Original Article

Association between the frequency of combined staple, main, and side dishes and nutritional adequacy among young Japanese women: A cross-sectional study

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Background and Objectives: Traditional Japanese diet comprises staple food, main dish, and side dish (SMS). Studies reporting the association between the frequency of SMS meals consumption and nutritional adequacy remain limited. We aimed to examine the association between the frequency of SMS meals consumption and nutritional adequacy in young Japanese women. **Methods and Study Design:** In this cross-sectional study, data from 329 female nutrition students aged 18–25 years were analysed. The frequency of SMS meals consumption more than twice a day was assessed using a self-administered questionnaire, and dietary intake was evaluated using a validated food frequency questionnaire. We examined the association between SMS meals consumption and likelihood of not meeting the Dietary Goal (DG) or the Estimated Average Requirement (EAR) as defined in the Japanese Dietary Reference Intakes for Japanese. Trend analyses were performed to evaluate the relationship between SMS meal frequency and the number of nutrients not meeting the DG or EAR, while adjusting for potential confounders. **Results:** Participants with high frequency of SMS meals consumption (5–7 days/week) had the lowest number of nutrients not meeting the EAR and DG, with significant linear trends observed across categories (p for trend <0.001 for DG; 0.001 for EAR). **Conclusions:** Frequency of SMS meals consumption is positively associated with improved nutrient intake among young Japanese women. However, given that the participants were dietetic students with relatively high nutrition literacy, caution is needed when generalising these findings to the wider population of young Japanese women.

Key Words: staple food, Japanese, nutritional adequacy, young woman, nutritional epidemiology

INTRODUCTION

A distinguishing feature of the traditional Japanese diet is the combination of staple food, a main dish, and side dish (SMS).[1] Staple food typically include rice, bread, noodles, or pasta; the main dish usually consists of fish, meat, eggs, or soy products; and side dish often comprise vegetables, mushrooms, or seaweed. The frequency of SMS meals consumption is positively associated with high intake of specific nutrients and food groups.[2-9] For example, a previous study reported that Japanese university students aged 18–24 years who regularly consumed SMS meals had high intakes of protein, polyunsaturated fatty acids (n-6 and n-3), soluble and insoluble dietary fibre, β-carotene, α-tocopherol, vitamin K, thiamine, riboflavin, folate, pantothenic acid, vitamin C, potassium, calcium, magnesium, iron, and copper.[2]

Several studies have reported the relationship between frequency of SMS meal consumption and nutritional adequacy, using indicators such as tentative Dietary Goals (DGs) for preventing noncommunicable diseases and Estimated Average Requirements (EARs) for avoiding nutrient insufficiencies, as defined in the Dietary Reference Intakes for Japanese 2025 (DRIs).[10] However, in many studies, researchers have relied on short-term dietary records (1–4 days), which may not accurately capture habitual dietary intake.[3,5,7,9] In a previous study,[8] the habitual diet intake was assessed using a food frequency

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questionnaire (FFQ). However, energy adjustment was conducted using the estimated energy requirement (EER) assuming a fixed level of modest physical activity, with a possibility that energy adjustment was not performed appropriately. Furthermore, adults aged 30–69 years were targeted, and the researchers did not focus on young women, who represent an important population for nutritional research because of their unique health challenges.[11-13] Since many young women are potential future mothers, their nutritional status is critical for their own health and for that of the next generation, highlighting the importance of identifying healthy dietary patterns in this specific population.

We aimed to examine the association between the frequency of SMS meal consumption and nutritional adequacy among young Japanese women, using data on habitual dietary intake obtained from a food frequency questionnaire (FFQ) and correcting for reporting bias based on physical activity levels.

METHODS

Study design and population

This cross-sectional study was conducted in April 2023, in Eniwa, Hokkaido, Japan. A total of 346 female undergraduate students (ranging from the first to the fourth year) who were enrolled in the Department of Nutrition at Hokkaido Bunkyo University participated in the study. Because all participants were students enrolled in a nutrition program at a single university, their awareness of healthy diet and nutrition-related behaviours may have differed from those of the general population of young Japanese women. The level of formal nutrition education varied by academic year, with first-year students having received minimal instruction. Therefore, our study was not based on a priori sample size calculation. Self-administered lifestyle and dietary questionnaires were distributed at the study site, and participants were asked to complete them directly. The completed questionnaires were reviewed by the research staff, and those with missing responses or logical inconsistencies were returned to the participants for correction.

Ethics approval

Written informed consent was obtained from all participants. This study was conducted in accordance with the guidelines of the Declaration of Helsinki, and the study protocol was approved by the Ethics Committee of Hokkaido Bunkyo University (Approval No. 04018).

Assessment of frequency of the combined SMS consumption

Participants were given a brief explanation of SMS and were then asked, 'How many days per week do you eat more than two meals per day that include *shushoku*, *shusai*, and *fukusai*'?

