Association between the frequency of combinations of staple foods, main dishes, and side dishes and nutrient adequacy in Japanese adults

Honoka Murahata, Kotone Nakamura, Eri Imai PhD

Department of Nutrition, School of Human Cultures, The University of Shiga Prefecture, Hikone, Japan

Authors' email addresses and contributions:
Author contributions were as follows: Conceptualization, E.I.; Data curation, H.M., K.N and E.I.; Formal analysis, H.M; Funding acquisition, E.I.; Investigation, E.I.; Methodology, E.I.; Project administration, E.I.; Resources, E.I.; Software, H.M.; Supervision, E.I.; Validation, E.I.; Visualization, H.M.; Writing—original draft preparation, H.M. and E.I.; Writing—review and editing, E.I.; All authors have read and agreed to the published version of the manuscript.

Corresponding Author: Dr Eri Imai, Department of Nutrition, School of Human Cultures, The University of Shiga Prefecture, 2500 Hassaka-cho, Hikone city, 522-8533 Japan. Tel: +81-749-28-8259. Fax: +81-749-28-8269. Email: imai.e@shc.usp.ac.jp

ABSTRACT

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 several years, numerous countries have confronted various types of malnutrition, including undernutrition,[1,2] overweight and obesity,[3,4] and the double burden of malnutrition.[5,6] The World Health Organization 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, the intake status has not been assessed from individual dietary data, and we need to clarify the current status. Furthermore, to plan social measures to increase the frequency, it is also important to investigate the intake status of each staple food, main dish, and side dish, as well as the timing when they are consumed (breakfast, lunch, dinner). In addition, although an SMS meal is considered a nutritionally balanced diet, there is very limited such evidence. Most previous Japanese studies have reported an association between the frequency of SMS meals and nutrient intake based on self-report.[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 ordinary people 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] examined the nutritional adequacy of SMS meals have cited the lack of use of Adachi's definition as a limitation, and no studies have evaluated the frequency of SMS meals and 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.

MATERIALS AND METHODS

Data source and participants

We used Individual-level data for 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 the dietary data and participant characteristics data for HNSS in 2015, covering 4,229 households chosen randomly from approximately 1% of the households of all 19 cities in Shiga and involving all household members aged ≥ 1 year. 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 government of Shiga prefecture in Japan, has stringent protocols and procedures that ensure confidentiality and protect individual participants from being identified. 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. The record 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 finally adopted Shiobara's classification in which staple food, main dish, and side dish are defined by the weight of ingredients familiar to the general public rather than the weight of nutrients. 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, main dish, and side dish. Moreover, dish codes were assigned to each dish category. There were 5 modifications from Shiobara's classification as follows: (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 includes

the beverage category, (4) "Small" definition is changed to a dish of ≥ 25 and <50 g, and (5) a dish of <25 g is classified as "others." Considering the possibility that participants consumed several types of small dishes, two or more "small" dishes were upgraded. For instance, two small staple foods were evaluated as staple foods.

For breakfast, lunch, and dinner, we calculated the percentage of participants who consumed an 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]

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, as described elsewhere.[21] Food group intake was calculated for each group.

Assessment of nutrient adequacy

We defined a well-balanced diet as a nutrient adequacy diet. Nutrient adequacy was assessed with the Dietary Reference Intakes for Japanese 2020 (DRIs–J) score. Detailed information on the DRIs–J score can be elsewhere.[25] We used the DRIs–J score updated to the DRIs–J 2020. In this study, the adequacy of the eighteen nutrients intake assessed included protein, fat, saturated fatty acid, carbohydrate, 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 eighteen 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). Body mass index (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 an SMS meal. A high frequency of SMS meals affected a higher proportion of individuals having a main dish and a side dish than a staple food. Among men, the increment in the percentage of consuming a side dish was higher

than that of a main dish. The increments in consuming a main dish and side dish were almost similar 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 that men 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 the 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 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 changed for some nutrients, the stratified analyses by age group showed roughly the same trends. (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, an SMS meal. One is that when the frequency of SMS meals was objectively evaluated using dietary data, only some individuals combined them frequently. The second finding is that the higher the frequency of SMS meals, the higher the percentage of nutrient adequacies.

We observed that only 22.7% of the total individuals consumed SMS meals at least twice daily. Our results are consistent with a previous study on Japanese adults aged 40–59 years who assumed the frequency from dietary data using more than one serving of 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 could 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 combinations of staple food, main dish, and side dish in the meal consumed by adult participants.

