Food group intakes and all-cause mortality among a young older Japanese population of the same age: the New Integrated Suburban Seniority Investigation Project

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ABSTRACT

Evaluating the effects of dietary intake on mortality in older populations has become increasingly important in modern aging societies. The objective of the present study was to investigate the associations between food group intakes and all-cause mortality among a young older population. We conducted a prospective study on 1,324 men and 1,338 women aged 64–65 years at baseline who were living in a suburban city from 1996 to 2005. The participants were followed for all-cause mortality from 1996 through 2015 to assess the effects of 17 food group intakes (g) per 1,000 kcal after multivariable adjustments in proportional hazard models. During follow-up (mean: 13.2 years), 339 deaths were registered. In women, total mortality was significantly and inversely associated with the consumption of milk and dairy products and vegetables. The hazard ratios across intake quartiles after multivariable adjustment were 1, 0.70 (95% confidence interval: 0.42–1.17), 0.66 (0.40–1.10), and 0.40 (0.22–0.75) (P for trend = 0.003) for milk and dairy products, and 1, 0.77 (0.46–1.28), 0.83 (0.50–1.38), and 0.42 (0.23–0.78) (P for trend = 0.008) for vegetables. In men, a positive association was found between total mortality and sugar and sweetener consumption (P for trend = 0.038). Higher consumption of milk and dairy products and vegetables was suggested to reduce all-cause mortality in young older women.

Keywords: food group intakes, young older people, mortality, milk and dairy products, vegetables

Abbreviations:
FFQ: food frequency questionnaire
HR: hazard ratio
CI: confidence interval.

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INTRODUCTION

Japan has been a leading country in terms of higher life expectancy for the past few decades. Among several factors that contribute to longevity, diet plays an important role for the prevention of diseases associated with mortality. Considering the rapid advancement and future needs of the aging society, evaluating the effects of dietary intake on mortality in older populations with a higher life expectancy has become increasingly important.

In general populations, although consuming higher amounts of fruits and vegetables has been found to be effective for reducing mortality, the influence of protein-rich foods such as meat or fish has been inconsistent among populations. In older populations in Western countries, adhering to a Mediterranean-like dietary pattern (i.e., higher intakes of fruits, vegetables, legumes, cereals, potatoes, and fish, accompanied by lower intakes of meat and dairy products) or the World Health Organization guidelines (e.g., including higher dietary fiber, vegetables, and fruit intakes) has been found to partially reduce mortality, which suggests consuming a variety of foods with not only sufficient vitamin and mineral, but also protein and energy intake, might contribute to longevity. In older populations in Asian countries, inverse associations between mortality and fish, fruit, and vegetable intakes have only been reported in a few studies; therefore, existing evidence remains limited.

Meanwhile, it may be helpful to assess young older populations who change their lifestyle, including their dietary habits, after retirement. Additionally, from the statistical point of view, confounding by age has been a common limitation of previous research. Because age is one of the strongest determinants for the incidence of disease, even after adjustment, residual confounding may remain. Therefore, it could be valuable to assess the influence of diet in young older populations with longer life expectancies without confounding by age.

The aim of the present study was to evaluate the association between food group intakes and all-cause mortality among a young older Japanese population of almost the same age.

METHODS

Study population

The participants of the present study were subjects in the New Integrated Suburban Seniority Investigation Project, an age-specific research project involving residents in Nisshin city, located in central Japan. Community-dwelling older people aged 64–65 years were invited by letter to undergo a free comprehensive medical health checkup and complete a questionnaire survey each year from 1996 to 2005. Among 3,073 potential participants, we excluded those with no dietary (n = 112) or health examination data (n = 4) at baseline, as well as those with no sufficient follow-up data (n = 2). We additionally excluded those with a history of cancer (n = 110), stroke (n = 124), or ischemic heart disease (n = 40) at baseline, as well as those whose estimated total energy intake was outside the sex-specific mean ± 3 standard deviations (n = 19). Finally, 2,662 subjects (1,324 men and 1,338 women) remained for the final analyses.

This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving the study participants were approved by the Ethics Committees of Nagoya University Graduate School of Medicine, the National Center for Geriatrics and Gerontology of Japan, Aichi Medical University School of Medicine, and Hokkaido University Graduate School of Medicine. Informed consent for participating in the study, including the follow-up, was obtained from all participants. An opt-out approach was applied from 1996 to 2001. The health checkup examinees who declined to participate in the study were recorded and excluded.
from the survey. From 2002 to 2005, written consent was obtained using an opt-in approach.

**Lifestyle measurements**

Lifestyle information was obtained using a self-administered questionnaire. Height and weight measurements were included in the health checkups. Body mass index was calculated using the following formula: body weight (kg) / (height [m])^2. Blood chemistry was performed after overnight fasting.

A food frequency questionnaire (FFQ) including 97 modern Japanese foods and dishes was used to evaluate the intakes of 17 food groups (rice, bread, noodles, sugars and sweeteners, confectionaries, fats and oils, nuts and seeds, pulses, fish and shellfish, meats, eggs, milk and dairy products, vegetables, green-yellow vegetables, other vegetables, fruits, and mushrooms), energy, saturated fatty acid, polyunsaturated fatty acid, and dietary fiber at baseline. The consumption of each food group was estimated based on the frequency of food items using an incremental scale (< once/month, once/month, 2–3 times/month, once/week, 2–4 times/week, 5–6 times/week, once/day, 2–3 times/day, ≥ 4 times/day). Portion sizes were fixed for all foods except rice. The FFQ has been validated for food group and nutrient intakes. The de-attenuated Pearson correlation coefficients adjusted for energy intake and age between the daily consumption of food groups based on the FFQs and that from dietary records for rice, bread, noodles, sugars and sweeteners, confectionaries, fats and oils, nuts and seeds, pulses, fish and shellfish, meats, eggs, milk and dairy products, vegetables, green-yellow vegetables, other vegetables, fruits, and mushrooms were 0.54, 0.71, 0.59, 0.13, 0.34, 0.49, 0.47, 0.54, 0.16, 0.36, 0.49, 0.75, 0.31, 0.39, 0.12, 0.67 and 0.28, respectively, for men, and 0.65, 0.35, 0.11, 0.27, 0.37, 0.57, 0.22, 0.66, 0.33, 0.61, 0.42, 0.69, 0.52, 0.57, 0.42, 0.66 and 0.48, respectively, for women.

