Original Article

Association of meal component combinations with nutrient adequacy in Japanese adults

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Background and Objectives: Consuming a diet that ensures adequate nutrient intake is essential to address all forms of malnutrition. In Japan, a meal combining staple food, main dish, and side dish is considered a balanced diet. This study was conducted to investigate the frequency of meals combining staple food, main dish, and side dish associated with nutrient adequacy. **Methods and Study Design:** This cross-sectional study included 6,264 adults. All data were obtained from the 2015 Health and Nutrition Survey in Shiga prefecture. Staple food, main dish, and side dish were each defined as a dish with primary ingredients of ≥50 g. Regarding the frequency, participants were divided into ≥2 and <2 times/d groups. The nutrient adequacy evaluated using the Dietary Reference Intakes for Japanese 2020 (DRIs–J) score is based on the reference values provided in the DRIs–J. The t-test was used to evaluate nutrient adequacy between the 2 groups. **Results:** Of the total participants, only 1,423 (22.7%) were classified into the ≥2 times/d group, and they had significantly higher DRIs–J scores than participants in the <2 times/d group ($p < 0.001$). The adequacy percentage of all nutrients except saturated fatty acid, particularly dietary fiber and most micronutrients, was >1.5-fold higher in the ≥2 times/d group than in the <2 times/d group ($p < 0.001$). **Conclusions:** This study provides important information that meals combining staple food, main dish, and side dish at least twice a day is effective in maintaining a diet with high nutrient adequacy.

Key Words: Japanese diet, dietary quality, dietary reference intakes, nutritional survey, nutrient adequacy

INTRODUCTION

Over the years, many countries have faced diverse forms of malnutrition, including undernutrition,[1,2] overweight and obesity,[3,4] and the double burden of malnutrition.[5,6] The WHO aims to eradicate all forms of malnutrition by 2030 as part of the Sustainable Development Goals.[7] We must consume a diet that ensures adequate nutrient intake to address nutritional problems.

The traditional Japanese diet, which was registered as the United Nations Educational, Scientific and Cultural Organization Intangible Cultural Heritage in 2013, is attracting international attention.[8] The typical Japanese diet combines staple food (grain dish), main dish, and side dish. A staple food, such as rice, bread, noodles, or pasta, is the primary source of carbohydrates. The Japanese people consume staple foods as the primary source of energy. A main dish is the major source of protein and fat with fish, meat, eggs, soybeans, or soy products. A side dish includes vegetables, tubers, mushrooms, seeds, or seaweeds, which are important sources of vitamins, minerals, and dietary fiber.[9,10]

A meal combining staple food, main dish, and side dish (SMS meal) is recommended by the third term of the National Health Promotion Movement in the 21st century (Healthy Japanese 21, 2024–2035),[11] the Japanese dietary guidelines,10 and the Japanese Spinning Top.[12] However, individual dietary data have not been used to assess intake status, leaving the current situation unclear. To develop effective social measures, it is crucial to investigate the intake patterns of staple foods, main dishes, and side dishes, along with their consumption timing (breakfast, lunch, or dinner). In addition, although a SMS meal is considered a nutritionally balanced diet, there is very limited evidence. Most of the previous Japanese studies have reported an association between the frequency of SMS meals and nutrient intake based on self-reported data.[13-15] The interpretation of staple food, main dish, and side dish varies from person to person. In 1984, Adachi first proposed the weight-based definition of staple food, main dish, and side dish so that the general population could easily consume a nutritionally balanced diet,[9] and this basic concept is still used in many recent studies and nutritional policies.[16-19] Ishikawa-Takata et al.[20] noted the lack of Adachi's definition as a limitation in their examination of the nutritional adequacy of SMS meals, and no studies have yet evaluated the frequency of SMS meals and their impact on nutrient adequacy.

Therefore, this study was conducted to (1) clarify the frequency of SMS meals using Japanese dietary data and (2) investigate the association between the frequency of SMS meals and nutrient adequacy using a weight-based definition.

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METHODS

Data source and participants

We used individual-level data from the Health and Nutrition Survey of Shiga prefecture (HNSS), Japan, 2015.[21] The HNSS provides the most significant prefectural representative sample available to monitor the dietary intake and lifestyle factors of Shiga prefecture residents. We analyzed dietary and participant characteristic data from the 2015 HNSS, which included 4,229 randomly selected households from approximately 1% of households across 19 cities in Shiga, encompassing all household members aged 1 year and older. Figure 1 shows a flow diagram of individuals included in the study. In the present study, data from 6,264 adults (2,906 men, and 3,358 women) were analyzed.

Ethics statement

The present analysis was based on a secondary analysis of observational survey data, the HNSS. The HNSS, conducted by the Shiga prefecture government in Japan, follows strict protocols to ensure confidentiality and protect the identities of individual participants. The present study was approved by the Shiga prefecture. The Shiga prefecture government anonymized all individual-level data before providing the authors with the datasets for this survey. No ethical review was sought based on the Ethical Guidelines for Medical and Health Research Involving Human Subjects, given this study used only information that the Shiga prefecture government had already anonymized.