Irrespective of the combination frequency, less than half of the participants consumed SMS meals at breakfast. A previous study targeting pregnant demonstrated that a lowest percentage of individuals consumed SMS meals for breakfast. [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 at lunch to increase the percentage of those who consumed an SMS meal at least twice daily.

Our study showed that consuming an SMS meal at least twice a day was associated with adequate intake of numerous nutrients compared with consuming an SMS meal less than twice a day. This association between the high frequency of combination and nutrient adequacy was consistent with the results of previous studies in Japan.[8,14,20,23,33] Although Ishikawa-Takata et al.[20] did not used the Adachi's definition of staple food, main dish, and side dish, they reported subjects who consumed SMS meals at least twice a day were more likely to meet the DRIs–J compared with subjects who consumed an SMS meal once a day or less. Moreover, studies outside Japan have reported a relationship between a nationally recommended eating style and better 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 results revealed that in individuals who consumed SMS meals at least twice a day, the intake of beans, soybeans, vegetables, and seaweeds was significantly higher. Interestingly, regarding food levels, individuals who consumed SMS meals at least twice a day had significantly lower intake of snacks and sweets, alcoholic beverages, and other beverages. A systematic review reported that ultra-processed foods, including snacks, sweets, and sugar-sweetened beverages, are associated with a high risk of all-cause mortality and several 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 combination cut out empty calories by obtaining energy from meals.

This study has some limitations. First, the dietary record was conducted for only 1 day; hence, the dietary data might not reflect the habitual frequency of SMS meals and the habitual nutrient intake. Nonetheless, the nutrient intake of our study individuals was similar to the Japanese habitual nutrient intake.[41] Second, we excluded a dish of <25 g from the classification of staple food, main dish, and side dish. Even if participants consumed more than three dishes of <25 g per meal, they were not evaluated as those with a staple food, a main dish, or a side dish. However, in the most populous city (25% of the prefecture population), <0.9% of the total individuals met the abovementioned condition. Third, measurements were self-reported and included somewhat vague scales, possibly leading to over- or under-reporting and misclassification. In this study, the group that ate staple foods, main dishes, and side dishes more than twice a day had a significantly higher energy intake than the group that ate them less than twice daily, but the BMI between the two groups was almost the same. Indeed, many previous studies also have shown that the BMI did not change even when the energy intake was significantly higher or tended to be high.[15,42,43] It is impossible to deny the reversal of the relationship between cause and effect, such as when overweight people are concerned about their BMI and reducing their energy intake. However, the primary purpose of the relationship between the frequency of SMS meals and nutrient adequacy was to assess the diet. It was not affected by the reversal of the relationship between cause and effect. Finally, we did not evaluate nutrient adequacy other than 18 nutrients and energy; these nutrients were excluded because of the lack of an evidence-based standard value.

There were several strengths in this study. First, it was conducted with a large sample size of more than 6,000 general adults with a wide age range. Second, a simple standard of 50 g of primary ingredient was used to evaluate staple food, main dish, and side dish. This standard could be universally used because the gram (kilogram) is one of the seven base units in the International System of Units,[44] and 50 g is equivalent to one egg. Ishikawa-Takata et al.[20] reported as a limitation that it did not use this basic concept of staple food, main dish, and side dish proposed by Adachi. To our knowledge, this is the first study to elucidate the relationship between the frequency of SMS meals and nutrient adequacy using the weight-based definition. As most countries currently have various nutritional problems, our findings add to a growing body of evidence showing that SMS meals are a key strategy to improve all forms of malnutrition.

This study provides important information that consuming an SMS meal, the typical Japanese eating style, at least twice a day is effectively in incorporating a diet with high nutrient adequacy. We recommend further studies in various other regions outside Japan and ethnic groups.

CONFLICT OF INTEREST AND FUNDING DISCLOSURE

REFERENCES

1. Bailey RL, West KP, Jr., Black RE. The epidemiology of global micronutrient deficiencies. Ann Nutr Metab. 2015;66 Suppl 2:22-33. doi: 10.1159/000371618.

2. Martins VJ, Toledo Florêncio TM, Grillo LP, do Carmo PFM, Martins PA, Clemente AP, Santos CD, de Fatima AVM, Sawaya AL. Long-lasting effects of undernutrition. International Journal of Environmental Research and Public Health. 2011;8(6):1817-46. doi: 10.3390/ijerph8061817.

3. Kelly T, Yang W, Chen CS, Reynolds K, He J. Global burden of obesity in 2005 and projections to 2030. International journal of obesity. 2008;32(9):1431-7. doi: 10.1038/ijo.2008.102.