**Follow-up and primary end point**

The primary end point was death from any cause during the follow-up period (1996–2015). We used the city’s resident register to identify participant deaths.

**Statistical analysis**

All analyses were performed separately in men and women. The participants’ baseline characteristics were compared between survivors and those who had died. Categorical and continuous data were statistically analyzed using the chi-squared test and Student’s t-test, respectively.

Food group intakes were included in the analysis as consumption per 1,000 kcal. Cox regression models were used to assess the associations between food group intake quartiles at baseline and mortality during follow-up. Those who moved out of Nisshin city during the follow-up period were treated as censored cases.

Hazard ratios (HRs) and 95% confidence intervals (CIs) were estimated using the lowest consumption group as a reference. In the Cox regression analysis, adjustments were made for total energy intake (continuous variable), survey year (1996–1999, 2000–2002, 2003–2005), body mass index (< 18.5, 18.5–24.9, ≥ 25.0 kg/m^2), smoking status (current/former and never), drinking status (current/almost none), walking time (< 30, 30–59, 60–119, ≥ 120 min/day), sleeping time (< 7.0, 7.0–7.9, ≥ 8.0 h/day), education level (high school graduate or above, yes/no), employment status (employment, yes/no), use of vitamin supplements (yes/no), hypertension (systolic blood pressure ≥ 140 mmHg, diastolic blood pressure ≥ 90 mmHg, and/or antihypertensive drug use, yes/no), and diabetes mellitus (fasting blood glucose ≥ 126 mg/dL, glycated hemoglobin levels ≥ 6.5%, and/or antidiabetic drug use, yes/no) were additionally adjusted as covariates. We considered the survey year because it took 10 years to recruit all the participants. P for trend was estimated using the median of each quartile for food group intake in the Cox regression model. Further
adjustments were made for saturated fatty acid and polyunsaturated fatty acid intakes because they may partially affect mortality (data not shown). For sensitivity analyses, we repeated the analysis after excluding the participants who had died within 3 years from baseline.

All statistical tests were two-sided, and $P < 0.05$ was considered statistically significant. All statistical analyses were conducted using STATA software (ver. 15; Stata Corp., College Station, TX, USA).

RESULTS

During follow-up (mean: 13.2 years), 339 participants (233 men and 106 women) died and 225 (109 men and 116 women) moved out of Nisshin city.

The participants’ background characteristics according to survival status are shown in Table 1. Body mass index was significantly different between the surviving and deceased men. Educational attainment was significantly higher, and the proportion of current smokers, prevalence of diabetes, and energy intake were significantly lower in surviving than in deceased men ($P < 0.05$ for all). Sleeping time was significantly shorter in surviving than in deceased women.

The associations observed between food group intakes and all-cause mortality in men and women are summarized in Tables 2 and 3, respectively. In men, a significant positive association was found between all-cause mortality and the intake of sugars and sweeteners after multivariable adjustment ($P$ for trend = 0.038); however, the HR for each intake quartile was not significant. Meanwhile, in women, inverse associations were found between all-cause mortality and the intakes of milk and dairy products and vegetables. The HRs across intake quartiles after multivariable adjustment were 1, 0.70 (95% CI: 0.42–1.17), 0.66 (0.40–1.10), and 0.40 (0.22–0.75) ($P$ for trend = 0.003) for milk and dairy products, and 1, 0.77 (0.46–1.28), 0.83 (0.50–1.38), and 0.42 (0.23–0.78) ($P$ for trend = 0.008) for vegetables. These associations remained after additional adjustments for saturated fatty acid and polyunsaturated fatty acid intakes. Although an inverse association with green-yellow vegetable intake was observed in women ($P$ for trend = 0.029), none of the HRs across intake quartiles were significant. Although the highest quartile of other vegetable intake was significantly associated with reduced mortality, the $P$ for trend was not significant ($P$ for trend = 0.052). However, the intakes of both green-yellow and other vegetables were significantly associated with reduced all-cause mortality after additional adjustments for saturated fatty acid and polyunsaturated fatty acid intakes. The HRs across intake quartiles were 1, 1.04 (95% CI: 0.63–1.71), 0.82 (0.48–1.43), and 0.50 (0.27–0.92) ($P$ for trend = 0.014) for green-yellow vegetables, and 1, 1.02 (0.60–1.73), 1.19 (0.70–2.04), and 0.44 (0.23–0.83) ($P$ for trend = 0.015) for other vegetables. Furthermore, after excluding the participants who had died within 3 years from baseline, the strong associations with milk and dairy products and vegetable intakes in women remained. Inverse associations were also found between all-cause mortality and mushroom intake. The HRs across intake quartiles after multivariable adjustment were 1, 0.94 (95% CI: 0.57–1.55), 0.75 (0.44–1.27), and 0.48 (0.26–0.90) ($P$ for trend = 0.015). However, after excluding the participants who had died within 3 years from baseline, the association with mushroom intake in women was partially attenuated.
## Table 1  Background characteristics of the participants at baseline by survival status

