	39	(2·4)	
Age, years, mean (SD)	31·6	(5·8)	32·5	(5·3)	27·9	(5·7)	29·8	(6·5)	<0·001
Body height, cm, mean (SD)	157·9	(5·8)	158·1	(5·2)	158·2	(5·3)	157·3	(6·9)	0·757
Body weight, kg, mean (SD)	53·2	(9·5)	53·1	(9·0)	52·8	(9·2)	54·3	(10·9)	0·869
Waist circumference, cm, mean (SD)	75·3	(9·9)	75·2	(9·4)	75·0	(9·9)	77·0	(11·6)	0·736
Body mass index category, *n* (%)									0·680
Underweight (< 18·5)	85	(17·4)	193	(18·2)	14	(19·7)	6	(15·4)	
Normal (18·5–25)	344	(70·4)	745	(70·3)	51	(71·8)	25	(64·1)	
Overweight (≥ 25)	60	(12·3)	122	(11·5)	6	(8·5)	8	(20·5)	
Occupation									0·002
Professional/manager	90	(18·4)	187	(17·6)	12	(16·9)	5	(12·8)	
Sales/service/clerical	227	(46·4)	426	(40·2)	33	(46·5)	24	(61·5)	
Security/transpotation/manual labour	45	(9·2)	70	(6·6)	1	(1·4)	3	(7·7)	
Others	127	(26·0)	377	(35·6)	25	(35·2)	7	(18·0)	
Living alone, *n* (%)	21	(4·3)	69	(6·5)	7	(9·9)	5	(12·8)	0·049
Current smoker, *n* (%)	73	(14·9)	118	(11·1)	15	(21·1)	5	(12·8)	0·028
Habitual alcohol drinker, *n* (%)	56	(11·5)	94	(8·9)	3	(4·2)	8	(20·5)	0·017
Step counts, mean (SD)	6772	(3533)	6871	(3596)	7736	(5411)	6601	(3390)	0·212

* Means for continuous values were compared using the analysis of variance, and proportions for categorical values were compared using the χ^2 test among the four groups.

reported[42]. Thus, caution should be observed in interpreting our results on women. The lower energy intake in the B–S– group suggests that the lower energy intake due to missing breakfast and snacks was not compensated for by lunch and dinner. However, because the results of this study were obtained from a one-day dietary record, similar trends observed in studies of habitual food intake need to be assessed.

The intake of folate, vitamin C, Ca, Fe, potassium and dietary fibre among breakfast and snack consumers were higher than those consuming three meals a day in USA adults[1]. Additionally, for young USA adults, snacks have been reported to be contributed to the intake of vitamin B_2, vitamin C, niacin, Ca and Fe[43], whereas breakfast skipping has been reported to be associated with inadequate intake of vitamin A, vitamin C and Mg[44]. These results from 24-h recall data are consistent with our results from dietary record data. Moreover, regarding the intake of food groups, the B+S+ group had higher intake of fruits than the B+S- group. Fruits contain a large amount of vitamins and minerals[45], and their consumption was higher among snack consumers[9]. In addition, women with a higher frequency of snack consumption were more likely to be health conscious[38], and the frequency of snack consumption in women was higher than that in men[46,47]. These reports may partly explain why the number of nutrients meeting adequate intake was higher among women than among men in this study. Moreover, among only men, Zn intake was lower and inadequate in the B+S+ group than the B+S– group. Zn content varies from food to food, irrespective of food group[23]. The secondary data for the NHNS did not have access to detailed food records. Detailed food sources of Zn in breakfast and snacks may need to be explored. Overall, snack consumption may lead to higher nutritional intake.

On the other hand, the lower intake of Cu, dietary fibre and potassium was observed among women in the B–S– group than

Table 2. Daily energy and nutrient intake of study participants stratified by breakfast and snack consumption among 1420 Japanese men and 1659 Japanese women aged 20–39 years from the NHNS 2012 data
(mean values and standard eror)