4. Ng M, Fleming T, Robinson M, Thomson B, Graetz N, Margono C, et al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet. 2014;384(9945):766-81. doi: 10.1016/s0140-6736(14)60460-8.

5. Popkin BM, Corvalan C, Grummer-Strawn LM. Dynamics of the double burden of malnutrition and the changing nutrition reality. Lancet. 2020;395(10217):65-74. doi: 10.1016/S0140-6736(19)32497-3.

6. Wells JC, Sawaya AL, Wibaek R, Mwangome M, Poullas MS, Yajnik CS, Demaio A. The double burden of malnutrition: aetiological pathways and consequences for health. Lancet. 2020;395(10217):75-88. doi: 10.1016/s0140-6736(19)32472-9.

7. Transforming our world: the 2030 Agenda for Sustainable Development. United Nations. 2015 [cited 2023/10/27]; Available from: https://documents-dds-ny.un.org/doc/UNDOC/GEN/N15/291/89/PDF/N1529189.pdf?OpenElement

8. Koyama T, Yoshita K, Sakurai M, Miura K, Naruse Y, Okuda N, Okayama A, Stamler J, Ueshima H, Nakagawa H. Relationship of Consumption of Meals Including Grain, Fish and Meat, and Vegetable Dishes to the Prevention of Nutrient Deficiency: The INTERMAP Toyama Study. J Nutr Sci Vitaminol (Tokyo). 2016;62(2):101-7. doi: 10.3177/jnsv.62.101.

9. Adachi M. A study on the core-dished and these combination as a framework of nutrition education on the basis of dish-selecting method. Japanese Journal of Health and Human Ecology. 1984;50(2):70-107. doi: https://doi.org/10.3861/jshhe.50.70.

10. Comment point of dietary guidelines (June, 2016). Ministry of Education, Culture, Sports, Science and Technology, Ministry of Health, Labour and Welfare, Ministry of Agriculture, Forestry and Fisheries. 2016 [cited 2023/8/28]; Available from: https://www.mhlw.go.jp/file/06-Seisakujouhou-10900000-Kenkoukyoku/0000132167.pdf

11. The explanation material for promotion in healthy Japanese 21 (the third). Ministry of Health, Labour and Welfare. 2023 [cited 2023/8/28]; Available from: https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/kenkou_iryou/kenkou/kenkounippon21_00006.html

12. Yoshiike N, Hayashi F, Takemi Y, Mizoguchi K, Seino F. A new food guide in Japan: the Japanese food guide Spinning Top. Nutr Rev. 2007;65(4):149-54. doi: 10.1111/j.1753-4887.2007.tb00294.x.

13. Hayashi F, Noguchi M, Uno K, Takemi Y. Factors Related to the Frequency of Consuming a "Japanese Healthy Meal" by Pregnant Women. The Japanese Journal of Nutrition and Dieteticsand Dietetic. 2020;78(1):24-36. doi: 10.5264/eiyogakuzashi.78.24.

14. Ishikawa Y, Miyagawa A, Takahashi Y, Yoshimura M, Yasukawa Y, Yoshino Y, Sakurai A, Noudomi A, Furuhata T. Frequency of having balanced meals consisting of the staple food, main dish, and side dish, physical conditions, living situation, nutrients, and dietary intake in pregnant women –A fact-finding survey in Matsudo City –. Journal of the Japan Dietetic Association. 2018;61(4):205-13. doi: 10.11379/jjda.61.205.

15. Kakutani Y, Kamiya S, Omi N. Association between the frequency of meals combining "Shushoku, Shusai, and Hukusai" (Staple food, main dish, and side dish) and intake of nutrients and food groups among Japanese young adults aged 18-24 years: a cross-sectional study. J Nutr Sci Vitaminol (Tokyo). 2015;61(1):55-63. doi: 10.3177/jnsv.61.55.

16. Shiobara Y, Murayama N, Yamamoto T, Ishida H, Nakanishi A, Sunto A, Hazano S, Nozoe M, Saito S, Yoshioka Y. Identifying Meal Patterns Based on Daily Meals Consumed by Elementary School

Students. The Japanese Journal of Nutrition and Dieteticsand Dietetic. 2020;78(2):66-77. doi: 10.5264/eiyogakuzashi.78.66.

17. Shiobara Y, Murayama N, Yamamoto T, Ishida H, Nakanishi A, Sunto A, Hazano S, Nozoe M, Yoshioka Y. Assessments of the Actual Situation and Adequacy of Nutrient Intake in Meal Patterns of Elementary School Students. The Japanese Journal of Nutrition and Dieteticsand Dietetic. 2023;81(1):3-19. doi: 10.5264/eiyogakuzashi.81.3.