|                    | Men (n = 1,324) |                     | Women (n = 1,338) |                     |
|--------------------|-----------------|---------------------|-------------------|---------------------|
|                    | Survived (n = 1,091) | Died (n = 233) | Survived (n = 1,232) | Died (n = 106) |
| Year of participation | Mean or % | SD | Mean or % | SD | Mean or % | SD | Mean or % | SD | P* |
| 1996–1999          | 30.8 | 47.6 | <0.001 | 36.9 | 53.8 | <0.001 |
| 2000–2002          | 34.2 | 40.3 |          | 30.8 | 30.2 |          |
| 2003–2005          | 35.0 | 12.0 |          | 32.3 | 16.0 |          |
| Body mass index (kg/m²) |          |          |          |          |          |          |
| <18.5              | 3.6 | 8.2 | 0.008 | 5.0 | 5.7 | 0.787 |
| 18.5–24.9          | 72.1 | 68.2 |          | 75.5 | 77.4 |          |
| ≥25.0              | 24.3 | 23.6 |          | 19.6 | 17.0 |          |
| Current drinker    | 69.3 | 72.1 | 0.397 | 18.9 | 23.6 | 0.242 |
| Current smoker     | 29.2 | 48.9 | <0.001 | 3.4 | 5.7 | 0.232 |
| Diabetes mellitus ‡ | 11.5 | 19.7 | 0.001 | 6.4 | 10.4 | 0.118 |
| Hypertension §      | 49.6 | 54.1 | 0.213 | 38.6 | 44.3 | 0.248 |
| Sleeping time (h/day) |          |          |          |          |          |          |
| <7.0               | 33.9 | 28.3 | 0.191 | 44.5 | 36.8 | 0.037 |
| 7.0–7.9            | 38.1 | 39.1 |          | 38.0 | 35.9 |          |
| ≥8.0               | 28.0 | 32.6 |          | 17.5 | 27.4 |          |
| Walking time (min/day) |          |          |          |          |          |          |
| <30                | 16.5 | 22.8 | 0.079 | 8.3 | 5.7 | 0.685 |
| 30–59              | 34.0 | 35.2 |          | 24.4 | 27.4 |          |
| 60–119             | 25.9 | 23.2 |          | 28.8 | 26.4 |          |
| ≥120               | 23.7 | 18.9 |          | 38.6 | 40.6 |          |
| Education (high school graduate or above) | 73.3 | 61.8 | <0.001 | 65.7 | 56.6 | 0.061 |
| Employment status (employee) | 47.9 | 43.8 | 0.248 | 18.0 | 14.2 | 0.317 |
| Vitamin supplement use | 12.8 | 11.6 | 0.604 | 20.7 | 21.7 | 0.808 |
| Daily dietary intake |          |          |          |          |          |          |
| Energy (kcal)      | 1,891 | 574 | 1,988 | 698 | 0.024† | 1,921 | 612 | 1,935 | 636 | 0.824† |
| Saturated fatty acid (g) | 13.6 | 6.0 | 14.4 | 7.1 | 0.067† | 16.2 | 6.9 | 16.4 | 7.7 | 0.752† |
| Polyunsaturated fatty acid (g) | 12.9 | 5.4 | 13.6 | 6.5 | 0.099† | 14.7 | 6.1 | 15.5 | 7.0 | 0.177† |