Frequency was self-reported using eight categories, ranging from zero to seven times per week. The cut-off point of 'more than two meals per day' was determined based on previous studies and the National Health and Nutrition Survey of Japan, which evaluated SMS meal frequency among Japanese populations.[2,8,14]

Although this question does not fully match the previously validated questionnaire used in earlier studies, both instruments capture the same underlying construct of SMS meal frequency. The validated instrument demonstrated moderate correlations with SMS meal frequency derived from 3-day photographic and dietary records (r=0.43 in men, r=0.44 in women), supporting the construct validity of self-reported SMS meal frequency.[15]

Assessment of physical activity

Physical activity was assessed using the Japanese version of the International Physical Activity Questionnaire–Short Form (IPAQ-SF),[16] and classified into low, moderate, or high levels. The Japanese version of the seven items IPAQ-SF was used to evaluate the duration and frequency of vigorous, moderate, and walking level physical activities. Validation studies conducted in Japan have reported that this instrument provides stable repeated measurements, with test-retest reliability ranging from r = 0.72 to 0.93 and demonstrates acceptable criterion related validity compared with objective measures (r = 0.39).[16]

Total physical activity was calculated as metabolic equivalent of task (MET)-min per week by summing the product of the reported duration and frequency for vigorous activity (8.0 METs), moderate activity (4.0 METs), and walking (3.3 METs), in accordance with the IPAQ scoring protocol. Participants were then categorised into low, moderate, or high activity levels based on established IPAQ criteria.

High activity was defined as meeting either of the following:

(1) vigorous-intensity activity on ≥3 days and accumulating ≥1500 MET-min/week, or

(2) ≥7 days of walking, moderate, or vigorous activity that together exceeded ≥3000 MET-min/week.

Moderate activity was defined as meeting any of the following:

(1) ≥3 days of vigorous activity of ≥20 min/day,

(2) ≥5 days of moderate activity or walking of ≥30 min/day, or

(3) ≥5 days of any combination of walking, moderate, or vigorous activity totalling ≥600 MET-min/week.

Low activity included all participants who did not meet the criteria for high or moderate activity.

Assessment of other variables

Age, sex, height, weight, living arrangements, sleeping, smoking status, and alcohol consumption were assessed using self-administered questionnaires. Body mass index (BMI) was calculated as weight (kg)/height squared (m^2). Alcohol consumption was categorised as follows: almost none; <1 cup/week; 1–2 cups/week, 3 cups/week, 4 cups/week, 5 cups/week, 6 cups/week; and daily. Individuals were categorised into four groups according to their smoking status: current daily smokers, occasional smokers, former smokers, and never smokers. Living arrangements were categorised as living alone, living with family, dormitory, boarding house, student housing, or others.

Assessment of dietary intake

Nutrient and food intakes over the previous month were assessed using a brief self-administered diet history questionnaire (BDHQ).[17,18] The BDHQ employed in this study was a four-page, fixed-portion questionnaire designed to estimate the intake of 58 food items. Energy and nutrient intakes were calculated based on responses to the BDHQ and the corresponding food composition data from the Standard Tables of Food Composition in Japan.[19]

The validity of the BDHQ was evaluated in 92 women (aged 31–69 years) by comparing its results with 16-day weighted dietary records, which served as the gold standard.[17,18] The median Spearman's correlation coefficient (interquartile range) between the BDHQ and dietary records for the energy-adjusted intake of the 42 nutrients for women was 0.54 (0.45–0.61). For food intake, the median Spearman's correlation coefficient for women was 0.44 (0.14–0.82).

Nutritional adequacy

Nutritional adequacy was evaluated by comparing the observed intake with the corresponding reference values defined in DRIs,[10] as previously reported.[20,21] DRIs include multiple reference values depending on their objectives, and the DG aims to prevent noncommunicable diseases, and EAR is intended to prevent deficiency.

To correct for the over- or underestimation inherent in self-reported dietary data, dietary intake was energy-adjusted using the EER. The EER was calculated based on each participant's physical activity level, which was assessed using the Japanese version of the IPAQ-SF.[16] According to the DRIs, the reference EER values in women aged 20–29 years were 1,700 kcal for low, 1,950 kcal for moderate, and 2,250 kcal for high physical activity levels. The adjustment formula was as follows:

Energy-adjusted intake (units/day) = observed intake (units/day) × EER (kcal/day) / observed energy intake (kcal/day).

For the DG-based evaluation, nutrient intake outside the recommended range was considered inadequate for the following: percentage energy from total fat, saturated fat, total protein, carbohydrates, and total dietary fibre; sodium (expressed as salt equivalents); and potassium. The salt equivalent was calculated as follows:

Salt (g) = 58.5 / 23 × sodium (g)

Macronutrient intake (total fat, saturated fat, carbohydrates, and protein) was expressed as a percentage of the total energy intake (crude values). Nutrients such as biotin, chromium, molybdenum, selenium, and iodine were excluded owing to insufficient data in Japan's food composition tables despite being included in the DRIs.