18. Yoshii E, Fukazawa H, Ainuki T, Akamatsu R, Hasegawa T. Characteristics of Dinner among Preschoolers by Vegetable Intake. The Japanese Journal of Nutrition and Dieteticsand Dietetic. 2021;79(6):345-54. doi: 10.5264/eiyogakuzashi.79.345.

19. Hayabuchi H, Hisano M, Matsunaga Y. Classification of Dishes to Create a Balanced Diet. The Japanese Journal of Nutrition and Dieteticsand Dietetic. 2003;61(4):235-42. doi: 10.5264/eiyogakuzashi.61.235.

20. Ishikawa-Takata K, Kurotani K, Adachi M, Takimoto H. Frequency of meals that includes staple, main and side dishes and nutrient intake: findings from the 2012 National Health and Nutrition Survey, Japan. Public Health Nutr. 2021;24(9):2618-28. doi: 10.1017/s1368980020001202.

21. Health and Nutrition Survey in Shiga prefecture 2015. Shiga Prefecture 2017 [cited 2023/10/27]; Available from: https://www.pref.shiga.lg.jp/ippan/kenkouiryouhukushi/kenkou/15050.html

22. Iwaoka F, Yoshiike N, Date C, Shimada T, Tanaka H. A validation study on a method to estimate nutrient intake by family members through a household-based food-weighing survey. J Nutr Sci Vitaminol (Tokyo). 2001;47(3):222-7. doi: 10.3177/jnsv.47.222.

23. Suzuki M, Masegi Y. Relationship of pregnant Woman's Frequency of Adhering to a Japanese Dietary Pattern with their Nutritional Intake, Dietary Behavior, and Dietary Knowledge. Journal of Japanese Society of Shokuiku. 2021;15(2):75-84. doi: 10.14986/shokuiku.15.75.

24. Standard Tables of Food Composition in Japan 2020. Ministry of Education, Culture, Sports, Science and Technology. 2020 [cited 2023/10/27]; Available from: https://www.mext.go.jp/a_menu/syokuhinseibun/mext_01110.html

25. Tanaka S, Muraki S, Inoue Y, Miura K, Imai E. The association between subjective health perception and lifestyle factors in Shiga prefecture, Japan: a cross-sectional study. BMC Public Health. 2020;20(1):1786. doi: 10.1186/s12889-020-09911-y.

26. the Survey of Attitudes Towards Shokuiku 2023. Ministry of Agriculture, Forestry and Fisheries. 2023 [cited 2023/10/27]; Available from: https://www.maff.go.jp/j/syokuiku/ishiki/r05/pdf/houkoku_1.pdf

27. Hamashita K, Akamatsu R. Relationship between eating slowly and frequency of consuming a balanced diet including staple foods, main dishes, and side dishes among Japanese adults. Japanese Journal of Health Education and Promotion. 2023;31(3):110-6. doi: 10.11260/kenkokyoiku.31.110.

28. Nakayasu M, Akamatsu R, Fukazawa H, Kojima Y, Shimpo M. Characteristics of People Who Cook More Often Now than before COVID-19 Pandemic and the Frequency of Intake of a Well-Balanced Japanese Diet. The Japanese Journal of Nutrition and Dieteticsand Dietetic. 2022;80(2):96-104. doi: 10.5264/eiyogakuzashi.80.96.

29. Nishinakagawa M, Sakurai R, Nemoto Y, Matsunaga H, Takebayashi T, Fujiwara Y. Influence of education and subjective financial status on dietary habits among young, middle-aged, and older adults in Japan: a cross-sectional study. BMC Public Health. 2023;23(1):1230. doi: 10.1186/s12889-023-16131-7.

30. Sakaguchi K, Takemi Y, Hayashi F, Akamatsu R. Relationship between the dietary behavior targets of Health Japan 21 (second term) and perceived food environment and health literacy. Japanese Journal of Public Health. 2023;70(1):3-15. doi: 10.11236/jph.22-031.

31. Sakamoto T, Inamura Y, Hayami N. Association between frequency of meal consumption consisting of grain, fish and meat, and vegetable dishes and self-rated health in Japanese adults: data from "The Survey of Attitude toward Shokuiku". JJHEP. 2021;29(4):348-54. doi: 10.11260/kenkokyoiku.29.348.