* Chi-squared test.
† Student’s t-test.
‡ Diabetes mellitus was defined as the use of antidiabetic medicine, fasting blood glucose ≥ 126 mg/dL, or glycated hemoglobin levels (National Glycohemoglobin Standardization Program) ≥ 6.5%.
§ Hypertension was defined as the use of antihypertensive drugs, systolic blood pressure ≥ 140 mmHg, or diastolic blood pressure ≥ 90 mmHg.
| Food Group | Intake quartiles (g/1,000 kcal) | Q1 | Q2 | Q3 | Q4 | P for trend |
|------------|-------------------------------|----|----|----|----|-------------|
| Rice       |                               | 128|190 |252 |346 |             |
| Death/total number |                  |54/277|60/271|49/282|70/261|             |
| Energy-adjusted HR (95% CI) |              |1 (reference)|1.02 (0.71–1.48)|0.81 (0.55–1.19)|1.17 (0.82–1.67)|0.484 |
| Multivariable-adjusted HR (95% CI) |             |1 (reference)|1.01 (0.70–1.47)|0.71 (0.48–1.06)|1.01 (0.70–1.46)|0.827 |
| Multivariable-adjusted HR (95% CI) |             |1 (reference)|1.11 (0.75–1.64)|0.75 (0.50–1.15)|1.02 (0.69–1.51)|0.765 |
| Bread      |                               |0.0 |3.0 |14.4|26.4|             |
| Death/total number |                  |74/257|51/280|57/274|51/280|             |
| Energy-adjusted HR (95% CI) |              |1 (reference)|0.73 (0.51–1.05)|0.77 (0.55–1.10)|0.79 (0.55–1.14)|0.365 |
| Multivariable-adjusted HR (95% CI) |             |1 (reference)|0.93 (0.65–1.35)|0.93 (0.65–1.34)|0.96 (0.65–1.40)|0.859 |
| Multivariable-adjusted HR (95% CI) |             |1 (reference)|0.98 (0.67–1.44)|1.03 (0.70–1.50)|0.92 (0.62–1.37)|0.747 |
| Noodles    |                               |14.3|31.1|58.5|101.0|             |
| Death/total number |                  |52/279|61/270|66/265|54/277|             |
| Energy-adjusted HR (95% CI) |              |1 (reference)|1.20 (0.83–1.73)|1.20 (0.83–1.74)|0.97 (0.66–1.42)|0.651 |
| Multivariable-adjusted HR (95% CI) |             |1 (reference)|1.24 (0.85–1.81)|1.20 (0.83–1.75)|0.95 (0.64–1.39)|0.489 |
| Multivariable-adjusted HR (95% CI) |             |1 (reference)|1.23 (0.83–1.81)|1.22 (0.83–1.81)|0.92 (0.61–1.38)|0.445 |
| Sugars and sweeteners (g/1,000 kcal) |      |1.0 |1.5 |2.1 |3.3 |             |
| Death/total number |                  |52/279|50/281|66/265|65/266|             |
| Energy-adjusted HR (95% CI) |              |1 (reference)|0.92 (0.62–1.36)|1.25 (0.87–1.80)|1.28 (0.89–1.84)|0.079 |
| Multivariable-adjusted HR (95% CI) |             |1 (reference)|0.97 (0.66–1.45)|1.35 (0.93–1.95)|1.38 (0.95–2.00)|0.038 |
| Multivariable-adjusted HR (95% CI) |             |1 (reference)|1.01 (0.66–1.53)|1.46 (0.99–2.14)|1.36 (0.91–2.03)|0.063 |
| Confectioner (g/1,000 kcal) |            |0.8 |3.1 |5.7 |13.6|             |
| Death/total number |                  |73/258|52/279|53/278|55/276|             |
| Energy-adjusted HR (95% CI) |              |1 (reference)|0.69 (0.48–0.98)|0.69 (0.49–0.99)|0.71 (0.50–1.01)|0.178 |
| Multivariable-adjusted HR (95% CI) |             |1 (reference)|0.73 (0.51–1.04)|0.86 (0.59–1.24)|0.88 (0.61–1.27)|0.857 |
| Multivariable-adjusted HR (95% CI) |             |1 (reference)|0.67 (0.46–0.98)|0.84 (0.58–1.24)|0.83 (0.56–1.22)|0.682 |
| Fats and oils (g/1,000 kcal) |          |2.5 |4.3 |6.2 |8.8 |             |
| Death/total number |                  |53/278|58/273|61/270|61/270|             |
| Energy-adjusted HR (95% CI) |              |1 (reference)|1.11 (0.76–1.61)|1.13 (0.78–1.64)|1.18 (0.81–1.70)|0.406 |
| Multivariable-adjusted HR (95% CI) |             |1 (reference)|1.10 (0.76–1.61)|1.15 (0.79–1.69)|1.21 (0.83–1.77)|0.321 |
| Multivariable-adjusted HR (95% CI) |             |1 (reference)|1.21 (0.81–1.80)|1.30 (0.87–1.94)|1.28 (0.86–1.92)|0.237 |
| Nuts and seeds (g/1,000 kcal) |              |0.1 |0.5 |0.9 |2.9 |             |
| Death/total number |                  |70/261|53/278|60/271|50/281|             |
| Energy-adjusted HR (95% CI) |              |1 (reference)|0.68 (0.48–0.98)|0.83 (0.59–1.18)|0.63 (0.44–0.91)|0.054 |
| Multivariable-adjusted HR (95% CI) |             |1 (reference)|0.63 (0.44–0.91)|0.94 (0.67–1.34)|0.70 (0.48–1.01)|0.230 |
| Multivariable-adjusted HR (95% CI) |             |1 (reference)|0.62 (0.42–0.91)|0.95 (0.66–1.37)|0.70 (0.47–1.03)|0.272 |
| Pulses     |                               |17.8|28.8|40.2|60.3|             |
| Death/total number |                  |67/264|56/275|48/283|62/269|             |
| Energy-adjusted HR (95% CI) |              |1 (reference)|0.80 (0.56–1.15)|0.73 (0.50–1.06)|0.94 (0.66–1.32)|0.812 |
| Multivariable-adjusted HR (95% CI) |             |1 (reference)|0.73 (0.51–1.05)|0.73 (0.50–1.05)|0.93 (0.65–1.32)|0.898 |
| Multivariable-adjusted HR (95% CI) |             |1 (reference)|0.73 (0.50–1.06)|0.78 (0.53–1.15)|0.95 (0.66–1.38)|0.915 |
| Fish and shellfish (g/1,000 kcal) |         |16.7|26.4|37.8|61.4|             |
| Death/total number |                  |56/275|46/285|61/270|70/261|             |
| Energy-adjusted HR (95% CI) |              |1 (reference)|0.83 (0.56–1.22)|1.06 (0.74–1.53)|1.21 (0.85–1.73)|0.113 |
| Multivariable-adjusted HR (95% CI) |             |1 (reference)|0.78 (0.53–1.16)|1.01 (0.70–1.46)|1.13 (0.79–1.62)|0.191 |
| Multivariable-adjusted HR (95% CI) |             |1 (reference)|0.79 (0.52–1.20)|1.12 (0.76–1.64)|1.14 (0.78–1.67)|0.216 |
## Food intake & mortality in younger old