Dietary data

Each individual's nutrient and food group intake were estimated by a 1-day household dietary record. In the present study, the food weighing method was applied to record the dietary data in this survey. Data included the approximate proportions the dish was divided into among the family members aged ≥ 1 year. A 1-day household dietary record was used to classify staple food, main dish, and side dish and to estimate energy and nutrient intake and food group intake of each individual. A previous study reported that energy and macronutrient intake estimated using this method highly correlated with the intake estimated using individualized diet records (Pearson's correlation coefficients: r = 0.90 for energy, 0.89 for protein, 0.91 for total fat, and 0.90 for carbohydrate).[22]

Frequency of meals combining staple food, main dish, and side dish

On the basis of previous studies,[16,17] we developed the objective criteria for classifying dishes into staple food, main dish, and side dish. We ultimately adopted Shiobara's classification, in which staple foods, main dishes, and side dishes are defined by the weight of ingredients commonly recognized by the general public, rather than by nutrient weight. All dishes were classified based on the weight of the primary ingredients. Shiobara defined staple food, main dish, and side dish as a dish containing ≥50 g of the primary ingredients based on Adachi's definition of staple food, main dish, and side dish.[9] If a dish is <50 g, Shiobara defined it as a small staple food, small main dish, or small side dish. Based on Shiobara's definition, we developed new classification criteria for staple food,

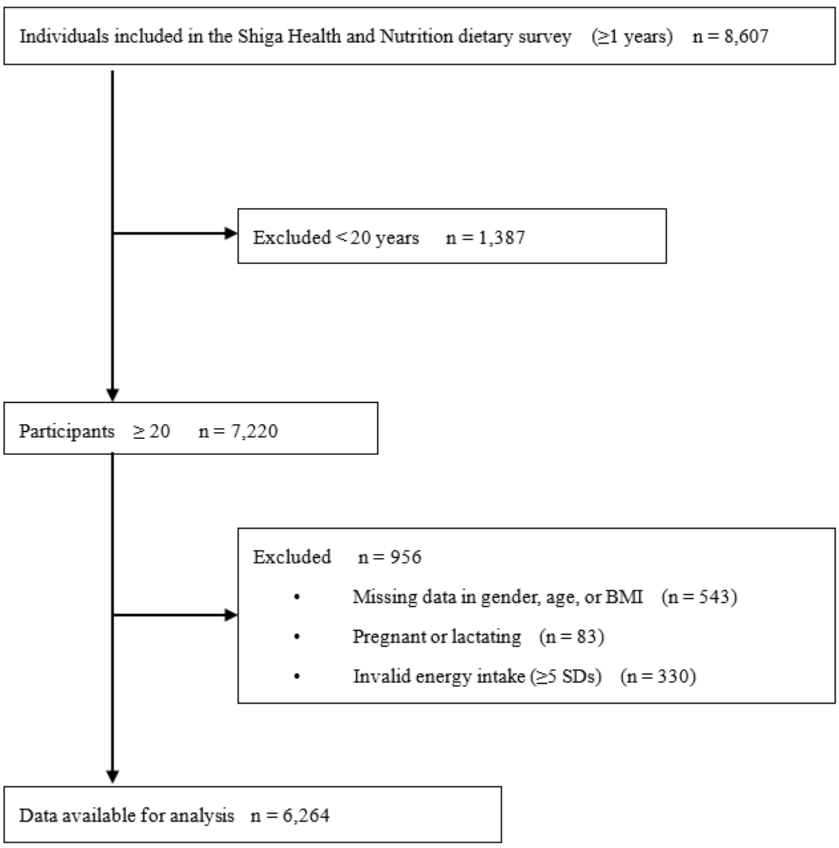

Figure 1. A flow diagram of individuals included in the study

main dish, and side dish. Moreover, dish codes were assigned to each dish category. The 5 modifications from Shiobara's classification are as follow: (1) when one dish corresponds to multiple definitions, it is classified as a combination dish, (2) soup is also classified in the same manner as (1), (3) alcohol is included in the beverage category, (4) the definition of a "small" dish is changed to ≥25 to <50 g, and (5) a dish <25 g is classified as "others." To account for the possibility that participants consumed multiple small dishes, two or more "small" dishes were upgraded. For example, two small staple foods were evaluated as a single staple food.

For breakfast, lunch, and dinner, we calculated the percentage of participants who consumed a SMS meal. We also calculated the frequency of SMS meals per day. A photograph of SMS meals is depicted in Figure 2. Depending on the frequency of SMS meals, participants were divided into two groups, "≥2 times/d" and "<2 times/d," based on previous studies and national recommendations.[11,14,23]

Figure 2. Photographs of the meal combining staple food, main dish, and side dish

Energy and nutrient intake and food group intake

Each individual's energy and nutrient intake and food group intake were calculated using the Japanese Standard Food Composition Table.[24] In this analysis, 18 nutrients used in the evaluation of nutrient adequacy were included. Foods were classified into 19 groups based on the food group classification used in the HNSS.[21] Food group intake was calculated for each group.