32. The National Health and Nutrition Survey in Japan 2015. Ministry of Health, Labour and Welfare. 2015 [cited 2023/10/27]; Available from: https://www.mhlw.go.jp/bunya/kenkou/eiyou/h27-houkoku.html

33. Koyama T, Yoshita K, Arai Y, Nakamura K, Sakurai M, Nishijo M, Nagasawa S-y, Morikawa Y, Tabata M, Nakagawa H. Relationship between Daily Intake Frequency of Meals Including a Staple Food, a Main dish and a Side dish and Nutrient Intake in Independent Elderly Individuals. Journal of Japan Society of Nutrition and Food Sciences. 2014;67(6):299-305. doi: 10.4327/jsnfs.67.299.

34. Feart C, Alles B, Merle B, Samieri C, Barberger-Gateau P. Adherence to a Mediterranean diet and energy, macro-, and micronutrient intakes in older persons. Journal of physiology and biochemistry. 2012;68(4):691-700. doi: 10.1007/s13105-012-0190-y.

35. Wengreen H, Munger RG, Cutler A, Quach A, Bowles A, Corcoran C, Tschanz JT, Norton MC, Welsh-Bohmer KA. Prospective study of Dietary Approaches to Stop Hypertension- and Mediterranean-style dietary patterns and age-related cognitive change: the Cache County Study on Memory, Health and Aging. Am J Clin Nutr. 2013;98(5):1263-71. doi: 10.3945/ajcn.112.051276.

36. Drake I, Gullberg B, Ericson U, Sonestedt E, Nilsson J, Wallström P, Hedblad B, Wirfält E. Development of a diet quality index assessing adherence to the Swedish nutrition recommendations and dietary guidelines in the Malmö Diet and Cancer cohort. Public Health Nutr. 2011;14(5):835-45. doi: 10.1017/s1368980010003848.

37. Kishino M, Hida A, Hara K, Mungai DN, Opiyo RO, Matsuda H, Tada Y, Ishikawa-Takata K, Irie K, Morimoto Y. High Adherence to the Food Pyramid's Recommendations Avoids the Risk of Insufficient Nutrient Intake among Farmers in Peri-Urban Kenya. Nutrients. 2021;13(12). doi: 10.3390/nu13124470.

38. The National Health and Nutrition Survey in Japan 2019. Ministry of Health, Labour and Welfare. 2020 [cited 2023/10/27]; Available from: https://www.mhlw.go.jp/bunya/kenkou/eiyou/h27-houkoku.html

39. Chen X, Zhang Z, Yang H, Qiu P, Wang H, Wang F, Zhao Q, Fang J, Nie J. Consumption of ultra-processed foods and health outcomes: a systematic review of epidemiological studies. Nutrition journal. 2020;19(1):86. doi: 10.1186/s12937-020-00604-1.

40. Zhao J, Stockwell T, Naimi T, Churchill S, Clay J, Sherk A. Association Between Daily Alcohol Intake and Risk of All-Cause Mortality: A Systematic Review and Meta-analyses. JAMA Netw Open. 2023;6(3):e236185. doi: 10.1001/jamanetworkopen.2023.6185.

41. Murakami K, Livingstone MBE, Sasaki S, Hirota N, Notsu A, Miura A, Todoriki H, Fukui M, Date C. Applying a meal coding system to 16-d weighed dietary record data in the Japanese context: towards the development of simple meal-based dietary assessment tools. Journal of nutritional science. 2018;7:e29. doi: 10.1017/jns.2018.21.

42. Narita M, Kitamura A, Takemi Y, Yokoyama Y, Morita A, Shinkai S. [Food diversity and its relationship with nutrient intakes and meal days involving staple foods, main dishes, and side dishes in community-dwelling elderly adults]. Japanese Journal of Public Health. 2020;67(3):171-82. doi: 10.11236/jph.67.3_171.

43. Sasaki S, Tsuji T, Katagiri A, Shimoda T, the Diets of the Fresh Students in D. Association between the Number of Food Items Bought in Convenience Stores and Nutrient and Food-group Intakes -A Survey of First-year Female College Students Taking Dietetic Courses-. J Nutr Sci Vitaminol (Tokyo). 2000;53(5):215-26. doi: 10.4327/jsnfs.53.215.

44. David N, Eite T. The International System of Units (SI), 2019 Edition. U.S. Department of Commerce 2019 [cited 2023/10/30]; Available from: https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.330-2019.pdf.

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		*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)	
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 / m²)	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.