Nutrient intakes below the EAR were classified as inadequate. The cut-point method was applied to the following 13 nutrients: total protein; vitamin A (expressed as retinol activity equivalents); vitamins B-1, B-2, and niacin (niacin equivalents); vitamin B-6, folate; vitamin C, and calcium, magnesium, iron, zinc, and copper. Because the iron requirement among menstruating women shows a highly skewed distribution,[22,23] the probability approach was adopted rather than the conventional cut-point method. An iron intake below 9.3 mg/day was regarded as insufficient, corresponding to a >50 % probability of inadequacy when iron bioavailability is assumed to be 15%,[24] as previously reported.[20]

The vitamin A content was calculated as follows:

Retinol + β-carotene / 12 + α-carotene / 24 + cryptoxanthin / 24

The niacin equivalents were calculated as follows:

Niacin (mg) + protein (mg) / 6000

Statistical analyses

The participants were grouped into tertiles according to SMS meal frequency (0–1 day/week (n = 93), 2–4 days/week (n = 141), 5–7 days/week (n = 95)). These cut-points were chosen to maintain adequate sample sizes within each category and reflect low, moderate, and high habitual SMS meal consumption. All statistical analyses were performed using the SAS software (version 9.4; SAS Institute Inc., Cary, NC, USA). Statistical significance was set at p <0.05. The main analyses were conducted using nutrient intakes adjusted for energy intake based on EER. Additionally, supplementary analyses were performed using nutrient intakes without EER-based energy adjustment, and the results are presented in the Supplementary Tables.

The baseline characteristics across tertiles (assigned ordinal values of 0–2) were evaluated using linear regression for continuous variables and the Mantel–Haenszel chi-square test for trends in categorical variables.

The proportion of participants with nutrient intake outside the DG range or below the EAR was calculated. The Cochran–Armitage trend test was used across tertiles (assigned ordinal values of 0–2) to evaluate the association between the frequency of SMS meal consumption and the prevalence not meeting the DG or EAR.

Multivariable logistic regression was performed to evaluate the association between SMS meal frequency and not meeting the DG or EAR adjusted for age (years, continuous), BMI (<18.5, 18.5-24.9, ≥25.0 kg/m²), living alone (yes/no), physical activity (low/moderate/high), current smoking status (yes/no), current alcohol consumption status (≥1 cup/week, <1 cup/week), energy intake (kcal, continuous), and supplement use (yes/no). The lowest tertile of SMS meal frequency was used as the reference group for the analysis. For nutrients with extremely low prevalence of inadequacy—specifically, total protein (EAR) and niacin, zinc, and copper (EAR)—logistic regression models could not be reliably estimated because of sparse data, including 0 cases in one or more tertiles. These nutrients were therefore excluded from logistic regression analyses. To assess overall nutritional adequacy, the number of nutrients not meeting the DRIs was counted for each participant (up to 7 nutrients for DG and 13 for EAR). Multiple linear regression analyses were conducted to assess trends in the number of nutrients not meeting the DG or EAR across SMS meal frequency categories, adjusting for the same covariates as described above.

Sensitivity analyses were conducted to examine the robustness of the findings. First, analyses were repeated among first-year students only, who had not yet received university-level nutrition education and therefore, had lower formal nutrition knowledge. Second, analyses were repeated after excluding participants who reported dietary

supplement use, to minimise the influence of supplement-derived nutrient intake on estimates of nutritional adequacy.

Multicollinearity among independent variables was assessed by calculating variance inflation factors (VIFs) using PROC REG in SAS (version 9.4; SAS Institute Inc., Cary, NC, USA). All VIF values were below 2, indicating no notable multicollinearity. Influential outliers were evaluated using studentised residuals, leverage values, and Cook's distance obtained from PROC REG in SAS. No observation exceeded commonly recommended cutoff criteria in the models predicting the number of nutrients not meeting the DG or EAR.

To determine whether the EER-based adjustment altered nutrient intake distributions, we compared histograms and calculated skewness and kurtosis before and after adjustment. The distributions were highly similar, suggesting that the adjustment did not distort nutrient intake patterns.

RESULTS

Questionnaires were distributed to 346 participants, and 10 were excluded owing to a lack of informed consent. In addition, two participants were excluded because they failed to return all the questionnaires, and five were excluded for not submitting the questionnaires by April 2023. The final analytic sample consisted of 329 women, with a mean age of 19.4 ± 1.2 years (range: 18–25 years), yielding a response rate of 95.5%.

The distribution of SMS meal frequency was as follows: 28.3% reported consuming SMS meals once a week or never, 42.9% consumed them 2–4 days per week, and 28.9% almost daily. The characteristics of the participants according to the SMS meal frequency are presented in Table 1.

Participants with high SMS meal frequency were significantly less likely to live alone, and this frequency was positively associated with current smoking. Regarding nutrients, high SMS meal frequency was significantly associated with high intake of total protein, potassium, calcium, magnesium, phosphorus, iron, zinc, copper, vitamin A, vitamin D, vitamin E, vitamin K, vitamin B-1, vitamin B-2, niacin, vitamin B-6, vitamin B-12, folate, pantothenic acid, vitamin C, and total dietary fibre. Participants with higher SMS meal frequency had greater intakes of potatoes, sugar, total vegetable, green and yellow vegetables, and other vegetables, and lower intakes of confectioneries, compared with those with lower SMS meal frequency.

The prevalence of participants not meeting the DG or EAR defined by the DRIs for the Japanese, categorised according to SMS meal frequency, is shown in Table 2. High SMS meal frequency was significantly associated with a low prevalence of not meeting the DG for protein, dietary fibre, and potassium. High SMS meal frequency was significantly associated with a low prevalence of not meeting the EAR for vitamin A, vitamin B-1, niacin, vitamin B-6, vitamin B-12, folate, vitamin C, calcium, magnesium, and iron.

