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Original article

The associations of dietary patterns with all-cause mortality and other lifestyle factors in the elderly: An age-specific prospective cohort study

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SUMMARY

Background & aims: The association between dietary pattern and mortality has been well studied in the general population; however, few studies have focused on the elderly. We aimed to examine the association of dietary pattern with subsequent overall mortality in elderly Japanese, and demonstrate the modifiable effect of lifestyle factors on this association.
Methods: Totally 2949 Japanese community-dwelling residents aged 64 or 65 years were included in the NISSIN Project in 1996–2005. A validated food frequency questionnaire was adopted to collect dietary information and factor analysis was used to extract dietary patterns. Unadjusted and adjusted hazard ratios (HRs) with 95% confidence intervals (CIs) were calculated through the Cox proportional hazard regression model.
Results: Over 31,233 person-years, 253 persons died. Three different dietary patterns were identified: meat-fat, healthy, and dairy-bread pattern. Increased risk for all-cause mortality for meat-fat pattern was observed among those who never smoked (HR, 2.81; 95% CI, 1.37–5.79); this association for dairy-bread pattern was observed among the never smokers (HR, 2.21; 95% CI, 1.20–4.06) and occasional drinkers (HR, 1.62; 95% CI, 1.09–2.39). For healthy pattern, decreased overall mortality risk was observed among never smokers (HR, 0.44; 95% CI, 0.24–0.80), occasional drinkers (HR, 0.63; 95% CI, 0.42–0.93), and those who walked ≥1 h/day (HR, 0.47; 95% CI, 0.28–0.77).
Conclusions: We found that tobacco use, alcohol consumption, and daily walking duration could modify the associations of three patterns with overall mortality. Healthy eating along with other healthy lifestyle factor among elderly populations can decrease the overall mortality risk.
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1. Introduction

Average life expectancy is increasing worldwide. It is expected that approximately 22% of the global population will be at least 60 years of age by 2050 [1], and approximately 40% of the Japanese population will be at least 65 years of age by 2060 [2]. Around 49% of the global disease burden is still caused by age-related noncommunicable diseases (NCD) in the population aged 60 years or more in high-income countries [3].

Ageing is complex process driven by a variety of molecular damaging processes [4]. Nutrition plays an imperative role in modulating these damage processes [5]. Increasing evidence has highlighted the critical effects of long-term dietary consumption on the delayed onset of age-related diseases [6]. In addition to the role of diet and/or nutrition, the analysis of dietary patterns has become of paramount interest to researchers worldwide as it is a method to avoid a series of limitations caused by studying the effect of nutrients and foods alone [7]. They have been derived

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using *a priori* approaches in which dietary indices are created according to the present healthy diet knowledge from recommendations or guidelines, and *a posteriori* approaches in which statistical models (i.e. factor analysis or cluster analysis) are applied to combine common underlying components of eating habits [7]. The latter approach is more applicable because it reflects actual eating habits and accounts for the multicollinearity of nutrients and food [8]. Using the above methods, the association of overall mortality with dietary patterns in adults have been well established [9]. Due to the psychological, social, and physiological difference between young adults and older adults, it is possible for dietary behavior to change based on age category [10], therefore applying results from general population to the old population might cause some errors.

Several studies on the elderly population have been done to report the impact of dietary patterns (such as index-based patterns [11–13], and empirically data-derived dietary patterns [14–20]) on mortality. However, the majority of such studies were conducted in Western countries, particularly in Europe; only one study published in 1999 came from Japan [21]. With expanding life expectancies, socioeconomic factors and lifestyles might have changed greatly during the past decades. Considering that dietary behaviors might be correlated to other lifestyle factors, the current study aimed to test the association between dietary patterns and all-cause mortality, and explore the interaction of dietary patterns with lifestyle factors in the Japanese elderly.

2. Methods

2.1. Study population

The New Integrated Suburban Seniority Investigation (NISSIN) Project, an on-going age-specific prospective cohort study, was established in 1996. The details of this cohort have been described elsewhere [22]. From 1996 through 2005, the community-dwelling residents aged 64 or 65 at the beginning of June were recruited from a city of central Japan to attend a free comprehensive health examination and complete a baseline survey, including a self-administrated food frequency questionnaire (FFQ). A totally 3073 participants (n = 1548, 50.4% men, overall response rate 43.9%) registered for enrollment into the NISSIN Project. Of all the eligible participants, those who moved out of the city before the follow-up was started (n = 2), those who did not report information of dietary consumption (n = 112), or those who had implausible energy intake (<500 kcal or >5000 kcal daily, n = 10) were excluded from this study. Thus, in total 2949 participants (n = 1486, 50.4% men) were enrolled into the study. The Ethics Committees of Hokkaido University Graduate School of Medicine, the Ethics Committees of the National Centre for Geriatrics and Gerontology in Japan, the Ethics Committees of Nagoya University Graduate School of Medicine, and the Ethics Committees of Aichi Medical University School of Medicine approved this study. Oral informed consent was gained through an opt-out approach from 1996 to 2001; thereafter, written informed consent was obtained using an opt-in approach.