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		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)	
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		*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)	
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

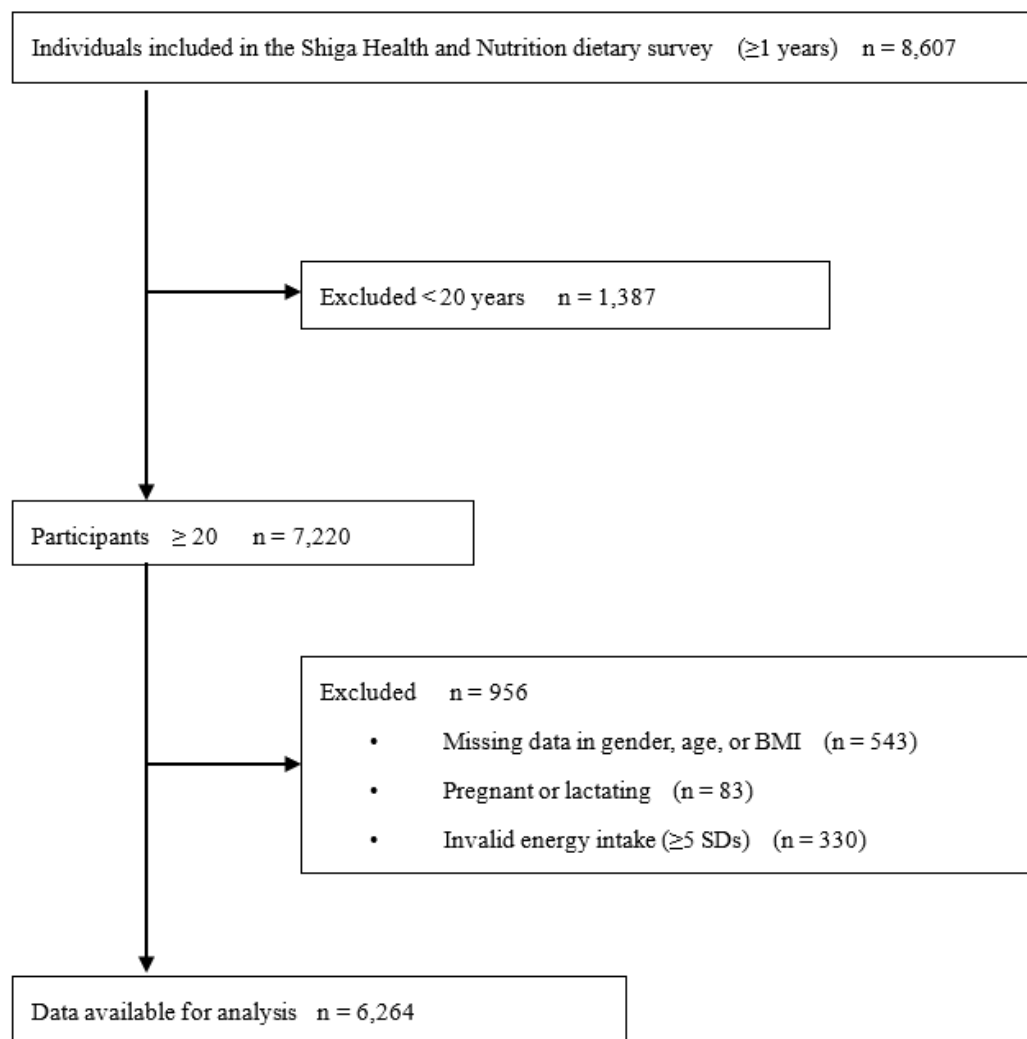SMS meal: meal combining staple food, main dish, and side dish
[†]Values are means ± SD. Food group intakes are used the density method (per 1,000kcal).
[‡]p-value are based on the t-test (Continuous variables).

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).   .