The adjusted ORs for confounding variables for not meeting the DG or EAR based on SMS meal frequency, categorised into three groups, are presented in Table 3. High SMS meal frequency was significantly associated with low adjusted ORs for not meeting the DG for total protein, total dietary fibre, and potassium. High SMS meal frequency was significantly associated with low adjusted ORs for not meeting the EAR for vitamins B-1, B-6, C, folate, and iron.

The total number of nutrients that did not meet the DG and EAR, stratified by the frequency of SMS meal consumption, is presented in Table 4. After adjusting for confounding factors, trend analyses indicated that high frequency of SMS meals was significantly associated with low total number of nutrients that did not meet the DG and EAR. For DG, the mean (standard deviation [SD]) was as follows: 4.7 (1.2), 0–1 day/week; 4.3 (1.2), 2–4 days/week; and 3.9 (1.4), 5–7 days/week; p for trend <0.001. For EAR, the mean (SD) was as follows: 4.1 (3.1), 0–1 day/week; 4.0 (3.0), 2–4 days/week; and 2.6 (2.5), 5–7 days/week; p for trend 0.001.

Among first-year students, the mean (SD) number of nutrients not meeting the DG was 4.8 (1.2) in the 0–1 day/week group, 3.9 (1.3) in the 2–4 days/week group, and 4.0 (1.4) in the 5–7 days/week group (p for trend = 0.049). For the EAR, the corresponding values were 3.7 (3.0), 3.2 (2.7), and 3.0 (2.6) (p for trend = 0.593). Although these results did not fully replicate the findings from the overall sample, the direction of the associations was similar.

Among participants who did not report dietary supplement use, the mean number (SD) of nutrients not meeting the DG was 4.7 (1.2) in the 0–1 day/week group, 4.3 (1.3) in the 2–4 days/week group, and 4.0 (1.5) in the 5–7 days/week group (p for trend = 0.004). For the EAR, the corresponding values were 4.3 (3.2), 4.1 (2.9), and 3.0 (2.6) (p for trend = 0.045). Although these results did not fully replicate the findings from the overall sample, the direction of the associations was similar.

Sensitivity analyses using unadjusted nutrient intakes yielded associations that were consistent in the direction and magnitude with the EER-adjusted analyses (Supplementary Tables 1–3). Nutrient intake distributions and the proportions of participants not meeting DG or EAR values were also highly similar between unadjusted and adjusted datasets, supporting the robustness of the findings.

DISCUSSION

In this study of young Japanese women, we found that high frequency of SMS meals consumption was associated with low number of nutrients that failed to meet the DGs and EARs defined by the DRIs. Specifically, high SMS meal frequency was significantly associated with low adjusted odds ratios (ORs) for not meeting the DG for protein, dietary fibre, and potassium. Similarly, it was associated with low adjusted ORs for not meeting the EAR for vitamins B-1, B-6, C and folate.

To our knowledge, this is the first study reporting the relationship between the frequency of SMS meal consumption and nutritional adequacy among young Japanese women, using data on habitual dietary intake and correcting for reporting bias based on physical activity levels.

A previous study of adults aged between 30–69 years reported using an FFQ to examine the relationship

Table 1. Participant characteristics stratified by frequency of staple food, main dish, and side dish meals consumption

