Original Article

# Association of physical prefrailty with prevalence of inadequate nutrient intake in community-dwelling Japanese elderly women: A cross-sectional study

Tatsumi Hayashi RD, BS[1,2], Yoshiharu Fukuda MD, PhD[3], Rumi Sato RD, BS[4], Masashi Ogasawara MPEd, CSCS[1,5], Kazuo Tamura MD, PhD[6,7]

[1]*Faculty of Economics, Shimonoseki City University, Daigaku-cho, Yamaguchi, Japan.*
[2]*Faculty of Food and Nutrition, Kyushu Nutrition Welfare University, Fukuoka, Japan.*
[3]*Graduate School of Public Health, Teikyo University, Tokyo, Japan.*
[4]*Council of Social Welfare, Bungo Ono City, Oita, Japan.*
[5]*Faculty of Business and Information Sciences, Jobu University, Gunma, Japan.*
[6]*Research Promotion Division, Fukuoka University, Fukuoka, Japan.*
[7]*NPO Clinical Hematology Oncology Treatment Study Group, Fukuoka, Japan.*

**Background and Objectives:** This study evaluated the association of physical prefrailty with the prevalence of inadequate nutrients among community-dwelling Japanese elderly women. **Methods and Study Design:** This cross-sectional study included 120 older women (age range, 65–79 years) at an elders college. Frailty was evaluated using the Japanese version of the Cardiovascular Health Study (J-CHS). Participants were classified as either prefrailty (1–2 deficits) or nonfrailty (0 deficits) based on set criteria. Both groups were compared in terms of physical function, exercise time, nutrient intake, and food group intake estimated by Food Frequency Questionnaire Based on Food Groups (FFQg), and estimated prevalence of inadequate nutrient intake, which was evaluated using each dietary reference value, set as the estimated average requirement (EAR) and dietary goal (DG), based on the Dietary Reference Intakes (DRIs) for Japanese, 2020. **Results:** Of the participants, 45.0% exhibited physical prefrailty. Binary logistic regression analysis identified that vitamin C intake below EAR (OR, 7.12; 95% CI, 1.47-34.41, $p$=0.014) was the only factor associated with physical prefrailty. **Conclusions:** In addition to measuring physical function, dietary surveys and evaluation of nutritional adequacy by DRIs are expected to be useful for the early prevention of physical prefrailty by linking to nutrition education among community-dwelling Japanese elderly adults.

**Key Words: prefrailty, nutrient intake, Dietary Reference Intakes for Japanese (2020), nutritional adequacy, Japanese healthy elderly women**

## INTRODUCTION

The Government of Japan has published Dietary Reference Intakes (DRIs) for Japanese, 2020,[1] which will be applicable for 5 years, i.e., 2020–2024. DRIs 2020 included the expansion into nutrition for the elderly, centered in prevention of frailty, in its development purposes, in addition to DRIs, 2015,[2] prevention of onset of lifestyle-related diseases (LRDs), and prevention of the progression of LRDs. One of the revisions to prevent frailty was to increase the lower limit of proteins that tentative dietary goals for preventing LRDs target to 15%.

The prevention of frailty in the elderly is a primary goal of geriatric medicine and has become important in the nutrition field as well. A limited number of research studies have focused on the characteristics of prefrailty in the elderly. Frailty affects various functions,[3] including walking, motility, muscle strength, cognition, nutritional state, endurance, and physical activity, making the individual extremely susceptible to harmful health effects.[4-6] Prefrailty elderly are more likely to return to a healthy state than frailty individuals, and they are characterized by frequently oscillating between frailty and nonfrailty states.[7] To our knowledge, no specific intervention method to improve the health of prefrailty elderly patients and reverse their frailness has been established.[8] It is assumed that early interventions for frailty, particularly in the prefrailty state, might improve the quality of life and reduce adverse outcomes.[5,9] Effective intervention is indispensable to prevent and improve prefrailty, and this urgently requires the identification of factors related to

**Corresponding Author:** Tatsumi Hayashi, Faculty of Economics, Shimonoseki City University, 4-20-301, Dannoura-cho, Shimonoseki, Yamaguchi 751-0814, Japan.
Tel: +81-90-5747-0849; Fax: +81-83-233-6715
Email: tatsumi-hayashi@eco.shimonoseki-cu.ac.jp; thayashi0814@gmail.com
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prefrailty.

Recent studies investigating frailty, nutrition, and specific food types have revealed that these related factors affect health in the elderly and are important lifestyle aspects that can reverse frailty.[10] A high protein intake was negatively associated with the state of frailty in the elderly. Sufficient protein intake may reverse or at least prevent functional decline in frailty elderly patients.[11] Also, in terms of diet quality, higher intake of total and animal proteins and dietary total antioxidant capacity were independently associated with lower prevalence of frailty in elderly Japanese women.[12] Another study has reported that low intake of energy, protein, vitamin D, vitamin E, vitamin C, and folate is an important element related to frailty.[13] There also are concerns that inadequate intake of trace nutrients in elderly populations could be associated with frailty.[14-16]

Rapid advances are being made for developing countermeasures to prevent and improve prefrailty and frailty. However, few studies have investigated the characteristics of prefrailty, which is the initial stage of frailty. Therefore, to evaluate the characteristics of prefrailty, we conducted a physical function evaluation and dietary survey among Japanese healthy elderly community-dwelling women and analyzed its association with the prevalence of inadequate nutrient intake based on DRIs for Japanese, 2020.

## METHODS

### *Study design and participants*

This cross-sectional study targeted 120 elderly community-dwelling women (age range, 65–79 years) at the elders college of Kitakyushu city, Japan, in 2016. The participants had not been certified as requiring long-term nursing care, were not residents of a facility, and had not been diagnosed with dementia. In addition, participants were prefrailty and nonfrailty elderly women. They could perform their activities of daily living (ADLs) independently even if some risks related to hypertension, dyslipidemia, hyperglycemia, or decreased kidney function were present. They had not received instructions from a doctor to implement any dietary restrictions. The measurements and surveys were performed over several sessions between August and September 2016 at a university facility within Kitakyushu city. All individual variables were measured and surveyed on the same day by multiple registered dietitians and health fitness programmers.

### *Ethical considerations*

This study was reviewed and approved by the Ethics Committee of the Elders College in Kitakyushu (Approval no. 1601). All participants provided consent in writing before the study was initiated.