	Breakfast consumers				Breakfast skippers			
	Non-snack consumers (B+S–)		Snack consumers (B+S+)		Snack consumers (B-S+)		Non-snack consumers (B-S–)	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Men, *n*	555		698		87		80	
Energy, kcal/d	2095	22	2372	24*	2128	65	1669	73*
Protein, % energy	14·4	0·1	13·7	0·1*	13·4	0·3	14·3	0·5
Fat, % energy	26·1	0·3	26·3	0·3	27·5	0·7	27·1	1·0
SFA, % energy	6·8	0·1	7·2	0·1	7·4	0·3	7·1	0·3
Carbohydrate, % energy	54·9	0·4	55·9	0·3	55·6	0·8	54·0	1·1
Vitamin A, μg RAE/d†	488	26	555	23	461	55	475	116
Vitamin B_1, mg/d	0·9	0·02	1·1	0·04	1·0	0·07	0·7	0·04
Vitamin B_2, mg/d	1·1	0·02	1·5	0·04*	1·1	0·09	0·8	0·06
Niacin, NEmg/d‡	27·9	0·4	31·5	0·5	27·2	1·1	23·1	1·4
Vitamin B_6, mg/d	1·1	0·03	1·5	0·08	1·3	0·16	0·9	0·05
Vitamin B_{12}, μg/d	5·7	0·3	5·9	0·3	4·8	0·5	5·1	0·8
Folate, μg/d	260	5	295	5	231	11	191	16
Vitamin C, mg/d	67	2	92	4	70	7	50	5
Ca, mg/d	423	10	518	9*	398	23	313	25
Mg, mg/d	231	3	267	3*	217	8	177	10
Fe, mg/d	7·4	0·1	8·3	0·1	7·2	0·3	5·9	0·3
Zn, mg/d	9·1	0·1	9·0	0·1*	8·6	0·3	7·3	0·4
Cu, mg/d	1·2	0	1·3	0	1·1	0	1·0	0·1
Dietary fibre, g/d	13·2	0·2	14·8	0·2	13·2	0·6	10·3	0·7
Na (salt-equivalent), g/d	10·7	0·2	11·8	0·2	10·8	0·5	8·8	0·4
K, mg/d	2022	30	2415	30*	1907	73	1554	100
Women, *n*	489		1060		71		39	
Energy, kcal/d	1575	20	1745	13*	1574	61	1253	78*
Protein, % energy	15·1	0·2	14·3	0·1*	14·1	0·4	15·4	0·7
Fat, % energy	27·6	0·3	28·2	0·2	28·9	0·9	30·8	1·6
SFA, % energy	7·4	0·1	7·9	0·1	8·3	0·4	9·5	0·8*
Carbohydrate, % energy	54·5	0·4	55·3	0·3	54·6	1·0	50·0	1·9*
Vitamin A, μg RAE/d†	442	25	503	14	404	39	265	30
Vitamin B_1, mg/d	0·8	0·02	0·8	0·02	0·9	0·12	0·6	0·06
Vitamin B_2, mg/d	1·0	0·03	1·1	0·02	1·1	0·11	0·8	0·07
Niacin, NEmg/d‡	21·9	0·4	23·6	0·2	21·8	1·5	17·8	1·6
Vitamin B_6, mg/d	1·0	0·06	1·1	0·03	1·1	0·16	0·7	0·06
Vitamin B_{12}, μg/d	4·8	0·3	4·7	0·2	4·6	0·8	2·8	0·5
Folate, μg/d	227	5	259	3*	204	17	152	11
Vitamin C, mg/d	68	3	82	2	61	7	53	18
Ca, mg/d	384	9	455	6	375	29	312	35
Mg, mg/d	188	3	221	2*	183	12	144	13
Fe, mg/d	6·1	0·1	6·9	0·1	6·0	0·5	4·5	0·3
Zn, mg/d	7·3	0·1	7·1	0·1	6·8	0·4	5·3	0·3
Cu, mg/d	0·9	0	1·0	0	0·9	0	0·6	0*
Dietary fibre, g/d	11·5	0·2	13·4	0·2*	11·0	0·9	7·6	0·6*
Na (salt-equivalent), g/d	8·8	0·2	9·3	0·1	8·3	0·4	6·8	0·4
K, mg/d	1735	31	2056	21*	1674	94	1195	83*

NE, niacin equivalent; RAE, retinol activity equivalent; SFA, saturated fatty acid.
* Indicates significant difference referenced to the B+S– groups by Dunnett test in the adjusted model with confounding variables of age, occupation (professional/manager, sales/service/clerical, security/transportation/manual labour and others), living alone (yes or no), current smoker (yes or no), habitual alcohol drinker (yes or no) and energy intake (except for the analysis on energy itself and nutrients provided as % energy (protein, fat, saturated fatty acid and carbohydrate)).
† Sum of retinol, β-carotene/12, α-carotene/24 and cryptoxanthin/24.
‡ Sum of niacin and protein/6000.

those in the B+S– group. Among USA and Korean adults, breakfast skippers had lower intake of vitamin B_1, niacin, folate, vitamin C and Ca than breakfast consumers, irrespective of dietary survey methods such as 24-h dietary recall and dietary record[5,48]. In addition, among Japanese adults, breakfast skippers had lower intake of folate, vitamin C, Ca, Mg, potassium and Fe than breakfast consumers[4]. However, breakfast skippers in these previous studies included both snack and non-snack consumers, unlike the classification in this study, which could explain the discrepancy in results. In young adults who skip breakfast and snacks, especially women, need to be considered in the future.