	Total (n=329)	0–1 day/week (n=93)	2–4 days/week (n=141)	5–7 days/week (n=95)	*p* for trend
Age, years	19.4 (1.2)	19.5 (1.2)	19.5 (1.2)	19.2 (1.3)	0.189
BMI, kg/m^2	21.2 (3.0)	21.3 (2.7)	20.8 (3.0)	21.5 (3.2)	0.737
BMI category, (%)					0.510
<18.5	16.1	12.9	19.2	14.7	
18.5–24.9	75.4	79.6	73.8	73.7	
≥25.0	8.5	7.5	7.1	11.6	
Physical activity, (%)					0.482
Low	22.5	23.7	22.7	21.1	
Moderate	56.2	61.3	52.5	56.8	
High	21.3	15.1	24.8	22.1	
Living alone, (%)	37.1	52.7	36.9	22.1	<0.001*
Sleeping (<6 h/day, %)	31.0	35.5	25.5	34.7	0.922
Current smoker, (%)	2.7	6.5	2.1	0.0	0.007*
Current alcohol consumer (≥1 cup/week, %)	19.2	20.4	17.7	20.0	0.943
Supplement use, (%)	30.1	25.8	31.9	31.6	0.391
Energy (kcal)	1377 (448)	1226 (412)	1393 (442)	1499 (454)	<0.001*
Nutrients					
Total protein (% energy)	14.6 (2.8)	14.3 (3.1)	14.3 (2.8)	15.4 (2.6)	0.005*
Total fat (% energy)	27.5 (6.5)	27.8 (7.1)	26.7 (6.2)	28.4 (6.2)	0.120
Saturated fat (% energy)	7.6 (2.1)	7.9 (2.4)	7.4 (2.0)	7.6 (1.8)	0.168
Carbohydrate (% energy)	54.6 (8.2)	54.3 (9.1)	55.5 (7.9)	53.7 (7.7)	0.224
Total dietary fibre (g/1,000 kcal)	6.2 (2.0)	5.8 (1.8)	5.9 (1.9)	7.1 (2.2)	<0.001*
Sodium (salt-equivalent) (g/1,000 kcal)	5.9 (1.3)	6.0 (1.3)	5.8 (1.3)	5.9 (1.2)	0.353
Potassium (mg/1,000 kcal)	1219 (381)	1148 (381)	1152 (330)	1387 (402)	<0.001*
Calcium (mg/1,000 kcal)	248 (91.6)	241 (102)	233 (78.8)	276 (93.0)	0.001*
Magnesium (mg/1,000 kcal)	119 (28.8)	114 (29.5)	115 (26.3)	130 (28.7)	<0.001*
Phosphorus (mg/1,000 kcal)	525 (108)	508 (119)	510 (100)	563 (98.3)	<0.001*
Iron (mg/1,000 kcal)	4.0 (1.1)	3.8 (1.1)	3.8 (0.9)	4.4 (1.1)	<0.001*
Zinc (mg/1,000 kcal)	4.5 (0.7)	4.4 (0.7)	4.4 (0.6)	4.7 (0.6)	0.001*
Copper (mg/1,000 kcal)	0.6 (0.1)	0.6 (0.1)	0.6 (0.1)	0.7 (0.1)	0.001*
Manganese (mg/1,000 kcal)	1.6 (0.5)	1.6 (0.6)	1.6 (0.5)	1.7 (0.5)	0.788
Vitamin A (μgRAE/1,000 kcal)	298 (153)	279 (151)	285 (150)	336 (155)	0.015*
Vitamin D (μg/1,000 kcal)	5.3 (3.3)	4.5 (3.3)	5.3 (3.2)	6.1 (3.2)	0.004*
Vitamin E (mg/1,000 kcal)	3.8 (1.1)	3.6 (1.0)	3.7 (1.0)	4.3 (1.2)	<0.001*
Vitamin K (μg/1,000 kcal)	159 (86.5)	149 (89.8)	149 (67.8)	186 (102)	0.002*
Vitamin B-1 (mg/1,000 kcal)	0.41 (0.09)	0.39 (0.10)	0.39 (0.09)	0.45 (0.09)	<0.001*
Vitamin B-2 (mg/1,000 kcal)	0.64 (0.19)	0.64 (0.20)	0.61 (0.17)	0.69 (0.20)	0.009*
Niacin (mg NE/1,000 kcal)	14.2 (3.6)	13.6 (3.8)	13.9 (3.4)	15.3 (3.4)	<0.001*
Vitamin B-6 (mg/1,000 kcal)	0.64 (0.18)	0.60 (0.18)	0.62 (0.17)	0.72 (0.18)	<0.001*
Vitamin B-12 (μg/1,000 kcal)	3.9 (2.1)	3.6 (2.1)	3.8 (2.0)	4.3 (2.1)	0.043*

BMI, body mass index; SD, standard deviation
Values were presented as mean (SD) or %
p-values for linear trends across tertiles (assigned ordinal numbers 0–2) of SMS meal are based on linear regression analysis for continuous variables and the Cochran-Armitage trend test of the trend for categorical variables.
*p<0.05

Table 1. Participant characteristics stratified by frequency of staple food, main dish, and side dish meals consumption (cont.)

	Total (n=329)	0–1 day/week (n=93)	2–4 days/week (n=141)	5–7 days/week (n=95)	*p* for trend
Nutrients					
Folate (μg/1,000 kcal)	161 (63.9)	150 (58.8)	150 (54.5)	187 (73.9)	<0.001*
Pantothenic acid (mg/1,000 kcal)	3.5 (0.7)	3.4 (0.8)	3.4 (0.7)	3.7 (0.7)	0.002*
Vitamin C (mg/1,000 kcal)	53.5 (25.5)	48.1 (23.1)	49.1 (22.2)	65.2 (28.7)	<0.001*
Food groups					
Cereals (g/1,000 kcal)	239 (77.2)	235 (86.0)	246 (76.5)	233 (68.6)	0.380
Potatoes (g/1,000 kcal)	28.3 (24.0)	25.9 (26.5)	26.0 (19.7)	33.9 (26.2)	0.023*
Sugar (g/1,000 kcal)	2.2 (1.6)	1.9 (1.5)	2.1 (1.5)	2.5 (1.8)	0.019*
Pulses (g/1,000 kcal)	29.4 (24.9)	26.5 (30.9)	29.4 (22.5)	32.2 (21.5)	0.295
Total vegetable (g/1,000 kcal)	135 (79.1)	113 (65.8)	122 (69.9)	174 (90.0)	<0.001*
Green and yellow vegetables (g/1,000 kcal)	50.2 (34.1)	39.7 (27.9)	45.8 (27.7)	66.9 (41.8)	<0.001*
Other vegetables (g/1,000 kcal)	84.3 (51.4)	73.5 (45.2)	76.3 (48.4)	106.7 (55.1)	<0.001*
Fruits (g/1,000 kcal)	43.4 (38.1)	42.8 (38.2)	40.8 (35.4)	48.0 (41.7)	0.352
Fish and shellfish (g/1,000 kcal)	31.3 (19.8)	27.8 (20.7)	31.6 (20.0)	34.2 (18.4)	0.083
Meat (g/1,000 kcal)	48.9 (23.7)	48.6 (24.8)	46.9 (22.3)	52.2 (24.6)	0.239
Eggs (g/1,000 kcal)	23.8 (15.1)	23.2 (15.0)	22.6 (14.2)	26.3 (16.5)	0.165
Dairy products (g/1,000 kcal)	62.8 (53.4)	68.7 (63.7)	57.3 (45.7)	67.1 (52.4)	0.169
Fats and oils (g/1,000 kcal)	6.7 (3.1)	6.9 (3.2)	6.6 (2.9)	6.8 (3.2)	0.791
Confectioneries (g/1,000 kcal)	28.5 (20.3)	31.9 (21.4)	29.6 (21.0)	23.7 (17.3)	0.017*
Favourite beverages (g/1,000 kcal)	206 (206)	226 (216)	210 (207)	182 (193)	0.323
Seasoning/Spice (g/1,000 kcal)	156 (75.3)	150 (73.8)	159 (82.5)	157 (65.3)	0.650