Assessment of nutrient adequacy

We defined a well-balanced diet as a nutrient adequate diet. Nutrient adequacy was assessed using the Dietary Reference Intakes for Japanese 2020 (DRIs–J) score. Detailed information on the DRIs–J score can be found in literature.[25] We used the DRIs–J score updated to the DRIs–J 2020. This study assessed the adequacy of intake for 18 nutrients, including protein, fat, saturated fatty acids, carbohydrates, dietary fiber, vitamin A, vitamin B-1, vitamin B-2, niacin, vitamin B-6, vitamin B-12, folic acid, vitamin C, calcium, magnesium, iron, zinc, and copper. To assess the adequacy of the 18 nutrients, a score of 1 was allocated if the nutrient met or exceeded the recommended daily allowance or tentative dietary goal for preventing life-style related diseases. These were determined by gender and age group based on the results of many nutritional epidemiology studies. Additionally, the nutrients having a tolerable upper intake level were given a score of 1 if the nutrient was below tolerable upper intake level. The adequacy of energy intake was assessed using the Estimated Energy Requirement. The total DRIs–J score was constructed by summing the scores of the 18 nutrients and energy intake. The DRIs–J scores ranged from 0 to 19.

Other variables

Information on gender, age, weight, and height was obtained using a self-administered questionnaire. Participants were divided into the following three age groups: 20–39 years (early adults), 40–64 years (late adults), and ≥65 years (elderly). BMI, calculated as body weight divided by height squared (kg/m^2), was classified into <18.5 kg/m^2 (underweight), 18.5–25 kg/m^2 (normal weight), and ≥25 kg/m^2 (obesity) in the stratified analysis. We defined living alone as those without duplicate household numbers.

Statistical analysis

On the basis of previous studies,[11,14,23] we divided the participants into two groups (≥2 and <2 times/d) according to the frequency of SMS meals. All statistical analyses were conducted using data derived from these two groups. For comparing the characteristics of the individuals according to their frequency of SMS meals, the t-test and the chi-square test were used for mean values and SD for continuous variables and percentages for categorical variables. The density method (per 1000 kcal) was used to adjust for nutrient and food group intake. Nutrient adequacy was evaluated using the DRIs–J score (continuous). The association between the frequency of SMS meals and nutrient intake, food group intake, and nutrient adequacy was investigated using the t-test. A stratified analysis by gender and age group was also performed. The chi-square test was used to compare the percentage of those who added scores for energy or each nutrient in the DRIs–J score between the frequency of SMS meals. For all analyses, statistical significance was defined as a two-tailed p-value of < 0.05. All statistical analyses were performed using SAS software (version 9.4; SAS Institute, Cary, NC, USA).

RESULTS

This analysis included 6,264 individuals (mean age ± SD: 55.1 ± 17.1 years, men: 46.4%). The frequency of SMS meals was 31.6% for 0 times/d, 45.7% for 1 time/d, 20.4% for 2 times/d, and 2.3% for 3 times/d. No gender difference was observed. Overall, there were 22.7% of individual with the frequency of SMS meals as ≥2 times/d. Table 1 shows the characteristics of the individuals according to the frequency of SMS meals. Compared with the <2 times/d group, the ≥2 times/d group consisted of a higher proportion of men, older people, and women living alone. The BMI showed no difference between the groups. For breakfast, only 40% of the participants consumed a SMS meal. A high frequency of SMS meals was associated with a higher proportion of individuals

Table 1. The characteristics of the individuals according to the frequency of meals combining staple food, main dish, and side dish by gender (n = 6,264)†

	All (n = 6,264)			Men (n = 2,906)			Women (n = 3,358)		
	Frequency of SMS meals			Frequency of SMS meals			Frequency of SMS meals		
	< 2 times/d (n = 4,841)	≥ 2 times/d (n = 1,423)	*p*-value‡	< 2 times/d (n = 2,137)	≥ 2 times/d (n = 769)	*p*-value‡	< 2 times/d (n = 2,704)	≥ 2 times/d (n = 654)	*p*-value‡
Men (%)	44.1	54.0	< 0.001						
Age group (%)									
20 – 39 years	20.8	18.1	< 0.001	22.1	20.7	0.097	19.9	15.1	< 0.001
40 – 64 years	45.6	42.2		43.3	41.0		47.4	43.6	
≥ 65 years	33.5	39.7		34.6	38.4		32.7	41.3	
BMI (kg / m^2)	22.5 ± 3.3	22.6 ± 3.2	0.572	23.3 ± 3.4	23.2 ± 3.1	0.538	21.9 ± 3.1	21.9 ± 3.2	0.612
Living alone (%)	2.8	3.4	0.249	2.2	1.4	0.191	3.3	5.7	0.004
Combination ratio (%)§									
Breakfast	4.6	40.0		4.5	38.9		4.6	41.3	
Staple food	79.8	86.6 (+6.8)		78.9	84.9 (+6.0)		80.6	88.7 (+8.1)	
Main dish	23.7	50.2 (+26.5)		24.9	48.0 (+23.1)		22.7	52.9 (+30.2)	
Side dish	28.4	59.7 (+31.3)		29.9	63.0 (+33.1)		26.4	56.8 (+30.4)	
Lunch	13.7	79.2		14.9	81.4		12.8	76.6	
Staple food	87.5	96.1 (+8.6)		87.5	97.1 (+9.6)		87.6	95.0 (+7.4)	
Main dish	45.1	86.8 (+41.7)		49.0	89.1 (+40.1)		42.0	84.1 (+42.1)	
Side dish	40.4	85.7 (+45.3)		38.0	87.1 (+49.1)		42.3	84.1 (+41.8)	
Dinner	40.8	91.0		41.6	91.2		40.1	90.8	
Staple food	76.9	95.9 (+19.0)		76.1	96.4 (+20.3)		77.6	95.4 (+17.8)	
Main dish	74.9	96.1 (+21.2)		77.7	96.4 (+18.7)		72.7	95.9 (+23.2)	
Side dish	76.6	96.7 (+20.1)		76.0	96.5 (+20.5)		77.0	96.9 (+19.9)	