No difference was found in nutrient intake between the B+S– and B–S+ groups. In contrast to the results of this study, American adults aged ≥ 20 years who skipped breakfast and consumed at least two snacks per day had lower intake of nutrients except for salt than those who consumed only three meals per day[1]. Although the frequency of snack consumption

Table 3. Multivariate-adjusted odds ratios for the presence of not meeting estimated average requirement (EAR) and tentative dietary goal to prevent lifestyle-related diseases (DG) among 1420 Japanese men and 1659 Japanese women aged 20–39 years from the NHNS 2012 data
(Odd ratio (OR) and 95 % confidence intervals (CI))

		Men								Women							
		Breakfast consumers				Breakfast skippers				Breakfast consumers				Breakfast skippers			
		Non-snack consumers (B+S–)		Snack consumers (B+S+)		Snack consumers (B–S+)		Non-snack consumers (B–S–)		Non-snack consumers (B+S–)		Snack consumers (B+S+)		Snack consumers (B–S+)		Non-snack consumers (B–S–)	
EAR	Vitamin A, μg RE/d, *n* (%)	447	(80·5)	507	(72·6)	69	(79·3)	68	(85.0)	347	(71.0)	646	(60·9)	53	(74·7)	32	(82·1)
	Adjusted OR (95 % CI)*		Reference	0·82	(0·62, 1·09)	0·95	(0·53, 1·72)	0·94	(0·47, 1·88)		Reference	0·74	(0·58, 0·94)	1·36	(0·75, 2·49)	1·44	(0·60, 3·49)
	Vitamin B_1, mg/d, *n* (%)	437	(78·7)	495	(70·9)	69	(79·3)	72	(90.0)	370	(75·7)	741	(69·9)	49	(69.0)	30	(76·9)
	Adjusted OR 95 % CI)*		Reference	0·99	(0·74, 1·32)	1·19	(0·65, 2·19)	1·47	(0·63, 3·42)		Reference	1·01	(0·77, 1·32)	0·80	(0·43, 1·48)	0·52	(0·22, 1·24)
	Vitamin B_2, mg/d, *n* (%)	406	(73·2)	400	(57·3)	67	(77.0)	69	(86·3)	329	(67·3)	518	(48·9)	46	(64·8)	30	(76·9)
	Adjusted OR (95 % CI)*		Reference	0·69	(0·53, 0·90)	1·45	(0·80, 2·60)	1·37	(0·66, 2·86)		Reference	0·58	(0·45, 0·74)	0·97	(0·53, 1·76)	0·85	(0·36, 2·03)
	Niacin, NE mg/d, *n* (%)	10	(1·8)	9	(1·3)	4	(4·6)	11	(13·8)	15	(3·1)	14	(1·3)	6	(8·5)	6	(15·4)
	Adjusted OR (95 % CI)*		Reference	1·01	(0·36, 2·85)	1·84	(0·49, 6·97)	1·42	(0·47, 4·34)		Reference	0·97	(0·41, 2·28)	3·64	(1·08, 12·3)	1·76	(0·50, 6·18)
	Vitamin B_6, mg/d, *n* (%)	306	(55·1)	304	(43·6)	54	(62·1)	67	(83·8)	335	(68·5)	586	(55·3)	49	(69.0)	34	(87·2)
	Adjusted OR 95 % CI)*		Reference	0·93	(0·72, 1·21)	1·28	(0·74, 2·21)	1·85	(0·92, 3·75)		Reference	0·73	(0·57, 0·95)	1·11	(0·60, 2·07)	1·96	(0·65, 5·90)
	Vitamin B_{12}, μg/d, *n* (%)	143	(25·8)	142	(20·3)	23	(26·4)	32	(40.0)	183	(37·4)	341	(32·2)	35	(49·3)	23	(59.0)
	Adjusted OR (95 % CI)*		Reference	0·97	(0·73, 1·28)	0·99	(0·57, 1·70)	1·08	(0·64, 1·84)		Reference	0·94	(0·74, 1·20)	1·59	(0·93, 2·71)	1·63	(0·81, 3·28)
	Folate, μg/d, *n* (%)	179	(32·3)	172	(24·6)	36	(41·4)	53	(66·3)	235	(48·1)	315	(29·7)	40	(56·3)	31	(79·5)
	Adjusted OR (95 % CI)*		Reference	0·93	(0·71, 1·21)	1·31	(0·78, 2·18)	2·04	(1·18, 3·53)		Reference	0·56	(0·44, 0·71)	1·40	(0·80, 2·46)	2·84	(1·19, 6·80)
	Vitamin C, mg/d, *n* (%)	420	(75·7)	435	(62·3)	64	(73·6)	71	(88·8)	379	(77·5)	673	(63·5)	57	(80·3)	36	(92·3)
	Adjusted OR (95 % CI)*		Reference	0·65	(0·50, 0·84)	0·90	(0·52, 1·54)	1·81	(0·85, 3·86)		Reference	0·56	(0·43, 0·72)	1·21	(0·64, 2·31)	2·63	(0·78, 8·86)
	Ca, mg/d, *n* (%)	458	(82·5)	502	(71·9)	75	(86·2)	72	(90.0)	397	(81·2)	766	(72·3)	62	(87·3)	36	(92·3)
	Adjusted OR (95 % CI)*		Reference	0·72	(0·54, 0·97)	1·50	(0·75, 2·97)	1·25	(0·55, 2·84)		Reference	0·78	(0·59, 1·03)	1·85	(0·85, 4·02)	1·89	(0·54, 6·60)
	Mg, mg/d, *n* (%)	468	(84·3)	486	(69·6)	76	(87·4)	73	(91·3)	388	(79·4)	676	(63·8)	56	(78·9)	36	(92·3)
	Adjusted OR (95 % CI)*		Reference	0·65	(0·47, 0·90)	1·57	(0·73, 3·38)	0·97	(0·38, 2·48)		Reference	0·58	(0·44, 0·78)	1·08	(0·53, 2·21)	1·90	(0·46, 7·83)
	Fe, mg/d†, *n* (%)	238	(42·9)	222	(31·8)	39	(44·8)	53	(66·3)	450	(92.0)	917	(86·5)	65	(91·6)	39	(100)
	Adjusted OR (95 % CI)*		Reference	1.00	(0·76, 1·30)	1·06	(0·61, 1·83)	1·04	(0·58, 1·89)		Reference	0·78	(0·52, 1·16)	1·03	(0·39, 2·73)	–	
	Zn, mg/d, *n* (%)	305	(55.0)	321	(46.0)	50	(57·5)	61	(76·3)	280	(57·3)	503	(47·5)	45	(63·4)	32	(82·1)
	Adjusted OR (95 % CI)*		Reference	1·55	(1·15, 2·10)	1·30	(0·69, 2·46)	0·77	(0·37, 1·64)		Reference	1·19	(0·90, 1·58)	1·70	(0·83, 3·48)	1·39	(0·46, 4·22)
	Cu, mg/d, *n* (%)	30	(5·4)	22	(3·2)	6	(6·9)	24	(30.0)	59	(12·1)	76	(7·2)	15	(21·1)	19	(48·7)
	Adjusted OR (95 % CI)*		Reference	0·96	(0·51, 1·82)	0·82	(0·29, 2·35)	2·04	(0·96, 4·35)		Reference	1·14	(0·73, 1·78)	1·70	(0·76, 3·83)	3·18	(1·30, 7·75)
DG	Protein, % energy, *n* (%)	21	(3·8)	14	(2.0)	1	(1·2)	4	(5.0)	191	(39·1)	398	(37·6)	36	(50·7)	11	(28·2)
	Adjusted OR (95 % CI)*		Reference	1·22	(0·97, 1·53)	0·91	(0·58, 1·43)	1·12	(0·69, 1·81)		Reference	0·92	(0·73, 1·15)	0·55	(0·34, 0·91)	1·65	(0·80, 3·40)
	Fat, % energy, *n* (%)	265	(47·8)	312	(44·7)	37	(42·5)	38	(47·5)	251	(51·3)	560	(52·8)	40	(56·3)	20	(51·3)
	Adjusted OR (95 % CI)*		Reference	0·88	(0·71, 1·11)	1·07	(0·68, 1·69)	0·88	(0·55, 1·40)		Reference	1·07	(0·86, 1·33)	0·88	(0·54, 1·44)	1·11	(0·58, 2·12)
	SFA, % energy, *n* (%)	231	(41·6)	339	(48·6)	44	(50·6)	36	(45.0)	240	(49·1)	633	(59·7)	46	(64·8)	25	(64·1)
	Adjusted OR (95 % CI)*		Reference	1·32	(1·05, 1·66)	0·92	(0·58, 1·44)	1·20	(0·75, 1·94)		Reference	1·56	(1·25, 1·94)	0·91	(0·54, 1·51)	0·89	(0·45, 1·74)
	Carbohydrate, % energy, *n* (%)	211	(38.0)	246	(35·2)	25	(28·7)	29	(36·3)	195	(39·9)	382	(36.0)	26	(36·6)	18	(46·2)
	Adjusted OR (95 % CI)*		Reference	0·91	(0·72, 1·15)	1·24	(0·76, 2·04)	0·89	(0·55, 1·45)		Reference	0·87	(0·69, 1·08)	0·96	(0·58, 1·59)	0·70	(0·37, 1·34)
	Dietary fibre, g/d, *n* (%)	503	(90·6)	615	(88·1)	81	(93·1)	77	(96·3)	450	(92.0)	882	(83·2)	63	(88·7)	38	(97·4)
	Adjusted OR (95 % CI)*		Reference	1·18	(0·79, 1·75)	1·63	(0·63, 4·17)	1·68	(0·43, 6·63)		Reference	0·55	(0·37, 0·81)	0·68	(0·29, 1·60)	2.00	(0·24, 16·3)