2.2. Dietary consumption assessment

Dietary consumption was evaluated by a validated FFQ at baseline [23]. The FFQ included 90-modern Japanese food items. The participants were asked to report the average intake frequency of each food regarding to the standard portion sizes in the year prior to the survey as well as the usual portion size of rice consumed [24]. For each food item, the average daily intake amount was calculated in grams by multiplying the intake frequency by the given portion size. Then the 90 items were classified into 20 food groups in the light of the similarity of food, including rice, bread, noodles, other cereals, potatoes, sugar, confectionery, oils and fats, nuts, beans, seafood, meat, eggs, dairy product, fruits, mushrooms, algae, green/yellow vegetables, other vegetables, and seasoning.

2.3. Covariate variables

Socio-demographic factors were collected by self-administered questionnaires, including marital status (married, other, or unknown), work status (not working, working, or unknown), education (lower than high school, high school or above, or unknown) and living arrangement (alone or with others). Lifestyle factors included alcohol consumption (never or current), tobacco use (never, ever, or current), daily walking time (<1 h/day, ≥1 h/day, or unknown), sleep duration, and social participation. The current drinkers were further asked to report the frequency and the type of beverages consumed (Japanese sake, beer, whiskey, Japanese spirits, wine, and others), and the average consumption amount each time (the unit was *gou*, with 1 *gou* equivalent to 23 g). The average daily consumption amount was estimated by the formula: average daily consumption amount = (average consumption amount at a time × frequency of alcohol consumption × 23 g)/7 days; alcohol consumption was grouped into two categories, occasional drinkers (never drinkers or alcohol consumption <23 g/day), and heavy drinkers (alcohol consumption ≥23 g/day) [25]. The ever smokers and current smokers were further asked for the daily number of cigarettes and periods they smoked. Then smoking status was grouped into never smokers, smokers (<20 pack-year) and heavy smokers (>=20 pack-year) based on Brinkman index. Sleep duration was recorded as a continuous variable measured in hours and minutes per day. It was converted into a categorical variable based on the median range of values (<7, =7, and >7 h/day). The evaluation of social participation investigated 20 items for social, educational, and individual activities; each item had three options, not participating, occasionally participating, and regularly participating; each response was assigned score 1, 2, or 3, respectively [26]. Social participation was grouped into two categories according to the gender-specific medians of the total scores (participating, or not). Functional capacity was assessed through the validated questionnaire of the Tokyo Metropolitan Institute of Gerontology Index of Competence (TMIG) with a total scores ranging from 0 to 13; a higher score indicated a greater functional capacity [27,28]. Depressive tendency was evaluated using the short-form Geriatric Depression Scale (GDS), which has been validated among the Japanese elderly; a total score of at least 6 was considered as significant depressive tendency [29]. Medical status involved hypertension, hyperlipidemia and diabetes mellitus (DM). Hypertension was defined as a measured systolic blood pressure ≥140 mmHg, diastolic blood pressure ≥90 mmHg, self-reported hypertension, or/and antihypertensive medication use. Hyperlipidemia was defined as a total cholesterol level ≥220 mg/dL, self-reported hyperlipidemia and/or hyperlipidemia medication use. Diabetes mellitus was defined as hemoglobin A1c (HbA1c) ≥6.5%, fasting plasma glucose ≥126 mg/dL, self-reported DM, and/or antidiabetic medication use. The results of HbA1c in our study was transformed into National Glycohemoglobin Standardization Program (NGSP) values based on the conversion formula: NGSP (%) = (1.02 × JDS (%)) + 0.25% [30] because the level of HbA1c was measured based on the Japanese Diabetes Society criteria. Self-reported history of diseases involved clinically diagnosed heart diseases, cerebrovascular diseases and cancer. Weight and height were measured to calculated body mass index (BMI, kg/m^2). Daily energy intake was calculated based on daily food intake and Japanese food composition table [23].

2.4. Outcomes

Each participant was followed annually until dying from any cause, moving out of the city, or the end of their 75th year of age, whichever occurred first. The death dates and moving out of the city were confirmed through the resident registry by the public health nurse of the city health center.

2.5. Statistical analysis

Dietary patterns were extracted through the *a posteriori* approach for exploratory factor analysis. Bartlett's Test of Sphericity ($P < 0.001$) and the Kaiser-Meyer-Olkin measure of sampling adequacy (MSA = 0.89) were tested to examine the strength of relationships among the food groups in order to determine whether factor analysis was appropriate. Eigenvalues (>1.5), the total variance, the scree plot, the size of residuals, and interpretability of factors were used to determine the number of factors for analysis. Orthogonal (varimax) transformation was applied to simplify the structure and interpret the results. Foods with rotated factor loadings >0.45 were considered the dominant contributors to dietary patterns; the patterns were labeled according to the interpretation of the factors included in that category.

The baseline characteristics of participants were summarized by gender-specific tertile for each dietary pattern. Hazard ratios (HRs) and 95% confidence intervals (CIs) for dietary patterns were calculated through Cox proportional hazard regression model. The proportional hazard assumption was examined by the Schoenfeld residuals test. Wald statistics were calculated to determine the Cochran-Armitage trend by entering the dietary pattern tertiles into the models as continuous variables. We tested the interaction between gender, lifestyle factors and dietary patterns against mortality. If there were interactions, the corresponding subgroup analyses were conducted.