BMI, body mass index; SD, standard deviation
Values were presented as mean (SD) or %
p-values for linear trends across tertiles (assigned ordinal numbers 0–2) of SMS meal are based on linear regression analysis for continuous variables and the Cochran-Armitage trend test of the trend for categorical variables.
*$p<0.05$

between SMS meal frequency and nutritional adequacy.[8] In that study, lower SMS meal frequency was associated with a higher likelihood of failing to meet the EAR for several nutrients, whereas no association was observed with failure to meet the DG.[8] In contrast, our findings among young Japanese women revealed clear associations for EAR and DG outcomes. This provides new population specific evidence that the SMS dietary pattern may have stronger relevance for younger individuals who typically exhibit poorer dietary balance. Several factors may explain differences between the present study and previous adult-based findings. First, our participants were students enrolled in a dietetics program and may have had greater nutrition awareness, potentially enhancing their ability to construct nutritionally balanced SMS meals. This suggests that, although SMS meal frequency is important, a basic level of nutrition literacy may also contribute to achieving nutritional adequacy. Second, unlike the previous study,[8] we addressed potential misreporting in self-administered dietary assessments by applying EER-based energy adjustment according to each participant's physical activity level, which may have reduced bias in estimated nutrient intakes.

Young women in Japan represent a nutritionally vulnerable population with several unique health risks.[14] Thinness is particularly common and has been associated with reduced basal metabolic rate,[25] menstrual irregularities,[26] lower bone mass and increased future osteoporosis risk,[12,13] and diminished muscle mass and quality resulting from low energy turnover.[13] Furthermore, impaired glucose tolerance has been reported to be substantially more frequent among thin young Japanese women than in those with normal weight.[27] By examining SMS meal patterns specifically in this high-risk population, our findings offer new evidence that routine consumption of meals comprising a staple food, main dish, and side dish may help mitigate multiple nutrition related vulnerabilities. This age focused perspective expands prior work targeting the general adult population and highlights the importance of dietary pattern-based approaches during early adulthood.

The Health Japan 21 (Third Term)[28] initiative has set a national target for increasing the proportion of adults who

Table 2. Prevalence of not meeting dietary goals or estimated average requirement of the Japanese Dietary Reference Intakes for Japanese 2025 among participants categorised into three groups based on frequency of staple food, main dish, and side dish meals consumption[†]

	Reference value	Prevalence of inadequacy (%)				*p* for trend
		Total (n=329)	0–1 day/week (n=93)	2–4 days/week (n=141)	5–7 days/week (n=95)	
Nutrients for DG						
Total fat (% energy)	20–30	45.0	51.6	41.8	43.2	0.247
Saturated fat (% energy)	≤7	62.6	67.7	58.9	63.2	0.522
Total protein (% energy)	13-20	32.8	41.9	34.8	21.1	0.002*
Carbohydrate (% energy)	50-65	36.5	40.9	34.8	34.7	0.385
Total dietary fibre (g)	≥18	90.6	97.9	94.3	77.9	<0.001*
Sodium (salt-equivalent) (g)	<7	98.2	97.9	97.9	99.0	0.572
Potassium (mg)	≥2600	66.6	72.0	71.6	53.7	0.007*
Nutrients for EAR						
Total protein (g)	≥40	1.8	2.2	2.8	0.0	0.267
Vitamin A (μg RAE)	≥450	40.7	46.2	41.8	33.7	0.080
Vitamin B-1 (mg)	≥0.6	14.9	20.4	19.2	3.2	<0.001*
Vitamin B-2 (mg)	≥1	24.9	25.8	27.7	20.0	0.354
Niacin (mg, NE)	≥9	0.0[‡]	0.0[‡]	0.0[‡]	0.0[‡]	NA[§]
Vitamin B-6 (mg)	≥1	24.0	32.3	27.7	10.5	<0.001*
Folate (μg)	≥200	19.5	26.9	19.9	11.6	0.008*
Vitamin C (mg)	≥80	32.8	43.0	36.2	17.9	<0.001*
Calcium (mg)	≥550	69.9	74.2	76.6	55.8	0.006*
Magnesium (mg)	≥230	50.5	54.8	54.6	40.0	0.041*
Iron (mg)	≥9.3	80.2	83.9	85.1	69.5	0.013*
Zinc (mg)	≥6	2.4	3.2	3.6	0.0	0.149
Copper (mg)	≥0.6	0.6	1.1	0.7	0.0	0.342

DG, dietary goals; EAR, estimated average requirement

[†]Nutrient intakes were adjusted for energy intake using the Estimated Energy Requirement (EER) based on physical activity level.