British Journal of Nutrition

Table 3. (*Continued*)

	Men								Women							
	Breakfast consumers				Breakfast skippers				Breakfast consumers				Breakfast skippers			
	Non-snack consumers (B+S–)		Snack consumers (B+S+)		Snack consumers (B–S+)		Non-snack consumers (B–S–)		Non-snack consumers (B+S–)		Snack consumers (B+S+)		Snack consumers (B–S+)		Non-snack consumers (B–S–)	
Na (salt-equivalent), g/d, *n* (%)	439	(79·1)	604	(86·5)	66	(75·9)	46	(57·5)	362	(74.0)	845	(79·7)	45	(63·4)	16	(41.0)
Adjusted OR (95 % CI)*		Reference	1·21	(0·88, 1·67)	0·91	(0·51, 1·64)	0·77	(0·45, 1·35)		Reference	0·96	(0·73, 1·27)	0·59	(0·33, 1·07)	0·44	(0·21, 0·93)
K, mg/d, *n* (%)	502	(90·5)	554	(79·4)	80	(92.0)	78	(97·5)	444	(90·8)	859	(81.0)	64	(90·1)	38	(97·4)
Adjusted OR (95 % CI)*		Reference	0·63	(0·43, 0·91)	1·53	(0·61, 3·83)	3·17	(0·48, 21·0)		Reference	0·57	(0·39, 0·83)	1·13	(0·43, 2·94)	2·55	(0·25, 26·0)