SMS meal: meal combining staple food, main dish, and side dish
†Values are percentage (%) or means ± SD.
‡*p*-value are based on the chi-square test (Categorical variables) or the t-test (Continuous variables).
§( ) shows the increment in the ≥ 2 times/d group relative to the < 2 times/d group.

consuming a main dish and a side dish, rather than a staple food. Among men, the increase in the percentage of individuals consuming a side dish was greater than that for a main dish. In contrast, the increases in consumption of a main dish and side dish were nearly equal among women.

The energy or energy-adjusted nutrient intake (per 1,000 kcal) according to the frequency of SMS meals is shown in Table 2. Overall, the ≥2 times/d group had significantly higher energy intake and intake of most nutrients but a lower carbohydrate intake ($p < 0.05$). Among men, there was no significant difference in the intake of most nutrients, including protein, saturated fatty acid, carbohydrate, B vitamins, and calcium.

Table 3 shows the food group intake according to the frequency of SMS meals. Overall, the ≥2 times/d group had significantly higher intake of beans, soybeans and their products, vegetables, seaweeds, seafood and seafood products, eggs, butter, and other fats and lower intake of rice, wheat and other grain products, snacks and sweets, alcoholic beverages, other beverages, and seasonings and spices ($p < 0.05$).

Table 4 shows the DRIs–J score according to the frequency of SMS meals. The ≥2 times/d group scored significantly higher than the <2 times/d group (10.3 ± 4.0 and 7.4 ± 4.1, respectively; $p < 0.001$). The stratified analysis also demonstrated the same result, except for men who lived alone. Women, older people, and normal-weight people had a higher DRIs–J score. Even when individuals were not divided into the two groups based on the frequency of SMS meals (0-3 times/d), the higher frequency of SMS meals was significantly associated with higher DRI-J score (0 times/d; 6.4, 1 times/d; 8.1, 2 times/d; 10.1, 3 times/d; 11.8, $p < 0.001$) (data not shown).

Figure 3 illustrates the proportion of participants who added scores for energy or each nutrient to the DRIs–J score. The ≥2 times/d group consisted of a significantly higher proportion of individuals with adequate intake for all nutrients than the <2 times/d group ($p < 0.001$), except for saturated fatty acid ($p = 0.952$). In particular, the adequacy ratio of dietary fiber and most micronutrients was >1.5-fold higher in the ≥2 times/d group than in the <2 times/d group. Although the significance varied for some nutrients, the stratified analyses by age group revealed similar trends overall. (Supplementary Figure 1). Even when the frequency of SMS meals (0–3 times/day) was not divided into two groups, a higher frequency of SMS meals was significantly associated with a higher nutrient adequacy ratio ($p < 0.001$, only saturated fatty acid $p = 0.473$) (data not shown).

DISCUSSION

Among the 6,264 Japanese adults, our study showed two significant findings concerning the typical Japanese eating style, a SMS meal. First, when the frequency of SMS meals was objectively evaluated using dietary data, only a subset of individuals combined them frequently. Second, a higher frequency of SMS meals was associated with a higher percentage of nutrient adequacies.

We observed that only 22.7% of the total individuals consumed SMS meals at least twice daily. Our results