[‡]"0.0" indicates that no participants were classified as inadequate for that nutrient at that SMS meal frequency category.

[§]NA indicates not applicable because the prevalence of inadequacy was 0.0% in all SMS meal frequency categories; therefore, a p value for trend could not be calculated.

p-values for linear trends across tertiles (assigned ordinal numbers 0–2) of staple, main, and side dish meal are based on the Cochran–Armitage trend test of the trend for categorical variables.

*$p<0.05$

consume SMS meals at least twice per day to 50%. However, data from the 2023 National Health and Nutrition Survey showed that only 28.6% of women aged between 20–29 years meet this target.[14] Given that our findings indicate a positive association between SMS meal frequency and nutritional adequacy among young women, the results support ongoing national strategies aimed at improving dietary balance and reducing micronutrient insufficiency. Promoting SMS style meal planning may represent a practical and culturally grounded approach for health promotion programs targeting young Japanese women, contributing directly to the goals of Health Japan 21 (Third Term).[28]

This study has some limitations. First, the validity of the BDHQ for estimating nutrient intake has been evaluated previously in adults aged 31–69 years, rather than in young women aged 18–20 years, who were the focus of the present study.[17,18] However, the National Health and Nutrition Survey of Japan reported comparable nutrient intakes between women aged 20–29 years and those aged 30–39 years.[14] These findings suggest that the BDHQ may also provide reasonable estimates of dietary intake among young women around 20 years of age. Second, residual confounding cannot be entirely ruled out. Although we adjusted for multiple factors including age, BMI, smoking, alcohol consumption, physical activity, and living arrangement, other unmeasured factors may still have influenced the observed associations. In particular, socioeconomic status, nutrition knowledge, and cooking skills were not directly assessed. However, because all participants were students in the same nutrition program, variability in socioeconomic background is likely limited. Moreover, since nutrition knowledge and cooking skills generally improve with each academic year, our adjustment for age—which correlates closely with academic year—may have partially accounted for differences in these competencies. However, some residual confounding remains possible. Third, the participants were dietetic students who may have had healthier dietary behaviours compared with the general population of young women. Their relatively high nutrition literacy may have contributed to greater awareness of balanced meal patterns and, consequently, higher nutritional adequacy, which could bias the observed associations toward more favourable dietary patterns and limit generalisability. Moreover, higher SMS meal frequency may reflect

Table 3. Adjusted odds ratio of not meeting dietary goals or estimated average requirement of the Japanese Dietary Reference Intakes for Japanese 2025 among participants categorised into three groups based on frequency of staple food, main dish, and side dish meals consumption[†‡]

	0–1 day/week (n=93)	2–4 days/week (n=141)	5–7 days/week (n=95)	*p* for trend[§]
Nutrients with DG				
Total fat	1.00 (reference)	0.64 (0.37, 1.11)	0.69 (0.37, 1.27)	0.237
Saturated fat	1.00 (reference)	0.54 (0.30, 0.98)	0.61 (0.31, 1.18)	0.148
Total protein	1.00 (reference)	0.83 (0.46, 1.48)	0.38 (0.19, 0.76)	0.008*
Carbohydrate	1.00 (reference)	0.87 (0.49, 1.56)	0.80 (0.41, 1.54)	0.499
Total dietary fibre	1.00 (reference)	0.42 (0.08, 2.12)	0.07 (0.01, 0.34)	<0.001*
Sodium (salt-equivalent)	1.00 (reference)	1.13 (0.14, 9.28)	1.72 (0.12, 24.15)	0.695
Potassium	1.00 (reference)	1.29 (0.67, 2.48)	0.46 (0.23, 0.94)	0.024*
Nutrients with EAR				
Total protein	NA[¶]	NA[¶]	NA[¶]	NA[¶]
Vitamin A	1.00 (reference)	1.03 (0.57, 1.86)	0.69 (0.35, 1.35)	0.284
Vitamin B-1	1.00 (reference)	1.30 (0.60, 2.84)	0.14 (0.04, 0.56)	0.015*
Vitamin B-2	1.00 (reference)	1.33 (0.68, 2.59)	0.86 (0.39, 1.89)	0.748
Niacin	NA[¶]	NA[¶]	NA[¶]	NA[¶]
Vitamin B-6	1.00 (reference)	1.01 (0.53, 1.95)	0.26 (0.10, 0.64)	0.007*
Folate	1.00 (reference)	0.77 (0.38, 1.55)	0.39 (0.16, 0.94)	0.039*
Vitamin C	1.00 (reference)	0.93 (0.51, 1.69)	0.32 (0.15, 0.68)	0.005*
Calcium	1.00 (reference)	1.45 (0.75, 2.82)	0.54 (0.27, 1.09)	0.057
Magnesium	1.00 (reference)	1.31 (0.72, 2.40)	0.61 (0.31, 1.20)	0.146
Iron	1.00 (reference)	1.33 (0.61, 2.90)	0.44 (0.20, 0.99)	0.028*
Zinc	NA[¶]	NA[¶]	NA[¶]	NA[¶]
Copper	NA[¶]	NA[¶]	NA[¶]	NA[¶]