| Food Group                  | Median Intake (g/1,000 kcal) | Deaths/Total Number | Energy-Adjusted HR (95% CI) | Multivariable-Adjusted HR (95% CI) |
|----------------------------|------------------------------|---------------------|-----------------------------|-----------------------------------|
| **Meats**                  |                              |                     |                             |                                   |
|                           | 10.4                         | 52/279              | 0.97 (0.66–1.42)            | 0.98 (0.67–1.44)                  |
|                           | 18.9                         | 53/278              | 1.16 (0.80–1.68)            | 1.13 (0.77–1.64)                  |
|                           | 26.2                         | 61/270              | 1.22 (0.84–1.76)            | 1.09 (0.75–1.59)                  |
|                           | 38.1                         | 67/264              | 0.196                       | 0.539                             |
| **Eggs**                   |                              |                     |                             |                                   |
|                           | 3.6                          | 55/269              | 1 (reference)              | 1 (reference)                     |
|                           | 10.2                         | 59/272              | 0.96 (0.66–1.39)            | 0.94 (0.65–1.37)                  |
|                           | 19.2                         | 66/265              | 1.07 (0.74–1.55)            | 1.10 (0.76–1.61)                  |
|                           | 32.7                         | 53/278              | 0.89 (0.61–1.30)            | 0.92 (0.63–1.34)                  |
| **Milk and dairy products**|                              |                     |                             |                                   |
|                           | 5.6                          | 71/260              | 1 (reference)              | 1 (reference)                     |
|                           | 48.2                         | 49/282              | 0.65 (0.45–0.94)            | 0.73 (0.50–1.06)                  |
|                           | 98.7                         | 59/272              | 0.78 (0.55–1.10)            | 0.85 (0.60–1.22)                  |
|                           | 160.9                        | 54/277              | 0.77 (0.54–1.10)            | 0.98 (0.67–1.42)                  |
| **Vegetables**             |                              |                     |                             |                                   |
|                           | 52.5                         | 53/278              | 1 (reference)              | 1 (reference)                     |
|                           | 85.7                         | 61/270              | 1.12 (0.77–1.62)            | 1.27 (0.88–1.85)                  |
|                           | 119.6                        | 59/272              | 1.05 (0.72–1.52)            | 1.08 (0.74–1.58)                  |
|                           | 177.9                        | 60/271              | 1.19 (0.82–1.72)            | 1.34 (0.92–1.95)                  |
| **Green-yellow vegetables**|                              |                     |                             |                                   |
|                           | 15.1                         | 61/270              | 1 (reference)              | 1 (reference)                     |
|                           | 31.2                         | 55/276              | 0.86 (0.60–1.25)            | 1.03 (0.71–1.49)                  |
|                           | 50.9                         | 59/272              | 0.98 (0.68–1.40)            | 1.12 (0.78–1.61)                  |
|                           | 103.1                        | 58/273              | 0.99 (0.69–1.42)            | 1.15 (0.80–1.65)                  |
| **Other vegetables**       |                              |                     |                             |                                   |
|                           | 31.1                         | 54/277              | 1 (reference)              | 1 (reference)                     |
|                           | 46.6                         | 58/273              | 1.04 (0.72–1.51)            | 1.06 (0.73–1.55)                  |
|                           | 62.4                         | 55/276              | 0.98 (0.67–1.43)            | 1.02 (0.70–1.50)                  |
|                           | 90.1                         | 66/265              | 1.20 (0.80–1.65)            | 1.18 (0.82–1.70)                  |
| **Fruits**                 |                              |                     |                             |                                   |
|                           | 21.0                         | 66/265              | 1 (reference)              | 1 (reference)                     |
|                           | 46.6                         | 61/270              | 0.89 (0.63–1.27)            | 1.01 (0.71–1.45)                  |
|                           | 62.4                         | 54/277              | 0.81 (0.56–1.16)            | 1.03 (0.71–1.45)                  |
|                           | 90.6                         | 52/279              | 0.83 (0.57–1.19)            | 1.12 (0.76–1.65)                  |
| **Mushrooms**              |                              |                     |                             |                                   |
|                           | 1.1                          | 60/271              | 1 (reference)              | 1 (reference)                     |
|                           | 2.3                          | 61/270              | 0.89 (0.63–1.27)            | 0.97 (0.66–1.41)                  |
|                           | 5.3                          | 58/273              | 0.81 (0.56–1.16)            | 1.05 (0.71–1.56)                  |
|                           | 9.4                          | 54/277              | 1.20 (0.84–1.72)            | 1.11 (0.74–1.66)                  |

HR, hazard ratio; CI, confidence interval.

* Median intakes by quartile of consumption for each food group (g/1,000 kcal).

† Adjusted for energy intake, survey year, body mass index, smoking status, drinking status, walking time, sleeping time, education levels, employment status, vitamin supplement use, hypertension, and diabetes mellitus.

‡ Excluding participants who died within 3 years from baseline (n = 23).
Table 3  Hazard ratios for all-cause mortality according to food group intake quartiles (/1,000 kcal) among women (n = 1,338)