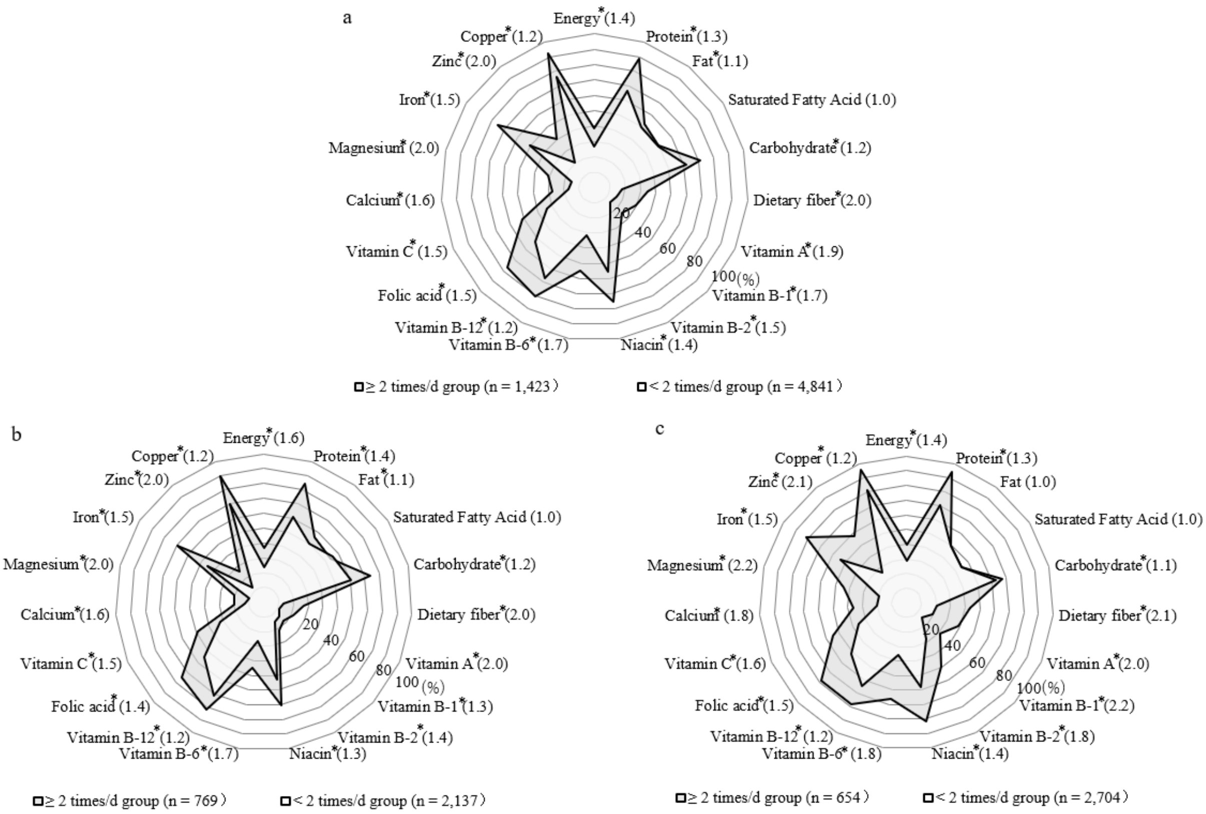

Figure 3. The proportion of participants who added scores for energy or each nutrient to the DRIs–J score according to the frequency of meals combining staple food, main dish, and side dish (n = 6,264) (a) all, (b) men, (c) women. Values are percentage (%). ( ) shows the ratio of the value of ≥ 2 times/d and < 2 times/d (fold). *p*-values are based on the chi-square test (Categorical variables). *$p < 0.001$ (< 2 times/d vs ≥ 2 times/d)

Table 2. The energy and nutrient intake according to the frequency of meals of combining staple food, main dish, and side dish by gender (n = 6,264)†