### *Prefrailty evaluation*

The Japanese version of the Cardiovascular Health Study (J-CHS)[17] was used to identify prefrailty. This tool, which is based on Cardiovascular Health Study (CHS) standards developed for frailty phenotypes by Fried et al[4] has been modified to screen for frailty among Japanese individuals. Participants were classified into prefrailty (1–2 deficits) or nonfrailty (0 deficits) groups based on the following set criteria: Shrinking - weight loss of ≥2 kg over the past 6 months, Low activity - not engaging in moderate level exercise or sports and also not engaging in low level exercise for health purposes,[18] Exhaustion - feeling fatigued for no particular reason in the past 2 weeks, Weakness - grip strength cutoff value <18 kg for women,[19] and Slowness - gait speed cutoff value <1.0 m/s.[20] In recent years, the J-CHS was revised by a research team of the Ministry of Health, Labour and Welfare to a criteria believed to be appropriate for Japanese individuals. The predictive validity of mortality and decreased ADLs as outcomes is being verified.[17]

### *Physical function evaluation*

Height and weight were measured simultaneously using a height/weight measurement device (AD-6350; A&D Co. Ltd. Japan), and these data were used to calculate BMI. A Smedley handheld dynamometer (Grip-D; Takei Ltd. Japan) was used to measure the grip strength as an index for muscle strength. The participants used their dominant hand while standing. Measurement was performed twice, with the larger value used for analysis. For gait speed measurement, markers were placed at the starting and end points of a 6 m walking route. The participants were then asked to walk for at least 2 m before the starting point and after the endpoint to ensure that they could walk at their usual pace. Measurement was performed once and the distance walked per second (m/s) was used for analysis. Grip strength was not measured in participants who had ischemic heart disease or cerebrovascular disorder in the past 6 months, participants for whom such measurement would clearly be dangerous due to a motor disorder, and participants whose blood pressure was ≥180/110 mmHg or resting pulse rate was ≥110 or ≤50 beats per minute (HEM-7134, OMRON Corp. Japan).

### *Evaluation of other variables, such as basic attributes and lifestyle habits*

Age, physical activity level (PAL), and alcohol consumption habits were evaluated based on participants' responses to questions in Food Frequency Questionnaire Based on Food Groups (FFQg)[21] (Ver.5. 2016; KENPAKUSHA Corp. Japan). For PAL, participants were asked about how they spent the 24 hours of each day. These were calculated automatically based on DRIs,[1] which were classified as low (I), medium (II), or high (III), and were used to calculate the estimated energy requirement.[1] To measure exercise habits, participants were asked to record habitual exercise time for the past week to determine whether they engaged in habitual exercise. Participants also were questioned regarding whether they had any diseases being treated, whether they lived with anyone, the number of remaining teeth, number of dentures, and number of functional teeth.

### *Evaluation of nutrient intake and intake by food group*

Nutrient intake and intake by food group were evaluated using the FFQg, which is a software developed to estimate mean daily nutrient intake levels over the past 1–2 months for individuals. It questions portion size and food frequency over 1 week in a survey format. These data were used to estimate levels of intake by food group and nutrient intake. Energy and nutrient intake levels were estimated using nutrient value estimation software (Excel Eiyou version 8.0; KENPAKUSHA Corp. Japan) based on the 2015 version (7th rev.) of the Standard Tables of Food Composition in Japan.[22] Individual energy and nutrient intake levels calculated using the FFQg have been confirmed as valid and effective when compared with actual consumption records over 7 days for estimating not only energy and nutrients but also intake by food group and table salt intake.[21] Moreover, since supplements containing specific nutrients are not included in the FFQg questions, participants were questioned orally about these during the interviews.

Of the diet variables, energy-adjusted intake, calculated using the method of residuals,[23] was used for daily nutrient intake and intake by food group.

### *Evaluation of inadequate nutrient intake*

Inadequacy of nutrient intake was evaluated by comparing with each dietary reference value according to the Japanese DRIs 2020.[1] Nutrient intake used energy-adjusted intake for each nutrient, as calculated with the method of residuals.[23] In DRIs 2020, age categories for adults over 65 years are 65–74 years and 75 years or over.[1]

Intake of the 18 nutrients of protein, vitamin A, vitamin B-1, vitamin B-2, niacin, vitamin B-6, vitamin B-12, folate, vitamin C, sodium (Na), calcium, magnesium (Mg), iron (Fe), zinc, copper (Cu), iodine, selenium (Se), and molybdenum (Mo) were considered inadequate if it was below the estimated average requirement (EAR).[1] For protein, vitamin B-1, vitamin B-2, and niacin, 22 EAR items were investigated in addition to evaluation using standards for body weight or energy intake volume. The EAR cutoff point method cannot be used for Fe in women as distribution of the required amount of iron varies.[24] Participants were confirmed to have entered menopause and Fe was evaluated in a similar manner based on EAR.

Provisional dietary goals (DG)[1] for preventing LRDs have been established for the seven nutrients of protein, fat, SFA, carbohydrates, dietary fiber, salt equivalent, and potassium (K). Intake of these nutrients was considered inadequate when the amount was outside of the range of the corresponding DG.

Adequate Intake (AI)[1] levels were established for the eight nutrients of n-6 PUFA, n-3 PUFA, vitamin D, vitamin E, vitamin K, pantothenic acid, phosphorus, and manganese as there is insufficient grounds for establishment of EAR for these nutrients. If AI level or higher was confirmed, there was a very low risk that intake is inadequate. Moreover, even if the intake level was below the AI, intake was considered adequate if an insufficiency or risk of such could not be proven.[1] Accordingly, if intake was below the AI, the data were excluded from analysis because it was impossible to hypothesize[25] on the prevalence of such inadequate intake.

### *Statistical analysis*

Participants were divided into prefrailty and nonfrailty groups, and differences in evaluation parameters were analyzed using the Mann-Whitney U test. Fisher's exact test or chi-squared test was used to compare categorical variables.

Individual numbers must be counted to estimate the prevalence of inadequate nutrient intake.[24,25] Based on methods used in previous reports,[26,27] we estimated the percentages of participants for whom the DRIs were not fulfilled for the 22 EAR and seven DG nutrients. Then, Fisher's exact test was used to compare these results between the prefrailty and nonfrailty groups. And, the numbers of EAR and DG nutrients for which the DRIs were not fulfilled were tabulated and compared using the Mann-Whitney U test.

The contribution of different food groups to inadequate nutrient intake was calculated.

Finally, binary logistic regression analysis was performed selecting the independent variables that were significant according to univariate analysis and using the nonfrailty (0) and prefrailty (1) groups as the dependent variables. Inadequate nutrient intake, which is an independent variable associated with the prevalence of prefrailty, was categorized by DRIs, 2020, into below EAR, not less than EAR, below recommended dietary allowance (RDA), and not less than RDA, and was entered into logistic regression models to assess the OR and 95% CI. Variables including the definition of frailty were excluded. Model 1 used the simultaneous method and model 2 used the forward-selection method with likelihood ratio (criterion for selection variables: 0.05 to enter, 0.10 to remove). All models were adjusted for energy intake, and energy intake was used as a continuous variable.