SAS statistical software package version 9.4 for Microsoft Windows (SAS Institute Inc., Cary, NC, USA) was used for calculation. All *P*-values were based on two-tailed tests of significance; $P < 0.05$ was taken as statistically significance. STATA Statistical Software, version 14.0 (Stata Corp, College Station, Tax) was used to plot the figures.

3. Results

Overall, 187 (12.6%) men and 66 (4.5%) women died over the study period of 31,233 person-years. Three dietary patterns were discerned (Table 1). The first factor with greater factor loadings of oils and fats, other cereals, meat, seasoning, potatoes, sugar and noodles was labeled as the meat and fat (meat-fat) pattern, explaining 31.2% of total variance. The second factor, which was characterized by vegetables, fruits, mushrooms, algae, seafood, beans, and seasoning was labeled as the healthy pattern, explaining 9.4% of total variance. The third factor, which had high factor loadings of dairy products and bread, and a low intake of rice, was labeled as the dairy and bread (dairy-bread) pattern, explaining about 7.6% of total variance.

Compared with those among the lowest tertile of the meat-fat pattern, those among the higher tertile were most likely to sleep more and had a higher level of functional capacity and energy intake; those in the higher tertile of the healthy pattern were most likely to participate in social activities and have a higher functional capacity and energy intake; those in the higher tertile of the dairy-bread pattern were unlikely to have a job, smoke and drink heavily and sleep >7 h/day, and most likely to have higher functional capacity and low energy intake, and participate in social activities (Table 2).

The participants among the highest tertile of meat-fat or healthy pattern all had a higher intake of protein, fat, carbohydrates, fiber, saturated, monounsaturated and polyunsaturated fat, basic vitamins, and minerals compared with those among the lowest tertile. For the dairy-bread pattern, the intake of minerals, vitamin A, vitamin C, saturated fat and cholesterol among the highest tertile tended to be higher than that among other tertile while the intake of carbohydrates and vitamin D was lower (Please see Supplementary Table S1).

Table 3 displays the associations between dietary patterns and overall mortality. The various Cox models fulfilled the proportional

Table 1
Rotated factor loadings for each dietary pattern.

	Meat-fat pattern	Healthy pattern	Dairy-bread pattern
Rice	0.22		**−0.58**
Bread	0.29	−0.19	**0.71**
Noodles	**0.46**		
Other cereals	**0.84**	0.12	
Potatoes	**0.53**	0.45	
Sugar	**0.65**	0.31	0.26
Confectionery	0.26	0.29	0.34
Oils and fats	**0.85**	0.10	0.12
Nuts	0.11	0.44	0.15
Beans	0.25	**0.57**	−0.18
Seafood	0.45	**0.50**	−0.13
Meat	**0.78**	0.20	−0.10
Eggs	0.41	0.12	0.21
Dairy product		0.31	**0.48**
Fruits		**0.65**	0.35
Mushrooms		**0.68**	
Algae		**0.67**	
Seasoning	**0.70**	**0.46**	
Green/Yellow vegetables	0.15	**0.64**	0.14
Other vegetables	0.40	**0.69**	−0.14
Variance explained VAR (%)	31.15	9.37	7.57
Cumulative explained VAR (%)	31.15	40.53	48.09

Factor analysis was performed based on 20 food groups. With orthogonal rotation, the factor loading scores are identified to the correlation coefficient; The magnitude of each loading indicates the importance of the corresponding in terms to the factor; Loadings >0.45 were indicated in bold typeface, other loadings of magnitude ≥0.10 are shown in non-bold typeface, and lower loadings were suppressed for clarity.

Table 2
The baseline characteristics of participants by tertiles of each dietary pattern.