DRI, dietary reference intakes; SFA, saturated fatty acid.
Percentage of subjects whose intake was in the range of DG or above the EAR.
Each energy-adjusted nutrient intake (unit/d) was compared with each DRI value (unit/d)[22], using the cut-point method.
* Adjusted for confounding variables of age category (20–29 and 30–39 years), occupation (professional/manager, sales/service/clerical, security/transportation/manual labour and others), living alone (yes or no), current smoker (yes or no), habitual alcohol drinker (yes or no) and energy intake (except for the analysis on energy itself and nutrients provided as %energy (protein, fat, saturated fat and carbohydrate)).
† The probability of inadequacy > 50 % for menstruating women whose bioavailability of iron is 15 % (< 9·3 mg/d) was considered inadequate for women aged 20–49 years.

per day was not examined in this study, the B–S+ group included those who snack at least once a day, whereas the previous study did not include those who consumed snacks only once[1]. This may partly explain the difference in the results. Thus, whether snack content changes according to the timing and frequency of snacks should be considered in future studies.

This study had some limitations. First, the participants were randomly selected from nationally representative households in Japan; however, only 51·9 % of the sampled households participated, and the individual-level response rate was unknown. This might have introduced some bias in the estimation of average intake in Japanese adults. Second, a dietary intake derived from a one-day weighed dietary record is unlikely to represent the usual intake. Therefore, caution is needed for interpreting our results, especially those regarding nutrient inadequacy. Incidentally, it is noted that the one-day household-based dietary record method used in NHNS has been compared with individual dietary records of Japanese participants, and the correlation coefficients of the intake of total energy and macronutrients were high (0·89–0·91)[49]. Thus, this method may be valid for estimating individual intake. Third, we only analysed those who consumed three meals a day because this study aimed to assess nutrient intake and nutrition adequacy based on the difference in breakfast and snack consumption. This might have introduced some bias regarding nutrient intake. Fourth, meal frequency and snack frequency have been linked to education and income[2]. However, we did not investigate the education and income levels of the participants; thus, we could not consider these relationships. Therefore, their influence on the results could not be determined. Fifth, we did not examine the timing and frequency of snack consumption. Snack timing and frequency have been positively associated with the intake of fruit and dairy products and negatively associated with the fish intake[2,50]. Sixth, a large number of participants (*n* 1373) were excluded from the present analysis because of missing information on their height and weight. The proportion of individuals with missing value was higher among breakfast skippers; however, there were no differences in macronutrient intakes between excluded persons and participants in this study (data not shown). Therefore, the exclusion of people with missing values from the analysis would not have a significant impact on the results of this study. Lastly, the number of people varied in each group, and the number of participants was small, especially the women in the B–S– groups, although the required sample size was B–S– (*n* 34) and B+S– (*n* 458) that was estimated using G × Power 3 with effect size 0·5, power 0·8 and allocation ratio n2/n1 12·5[51]. Further study may need to be conducted in target population with a large sample size where the statistical power of the B–S–group is sufficient.

This cross-sectional study showed that breakfast and snack consumption is related to nutrient intake among Japanese adults. In young Japanese adults whose energy intake is within an appropriate range, snack consumption could supplement nutrients that may not be adequately consumed by three meals. Overall, Japanese adults are likely to consume nutrient-rich snacks, and further investigation on the nutrients and consumption of snacks is warranted.

Table 4. Daily food group intake of study participants stratified by breakfast and snack consumption among 1420 Japanese men and 1659 Japanese women aged 20–39 years from the NHNS 2012 data
(Numbers; mean values and standard error)