OR, odds ratio; CI, Confidence Interval; DG, dietary goal; EAR, estimated average requirement; SMS, staple food, main dish, and side dish; BMI, body mass index
Values are presented as OR (95%CI)
[†]Multivariable adjusted ORs for nutrient intake inadequacy by SMS meal frequency were estimated using logistic regression adjusted for age (years, continuous), BMI (<18.5, 18.5− 24.9, ≥25.0 kg/m²), living alone (yes/no), physical activity (low/moderate/high), current smoking status (yes/no), current alcohol consumption status (≥1 cup/week, <1 cup/week), energy intake (kcal, continuous), and supplement use (yes/no). Total protein (EAR) and niacin, zinc, and copper (EAR) are excluded from logistic regression analyses owing to their extremely low prevalence of inadequacy.
[‡]Nutrient intakes were adjusted for energy intake using the Estimated Energy Requirement (EER) based on physical activity level..
[§]*p* for trend was obtained by assigning ordinal scores (0–2) to the SMS meal frequency categories and including this variable as a continuous term in the multivariable logistic regression model.
[¶]NA indicates not available because logistic regression models were not estimated due to sparse data (extremely low prevalence of inadequacy, including 0 cases in one or more categories).
*$p<0.05$

Table 4. Number of nutrients not meeting tentative dietary goals (n=7) of the Japanese Dietary Reference Intakes and estimated average requirements (n=13) status among participants stratified by frequency of staple food, main dish, and side dish meals consumption[†]

	Total (n=329)	0–1 day/week (n=93)	2–4 days/week (n=141)	5–7 days/week (n=95)	*p* for trend
Not meeting DG	4.3 (1.3)	4.7 (1.2)	4.3 (1.2)	3.9 (1.4)	<0.001*
Not meeting EAR	3.6 (2.9)	4.1 (3.1)	4.0 (3.0)	2.6 (2.5)	0.001*

DG, dietary goals; EAR, estimated average requirement; SD, standard deviation; BMI, body mass index
Values are presented as Mean (SD)
[†]Nutrient intakes were adjusted for energy intake using the Estimated Energy Requirement (EER) based on physical activity level..
p for trend was estimated using multiple linear regression by assigning ordinal scores (0-2) to the SMS meal frequency categories and entering this variable as a continuous term, adjusted for age (years, continuous), BMI (<18.5, 18.5-24.9, ≥25.0 kg/m²), living alone (yes/no), physical activity (low/moderate/high), current smoking status (yes/no), current alcohol consumption status (≥1 cup/week, <1 cup/week), energy intake (kcal, continuous), and supplement use (yes/no).
*$p<0.05$

broader behavioural characteristics—such as greater nutrition knowledge, stronger cooking confidence, or more structured meal planning—rather than the direct effect of combining staple, main, and side dish. These behavioural determinants, along with factors such as home cooking frequency, budgeting practices, and access to diverse food items, may influence SMS meal frequency and overall diet quality. Thus, SMS meal frequency may function as a proxy for these underlying behaviours, and the associations should not be interpreted as causal. Although our

sensitivity analysis was restricted to first-year students—who had minimal formal nutrition education—showed a similar direction of association, some degree of behavioural confounding cannot be ruled out. Fourth, differences in participants' perceptions and understanding of SMS meals may have affected their responses. Nonetheless, given the nutritional background of the participants, a relatively consistent understanding of SMS meals was assumed. Fifth, the SMS meal frequency was assessed using a single self-reported questionnaire that was not formally validated and did not exactly match the instrument used in previous validation research. Some degree of non-differential misclassification is therefore possible, which would likely bias the results toward the null. However, a prior validation study[15] have shown moderate correlations between questionnaire-based SMS meal frequency and both photographic and dietary records, suggesting that any misclassification is unlikely to meaningfully alter the observed associations. Finally, although we assumed that the estimated average energy requirements accurately reflected the actual energy intake and adjusted nutrient intake accordingly, because the measurement errors for energy and nutrients were not identical, some degree of bias may have been introduced.

Conclusion

Our findings suggest that frequent consumption of SMS meals is associated with improved nutrient intake among young Japanese women. These results may inform public health strategies aimed at preventing nutrient deficiencies and addressing the health risks associated with thinness in this population. However, given that the participants were dietetic students with relatively high nutrition literacy, caution is needed when generalising these findings to the wider population of young Japanese women.

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DISCLOSURE ON THE USE OF AI AND AI-ASSISTED TECHNOLOGIES

AI-assisted technologies (ChatGPT, OpenAI) were used solely for language proofreading to improve the clarity and readability of the manuscript. The authors reviewed and edited all content and take full responsibility for the final version of the manuscript.

CONFLICT OF INTEREST AND FUNDING DISCLOSURES

No conflicts of interest are to be declared.

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