	Meat – fat pattern			Healthy pattern			Dairy – bread pattern		
	T1	T2	T3	T1	T2	T3	T1	T2	T3
Female	487 (49.6)	488 (49.6)	488 (49.5)	488 (49.6)	486 (49.6)	489 (49.6)	488 (49.7)	487 (49.5)	488 (49.6)
Married	870 (88.7)	867 (88.2)	886 (90.0)	832 (84.6)	881 (89.9)	910 (92.3)	870 (88.6)	865 (88.0)	888 (90.2)
Working	429 (43.7)	385 (39.2)	398 (40.4)	416 (42.3)	411 (41.9)	385 (39.1)	446 (45.4)	418 (42.5)	348 (35.4)
Education≥ HS	656 (66.9)	678 (69.0)	685 (69.5)	633 (64.4)	665 (67.9)	721 (73.1)	564 (57.4)	679 (69.1)	776 (78.9)
Never smokers	551 (56.2)	545 (55.4)	533 (54.1)	509 (51.8)	538 (54.9)	582 (59.0)	510 (51.9)	541 (55.0)	578 (58.7)
Smokers	144 (14.7)	156 (15.9)	139 (14.1)	151 (15.4)	145 (14.8)	143 (14.5)	145 (14.8)	144 (14.6)	150 (15.2)
Heavy smokers	278 (28.3)	271 (27.6)	310 (31.5)	317 (32.2)	291 (29.7)	251 (25.4)	318 (32.4)	291 (29.6)	250 (25.4)
Heavy drinkers (≥23 g/day)	204 (20.8)	197 (20.0)	195 (19.5)	201 (20.4)	202 (20.6)	193 (19.6)	247 (25.2)	201 (20.4)	148 (15.0)
Walking ≥1 h s/d	552 (56.3)	571 (58.1)	549 (55.7)	541 (55.0)	541 (55.2)	590 (59.8)	554 (56.4)	554 (56.4)	564 (57.3)
Living along	62 (6.3)	54 (5.5)	45 (4.6)	76 (7.7)	37 (3.8)	48 (4.9)	42 (4.3)	57 (5.8)	62 (6.3)
Sleep time <7 h/d	415 (42.3)	363 (36.9)	346 (35.1)	355 (36.1)	375 (38.3)	394 (40.0)	352 (35.9)	378 (38.5)	394 (40.0)
Sleep time = 7 h/d	293 (29.9)	309 (31.4)	304 (30.9)	318 (32.4)	294 (30.0)	294 (29.8)	291 (29.6)	307 (31.2)	308 (31.3)
Sleep time >7 h/d	272 (27.7)	310 (31.5)	335 (34.0)	309 (31.4)	310 (31.6)	298 (30.2)	339 (34.5)	296 (30.1)	282 (28.7)
GDS ≥6	207 (21.1)	223 (22.7)	213 (21.6)	261 (26.6)	186 (19.0)	196 (19.9)	237 (24.1)	206 (21.0)	209 (20.3)
TMIG ≤10	62 (6.3)	54 (5.5)	36 (3.7)	54 (5.5)	62 (6.3)	36 (3.7)	61 (6.2)	57 (5.8)	34 (3.6)
Social Participation	451 (46.0)	475 (48.3)	495 (50.3)	416 (42.3)	475 (48.5)	530 (53.8)	425 (43.3)	487 (49.5)	509 (51.7)
Heart disease (Yes)	116 (11.8)	116 (11.8)	86 (8.7)	97 (9.9)	101 (10.3)	120 (12.2)	105 (10.7)	104 (10.6)	109 (11.1)
CVD (Yes)	36 (3.7)	51 (5.2)	43 (4.4)	32 (3.3)	55 (5.6)	43 (4.4)	41 (4.2)	46 (4.7)	43 (4.4)
Cancer (Yes)	38 (3.9)	40 (4.1)	33 (3.4)	27 (2.8)	40 (4.1)	44 (4.5)	33 (3.4)	41 (4.2)	37 (3.8)
Hypertension (Yes)	456 (46.5)	475 (48.3)	427 (43.4)	457 (46.5)	452 (46.1)	449 (45.5)	469 (47.8)	451 (45.9)	438 (44.5)
Hyperlipidemia (Yes)	469 (47.8)	476 (48.4)	465 (47.2)	464 (47.2)	484 (49.4)	462 (46.9)	448 (45.6)	458 (46.6)	504 (51.2)
Diabetes mellitus (Yes)	135 (13.8)	110 (11.2)	99 (10.1)	102 (10.4)	113 (11.5)	129 (13.1)	118 (12.0)	120 (12.2)	106 (10.8)
BMI (kg/m^2)	23.0 ± 2.8	23.1 ± 2.7	23.0 ± 2.9	23.2 ± 2.9	23.0 ± 2.8	22.9 ± 2.7	23.1 ± 2.8	23.1 ± 2.9	22.9 ± 2.7
DEI (kcal)	1484 ± 380	1809 ± 400	2427 ± 602	1649 ± 527	1838 ± 515	2234 ± 635	2014 ± 675	1834 ± 587	1874 ± 554

CVD: Cerebrovascular disease; HS: high school; GDS: geriatric depression scale; TMIG: Tokyo Metropolitan Institute of Gerontology Index of Competence; BMI, body mass index; DEI: Daily energy intake; hrs/d: hours/day. Smokers: <20 pack-year; heavy smokers: ≥20 pack-year; heavy drinkers: ≥23 g/day.
Data are shown in number (%) for categorical variables and mean ± standard deviation for continuous variables.

hazard assumption; the *P*-values were >0.05 for the three dietary patterns. The significantly positive association between meat-fat pattern and overall mortality was attenuated and was not statistically significant any more after further adjustments for sociodemographic and lifestyle factors, functional capacity, depressive tendency, BMI, daily energy intake, medical status, and history of diseases (HR, 1.25; 95% CI, 0.84–1.88). The middle tertile of healthy pattern contributed to over 30% reduction in risk of mortality compared with the lowest tertile before and after adjustments for all potential confounding factors (HR, 0.65; 95% CI, 0.48–0.89). The dairy-bread pattern was marginally related to higher risk of mortality (HR, 1.34; 95% CI, 0.98–1.83).

Interaction was found between meat-fat pattern and tobacco use ($P = 0.024$), healthy pattern and tobacco use ($P = 0.009$), healthy pattern and alcohol consumption ($P = 0.042$), healthy pattern and daily walking time ($P = 0.011$), and dairy-bread pattern and tobacco use ($P = 0.05$). The meat-fat pattern (HR, 2.81; 95% CI, 1.37–5.79; $P_{\text{for trend}} = 0.005$) and the dairy-bread pattern (HR, 2.21; 95% CI, 1.20–4.06; $P_{\text{for trend}} = 0.014$) increased hazard of all-cause mortality in the never smokers subgroup. However the healthy pattern

Table 3
Associations between dietary patterns and all-cause mortality for old men and women.