	All (n = 6,264)			Men (n = 2,906)			Women (n = 3,358)		
	Frequency of SMS meals			Frequency of SMS meals			Frequency of SMS meals		
	< 2 times/d (n = 4,841)	≥ 2 times/d (n = 1,423)	*p*-value‡	< 2 times/d (n = 2,137)	≥ 2 times/d (n = 769)	*p*-value‡	< 2 times/d (n = 2,704)	≥ 2 times/d (n = 654)	*p*-value‡
Energy									
(kJ/d)	7,130 ± 1,925	8,422 ± 1,766	< 0.001	7,770 ± 2,017	8,891 ± 1,711	< 0.001	6,619 ± 1,682	7,866 ± 1,665	< 0.001
(kcal/d)	1,704 ± 460	2,013 ± 422	< 0.001	1,857 ± 482	2,125 ± 409	< 0.001	1,582 ± 402	1,880 ± 398	< 0.001
Protein (g/d)	38.7 ± 8.3	39.6 ± 6.8	< 0.001	38.5 ± 8.5	38.8 ± 6.8	0.262	38.9 ± 8.1	40.5 ± 6.8	< 0.001
Fat (g/d)	30.2 ± 8.5	31.0 ± 7.1	< 0.001	29.5 ± 8.5	30.2 ± 6.9	0.012	30.8 ± 8.5	32.0 ± 7.3	< 0.001
Saturated fatty acid (g/d)	8.11 ± 3.04	8.03 ± 2.56	0.291	7.74 ± 2.92	7.74 ± 2.41	0.978	8.41 ± 3.10	8.37 ± 2.69	0.748
Carbohydrate(g/d)	136 ± 23	134 ± 18	< 0.001	135 ± 24	135 ± 18	0.747	138 ± 23	134 ± 18	< 0.001
Dietary fiber(g/d)	8.2 ± 3.2	8.9 ± 3.1	< 0.001	7.7 ± 3.0	8.4 ± 2.9	< 0.001	8.7 ± 3.2	9.5 ± 3.1	< 0.001
Vitamin A (µgRAE/d)	310 ± 334	345 ± 269	< 0.001	286 ± 312	321 ± 218	< 0.001	329 ± 349	374 ± 316	< 0.001
Vitamin B-1 (mg/d)	0.49 ± 0.21	0.49 ± 0.18	0.795	0.49 ± 0.23	0.48 ± 0.18	0.131	0.49 ± 0.20	0.50 ± 0.17	0.029
Vitamin B-2 (mg/d)	0.61 ± 0.25	0.62 ± 0.20	0.337	0.58 ± 0.23	0.58 ± 0.19	0.891	0.63 ± 0.26	0.66 ± 0.21	0.007
Niacin (mgNE/d)	8.4 ± 3.4	8.7 ± 3.2	0.002	8.5 ± 3.5	8.6 ± 3.3	0.482	8.3 ± 3.2	8.8 ± 3.0	< 0.001
Vitamin B-6 (mg/d)	0.63 ± 0.20	0.68 ± 0.17	< 0.001	0.63 ± 0.20	0.66 ± 0.17	< 0.001	0.64 ± 0.20	0.70 ± 0.18	< 0.001
Vitamin B-12 (mg/d)	3.5 ± 3.9	3.7 ± 3.6	0.018	3.5 ± 4.0	3.6 ± 3.5	0.484	3.4 ± 3.8	3.8 ± 3.7	0.009
Folic acid (µg/d)	160 ± 71	173 ± 65	< 0.001	150 ± 65	162 ± 61	< 0.001	168 ± 74	186 ± 66	< 0.001
Vitamin C (mg/d)	55 ± 41	62 ± 38	< 0.001	48 ± 36	56 ± 34	< 0.001	60 ± 44	68 ± 41	< 0.001
Calcium (mg/d)	279 ± 127	284 ± 126	0.174	256 ± 119	257 ± 110	0.715	297 ± 130	315 ± 136	0.002
Magnesium (mg/d)	136 ± 39	142 ± 39	< 0.001	131 ± 38	135 ± 36	0.017	140 ± 39	151 ± 41	< 0.001
Iron (mg/d)	4.3 ± 1.4	4.5 ± 1.3	< 0.001	4.1 ± 1.4	4.3 ± 1.2	< 0.001	4.4 ± 1.5	4.9 ± 1.4	< 0.001
Zinc (mg/d)	4.4 ± 1.0	4.6 ± 0.9	< 0.001	4.4 ± 1.0	4.6 ± 0.9	< 0.001	4.4 ± 0.9	4.6 ± 0.9	< 0.001
Copper (mg/d)	0.61 ± 0.14	0.63 ± 0.14	< 0.001	0.59 ± 0.14	0.62 ± 0.14	< 0.001	0.62 ± 0.14	0.65 ± 0.14	< 0.001

SMS meal: meal combining staple food, main dish, and side dish; RAE: Retinol Activity Equivalents; NE: Niacin Equivalents
†Values are means ± SD. Nutrient intakes are used the density method (per 1,000kcal). Values are means ± SD.
‡*p*-value are based on the t-test (Continuous variables).

Table 3. The food group intake according to the frequency of meals combining staple food, main dish, and side dish by gender (n = 6,264)†

	All (n = 6,264)			Men (n = 2,906)			Women (n = 3,358)		
	Frequency of SMS meals			Frequency of SMS meals			Frequency of SMS meals		
	< 2 times/d (n = 4,841)	≥ 2 times/d (n = 1,423)	*p*-value‡	< 2 times/d (n = 2,137)	≥ 2 times/d (n = 769)	*p*-value‡	< 2 times/d (n = 2,704)	≥ 2 times/d (n = 654)	*p*-value‡
Rice, wheat, and other grain products (g/d)	231 ± 80	223 ± 62	< 0.001	241 ± 81	238 ± 60	0.219	223 ± 79	205 ± 59	< 0.001
Potatoes and potato products (g/d)	33 ± 39	33 ± 34	0.785	31 ± 37	31 ± 33	0.847	35 ± 41	35 ± 35	0.961
Sugar and sweetener (g/d)	3 ± 4	4 ± 4	0.228	3 ± 4	3 ± 3	0.729	4 ± 4	4 ± 4	0.012
Beans, soybeans, and their products (g/d)	32 ± 39	35 ± 39	0.042	30 ± 39	29 ± 32	0.476	34 ± 40	41 ± 45	< 0.001
Seeds and nuts (g/d)	1 ± 3	1 ± 4	0.107	1 ± 3	1 ± 3	0.156	1 ± 3	2 ± 5	0.232
Vegetables (g/d)	167 ± 99	193 ± 85	< 0.001	158 ± 95	188 ± 84	< 0.001	173 ± 102	199 ± 87	< 0.001
Fruits (g/d)	55 ± 71	58 ± 63	0.204	43 ± 62	50 ± 58	0.012	65 ± 76	68 ± 68	0.378
Mushrooms (g/d)	9 ± 17	9 ± 14	0.783	9 ± 18	8 ± 13	0.604	9 ± 16	9 ± 14	0.769
Seaweeds (g/d)	6 ± 13	6 ± 12	0.025	5 ± 12	6 ± 11	0.198	6 ± 14	7 ± 14	0.042
Seafood and seafood products (g/d)	40 ± 39	43 ± 36	< 0.001	40 ± 40	42 ± 35	0.222	39 ± 39	45 ± 36	< 0.001
Meat and meat products (g/d)	53 ± 42	54 ± 36	0.538	57 ± 45	58 ± 37	0.730	50 ± 39	49 ± 34	0.652
Eggs (g/d)	21 ± 21	25 ± 20	< 0.001	21 ± 21	24 ± 19	< 0.001	22 ± 21	26 ± 21	< 0.001
Milk and dairy products (g/d)	53 ± 68	49 ± 60	0.053	41 ± 57	39 ± 53	0.414	62 ± 74	61 ± 66	0.704
Butter and other fats (g/d)	5 ± 5	5 ± 4	0.017	5 ± 5	6 ± 4	0.036	5 ± 5	5 ± 5	0.226
Snacks and sweets (g/d)	14 ± 24	11 ± 18	< 0.001	10 ± 20	8 ± 15	< 0.001	17 ± 26	14 ± 20	0.008
Alcoholic beverages (g/d)	38 ± 102	30 ± 77	0.001	65 ± 132	42 ± 91	< 0.001	17 ± 63	15 ± 53	0.443
Tea (g/d)	80 ± 160	73 ± 136	0.078	67 ± 141	63 ± 118	0.507	91 ± 173	84 ± 154	0.297
Other beverages (g/d)	113 ± 144	92 ± 111	< 0.001	102 ± 138	89 ± 111	0.008	121 ± 148	95 ± 110	< 0.001
Seasonings and spices (g/d)	69 ± 74	60 ± 60	< 0.001	69 ± 73	57 ± 52	< 0.001	69 ± 75	64 ± 68	0.077