| Intake quartiles | Q1 | Q2 | Q3 | Q4 | P for trend |
|------------------|----|----|----|----|-------------|
| Rice (g/1,000 kcal) | 110 | 165 | 219 | 301 |             |
| Deaths/total number | 27/308 | 22/312 | 25/310 | 32/302 |             |
| Energy-adjusted HR (95% CI) | 1 (reference) | 0.75 (0.42–1.31) | 0.81 (0.47–1.39) | 0.99 (0.59–1.66) | 0.838 |
| Multivariable-adjusted HR (95% CI) | 1 (reference) | 0.74 (0.42–1.31) | 0.77 (0.44–1.33) | 0.95 (0.56–1.62) | 0.977 |
| Multivariable-adjusted HR (95% CI) | 1 (reference) | 0.76 (0.40–1.43) | 0.91 (0.51–1.64) | 1.12 (0.63–2.00) | 0.490 |
| Bread (g/1,000 kcal) | 0.8 | 4.5 | 17.4 | 26.6 |             |
| Deaths/total number | 25/311 | 26/308 | 31/304 | 24/310 |             |
| Energy-adjusted HR (95% CI) | 1 (reference) | 1.11 (0.64–1.92) | 1.35 (0.79–2.29) | 1.04 (0.59–1.84) | 0.692 |
| Multivariable-adjusted HR (95% CI) | 1 (reference) | 1.17 (0.67–2.05) | 1.42 (0.83–2.44) | 1.06 (0.60–1.89) | 0.650 |
| Multivariable-adjusted HR (95% CI) | 1 (reference) | 1.18 (0.65–2.14) | 1.30 (0.73–2.33) | 1.16 (0.63–2.13) | 0.591 |
| Noodles (g/1,000 kcal) | 1.3 | 1.9 | 2.5 | 3.5 |             |
| Deaths/total number | 24/311 | 25/309 | 22/311 | 35/299 |             |
| Energy-adjusted HR (95% CI) | 1 (reference) | 1.02 (0.58–1.80) | 0.90 (0.50–1.60) | 1.52 (0.90–2.55) | 0.100 |
| Multivariable-adjusted HR (95% CI) | 1 (reference) | 1.05 (0.59–1.85) | 0.98 (0.54–1.76) | 1.60 (0.95–2.72) | 0.064 |
| Multivariable-adjusted HR (95% CI) | 1 (reference) | 0.98 (0.53–1.80) | 0.94 (0.50–1.77) | 1.64 (0.94–2.87) | 0.053 |
| Sugars and sweeteners (g/1,000 kcal) | 2.3 | 5.6 | 11.4 | 20.9 |             |
| Deaths/total number | 31/304 | 29/305 | 20/315 | 26/308 |             |
| Energy-adjusted HR (95% CI) | 1 (reference) | 1.01 (0.61–1.68) | 0.63 (0.36–1.11) | 0.87 (0.52–1.47) | 0.429 |
| Multivariable-adjusted HR (95% CI) | 1 (reference) | 1.06 (0.63–1.77) | 0.68 (0.38–1.21) | 0.98 (0.57–1.67) | 0.720 |
| Multivariable-adjusted HR (95% CI) | 1 (reference) | 1.06 (0.62–1.83) | 0.68 (0.37–1.26) | 0.91 (0.51–1.62) | 0.544 |
| Fats and oils (g/1,000 kcal) | 2.7 | 4.6 | 6.4 | 8.9 |             |
| Deaths/total number | 19/316 | 22/312 | 34/301 | 31/303 |             |
| Energy-adjusted HR (95% CI) | 1 (reference) | 1.10 (0.59–2.04) | 1.75 (0.99–3.09) | 1.58 (0.89–2.80) | 0.059 |
| Multivariable-adjusted HR (95% CI) | 1 (reference) | 1.11 (0.60–2.06) | 1.80 (1.01–3.20) | 1.52 (0.85–2.71) | 0.082 |
| Multivariable-adjusted HR (95% CI) | 1 (reference) | 1.28 (0.65–2.52) | 2.14 (1.14–4.02) | 1.65 (0.87–3.13) | 0.076 |
| Nuts and seeds (g/1,000 kcal) | 0.2 | 0.6 | 1.1 | 3.2 |             |
| Deaths/total number | 27/308 | 23/311 | 27/308 | 29/305 |             |
| Energy-adjusted HR (95% CI) | 1 (reference) | 0.82 (0.47–1.44) | 0.96 (0.56–1.64) | 1.11 (0.65–1.89) | 0.444 |
| Multivariable-adjusted HR (95% CI) | 1 (reference) | 0.81 (0.46–1.42) | 1.00 (0.58–1.72) | 1.21 (0.71–2.08) | 0.259 |
| Multivariable-adjusted HR (95% CI) | 1 (reference) | 0.76 (0.42–1.38) | 0.89 (0.50–1.58) | 1.06 (0.59–1.89) | 0.540 |
| Pulses (g/1,000 kcal) | 22.4 | 34.9 | 47.7 | 72.4 |             |
| Deaths/total number | 21/314 | 37/297 | 21/314 | 27/307 |             |
| Energy-adjusted HR (95% CI) | 1 (reference) | 1.79 (1.05–3.06) | 1.05 (0.57–1.92) | 1.39 (0.79–2.46) | 0.690 |
| Multivariable-adjusted HR (95% CI) | 1 (reference) | 1.83 (1.07–3.14) | 1.07 (0.58–1.98) | 1.37 (0.77–2.43) | 0.750 |
| Multivariable-adjusted HR (95% CI) | 1 (reference) | 1.64 (0.93–2.88) | 0.82 (0.42–1.59) | 1.43 (0.80–2.59) | 0.569 |
| Fish and shellfish (g/1,000 kcal) | 21.0 | 32.7 | 45.6 | 69.4 |             |
| Deaths/total number | 30/305 | 22/312 | 33/302 | 21/313 |             |
| Energy-adjusted HR (95% CI) | 1 (reference) | 0.70 (0.40–1.21) | 1.07 (0.65–1.78) | 0.69 (0.39–1.22) | 0.394 |
| Multivariable-adjusted HR (95% CI) | 1 (reference) | 0.69 (0.39–1.21) | 1.06 (0.63–1.76) | 0.66 (0.37–1.17) | 0.313 |
| Multivariable-adjusted HR (95% CI) | 1 (reference) | 0.67 (0.36–1.23) | 1.17 (0.68–2.02) | 0.70 (0.38–1.30) | 0.525 |
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| Food Group                        | Q1 (g/1,000 kcal) | Q2 (g/1,000 kcal) | Q3 (g/1,000 kcal) | Q4 (g/1,000 kcal) | Energy-adjusted HR (95% CI) | Multivariable-adjusted HR (95% CI) | Multivariable-adjusted HR (95% CI) |