	Cases/person-year	Model 1[a,d]	Model 2[b,d]	Model 3[c,d]
Meat-fat pattern				
Tertile 1	67/10,468	1.00	1.00	1.00
Tertile 2	85/10,370	1.29 (0.94, 1.78)	1.19 (0.85, 1.67)	1.21 (0.86, 1.69)
Tertile 3	101/10,385	1.53 (1.12, 2.08)*	1.25 (0.84, 1.86)	1.25 (0.84, 1.88)
$P_{\text{for trend}}$		0.007*	0.275	0.271
Healthy pattern				
Tertile 1	100/10,324	1.00	1.00	1.00
Tertile 2	71/10,643	0.68 (0.50, 0.93)*	0.66 (0.48, 0.90)*	0.64 (0.47, 0.88)*
Tertile 3	82/10,256	0.83 (0.62, 1.12)	0.77 (0.55, 1.06)	0.74 (0.53, 1.02)
$P_{\text{for trend}}$		0.194	0.082	0.051
Dairy-bread pattern				
Tertile 1	90/10,515	1.00	1.00	1.00
Tertile 2	75/10,431	0.84 (0.62, 1.14)	0.96 (0.70, 1.31)	0.95 (0.69, 1.30)
Tertile 3	88/10,277	1.00 (0.74, 1.34)	1.33 (0.98, 1.81)	1.34 (0.98, 1.83)
$P_{\text{for trend}}$		0.980	0.080	0.077

*$P < 0.05$.
[a] Crude model.
[b] Adjustment for survey year, married status, work status, education, tobacco use, alcohol consumption, daily walking time, sleep duration, living arrangement, TMIG scores, GDS scores, social participation, body mass index and daily energy intake.
[c] Adjustment for the variables in model 2 plus history of cancer, heart disease and cerebrovascular disease, and medical status of hypertension, hyperlipidemia and diabetes mellitus.
[d] Strata by gender.