SMS meal: meal combining staple food, main dish, and side dish
†Values are means ± SD. Food group intakes are used the density method (per 1,000kcal).
‡*p*-value are based on the t-test (Continuous variables).

Table 4. The DRIs–J score according to the frequency of meals combining staple food, main dish, and side dish by gender (n = 6,264)[†]

	All (n = 6,264)			Men (n = 2,906)			Women (n = 3,358)		
	Frequency of SMS meals		*p*-value[‡]	Frequency of SMS meals		*p*-value[‡]	Frequency of SMS meals		*p*-value[‡]
	< 2 times/d (n = 4,841)	≥ 2 times/d (n = 1,423)		< 2 times/d (n = 2,137)	≥ 2 times/d (n = 769)		< 2 times/d (n = 2,704)	≥ 2 times/d (n = 654)	
All	7.4 ± 4.1	10.3 ± 4.0	< 0.001	6.9 ± 3.9	9.4 ± 3.8	< 0.001	7.8 ± 4.2	11.3 ± 4.1	< 0.001
Age group									
20 – 39 years	5.9 ± 3.5	8.3 ± 3.7	< 0.001	5.7 ± 3.4	7.6 ± 3.4	< 0.001	6.0 ± 3.6	9.4 ± 3.8	< 0.001
40 – 64 years	7.2 ± 3.9	9.6 ± 3.9	< 0.001	6.5 ± 3.6	8.8 ± 3.5	< 0.001	7.7 ± 4.1	10.5 ± 4.1	< 0.001
≥ 65 years	8.6 ± 4.2	11.9 ± 3.8	< 0.001	8.2 ± 4.1	10.9 ± 3.7	< 0.001	9.0 ± 4.3	12.9 ± 3.6	< 0.001
BMI									
< 18.5 kg/m^2	6.7 ± 4.0	10.2 ± 4.2	< 0.001	5.3 ± 3.6	8.7 ± 3.4	< 0.001	7.2 ± 4.0	10.8 ± 4.4	< 0.001
18.5 – 25 kg/m^2	7.5 ± 4.1	10.4 ± 4.0	< 0.001	7.1 ± 3.9	9.5 ± 3.8	< 0.001	7.8 ± 4.2	11.3 ± 4.0	< 0.001
≥ 25 kg/m^2	7.4 ± 4.0	9.9 ± 4.2	< 0.001	6.9 ± 3.6	9.1 ± 3.8	< 0.001	8.2 ± 4.3	11.8 ± 4.3	< 0.001
Living alone									
Yes	8.4 ± 4.6	12.3 ± 4.2	< 0.001	6.4 ± 3.7	6.2 ± 2.2	0.864	9.4 ± 4.7	14.1 ± 2.6	< 0.001
No	7.4 ± 4.1	10.2 ± 4.0	< 0.001	6.9 ± 3.9	9.4 ± 3.8	< 0.001	7.8 ± 4.2	11.2 ± 4.1	< 0.001

SMS meal: meal combining staple food, main dish, and side dish; DRIs–J: Dietary Reference Intakes for Japanese 2020
[†]Values are means ± SD.
[‡]*p*-value are based on the t-test (Continuous variables).

align with a previous study on Japanese adults aged 40–59 years, which estimated the frequency of meals using more than one serving from the Japanese food guide spinning top.[8] That study demonstrated that only 25.1% of all participants consumed SMS meals ≥1.75 times/d. In contrast, in Japanese studies and surveys, 39.5%–58.7% of the total participants self-reported consuming SMS meals at least twice a day, almost every day.[14,26-31] These data suggest that the number of people who consume SMS meals is lower than their self-assessment. Our findings emphasized the need for further policies to improve the frequency of SMS meals. To our knowledge, this is the first study to elucidate the details of meal component combinations of staple food, main dish, and side dish in adult participants.