All statistical analyses were performed using IBM SPSS version 22.0 (IBM Japan Ltd.). All tests were 2-tailed, and $p<0.05$ was considered significant in all comparisons.

## RESULTS

### *Basic characteristics*

Data were analyzed for 120 elderly community-dwelling women aged 65–79 years. Prefrailty was confirmed in 45.0% (Table 1). Median age was 75.0 and 71.0 years in the prefrailty and nonfrailty groups, respectively (no significant difference). In terms of physical function, while grip strength was lower in the prefrailty group, no significant difference was noted ($p$=0.064), and 25.9% of participants were found to be below the cutoff value in the prefrailty group. Median gait speed was significantly lower in the prefrailty (1.16 m/s; 22.2% of participants were below the cutoff value) than in the nonfrailty (1.40 m/s) groups ($p<0.001$). In the prefrailty group, 22.2% of participants experienced fatigue and the majority (51.9%) had low physical activity. Median exercise time was 60 min/day in the nonfrailty group, which was significantly greater than that in the prefrailty group ($p<0.001$). Just over 20% of participants in both groups lived alone. The numbers of remaining teeth were 16 and 20 in the prefrailty and nonfrailty groups, respectively ($p$=0.067), and all participants had entered menopause (data not shown).

The PAL classification was I (low) for 53.7% of prefrailty group and II (medium) for 60.6% in the nonf-

**Table 1.** Basic characteristics of Japanese elderly women classified according to frailty criteria† of J-CHS

| Characteristics | All (n=120) | Prefrailty† (n=54, 45.0%) | Nonfrailty (n=66, 55.0%) | *p*-value |
|---|---|---|---|---|
| | Median (IQR) or n (%) | Median (IQR) or n (%) | Median (IQR) or n (%) | |
| Frailty criteria† of J-CHS, n (%) | | | | |
| Shrinking | - | - | - | |
| Low activity | 28 (23.3) | 28 (51.9) | - | |
| Exhaustion | 12 (10.0) | 12 (22.2) | - | |
| Weakness‡ | 14 (11.7) | 14 (25.9) | - | |
| Slowness§ | 12 (10.0) | 12 (22.2) | - | |
| Frailty score (0–5)†, n (%) | | | | |
| 0 deficits | 66 (55.0) | - | 66 (100.0) | |
| 1 deficits | 42 (35.0) | 42 (77.8) | - | |
| 2 deficits | 12 (10.0) | 12 (22.2) | - | |
| Age (years) , n (%) | 73.0 (68.0-76.0) | 75.0 (68.0-77.0) | 71.0 (68.0-75.8) | 0.267†† |
| 65-74 | 62 (51.7) | 23 (42.6) | 39 (59.1) | 0.098‡‡ |
| 75+ | 58 (48.3) | 31 (57.4) | 27 (40.9) | |
| Living alone [Yes, n (%)] | 28 (23.3) | 12 (22.2) | 16 (24.2) | 0.831‡‡ |
| Body height (cm) | 154 (151-157) | 153 (151-156) | 155 (151-159) | 0.168†† |
| Body weight (kg) | 52.0 (50.0-58.0) | 53.0 (47.0-57.9) | 52.0 (50.0-57.8) | 0.964†† |
| Body mass index (kg/m$^2$)¶, n (%) | 22.0 (20.9-23.5) | 21.9 (20.6-24.0) | 22.2 (21.1-23.4) | 0.979†† |
| <21.5 | 43 (35.8) | 22 (40.7) | 21 (31.8) | 0.097§§ |
| 21.5 - 24.9 | 59 (49.2) | 21 (38.9) | 38 (57.6) | |
| ≥25.0 | 18 (15.0) | 11 (20.4) | 7 (10.6) | |
| Systolic blood pressure (mmHg) | 138 (126-150) | 135 (126-148) | 138 (127-150) | 0.897†† |
| Diastolic blood pressure (mmHg) | 78.0 (73.0-88.0) | 78.0 (73.5-86.0) | 78.0 (72.7-88.0) | 0.944†† |
| Resting pulse rate (beat/min) | 70.0 (64.0-76.0) | 69.5 (67.0-77.0) | 70.0 (64.0-75.0) | 0.331†† |
| Grip strength (kg) | 22.5 (20.0-24.0) | 21.0 (18.0-24.0) | 23.5 (20.0-24.0) | 0.064†† |
| Gait speed (m/sec) | 1.34 (1.16-1.44) | 1.16 (0.95-1.43) | 1.40 (1.33-1.50) | < 0.001†† |
| Exercise habit [Yes, n (%)] | 92 (76.7) | 26 (48.1) | 66 (100.0) | |
| Exercise time (min/day) | 42.0 (18.0-60.0) | 0.0 (0.0-48.0) | 48.0 (30.0-60.0) | < 0.001†† |
| Sleeping hours (hours/day) | 7.0 (6.0-7.0) | 7.0 (6.0-7.0) | 7.0 (6.0-7.0) | 0.709†† |
| Alcohol drinking [Yes, n (%)] | 44 (36.7) | 18 (33.3) | 26 (39.4) | 0.569‡‡ |
| Presence of disease during treatment [Yes, n (%)] | 66 (55.0) | 29 (53.7) | 37 (56.1) | 0.855‡‡ |
| Number of remaining teeth | 20.0 (13.0-22.0) | 16.0 (10.5-21.5) | 20.0 (18.0-22.0) | 0.067†† |
| Number of prosthetic teeth | 6.0 (0.0-12.5) | 9.0 (0.0-14.0) | 6.0 (0.0-10.0) | 0.325†† |
| Number of functional teeth | 25.0 (22.0-28.0) | 24.5 (22.0-26.0) | 26.0 (22.0-28.0) | 0.118†† |

J-CHS: Japanese version of the Cardiovascular Health Study[17]; IQR: interquartile range.
Values are numbers of subjects (%) or medians and interquartile ranges are 25th percentile-75th percentile.
†Frailty score (0–5) was defined as Shrinking (1 point), Low activity (1 point), Exhaustion (1 point), Weakness (1 point) and Slowness (1 point). A score of 1 or 2 indicated prefrailty.
‡Weakness Grip strength <18kg[19]. §Slowness Gait speed <1.0m/s[20].
¶Body Mass Index category was based on the Dietary Reference Intakes (DRIs) for Japanese, 2020[1]
††Mann-Whitney U test.
‡‡Fisher's exact test
§§Chi-squared test.

railty group, revealing a significant difference between the two groups (*p*=0.014; Supplementary table 1).