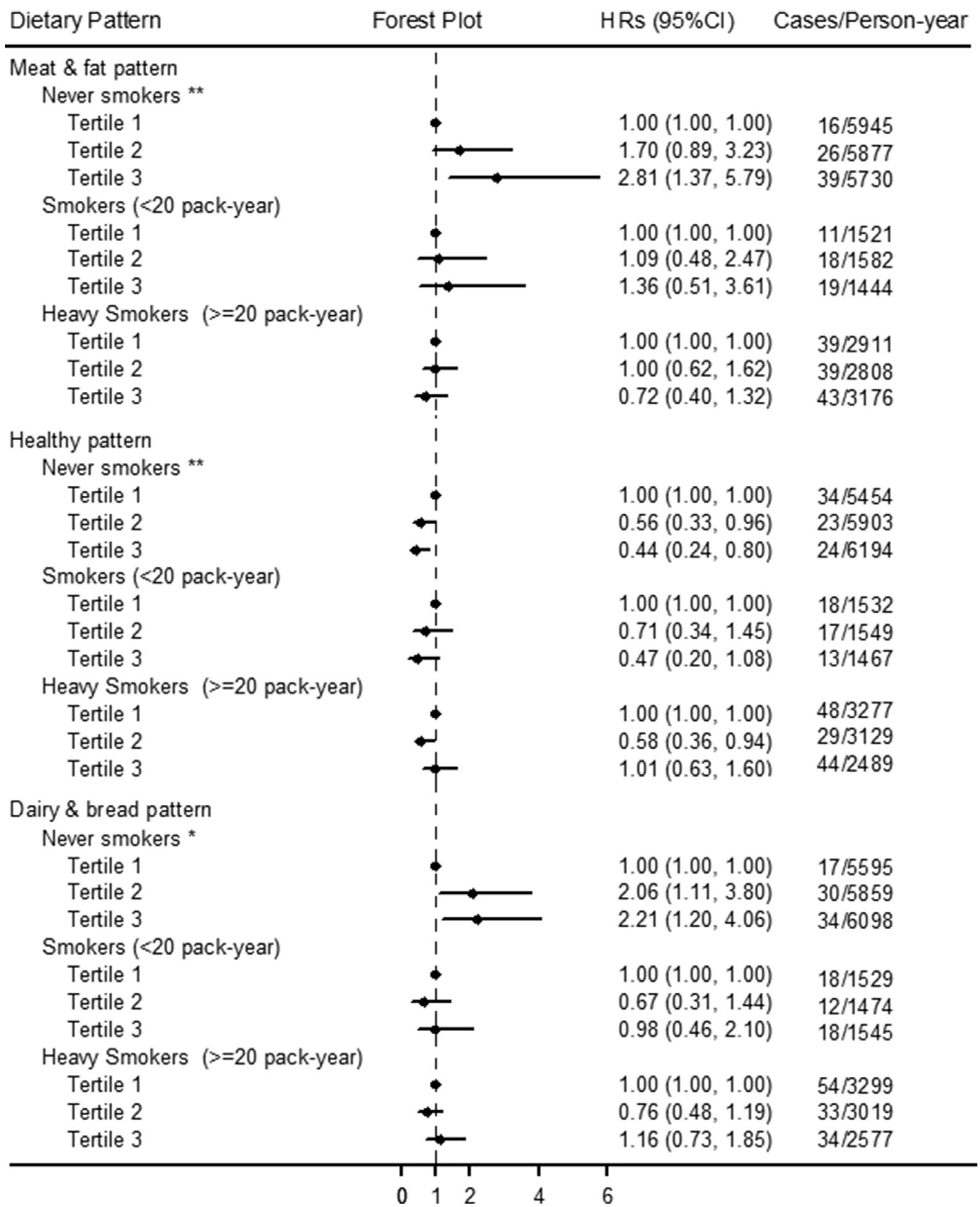

Fig. 1. The associations between dietary patterns and all-cause mortality by tobacco use after full adjustment for survey year, married status, work status, education, tobacco use, alcohol consumption, daily walking time, sleep duration, living arrangement, TMIG scores, GDS scores, social participation, body mass index, daily energy intake, history of diseases, and medical status. $^{*}P < 0.05$; $^{**}P < 0.01$.

generated a protective effect on mortality (HR, 0.44; 95% CI, 0.24–0.80; $P_{\text{for trend}} = 0.006$) for the never smokers subgroup (Fig. 1). The healthy pattern reduced hazard of all-cause mortality among occasional drinkers (HR, 0.63; 95% CI, 0.42–0.93; $P_{\text{for trend}} = 0.016$) whereas there was increased hazard of all-cause mortality for the dairy-bread pattern (HR, 1.62; 95% CI, 1.09–2.39; $P_{\text{for trend}} = 0.016$) (Fig. 2). There was a decreased risk of mortality among the healthy pattern for those who walked ≥1 h/day (HR, 0.47; 95% CI, 0.28–0.77; $P_{\text{for trend}} = 0.002$) (Fig. 3). There were no statistically significant associations between the three dietary patterns and mortality for heavy smokers, heavy drinkers, or those who walked <1 h/day.

4. Discussion

In our study, three dominant dietary patterns were identified: the meat-fat pattern, the healthy pattern, and the dairy-bread pattern. We found that the unhealthy patterns (meat-fat or bread-dairy pattern) increased risk of mortality while the healthy