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

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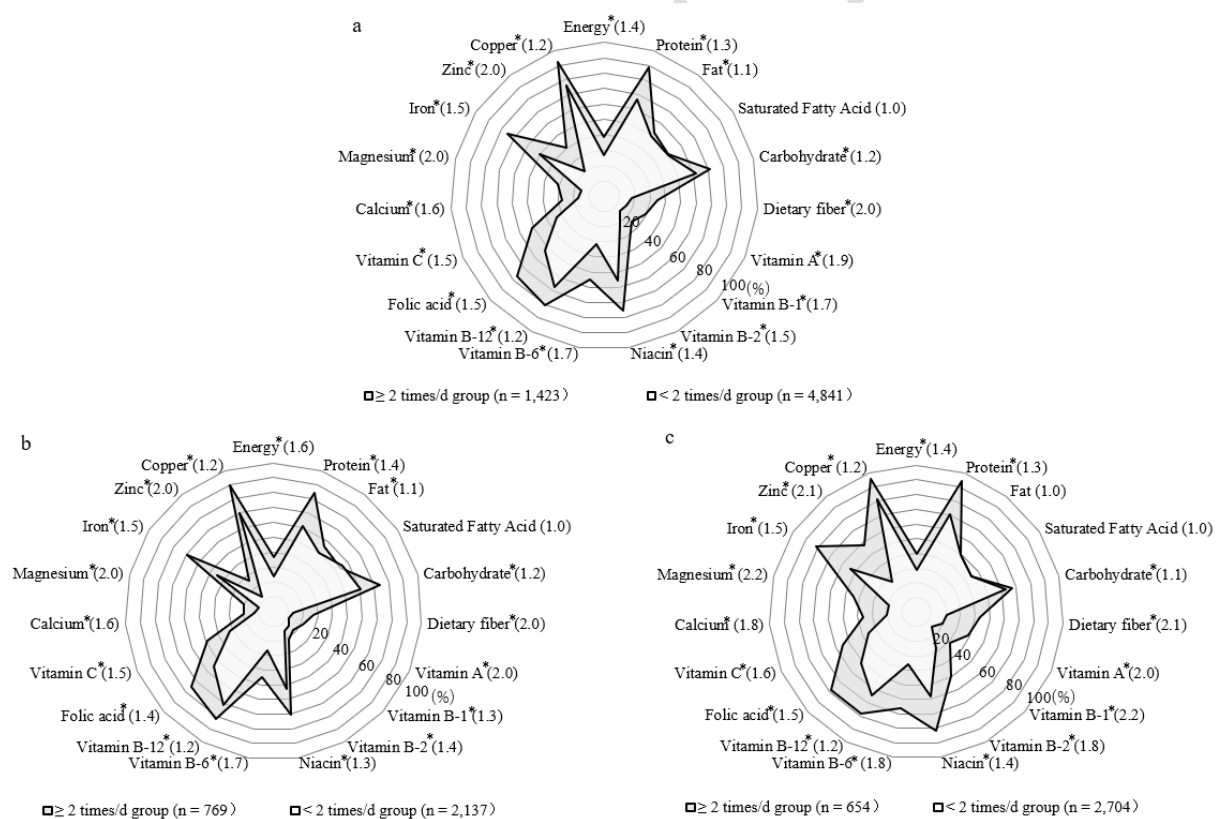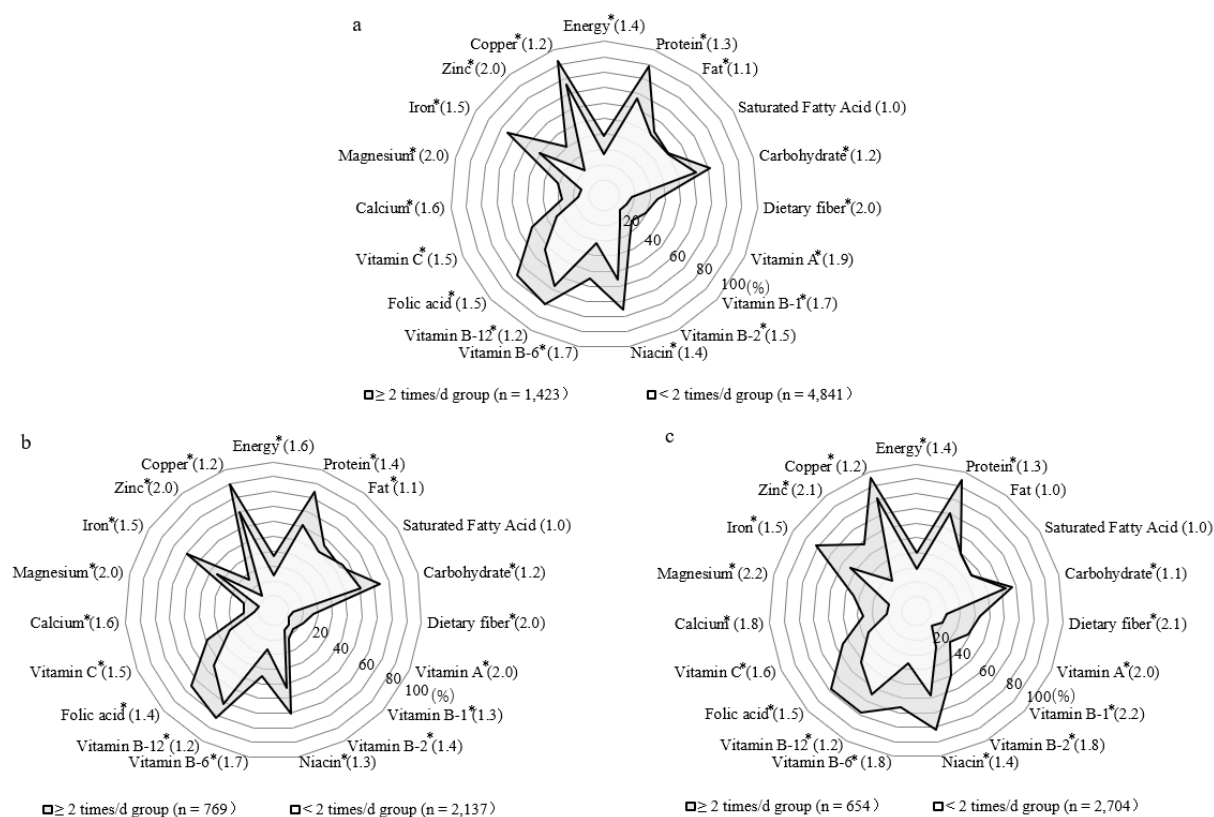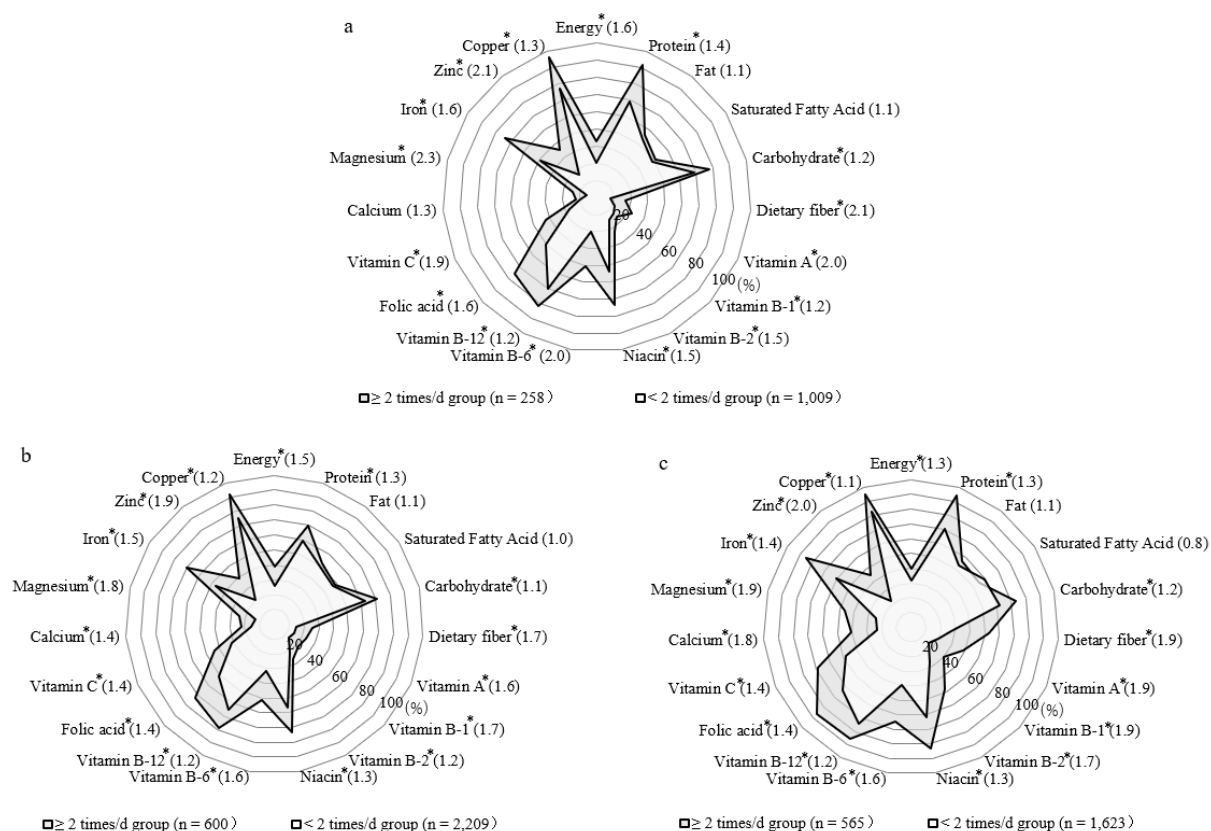

Figure 3. Photographs

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)

Supplementary Figure 1. 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) 20–39 years, (b) 40–64 years, (c) ≥65 years. 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)