***Nutrient intake, nutrient ratios, and intake by food group***

Table 2 shows the median values and interquartile ranges for nutrient intake and nutrient ratios adjusted for energy using the method of residuals.[23] Significant differences were observed for vitamins D and C intake, with lower values noted in the prefrailty group (*p*=0.004, *p*=0.038, respectively). No significant differences were observed between the groups for energy intake or other nutrients and nutrient ratios. No participants regularly took nutritional supplements. Supplementary table 2 shows the calculated other nutrient intake and nutritional ratio.

Table 3 shows the median values and interquartile ranges for intake by food group adjusted for energy using the method of residuals.[23] Median intake of vegetables was significantly lower in the prefrailty (262 g) than in the nonfrailty (307 g) groups (*p*=0.011). No significant differences were observed between the two groups for any of the other food groups.

***Inadequate nutrient intake***

Table 4 shows the percentages of participants who did not meet the DRIs (unit/day). The prevalence of insufficient nutrient intake below vitamin C EAR was 22.2% in the prefrailty and 3.0% in the nonfrailty groups (*p*=0.001). Mg was 38.9% in the prefrailty and 21.2% in the nonfrailty groups (*p*=0.043). No instance of insufficient intake below EAR for protein, niacin, vitamin B-12, folate, Na, Cu, Se, and Mo was observed. No significant differences were observed between the groups for other nutrient EAR, including vitamin A, nor for the seven nutrients for which DG was set. However, the prevalence of insufficient nutrient intake outside of the DG for SFA (% of energy), dietary fiber, salt equivalent, and K was high in both groups.

The median number (interquartile ranges) of inadequate nutrients below the EAR or outside the DG were 7.0

**Table 2.** Comparison of nutrients intake and nutritional ratio in prefrailty† women and nonfrailty women classified according to frailty criteria† of J-CHS

| Variables | All (n=120) | Prefrailty† (n=54) | Nonfrailty (n=66) | *p* value§ |
|---|---|---|---|---|
| | Median (IQR) | Median (IQR) | Median (IQR) | |
| Energy (kcal) | 1798 (1576-1939) | 1767 (1567-1928) | 1800 (1604-1974) | 0.387 |
| Protein‡ (g) | 69.4 (64.1-73.2) | 67.3 (60.7-74.2) | 70.5 (65.5-72.9) | 0.075 |
| Animal protein‡ (g) | 37.7 (32.9-42.1) | 34.8 (31.1-40.9) | 38.4 (34.3-42.3) | 0.057 |
| Fat‡ (g) | 56.4 (50.3-60.6) | 59.1 (49.2-60.5) | 56.0 (50.6-62.0) | 0.548 |
| Saturated fatty acids‡ (g) | 18.45 (15.94-22.59) | 19.15 (16.23-23.26) | 17.69 (15.59-21.60) | 0.151 |
| Carbohydrates‡ (g) | 241 (207-281) | 237 (205-279) | 243 (208-284) | 0.435 |
| Dietary fiber‡ (g) | 15.4 (13.5-16.8) | 14.9 (13.5-16.6) | 15.8 (13.4-17.0) | 0.268 |
| Vitamin A‡ (µgRAE) | 605 (482-784) | 581 (479-782) | 620 (481-785) | 0.932 |
| Vitamin D‡ (µg) | 7.8 (6.9-9.0) | 7.5 (5.1-8.3) | 8.1 (7.3-9.3) | 0.004 |
| Vitamin E‡ (µg) | 7.1 (6.5-7.9) | 7.0 (6.4-8.0) | 7.2 (6.6-7.9) | 0.376 |
| Vitamin K‡ (µg) | 253 (213-311) | 258 (201-305) | 253 (218-313) | 0.784 |
| Vitamin B-1‡ (mg) | 0.88 (0.77-0.98) | 0.87 (0.73-0.95) | 0.89 (0.78-0.98) | 0.513 |
| Vitamin B-2‡ (mg) | 1.19 (1.01-1.36) | 1.18 (0.96-1.32) | 1.19 (1.06-1.36) | 0.728 |
| Niacin‡ (mgNE) | 28.1 (25.4-31.2) | 27.1 (24.7-29.7) | 28.7 (26.0-32.7) | 0.447 |
| Vitamin B-6‡ (mg) | 1.26 (1.08-1.50) | 1.28 (1.17-1.49) | 1.21 (1.07-1.50) | 0.229 |
| Vitamin B-12‡ (µg) | 7.8 (6.3-9.6) | 7.4 (5.4-9.1) | 8.1 (7.0-9.8) | 0.060 |
| Folate‡ (µg) | 348 (312-428) | 344 (298-410) | 348 (315-428) | 0.316 |
| Vitamin C‡ (mg) | 106 (87-128) | 101 (82-121) | 113 (92-138) | 0.038 |
| Sodium‡ (mg) | 3443 (2981-4397) | 3469 (2901-4396) | 3443 (3062-4397) | 0.720 |
| Salt equivalent‡ (g) | 9.0 (7.7-11.1) | 9.4 (7.9-11.5) | 8.5 (7.7-10.1) | 0.131 |
| Potassium‡ (mg) | 2536 (2232-2442) | 2300 (2235-2404) | 2393 (2229-2451) | 0.133 |
| Calcium‡ (mg) | 718 (610-841) | 721 (602-847) | 718 (640-833) | 0.983 |
| Magnesium‡ (mg) | 237 (224-270) | 235 (216-265) | 239 (228-272) | 0.296 |
| Iron‡ (mg) | 7.4 (6.6-8.5) | 7.4 (6.9-9.0) | 7.4 (6.5-8.1) | 0.547 |
| Zinc‡ (mg) | 8.5 (7.9-9.1) | 8.5 (7.9-9.1) | 8.5 (7.8-9.1) | 0.665 |
| Copper‡ (mg) | 1.12 (1.04-1.28) | 1.13 (1.07-1.18) | 1.11 (1.03-1.32) | 0.562 |
| Iodine‡ (µg) | 149 (109-227) | 152 (102-217) | 145 (116-235) | 0.783 |
| Selenium‡ (µg) | 61 (55-66) | 60 (55-66) | 63 (56-66) | 0.054 |
| Molybdenum‡ (µg) | 150 (139-166) | 153 (143-168) | 147 (133-163) | 0.128 |
| Protein‡ energy ratio (% energy) | 15.4 (14.0-17.5) | 14.9 (14.1-17.0) | 15.5 (13.9-17.6) | 0.704 |
| Animal protein‡ ratio (%) | 52.8 (48.8-59.1) | 52.4 (47.6-59.1) | 52.9 (49.3-59.0) | 0.629 |
| Fat‡ energy ratio (% energy) | 27.9 (25.1-31.6) | 27.8 (25.9-31.4) | 28.1 (24.8-31.6) | 0.658 |
| SFA‡ energy ratio (% energy) | 9.5 (8.2-11.9) | 9.6 (8.4-12.9) | 9.1 (8.1-11.3) | 0.134 |
| Carbohydrates‡ energy ratio (% energy) | 54.4 (50.4-58.1) | 55.4 (50.0-58.3) | 53.3 (51.5-58.0) | 0.975 |

J-CHS: Japanese version of the Cardiovascular Health Study[17]; IQR: interquartile range; RAE: retinol activity equivalent; NE: niacin equivalents.