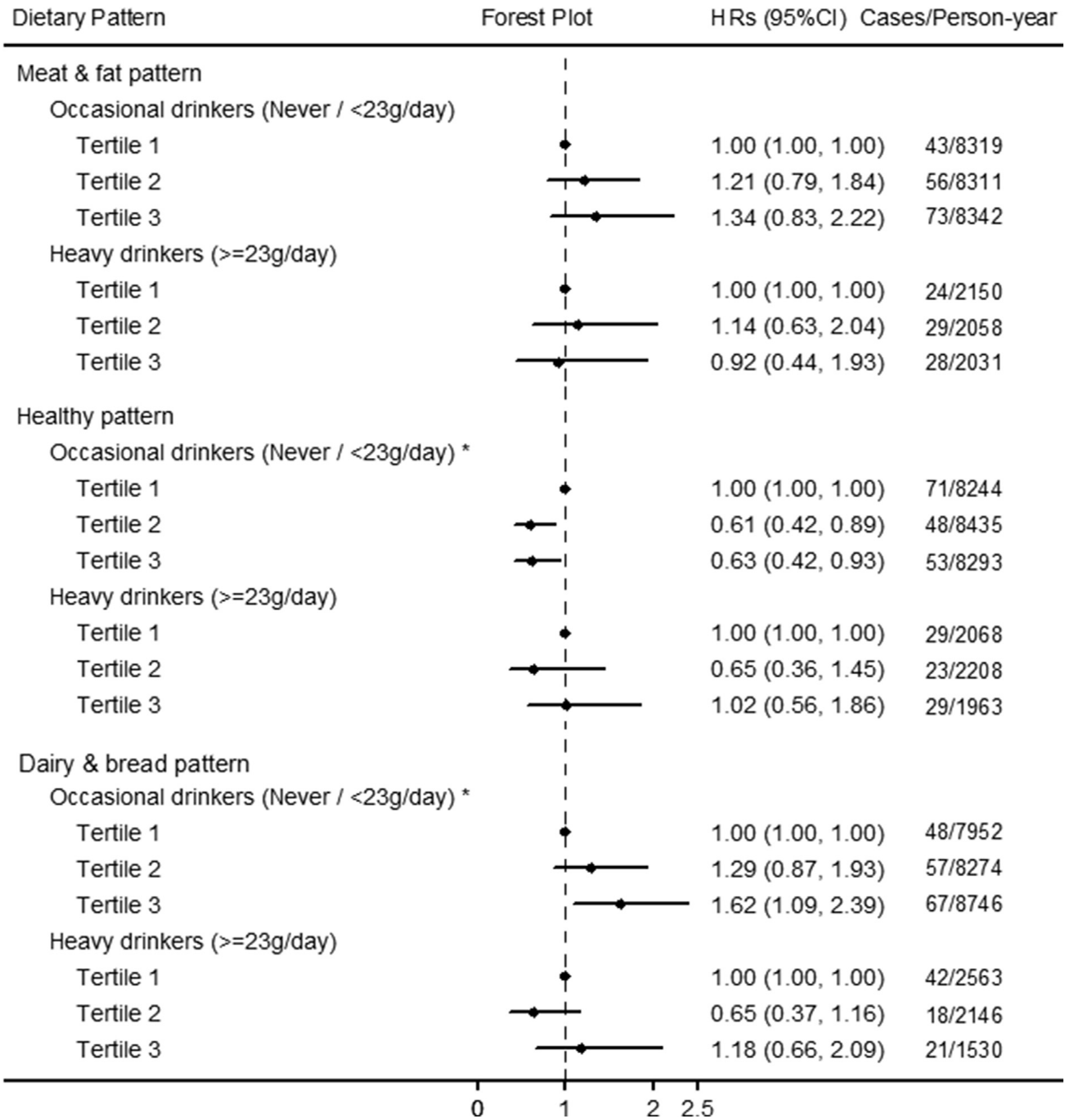

Fig. 2. The associations between dietary patterns and all-cause mortality by alcohol consumption after full adjustment for survey year, married status, work status, education, tobacco use, alcohol consumption, daily walking time, sleep duration, living arrangement, TMIG scores, GDS scores, social participation, body mass index, daily energy intake, history of diseases, and medical status. $^{*}P < 0.05$.

pattern was protective against mortality when participants practiced at least one healthy lifestyle factor, such as never smoking, occasionally drinking or walking ≥1 h/day.

This is the first study showing the modifiable effect of lifestyle factors of smoking status, drinking status, or walking ≥1 h/day on the association between dietary patterns and mortality in the elderly population. Our findings showed that the mortality risk was decreased by 37–56% in the highest tertile of the healthy pattern within the subgroups of never smokers, occasional drinkers, and those who walked for over 1 h/day. Our findings were consistent with those reported in previous studies showing that adherence to at least two healthy lifestyle factors was linked to lower mortality in the elderly [31]. Our study also provided new nutritional evidence for the aged society, particularly in Japan. The remaining dietary components included in the healthy pattern in this study, except for seafood, were all plant-based, which were consistent with the only early study conducted in Japan [21]. As was observed for the healthy pattern in this study, the healthy traditional pattern, the healthy food pattern, and plant-based pattern has been previously reported to be related to a decreased risk of mortality among elderly Dutch women [19], elderly American adults [15] and the European elderly [17]. The dietary components included in our healthy pattern which have been recently reported as key ingredients for healthy aging, including fruits, vegetables, fish, whole grains, legumes/pulses and potatoes [32]. Frequent consumption of these key ingredients has been shown to be protective against systemic inflammation and endothelial dysfunction [33].