	Breakfast consumers				Breakfast skippers			
	Non-snack consumers (B+S–)		Snack consumers (B+S+)		Snack consumers (B-S+)		Non-snack consumers (B-S–)	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Men, *n*	555		698		87		80	
Grains, g/d	578	8·0	591·3	7·8 *	549·5	19·4	469·3	22·2
Potatoes, g/d	49·0	2·8	57·0	2·5	50·3	7·0	44·8	9·6
Sugars, g/d	4·8	0·3	6·7	0·3	5·2	1·1	4·4	0·8
Pulses, g/d	57·8	4·0	56·2	2·9	39·8	6·9	39·2	7·4
Sesame and nuts, g/d	1·0	0·2	1·8	0·3	1·4	0·5	0·4	0·1
Vegetables, g/d	276	7·5	287·8	6·8	266·6	18·3	213·6	16·0
Fruits, g/d	37·3	3·6	70·1	5·4 *	40·2	10·2	23·8	7·7
Mushrooms, g/d	16·2	1·4	18·5	1·3	16·6	3·3	16·9	3·4
Seaweeds, g/d	8·2	0·7	10·2	0·7	5·9	1·9	10·3	2·9
Fish and shellfishes, g/d	67·6	3·1	69·6	2·9	61·8	7·1	58·3	13·0
Meat and poultry, g/d	133·4	4·0	129·7	3·4	135·3	9·8	118·8	9·6
Eggs, g/d	39·8	1·6	40·6	1·4	25·0	3·3	27·3	4·3
Dairy products, g/d	65·0	5·7	106·4	5·7 *	48·3	8·2	34·9	11·4
Fats and oils, g/d	13·8	0·5	14·4	0·5	14·7	1·4	10·8	1·1
Confectionaries, g/d	8·3	1·4	31·4	2·0 *	44·0	6·8 *	2·2	1·6
Tea (Green tea, black tea and Chinese tea), g/d	184·9	12·2	262·7	13·2 *	304·2	43·9	161·8	27·4
Coffee and cocoa, g/d	90·7	6·2	232·6	9·5 *	111·1	17·0	34·0	10·2
Soft drink, g/d	137·7	10·8	218·1	12·6 *	211·8	34·3	150·8	36·6
Seasonings, g/d	106·8	4·5	117·7	4·3	116·1	12·8	84·0	8·7
Women, *n*	489		1060		71		39	
Grains, g/d	395·1	6·7	389·6	4·6 *	334·7	16·0	279·3	17·4
Potatoes, g/d	48·1	2·6	50·5	1·9	39·7	6·3	27·7	6·7
Sugars, g/d	5·4	0·4	6·5	0·2	7·4	1·3	2·4	0·7
Pulses, g/d	49·0	3·2	51·4	2·1	37·6	7·7	22·3	7·6
Sesame and nuts, g/d	1·1	0·2	1·7	0·2	1·2	0·7	0·6	0·3
Vegetables, g/d	241·0	7·2	256·6	4·4	204·6	16·0	137·8	14·5
Fruits, g/d	47·7	4·2	81·9	3·2 *	47·5	8·8	66·7	30·7
Mushrooms, g/d	14·0	1·1	15·7	0·7	19·6	4·5	13·3	3·7
Seaweeds, g/d	6·5	0·7	10·9	0·8	4·0	1·4	5·3	2·1
Fish and shellfishes, g/d	56·6	2·9	52·5	1·7	47·8	7·1	34·0	8·5
Meat and poultry, g/d	89·0	3·1	86·7	1·8	89·1	9·6	91·2	11·7
Eggs, g/d	33·2	1·5	33·5	1·0	29·8	4·0	28·2	5·9
Dairy products, g/d	77·2	5·1	104·6	3·7	96·5	15·6	66·7	27·2
Fats and oils, g/d	10·8	0·4	10·9	0·3	10·1	0·9	8·2	1·1
Confectionaries, g/d	13·3	1·8	39·1	1·6 *	50·1	7·5 *	12·7	6·0
Tea (Green tea, black tea and Chinese tea), g/d	179·2	11·5	279·3	10·7 *	281·6	39·6	194·9	51·3
Coffee and cocoa, g/d	86·2	6·8	170·9	6·7 *	112·8	22·9	61·0	20·1
Soft drink, g/d	111·7	9·5	164·4	8·2 *	162·2	33·1	61·4	22·0
Seasonings, g/d	82·3	4·0	82·3	2·5	72·3	8·3	51·7	7·8

* Indicates significant difference referenced to the B+S– groups by Dunnett test in the adjusted model with confounding variables of age, occupation (professional/manager, sales/service/clerical, security/transportation/manual labour and others), living alone (yes or no), current smoker (yes or no), habitual alcohol drinker (yes or no) and energy intake (except for the analysis on energy itself and nutrients provided as % energy (protein, fat, saturated fatty acid and carbohydrate)).

Acknowledgements

Financial support: This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors. *Conflict of interest:* There are no conflicts of interest. *Authorship:* All the authors designed the research. M. M. analysed the data and wrote the first draft of the manuscript. E. O., R. T. and A. F. took part in the interpretation of the data and provided critical revisions of the manuscript for important intellectual content. H. T. had the primary responsibility for the final content. All authors read and approved the final manuscript.

References

1. Kerver JM, Yang EJ, Obayashi S, *et al.* (2006) Meal and snack patterns are associated with dietary intake of energy and nutrients in US adults. *J Am Diet Assoc* **106**, 46–53.
2. Murakami K & Livingstone MB (2016) Associations between meal and snack frequency and diet quality in US adults: National Health and Nutrition Examination Survey 2003–2012. *J Acad Nutr Diet* **116**, 1101–1113.
3. Leech RM, Livingstone KM, Worsley A, *et al.* (2016) Meal frequency but not snack frequency is associated with micronutrient intakes and overall diet quality in Australian men and women. *J Nutr* **146**, 2027–2034.