Values are medians and interquartile ranges are 25th percentile-75th percentile.

†Frailty score (0–5) was defined as Shrinking (1 point), Low activity (1 point), Exhaustion (1 point), Weakness (1 point) and Slowness (1 point). A score of 1 or 2 indicated prefrailty.

‡Nutrient intakes were energy-adjusted according to the residual method[23].

§Mann-Whitney U test.

**Table 3.** Comparison of intake by food group in prefrailty† women and nonfrailty women classified according to frailty criteria† of J-CHS

| Food groups (g/day) | All (n=120) | Prefrailty† (n=54) | Nonfrailty (n=66) | *p*-value‡‡ |
|---|---|---|---|---|
| | Median (IQR) | Median (IQR) | Median (IQR) | |
| Cereals‡§ | 401 (332-458) | 409 (336-457) | 396 (327-461) | 0.883 |
| Potatoes‡§ | 53 (26-87) | 56 (27-97) | 49 (25-82) | 0.435 |
| Sugar and sweeteners‡§ | 11 (9-14) | 12 (10-14) | 11 (8-14) | 0.055 |
| Soy products‡§ | 76 (49-99) | 73 (49-100) | 77 (49-93) | 0.776 |
| Total vegetables‡§ | 293 (239-334) | 262 (206-323) | 307 (249-337) | 0.011 |
| Green and yellow vegetables‡§ | 103 (82-123) | 102 (74-123) | 104 (85-124) | 0.114 |
| Fruits‡§ | 145 (78-219) | 143 (84-195) | 147 (77-226) | 0.296 |
| Algaes‡§ | 6 (5-10) | 6 (4-9) | 6 (5-12) | 0.157 |
| Fish and shellfish‡¶ | 74 (62-86) | 74 (60-85) | 77 (62-86) | 0.506 |
| Meat‡¶ | 58 (39-73) | 66 (47-73) | 55 (31-71) | 0.070 |
| Eggs‡¶ | 30 (19-49) | 40 (19-50) | 28 (18-49) | 0.167 |
| Dairy products‡¶ | 180 (118-236) | 189 (137-229) | 178 (113-238) | 0.966 |
| Fats and oils‡†† | 13 (11-17) | 13 (12-17) | 13 (10-17) | 0.120 |
| Nuts and seeds‡†† | 3 (0-4) | 2 (1-4) | 3 (0-5) | 0.352 |
| Confectioneries‡†† | 48 (29-58) | 51 (41-59) | 40 (28-56) | 0.078 |
| Favorite beverages (excluding alcoholic beverages) ‡†† | 28 (1-129) | 84 (1-200) | 23 (1-88) | 0.055 |
| Alcohol beverages‡†† | 2 (0-6) | 2 (0-5) | 2 (0-6) | 0.068 |
| Seasonings and spices‡†† | 19 (16-28) | 20 (17-33) | 19 (16-26) | 0.138 |
| Plant foods§†† | 965 (890-1072) | 942 (854-1049) | 1003 (895-1110) | 0.056 |
| Animal foods¶†† | 338 (274-393) | 338 (305-410) | 324 (270-389) | 0.527 |
| Total foods†† | 1452 (1339-1617) | 1459 (1333-1629) | 1447 (1356-1616) | 0.611 |

J-CHS: Japanese version of the Cardiovascular Health Study[17]; IQR: interquartile range.
Values are medians and interquartile ranges are 25th percentile-75th percentile.
†Frailty score (0–5) was defined as Shrinking (1 point), Low activity (1 point), Exhaustion (1 point), Weakness (1 point) and Slowness (1 point). A score of 1 or 2 indicated prefrailty.
‡Nutrient intakes were energy-adjusted according to the residual method[23].
§Plant foods, g/day = (Cereals‡ + Potatoes‡ + Sugar and sweeteners‡ + Soy products‡ + Total vegetables‡ + Fruits‡ + Algaes‡ + Nuts and seeds‡), g/day.
¶Animal foods, g/day = (Fish and shellfish‡ + Meat ‡+ Eggs‡+ Dairy products‡), g/day.
††Total foods, g/day = (Plant foods + Animal foods + Fats and oils‡ + Confectioneries‡ + Favorite beverages‡ + Alcohol beverages‡ + Seasonings and spices‡), g/day.
‡‡Mann-Whitney U test.

**Table 4.** Result of study participants with inadequate intake according to the Dietary Reference Intakes (DRIs) for Japanese,2020, using the cut-point method for Japanese in prefrailty† women and nonfrailty women classified according to frailty criteria† of J-CHS