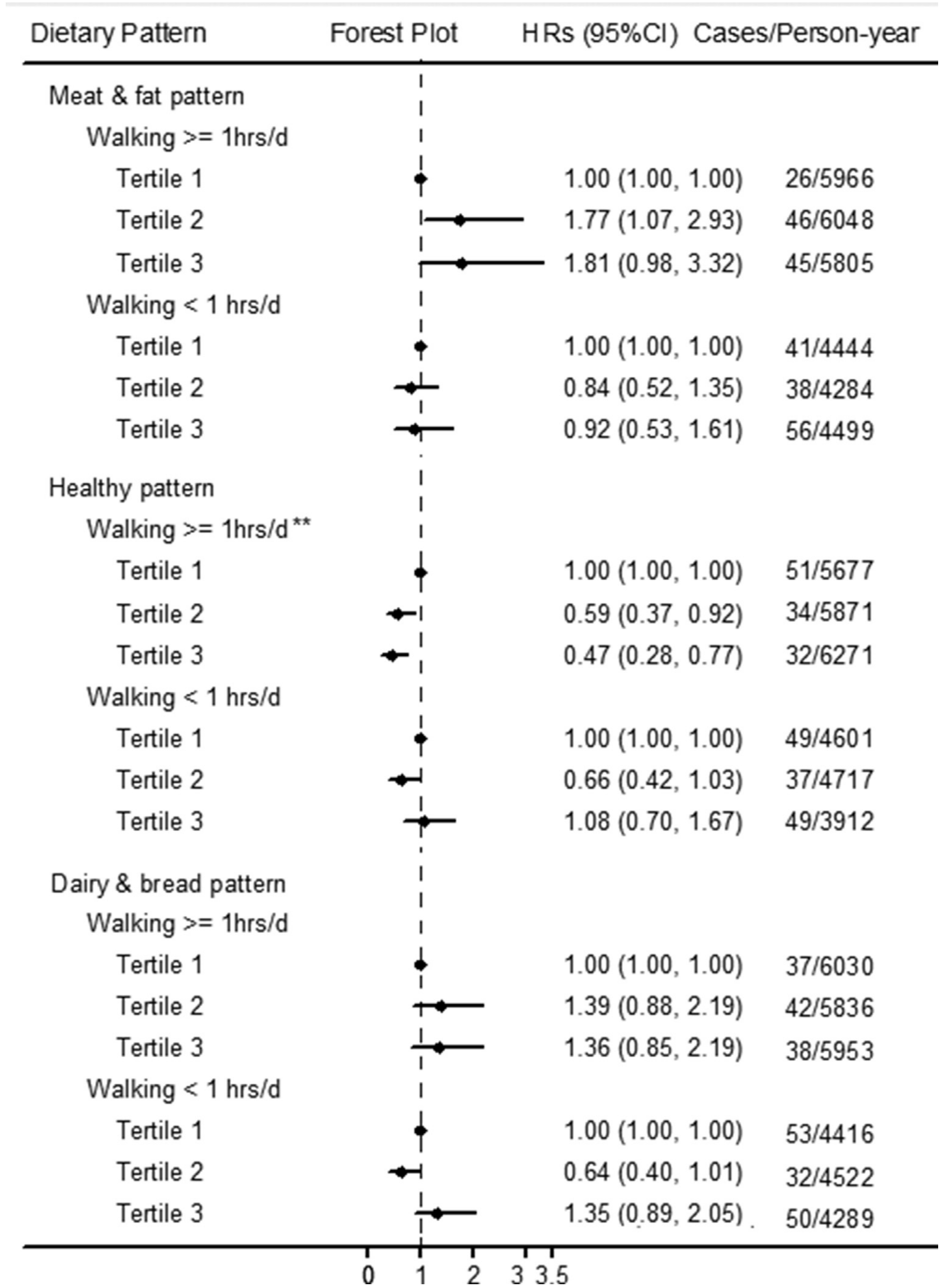

Fig. 3. The associations between dietary patterns and all-cause mortality by daily walking time after full adjustment for survey year, married status, work status, education, tobacco use, alcohol consumption, daily walking time, sleep duration, living arrangement, TMIG scores, GDS scores, social participation, body mass index, daily energy intake, history of diseases, and medical status. $^{**}P < 0.01$.

We further found that the mortality risk was 34–180% higher in the highest tertile of the meat-fat pattern or dairy-bread pattern in the subgroups of never smokers, occasional drinkers, and those who walked for over 1 h/day. Despite partly similar to the components of our meat-fat pattern, the dietary pattern with frequent intake of meat, fried foods, and alcohol, was no longer associated with mortality in elderly Americans after adjustment for the relevant covariates [15]. A sweet and dairy pattern abstracted in the elderly Americans was not significantly associated with mortality [14]. Other two analogous dietary patterns, high-fat dairy and sweet-dessert patterns, were reported to cause increased mortality in the elderly Americans [15]. The inconsistent previous studies lend support to our stratified analysis by lifestyle factors. Our findings also gave reminders for the elderly that unhealthy eating behaviors would lead to higher mortality even though other healthy lifestyle was maintained. Thus, it is recommended that the elderly maintain healthy eating behaviors as well as healthy lifestyles in order to reduce the mortality risk later in life.

Additionally, we did not found the associations between dietary patterns and mortality among the subgroup of heavy smokers, heavy drinkers, and those who walked <1 h/day. It is assumed that the impact of dietary patterns might be weaker than those of unhealthy lifestyle factors. Former/current smoking [34], heavy drinking [25] and shorter daily walking time [35] have been considered to contribute to higher risk of mortality in the elderly. However, we did not eliminate the negative impact of heavy smoking, heavy drinking and inactivity on mortality; the additive hazard ratios of the cross group of unhealthy lifestyle factors and dietary patterns were higher than those of healthy lifestyle factors and dietary patterns (Please see Supplementary Tables S2, S3, and S4).

This was an age-specific prospective cohort study for the elderly in order to determine the association between dietary patterns and all-cause mortality; the effect of age on this association was eliminated in this study by adjusting for it. Adjustments for living arrangement, social participation, functional capacity and depressive tendencies, which are important indicators of the elderly populations' lifestyles and health, improved the validity of these study findings. The long follow-up period allowed investigators to investigate lifestyle factors that might attribute to long-term survival.

Despite the strengths of this study there were several limitations noted. The statistical power of this study might be limited, owing to the relatively small sample size and number of deaths. Changes in dietary behaviors over follow-up period were likely to occur for the elderly with age-related diseases present. Self-reported lifestyle data may result in some misclassification and residual confounding. The limiting generalizability of the results has to be noted due to our study population tended to be healthier than general Japanese population aged 60–69 years compared with the data in the National Health and Nutrition Survey 2004 and the National survey of Dental Disease 2005. But it may be possible to generalize the results into some healthy elderly if some bias was considered. The study also had to consider the inherent methodologic limitation of the exploratory factor analysis on the subjectivity of deciding the factor numbers, the labeling of the dietary patterns and the rotation method.

In conclusion, our current study identified three dietary patterns in this age-specific prospective cohort study. We found smoking status, drinking status, or walking for over 1 h/day could modify the associations of dietary patterns with overall mortality. It is suggested that elderly populations should make efforts to maintain multiple healthy lifestyle factors in order to minimize risk of mortality and promote survival later in life.

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Statement of authorship

WJZ contributed to data analysis, results interpretation, and the manuscript preparation. SU and EO contributed to data-analysis. KW, TK, MA, and AT coordinated, designed the study, and collected the data. All the authors contributed to review, edit and approve the final manuscript.

Conflicts of interest

We have no competing interests to declare.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.clnu.2018.01.018.

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