|----------------------------------|-------------------|-------------------|-------------------|-------------------|----------------------------|------------------------------------|------------------------------------|
| Meats                            | 12.5              | 22.2              | 31.4              | 46.4              | 1 (reference) 0.97 (0.54–1.74) | 1 (reference) 0.97 (0.54–1.74)    | 1 (reference) 0.96 (0.50–1.82)    |
| Deaths/total number              | 23/312            | 23/311            | 26/309            | 34/300            | 1 (reference) 1.06 (0.60–1.87) | 1.08 (0.61–1.92)                  | 1.19 (0.65–2.21)                   |
| Energi-adjusted HR (95% CI)      | 1 (reference)     | 0.97 (0.54–1.74)  | 1.06 (0.60–1.87)  | 1.40 (0.81–2.42)  | 0.168                      | 0.97 (0.54–1.74)                  | 1.06 (0.60–1.87)                   |
| Multivariable-adjusted HR (95% CI) | 1 (reference) 1.06 (0.60–1.87) | 1.16 (0.65–2.21)  | 1.54 (0.84–2.80)  | 0.095                      | 0.96 (0.50–1.82)                  | 1.19 (0.65–2.21)                   | 1.54 (0.84–2.80)                   |
| Eggs                             | 3.9               | 12.2              | 19.8              | 31.8              | 1 (reference) 0.97 (0.54–1.74) | 1.08 (0.61–1.92)                  | 1.42 (0.82–2.49)                   |
| Deaths/total number              | 32/303            | 27/307            | 18/317            | 29/305            | 1 (reference) 0.97 (0.54–1.74) | 1.06 (0.60–1.87)                  | 1.42 (0.82–2.49)                   |
| Milk and dairy products           | 20.4              | 83.5              | 129.4             | 195.1             | 1 (reference) 0.97 (0.54–1.74) | 1.06 (0.60–1.87)                  | 1.42 (0.82–2.49)                   |
| Deaths/total number              | 39/296            | 26/308            | 26/309            | 15/319            | 1 (reference) 0.97 (0.54–1.74) | 1.06 (0.60–1.87)                  | 1.42 (0.82–2.49)                   |
| Vegetables                       | 79.4              | 116.3             | 150.1             | 215.3             | 1 (reference) 0.97 (0.54–1.74) | 1.06 (0.60–1.87)                  | 1.42 (0.82–2.49)                   |
| Deaths/total number              | 35/500            | 27/307            | 29/306            | 15/319            | 1 (reference) 0.97 (0.54–1.74) | 1.06 (0.60–1.87)                  | 1.42 (0.82–2.49)                   |
| Green-yellow vegetables           | 27.7              | 47.8              | 71.9              | 123.8             | 1 (reference) 0.97 (0.54–1.74) | 1.06 (0.60–1.87)                  | 1.42 (0.82–2.49)                   |
| Deaths/total number              | 32/303            | 33/301            | 25/310            | 16/318            | 1 (reference) 0.97 (0.54–1.74) | 1.06 (0.60–1.87)                  | 1.42 (0.82–2.49)                   |
| Other vegetables                  | 40.3              | 59.1              | 76.8              | 104.5             | 1 (reference) 1.07 (0.66–1.74) | 1.29 (0.77–2.16)                  | 0.52 (0.27–0.97)                   |
| Deaths/total number              | 26/309            | 31/303            | 34/301            | 15/319            | 1 (reference) 1.12 (0.67–1.89) | 1.29 (0.77–2.16)                  | 0.52 (0.27–0.97)                   |
| Fruits                            | 54.3              | 100.7             | 144.8             | 213.6             | 1 (reference) 1.33 (0.80–2.20) | 0.97 (0.56–1.69)                  | 0.88 (0.49–1.57)                   |
| Deaths/total number              | 26/309            | 35/299            | 24/311            | 21/313            | 1 (reference) 1.44 (0.86–2.42) | 1.03 (0.58–1.82)                  | 0.92 (0.51–1.67)                   |
| Mushrooms                         | 2.0               | 5.5               | 8.4               | 13.2              | 1 (reference) 1.46 (0.85–2.50) | 0.82 (0.44–1.53)                  | 0.83 (0.44–1.56)                   |
| Deaths/total number              | 35/300            | 31/303            | 25/310            | 15/319            | 1 (reference) 1.07 (0.62–1.83) | 0.78 (0.44–1.38)                  | 0.56 (0.29–1.07)                   |