| Nutrients and reference value‡ | All (n=120) | | Prefrailty† (n=54) | | Nonfrailty (n=66) | | *p*-value†† |
|---|---|---|---|---|---|---|---|
| | number | % | number | % | number | % | |
| Nutrient with EAR§ | | | | | | | |
| Protein | | | | | | | |
| ≥40.0 g | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | - |
| ≥0.73 g/kgBW | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | - |
| Vitamin A | | | | | | | |
| 65-74 years: ≥500 μgRAE, 75 years+: ≥450 μgRAE | 28 | 23.3 | 16 | 29.6 | 12 | 18.2 | 0.192 |
| Vitamin B-1 | | | | | | | |
| 65-74 years: ≥0.9 mg, 75 years+: ≥0.8 mg | 58 | 48.3 | 28 | 51.9 | 30 | 45.5 | 0.582 |
| ≥0.45 mg/1,000 kcal | 40 | 33.3 | 20 | 37.0 | 20 | 30.3 | 0.444 |
| Vitamin B-2 | | | | | | | |
| 65-74 years: ≥1.0 mg, 75 years+: ≥0.9 mg | 19 | 15.8 | 10 | 18.5 | 9 | 13.6 | 0.616 |
| ≥0.50 mg/1,000 kcal | 16 | 13.3 | 9 | 16.7 | 7 | 10.6 | 0.420 |
| Niacin | | | | | | | |
| ≥9 mgNE | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | - |
| ≥4.8 mgNE/1,000 kcal | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | - |
| Vitamin B-6 | | | | | | | |
| ≥1.0 mg | 12 | 10.0 | 4 | 7.4 | 8 | 12.1 | 0.543 |
| Vitamin B-12 | | | | | | | |
| ≥2.0 μg | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | - |
| Folate | | | | | | | |
| ≥200 μg | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | - |
| Vitamin C | | | | | | | |
| ≥80 mg | 14 | 11.7 | 12 | 22.2 | 2 | 3.0 | 0.001 |
| Sodium | | | | | | | |
| ≥600 mg | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | - |
| Calcium | | | | | | | |
| 65-74 years: ≥550 mg, 75 years+: ≥500 mg | 5 | 4.2 | 4 | 7.4 | 1 | 1.5 | 0.173 |
| Magnesium | | | | | | | |
| 65-74 years: ≥230 mg, 75 years+: ≥220 mg | 35 | 29.2 | 21 | 38.9 | 14 | 21.2 | 0.043 |
| Iron | | | | | | | |
| ≥5 mg | 2 | 1.7 | 0 | 0.0 | 2 | 3.0 | - |

J-CHS: Japanese version of the Cardiovascular Health Study[17]; EAR: estimated average requirement; BW: Body weight; RAE: retinol activity equivalent; NE: niacin equivalents; DG: tentative dietary goals for preventing lifestyle-related diseases (LRDs).

†Frailty score (0–5) was defined as Shrinking (1 point), Low activity (1 point), Exhaustion (1 point), Weakness (1 point) and Slowness (1 point). A score of 1 or 2 indicated prefrailty.

‡Dietary Reference Intakes (units/d), 2020 for Japanese females aged 65-74 and 75+years old[1].

§The EAR is the average daily nutrient intake level required in a population, calculated on the basis of the distribution of the measured requirements in a study population. To prevent inadequate intake, EAR was determined[1].

¶The DGs required for the prevention of LRDs were set as the current goals for Japanese individuals to reach the average daily intake of nutrients, and, thereby, prevent LRDs[1].

††Fisher's exact test.

**Table 4.** Result of study participants with inadequate intake according to the Dietary Reference Intakes (DRIs) for Japanese,2020, using the cut-point method for Japanese in prefrailty† women and nonfrailty women classified according to frailty criteria† of J-CHS (cont.)

| Nutrients and reference value‡ | All (n=120) | | Prefrailty† (n=54) | | Nonfrailty (n=66) | | *p*-value†† |
|---|---|---|---|---|---|---|---|
| | number | % | number | % | number | % | |
| Zinc | | | | | | | |
| 65-74 years: ≥7 mg, 75 years+: ≥6 mg | 9 | 7.5 | 7 | 13.0 | 2 | 3.0 | 0.766 |
| Copper | | | | | | | |
| ≥0.6 mg | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | - |
| Iodine | | | | | | | |
| ≥95 μg | 22 | 18.3 | 11 | 20.4 | 11 | 16.7 | 0.642 |
| Selenium | | | | | | | |
| ≥20 μg | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | - |
| Molybdenum | | | | | | | |
| ≥20 μg | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | - |
| Nutrient with DG ¶ | | | | | | | |
| Protein | | | | | | | |
| 15-20 % of energy | 52 | 43.3 | 27 | 50.0 | 25 | 37.9 | 0.199 |
| Fat | | | | | | | |
| 20-30 % of energy | 46 | 38.3 | 22 | 40.7 | 24 | 36.4 | 0.706 |
| Saturated fatty acids | | | | | | | |
| ≤7 % of energy | 98 | 81.7 | 47 | 87.0 | 51 | 77.3 | 0.236 |
| Carbohydrates | | | | | | | |
| 50-65 % of energy | 40 | 33.3 | 17 | 31.5 | 23 | 34.8 | 0.845 |
| Dietary fiber | | | | | | | |
| ≥17.0 g | 90 | 75.0 | 42 | 77.8 | 48 | 72.7 | 0.672 |
| Salt equivalent | | | | | | | |
| <6.5 g | 108 | 90.0 | 50 | 92.6 | 58 | 87.9 | 0.543 |
| Potassium | | | | | | | |
| ≥2,600 mg | 105 | 87.5 | 48 | 88.9 | 57 | 86.4 | 0.785 |

J-CHS: Japanese version of the Cardiovascular Health Study[17]; EAR: estimated average requirement; BW: Body weight; RAE: retinol activity equivalent; NE: niacin equivalents; DG: tentative dietary goals for preventing lifestyle-related diseases (LRDs).
†Frailty score (0–5) was defined as Shrinking (1 point), Low activity (1 point), Exhaustion (1 point), Weakness (1 point) and Slowness (1 point). A score of 1 or 2 indicated prefrailty.
‡Dietary Reference Intakes (units/d), 2020 for Japanese females aged 65-74 and 75+years old[1].
§The EAR is the average daily nutrient intake level required in a population, calculated on the basis of the distribution of the measured requirements in a study population. To prevent inadequate intake, EAR was determined[1].
¶The DGs required for the prevention of LRDs were set as the current goals for Japanese individuals to reach the average daily intake of nutrients, and, thereby, prevent LRDs[1].
††Fisher's exact test.

(6.0–9.0) in prefrailty and 6.0 (5.0–7.0) in nonfrailty; a significant difference was observed ($p$=0.002) (data not shown).

The main food groups that contributed to vitamin C intake were vegetables (56.5%), fruits (25.1%), and potatoes (11.7%). Mg intake was in order of cereals (28.2%), vegetables (21.2%), soy products (15.9%), fish and shellfish (7.8%), and dairy products (7.1%) (data not shown).

***Factors associated with physical prefrailty***

Table 5 shows the results of binary logistic regression analysis. In model 1, which used the simultaneous method, vitamin C intake below EAR (OR, 6.74; 95% CI, 1.36–33.18, $p$=0.019), and Mg intake below EAR (OR, 2.97; 95% CI, 1.02–8.62, $p$=0.044) were significant factors associated with physical prefrailty. Finally, in model 2, which used the forward-selection method, vitamin C intake below EAR (OR, 7.12; 95% CI, 1.47–34.41, $p$=0.014) was identified as a significant factor associated with physical prefrailty.

Vitamin D intake (Table 2), which was significantly observed between the two groups in terms of nutrient intake, cannot confirm the prevalence of inadequacy nutrient intake because the reference value is set to AI.