4. Murakami K, Livingstone MBE, Fujiwara A, *et al.* (2018) Breakfast in Japan: findings from the 2012 National Health and Nutrition Survey. *Nutrients* **10**, 1551.
5. Min C, Noh H, Kang YS, *et al.* (2011) Skipping breakfast is associated with diet quality and metabolic syndrome risk factors of adults. *Nutr Res Pract* **5**, 455–463.
6. Yoshimura E, Hatamoto Y, Yonekura S, *et al.* (2017) Skipping breakfast reduces energy intake and physical activity in healthy women who are habitual breakfast eaters: a randomized crossover trial. *Physiol Behav* **174**, 89–94.
7. Halsey LG, Huber JW, Low T, *et al.* (2012) Does consuming breakfast influence activity levels? An experiment into the effect of breakfast consumption on eating habits and energy expenditure. *Public Health Nutr* **15**, 238–245.
8. Ovaskainen ML, Reinivuo H, Tapanainen H, *et al.* (2006) Snacks as an element of energy intake and food consumption. *Eur J Clin Nutr* **60**, 494–501.
9. Zizza CA & Xu B (2012) Snacking is associated with overall diet quality among adults. *J Acad Nutr Diet* **112**, 291–296.
10. Whybrow S & Kirk T (2003) Nutrient intakes and snacking frequency in female students. *J Hum Nutr Diet* **10**, 237–244.
11. Murakami K & Livingstone MB (2016) Associations between meal and snack frequency and diet quality and adiposity measures in British adults: findings from the National Diet and Nutrition Survey. *Public Health Nutr* **19**, 1624–1634.
12. Krok-Schoen JL, Jonnalagadda SS, Luo M, *et al.* (2019) Nutrient intakes from meals and snacks differ with age in middle-aged and older Americans. *Nutrients* **11**, 1301.
13. Zizza C, Siega-Riz AM & Popkin BM (2001) Significant increase in young adults' snacking between 1977–1978 and 1994–1996 represents a cause for concern! *Prev Med* **32**, 303–310.
14. Fayet-Moore F, McConnell A, Cassettari T, *et al.* (2019) Breakfast choice is associated with nutrient, food group and discretionary intakes in Australian adults at both breakfast and the rest of the day. *Nutrients* **11**, 175.
15. Howarth NC, Huang TT, Roberts SB, *et al.* (2007) Eating patterns and dietary composition in relation to BMI in younger and older adults. *Int J Obes* **31**, 675–684.
16. Yokoyama Y, Onishi K, Hosoda T, *et al.* (2016) Skipping breakfast and risk of mortality from cancer, circulatory diseases and all causes: findings from the Japan Collaborative Cohort study. *Yonago Acta Med* **59**, 55–60.
17. Ministry of Health, Labour and Welfare (2014) The National Health and Nutrition Survey in Japan, 2012. https://www.mhlw.go.jp/bunya/kenkou/eiyou/h24-houkoku.html (accessed July 2022).
18. Ministry of Health, Labour and Welfare (2017) The National Health and Nutrition Survey in Japan, 2016. https://www.mhlw.go.jp/bunya/kenkou/eiyou/h28-houkoku.html (accessed July 2022).
19. Saito A, Imai S, Htun NC, *et al.* (2018) The trends in total energy, macronutrients and sodium intake among Japanese: findings from the 1995–2016 National Health and Nutrition Survey. *Br J Nutr* **120**, 424–434.
20. Ministry of Internal Affairs and Communications, Statistics Bureau (2011) The 2010 National Census. https://www.stat.go.jp/data/kokusei/2010/ (accessed July 2022).
21. Takimoto H, Yoshiike N, Katagiri A, *et al.* (2003) Nutritional status of pregnant and lactating women in Japan: a comparison with non-pregnant/non-lactating controls in the National Nutrition Survey. *J Obstet Gynaecol Res* **29**, 96–103.
22. Health Promotion Act Law No 103 (2002).
23. Ministry of Education, Culture, Sports, Science and Technology (2010) Standard Tables of Food Composition in Japan, 2010. https://www.mext.go.jp/b_menu/shingi/gijyutu/gijyutu3/houkoku/1298713.htm (accessed July 2022).
24. Ministry of Health, Labour and Welfare (2020) Dietary Reference Intakes for Japanese (2020 Edition). https://www.mhlw.go.jp/content/10904750/000586553.pdf. (accessed July 2022).
25. Okubo H, Sasaki S, Murakami K, *et al.* (2010) Nutritional adequacy of four dietary patterns defined by cluster analysis in Japanese women aged 18–20 years. *Asia Pac J Clin Nutr* **19**, 555–563.
26. Kobayashi S, Asakura K, Suga H, *et al.* (2017) Living status and frequency of eating out-of-home foods in relation to nutritional adequacy in 4017 Japanese female dietetic students aged 18–20 years: a multicenter cross-sectional study. *J Epidemiol* **27**, 287–293.
27. Kohri T, Kaba N, Itoh T, *et al.* (2016) Effects of the National School Lunch Program on bone growth in Japanese elementary school children. *J Nutr Sci Vitaminol* **62**, 303–309.
28. WHO/FAO (2006) Guidelines on Food Fortification With Micronutrients. Geneva: WHO/FAO.
29. Saito A, Okada E, Tarui I, *et al.* (2019) The association between milk and dairy products consumption and nutrient intake adequacy among Japanese adults: analysis of the 2016 National Health and Nutrition Survey. *Nutrients* **11**, 2361.
30. Mishra GD, Lee JS, Hayashi K, *et al.* (2017) How do health behaviours relate to dietary practice patterns among Japanese adults? *Asia Pac J Clin Nutr* **26**, 351–357.
31. Tanaka R, Tsuji M, Kusuhara K, *et al.* (2018) Association between time-related work factors and dietary behaviors: results from the Japan Environment and Children's Study (JECS). *Environ Health Prev Med* **23**, 62.
32. Fujiwara A, Okada E, Okada C, *et al.* (2020) Association between free sugars intake and nutrient dilution among Japanese adults: the 2016 National Health and Nutrition Survey, Japan. *Eur J Nutr* **59**, 3827–3839.
33. Fujiwara A, Okada E, Okada C, *et al.* (2021) Association between free sugar intake and nutrient dilution among Japanese children and adolescents: the 2016 National Health and Nutrition Survey, Japan. *Br J Nutr* **125**, 1394–1404.
34. Sakurai M, Yoshita K, Nakamura K, *et al.* (2017) Skipping breakfast and 5-year changes in body mass index and waist circumference in Japanese men and women. *Obes Sci Pract* **3**, 162–170.
35. Smith KJ, McNaughton SA, Cleland VJ, *et al.* (2013) Health, behavioral, cognitive, and social correlates of breakfast skipping among women living in socioeconomically disadvantaged neighborhoods. *J Nutr* **143**, 1774–1784.
36. Pendergast FJ, Livingstone KM, Worsley A, *et al.* (2016) Correlates of meal skipping in young adults: a systematic review. *Int J Behav Nutr Phys Act* **13**, 125.
37. Nakamoto M, Tanaka Y, Ono S, *et al.* (2019) Associations of marital and parental status and family members living together with health-related behaviors in Japanese young workers : a cross-sectional study. J Med Invest JMI 66, 141–147.
38. Hartmann C, Siegrist M & van der Horst K (2013) Snack frequency: associations with healthy and unhealthy food choices. *Public Health Nutr* **16**, 1487–1496.
39. Murakami K, Shinozaki N, Livingstone MBE, *et al.* (2020) Characterisation of breakfast, lunch, dinner and snacks in the Japanese context: an exploratory cross-sectional analysis. *Public Health Nutr* **25**, 689–701.
40. Murakami K, Livingstone MBE, Okubo H, *et al.* (2018) Prevalence and characteristics of misreporting of energy intake in Japanese adults: the 2012 National Health and Nutrition Survey. *Public Health Nutr* **25**, 689–701.
41. Murakami K, Sasaki S & Okubo H (2012) Characteristics of under- and over-reporters of energy intake among young Japanese women. *J Nutr Sci Vitaminol* **58**, 253–262.