Irrespective of the combination frequency, less than half of the participants consumed SMS meals at breakfast. A previous study demonstrated that the lowest percentage of individuals consumed SMS meals for breakfast in pregnant women.[23] A national survey reported that most people believe that it is most challenging to consume side dishes.[32] We propose initiating social measures to encourage people to consume main dishes and side dishes during lunch to having SMS meals at least twice daily.

Our study found that consuming an SMS meal at least twice daily was associated with adequate intake of numerous nutrients compared to consuming SMS meals less frequently. This association between a high frequency of SMS meal combinations and nutrient adequacy aligns with findings from previous studies in Japan.[8,14,20,23,33] Although Ishikawa-Takata et al.[20] did not use Adachi's definition of staple food, main dish, and side dish, they found that individuals consuming SMS meals at least twice daily were more likely to meet the DRIs–J compared to those consuming them once daily or less. Additionally, studies outside Japan have reported a similar relationship between nationally recommended eating styles and improved nutrient intake[34,35] or nutrient adequacy.[36,37] For instance, a study using the diet quality index based on Swedish nutrition recommendations and dietary guidelines reported that individuals with high scores meet the recommended intake levels for vitamins and minerals.[36] Regarding nutrient levels, there were significant differences in dietary fiber and micronutrients between consuming SMS meals at least twice a day and consuming SMS meals less than twice a day. Dietary fiber and most micronutrients are generally obtained from plant-based foods, which are the primary ingredients of side dishes.[38] Our findings showed that individuals consuming SMS meals at least twice daily had significantly higher intakes of beans, soybeans, vegetables, and seaweeds. Conversely, their consumption of snacks, sweets, alcoholic beverages, and other beverages was significantly lower. Notably, a systematic review has linked ultra-processed foods, including snacks, sweets, and sugar-sweetened beverages, to a higher risk of all-cause mortality and various adverse health outcomes,[39] and high alcohol intake is associated with risk of all-cause mortality.[40] Our results demonstrated that individuals with a high frequency of SMS meal combinations reduced empty calorie intake by obtaining energy primarily from balanced meals.

This study has some limitations. First, the dietary record was collected for only one day, which may not accurately represent the habitual frequency of SMS meals or habitual nutrient intake. However, the nutrient intake observed in our study was comparable to the typical nutrient intake of the Japanese population.[41] Second, we excluded dishes weighing <25 g from the classification of staple food, main dish, and side dish. Consequently, participants consuming more than three dishes of <25 g per meal were not classified as having a staple food, main dish, or side dish. However, in the most populous city (comprising 25% of the prefecture's population), this condition applied to fewer than 0.9% of individuals.

Third, measurements were self-reported and involved somewhat imprecise scales, potentially resulting in over- or under-reporting and misclassification. Notably, while the group consuming staple foods, main dishes, and side dishes more than twice daily had significantly higher energy intake than those consuming them less frequently, BMI was similar between the groups. This aligns with findings from many previous studies, which also reported unchanged BMI despite significantly higher or elevated energy intake.[15,42,43] It is important to acknowledge the possibility of reverse causality, such as overweight individuals reducing their energy intake due to BMI concerns. However, the primary aim of examining the relationship between SMS meal frequency and nutrient adequacy was to evaluate dietary patterns, which were not influenced by reverse causality. Lastly, we did not assess nutrient adequacy beyond the 18 nutrients and energy included in this study, as other nutrients were excluded due to the absence of evidence-based standard values.

This study had several strengths. First, it involved a large sample of over 6,000 general adults spanning a wide age range. Second, it employed a straightforward standard of 50 g of the primary ingredient to classify staple food, main dish, and side dish. This standard is universally applicable, as the gram (kilogram) is one of the seven base units in the International System of Units, and 50 g is approximately the weight of one egg. Ishikawa-Takata et al.[20] acknowledged as a limitation their study's lack of adherence to Adachi's basic concept of staple food, main dish, and side dish. To our knowledge, this is the first study to clarify the relationship between the frequency of SMS meals and nutrient adequacy using a weight-based definition. Given the widespread nutritional challenges faced by many countries, our findings contribute to the growing evidence that SMS meals are a vital strategy for addressing all forms of malnutrition.

This study provides valuable insight, showing that consuming an SMS meal, the typical Japanese eating style, at least twice a day is effective in achieving a diet with high nutrient adequacy. We recommend further studies in other regions outside Japan and across different ethnic groups to expand on these findings.

CONFLICT OF INTEREST AND FUNDING DISCLOSURE

The authors declare no conflict of interest.

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