## DISCUSSION

This cross-sectional study of community-dwelling Japanese healthy elderly women (n=120, age 65–79 years) at the elders college, factors significantly related to physical prefrailty was vitamin C indicating inadequate nutrient intake below EAR. Ours study investigated physical function, exercise time, nutrient intake, intake by food group, then estimated prevalence of inadequate nutrient intake using DRIs, 2020[1] EAR and DG values, and clarified the characteristics of physical prefrailty and identified associations with physical prefrailty.

Physical prefrailty was confirmed in 45.0% of the study participants. Using set standards in participants attending a community college in Japan (n=620, age 60–89 years), Fried et al.[4] reported that 46.6% of women were prefrailty,[28] which was a similar result to that of our study. A review that identified five large-scale community-based studies conducted in Japan (n=11,940, age 65–96 years) found prevalence of 48.1% and 7.5% for prefrailty and frailty, respectively.[29]

Investigation of the characteristics of prefrailty participants revealed that approximately half could be classified as “low activity” according to the J-CHS diagnostic criteria. Although the median gait speed exceeded the J-CHS diagnostic criteria cutoff value, it was 1.16 m/s, which was significantly lower than that of the nonfrailty participants. Moreover, 22.2% of the prefrailty participants exhibited two deficits according to the J-CHS diagnostic criteria (Table 1).

In our study, the OR for vitamin C intake that was below the EAR set in DRIs, 2020[1] of 80 mg/day was 7.12. Vitamin C intake was significantly lower in the prefrailty than the nonfrailty groups (Table 2). The percentage of participants with vitamin C intake that was below the EAR was significantly high at 22.2% (Table 4). The reference values given in the Dietary Reference vary with each country, so it is not possible to easily compare these values with those of other countries. Borg et al. suggested that the borderline for insufficient trace nutrients was 20% to 30%.[15] The percentage of elderly community-dwelling women in Europe and America with vitamin C intake below the EAR (50 mg/day) was 23%,[15] while that of elderly women with inadequate nutritional intake (EAR, 50 mg/day), when analyzed based on nutritional data in the European Nutrition and Health Report II, was 4.4% to 24.5%.[14] In our study, we ultimately found that physical prefrailty and Mg intake volume was not correlated with inadequate nutritional intake below EAR. A report on the prevalence of inadequate nutritional intake below EAR among elderly Japanese individuals aged 65 years or older who lived alone found that the prevalence of women with vitamin C intake below EAR was 4.2%, whereas that of Mg intake below EAR was 17.2%.[16] Thus, both results were lower than that in the present study. Borg et al. reported that the prevalence of Mg intake below EAR (265 mg/day) was 41% among women.[15]

Vitamin C is an essential trace nutrient that has various

**Table 5.** Result of logistic regression for factors associated with physical prefrailty‡

| Variables and indicator | Model 1† Simultaneous method | | Model 2† Forward-selection method | |
|---|---|---|---|---|
| | OR (95% CI) | *p*-value | OR (95% CI) | *p*-value |
| Vitamin C (mg/day) § | | | | |
| ≥RDA: 100 mg/day | 1.00 Reference | | 1.00 Reference | |
| 80 - 100 mg/day | 1.06 (0.84-1.89) | 0.220 | - | - |
| <EAR: 80 mg/day | 6.74 (1.36-33.18) | 0.019 | 7.12 (1.47-34.41) | 0.014 |
| Magnesium (mg/day) § | | | | |
| ≥RDA: 280 mg/day or 260 mg/day¶ | 1.00 Reference | | 1.00 Reference | |
| 230 - 280 mg/day or 220 - 260 mg/day | 2.03 (0.81-5.07) | 0.128 | - | - |
| <EAR: 230 mg/day or 220 mg/day¶ | 2.97 (1.02-8.62) | 0.044 | 2.94 (0.94-8.55) | 0.069 |

J-CHS: Japanese version of the Cardiovascular Health Study[17]; OR: odds ratio; CI: confidence interval; RDA: recommended dietary allowance; EAR: estimated average requirement.
Values are ORs (95%CIs).
†All models were adjusted for energy intake (as continuous).
‡Frailty score (0–5) was defined as Shrinking (1 point), Low activity (1 point), Exhaustion (1 point), Weakness (1 point) and Slowness (1 point). A score of 1 or 2 indicated prefrailty.
§Vitamin C and magnesium intakes categorization were based on the Dietary Reference Intakes (DRIs) for Japanese, 2020[1].
¶Magnesium intake categorization of 280 mg/day (65-74 years old) or 260 mg/day (75+ years old) was based on the DRIs for Japanese, 2020 RDA value, 230 mg/day (65-74 years old) or 220 g/day (75+ years old) was based on the DRIs for Japanese, 2020 EAR value[1].

roles, including immune adjustment, it needs to be regularly and appropriately ingested as only small amounts of the water-soluble vitamin can be stored within the body.[30] Most elderly individuals experience inflammation and most patients confirmed to be frailty exhibit chronic inflammation.[31] Oxidative stress can have an important role in the onset of frailty,[32] making antioxidant vitamins, such as vitamins A, C, and E, essential trace nutrients for preventing frailty. A trace nutrient deficiency could be a major factor increasing women's risk of frailty.[33] Moreover, aging-associated difficulties related to selecting food products and decreased functions could result in reduced intake of fresh foods, such as fruit and vegetables, resulting in significantly insufficient intake of vitamin C.[34]

Tamaki et al. reported that the only diet-related factor correlated with the frailty state of elderly Japanese women diagnosed according to the J-CHS criteria (frail, prefrail, and robust) was vitamin C intake,[35] which was consistent with our results.

In our study, protein intake was not identified as a factor in physical prefrailty. In previous studies, high protein intake (≥1.1 g/kg/day) was associated with a lower risk of frailty development after 3 years in community-dwelling older women.[36] Another study reported that total protein (≥1.28 g/kg/day) and animal protein intake were inversely associated with frailty and its components (slowness) after a mean of 3.5 years.[37] Moreover, the distribution of protein intake in the main meals (breakfast, lunch, dinner) was associated with a higher gait speed, an important measure of survival in the elderly.[38] Our results showed that the prefrailty group had a median protein intake of 1.29 g/kg/day and an animal protein ratio of 52.4%, and no participant had levels below the EAR (40 g). It was speculated that protein intake was sufficient and was not an associated factor. However, in the newly revised DRIs, 2020,[1] the lower limit of protein DG (15–20% of energy) has been increased. The inadequate proportions were 50.0% for prefrailty and 37.9% for nonfrailty, which was a worrying condition.