42. Hebert JR, Ma Y, Clemow L, *et al.* (1997) Gender differences in social desirability and social approval bias in dietary self-report. *Am J Epidemiol* **146**, 1046–1055.
43. Khan MA & Lipke LK (1982) Snacking and its contribution to food and nutrient intake of college students. *J Am Diet Assoc* **81**, 583–587.
44. Deshmukh-Taskar PR, Radcliffe JD, Liu Y, *et al.* (2010) 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* **29**, 407–418.
45. Science and Technology Agency (2020) Standard Tables of Food Composition in Japan, 2020. Tokyo: Ministry of Education, Culture, Sports, Science and Technology.
46. Murakami K & Livingstone MB (2015) Eating frequency is positively associated with overweight and central obesity in U.S. adults. *J Nutr* **145**, 2715–2724.
47. Murakami K, Livingstone MBE, Masayasu S, *et al.* (2021) Eating patterns in a nationwide sample of Japanese aged 1–79 years from MINNADE study: eating frequency, clock time for eating, time spent on eating and variability of eating patterns. *Public Health Nutr* **25**, 1515–1527.
48. Zhang L, Cordeiro LS, Liu J, *et al.* (2017) The association between breakfast skipping and body weight, nutrient intake, and metabolic measures among participants with metabolic syndrome. *Nutrients* **9**, 384.
49. Iwaoka F, Yoshiike N, Date C, *et al.* (2001) A validation study on a method to estimate nutrient intake by family members through a household-based food-weighing survey. *J Nutr Sci Vitaminol* **47**, 222–227.
50. Murakami K, Shinozaki N, Livingstone MBE, *et al.* (2020) Meal and snack frequency in relation to diet quality in Japanese adults: a cross-sectional study using different definitions of meals and snacks. *Br J Nutr* **124**, 1219–1228.
51. Faul F, Erdfelder E, Lang AG, *et al.* (2007) G × Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav Res Meth* **39**, 175–191.

British Journal of Nutrition