HR, hazard ratio; CI, confidence interval.

* Median intakes by quartile of consumption for each food group (g/1,000 kcal).

† Adjusted for energy intake, survey year, body mass index, smoking status, drinking status, walking time, sleeping time, education levels, employment status, vitamin supplement use, hypertension, and diabetes mellitus.

‡ Excluding participants who died within 3 years from baseline (n = 13).
DISCUSSION

In this age-specific and prospective cohort study in a Japanese young older population, inverse associations were observed between all-cause mortality and the intakes of milk and dairy products and vegetables in women, while a positive association was found between all-cause mortality and sugar and sweetener consumption in men.

Although the association between mortality and the consumption of milk and dairy products remains controversial, meta-analyses have reported inverse associations between these foods and mortality, especially cardiovascular disease mortality.\textsuperscript{20,21} In Asian populations, the consumption of milk and dairy products has been shown to decrease cardiovascular disease mortality.\textsuperscript{22,23} Dietary calcium from dairy products has also been associated with a reduction in stroke mortality in Japan.\textsuperscript{24} However, in older populations, the association between mortality and the consumption of milk and dairy products has been inconsistent, showing different effects depending on the type of dairy product.\textsuperscript{25,26} Few studies have evaluated the association between mortality and the consumption of milk and dairy products in older Asian populations. The nutrient composition of milk and dairy products, which includes not only calcium, but also protein and vitamin D, can have favorable effects on human health.\textsuperscript{27} High-quality protein, such as milk protein, has also been found to improve health in older individuals.\textsuperscript{28} Our findings are therefore consistent with those from previous studies in the Asian general population. The consumption of different types of milk and dairy products across populations might be the reason for the inconsistencies observed in previous research in Western countries.\textsuperscript{29}

Increasing fruit and vegetable consumption has been recommended for the prevention of chronic diseases, including cancer and cardiovascular diseases, which are the leading causes of death worldwide.\textsuperscript{30,31} This rationale is supported by the biologically favorable effects of a large number of antioxidant nutrients in these food groups, such as vitamins, carotene, and fiber. A recent meta-analysis found that higher fruit and vegetable consumption was associated with a reduction in all-cause mortality, particularly cardiovascular mortality.\textsuperscript{2} Likewise, in older populations, significant associations between lower all-cause or cardiovascular disease mortality and higher vegetable consumption and dietary patterns with a relatively high intake of fruit and vegetables have been reported.\textsuperscript{8,9,32} Additionally, in older women, an inverse association between mortality and the total serum concentrations of carotenoids has been noted.\textsuperscript{33} Vegetables are among the principal dietary sources of carotenoids. Other groups of vegetables, such as cruciferous vegetables, have also been investigated in regard to cancer prevention.\textsuperscript{34} In the present study, higher consumption of total vegetables was associated with lower all-cause mortality in young older women, which is consistent with previous studies. Total vegetable consumption in those aged ≥ 60 years tends to be higher than that in younger generations in Japan.\textsuperscript{15} Our findings suggest that increased vegetable consumption remains one of the most important dietary factors for longevity, and that recommending sufficient vegetable intake remains valid in young older populations.

Meanwhile, in the present study, fruit intake was not associated with mortality reduction in either men or women. Although some previous studies have found inverse correlations between mortality and higher fruit intake, the results of this study do not support these findings.\textsuperscript{36,37} Although fruit contains micronutrients that might promote longevity, such as $\beta$-cryptoxanthin, the characteristics of the compositions of each type of fruit are diverse.\textsuperscript{38} In addition, the association between mortality and fruit intake might be influenced by the main subtypes of fruit intake in different populations.\textsuperscript{39}

We also observed a significant inverse association between all-cause mortality and mushroom intake in women; however, this association was partially attenuated after excluding the participants who had died within 3 years from baseline. Higher mushroom intake has been suggested to provide
protective effects against cardiovascular diseases and certain types of cancer.\cite{40,41} One review mentioned that the relevant nutritional aspects of mushrooms, such as dietary fiber and potassium, as well as bioactive compounds, may exert positive effects on metabolic markers such as blood lipid concentration and blood pressure. As an example of a plausible mechanism, soluble fiber may help inhibit cholesterol and triglyceride absorption. Eritadenine in *Lentinula edodes* (shiitake) also seems to contribute hypcholesterolemic action by modifying hepatic phospholipid metabolism. Additionally, antitumor effects of polysaccharides in mushrooms have also been reported.\cite{42} Although their biological effectiveness against specific cancers is not clear, polysaccharides may have the ability to induce apoptosis and other forms of cancer cell death through immunological mechanisms. Because evaluations in large cohort studies remain limited, further studies are needed to clarify the effectiveness of higher mushroom intake for reducing mortality.

In the present study, no inverse associations were found between mortality and any food group in men. One possible reason for this might be that the intakes of food groups related to mortality reduction were lower in men than in women. In addition, factors other than diet, such as smoking or diabetes, might have affected mortality more strongly than dietary intake in men. Meanwhile, a significant positive association was observed between mortality and the consumption of sugars and sweeteners only in men; however, this trend was attenuated in the analysis after excluding the participants who had died within 3 years from baseline. A previous study reported a positive association between mortality, especially cardiovascular mortality, and the consumption of added sugars.\cite{43} However, in the present study, the validity of daily sugar and sweetener consumption as estimated by the FFQ was extremely low (Pearson correlation coefficient adjusted for energy and age in men = 0.13).\cite{17,18} Furthermore, the current estimation of sugar and sweetener intake did not include sweetened beverages. Therefore, the validity of the association between mortality and sugar and sweetener intake is lower in the present compared with previous studies.

In the multivariable adjustment analysis, we included employment status as a confounder. In 2018, the employment rate among Japanese aged 65–69 years was 57.2% for men and 36.6% for women.\cite{44} Although the number of working people aged 65–69 years has been gradually increasing, many employment patterns have changed, e.g., from a full- to a part-time job. Therefore, an evaluation at 65 years of age may be worthwhile as the starting point of a new lifestyle. However, because the employment patterns of young older adults may become more diverse over time, these could be important confounders when assessing mortality risk or health status.

The strength of this study is that all participants were almost the same age at baseline, which excluded confounding by age. However, some limitations should be noted. First, we obtained information on dietary intake only at baseline; thus, changes in dietary habits during follow-up could not be considered. Second, due to the limitations of the FFQ, detailed groups of dairy products, fruits, and vegetables (e.g., nonfat dairy products, cruciferous or *Allium* vegetables, citrus fruits) could not be specified. Finally, cause-specific mortality could not be assessed in the present study because of the small number of deaths. Additional studies in larger populations with longer follow-up periods are needed to clarify further the associations between the intake of different food groups and specific causes of death in young older people.

**CONCLUSION**

In conclusion, the present study revealed inverse associations between all-cause mortality and the consumption of milk and dairy products and vegetables in a cohort of young older Japanese women.
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CONFLICT OF INTEREST

The authors declare no competing financial interests.

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