Several limitations of our study must be mentioned. First, this was a cross-sectional study. Although we were able to prove significant associations between physical prefrailty and inadequate vitamin C intake below the EAR, the relationships of cause and effect remain unclear. Second, the small sample size reduced estimation precision, which limited statistical power to detect significant associations. As the insertion of adjustment variables into the binary logistic regression analysis had to be limited, residual confounding may have occurred. Third, the participants were students at the elders training college, and were not recruited randomly from the community. Because the participants were targeted at healthy elderly women, this may have resulted in underestimation of the actual prevalence of prefrailty. Accordingly, it is not completely clear whether the results obtained from the sample can be generalized for other community-dwelling populations. Fourth, while we evaluated insufficient nutrient intake using DRIs (units/day) because the number of individuals within a group who intake below the EAR of certain nutrients can be approximated as appropriate,[24] another more precise method of evaluation might exist. Finally, we were unable to obtain detailed responses regarding smoking status, chronic comorbidities, and physician-prescribed medication. The possibility of these factors affecting prefrailty cannot be ignored. Accordingly, these issues must be considered carefully when interpreting all results of our study.

In conclusion, we demonstrated that physical prefrailty in community-dwelling elderly women is characterized with inadequate vitamin C intake below the EAR. This result suggested that those involved in the elderly should consider the need for interventions that combined diet to avoid prefrailty development in community-dwelling elderly. In addition to measuring physical function, dietary surveys and evaluation of nutritional adequacy by DRIs are expected to be useful for early prevention of physical prefrailty. Additional prospective studies with a larger sample size are needed to confirm whether this factor is a modifiable factor in physical prefrailty.

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**AUTHOR DISCLOSURES**

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## Supplementary Tables

**Supplementary table 1.** Physical activity level of Japanese elderly women classified according to frailty criteria† of J-CHS

| Physical activity level‡ | All (n=120) | Prefrailty† (n=54, 45.0%) | Nonfrailty (n= 66, 55.0%) | *p*-value§ |
|---|---|---|---|---|
| Low (I), n (%) | 46 (38.3) | 29 (53.7) | 17 (25.8) | 0.014 |
| Medium (II), n (%) | 62 (51.7) | 22 (40.7) | 40 (60.6) | |
| High (III), n (%) | 12 (10.0) | 3 ( 5.6) | 9 (13.6) | |

J-CHS: Japanese version of the Cardiovascular Health Study[17]
Values are numbers of subjects (%).
†Frailty score (0–5) was defined as Shrinking (1 point), Low activity (1 point), Exhaustion (1 point), Weakness (1 point) and Slowness (1 point). A score of 1 or 2 indicated prefrailty.
‡Categorization is according to the Dietary Reference Intakes for Japanese, 2020[1].
§Chi-square test.

**Supplementary table 2.** Comparison of nutrients intake and nutritional ratio in prefrailty† and nonfraitly women classified according to frailty criteria† of J-CHS

| Variables | All (n=120) | Prefrailty† (n=54) | Nonfrailty (n=66) | *p*-value§ |
|---|---|---|---|---|
| | Median (IQR) | Median (IQR) | Median (IQR) | |
| Energy, kcal | 1798 (1576-1939) | 1767 (1567-1928) | 1800 (1604-1974) | 0.387 |
| Energy intake/BW, kcal/kg | 33.8 (29.2-37.9) | 32.1 (29.1-38.0) | 34.0 (29.6-36.9) | 0.405 |
| Protein‡, g | 69.4 (64.1-73.2) | 67.3 (60.7-74.2) | 70.5 (65.5-72.9) | 0.075 |
| Protein‡/BW, g/kg | 1.28 (1.18-1.41) | 1.29 (1.16-1.39) | 1.28 (1.19-1.50) | 0.337 |
| Fat‡, g | 56.4 (50.3-60.6) | 59.1 (49.2-60.5) | 56.0 (50.6-62.0) | 0.548 |
| Monounsaturated fatty acids‡, g | 21.45 (18.42-26.05) | 22.69 (19.43-27.49) | 19.93 (17.16-24.40) | 0.089 |
| n-6 poly-unsaturated fatty acids‡, g | 9.93 (8.95-11.43) | 10.03 (9.54-11.62) | 9.72 (7.83-11.40) | 0.316 |
| n-3 poly-unsaturated fatty acids‡, g | 2.53 (2.09-2.97) | 2.45 (2.09-2.75) | 2.69 (2.09-3.22) | 0.065 |
| Cholesterol‡, mg | 308 (260-374) | 342 (259-387) | 300 (266-370) | 0.370 |
| Dietary fiber‡, g | 15.4 (13.5-16.8) | 14.9 (13.5-16.6) | 15.8 (13.4-17.0) | 0.268 |
| Soluble dietary fiber‡, g | 3.8 (3.4-4.7) | 3.8 (3.3-4.4) | 3.7 (3.4-5.5) | 0.858 |
| Insoluble dietary fiber‡, g | 11.6 (9.9-12.5) | 11.4 (9.5-12.2) | 11.9 (10.0-13.3) | 0.148 |
| Pantothenic acid‡, mg | 5.72 (5.14-6.28) | 5.64 (4.99-6.14) | 5.85 (5.24-6.32) | 0.276 |
| Biotin‡, µg | 33.9 (28.1-37.9) | 34.1 (27.4-40.9) | 33.1 (28.4-36.8) | 0.473 |
| Phosphorus‡, mg | 1145 (1045-1265) | 1168 (1011-1269) | 1129 (1045-1258) | 0.833 |
| Manganese‡, mg | 3.42 (3.14-3.79) | 3.51 (3.23-3.72) | 3.41 (3.10-3.90) | 0.657 |
| Chromium‡, µg | 8 (7-10) | 8 (6-10) | 8 (7-9) | 0.751 |
| Cereal‡ energy ratio, % energy | 36.0 (32.1-43.7) | 35.0 (30.9-43.2) | 37.0 (32.5-44.6) | 0.399 |
| Alcohol‡ energy ratio, % energy | 0.4 (0.0-1.9) | 0.0 (0.0-2.2) | 0.6 (0.0-1.8) | 0.776 |

J-CHS: Japanese version of the Cardiovascular Health Study[17]; IQR: interquartile range; BW: Body weight.
Values are medians and interquartile ranges are 25th percentile-75th percentile.
†Frailty score (0–5) was defined as Shrinking (1 point), Low activity (1 point), Exhaustion (1 point), Weakness (1 point) and Slowness (1 point). A score of 1 or 2 indicated prefrailty.
‡Nutrient intakes were energy-adjusted according to the residual method [23].
§Mann-Whitney U test.