Associations between the Intake of Miso Soup and Japanese Pickles and the Estimated 24-hour Urinary Sodium Excretion: A Population-based Cross-sectional Study

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Abstract

Objective In Japan, reducing the consumption of miso soup and Japanese pickles, both traditional Japanese dishes, is recommended in order to decrease dietary salt intake. With the Westernization of dietary habits, however, these dishes are now consumed less frequently, and thus a reduction in their effect on sodium intake is suspected. This study examined cross-sectional associations between the frequency of intake of miso soup and Japanese pickles and the estimated 24-hour urine sodium excretion using data obtained from health examination surveys conducted in 2013 in Sado City, Japan.

Methods The level of daily salt intake was estimated based on spot urine sodium and creatinine measurements. The frequency of intake of miso soup and Japanese pickles was determined using a self-reported questionnaire. Multiple linear regression models were used to assess associations.

Results Among a total of 8,821 participants (3,956 men; age range, 19-97 years), the mean daily salt intake was 9.4 g/day. The frequency of intake of miso soup and Japanese pickles increased with age and was associated with the level of daily salt intake (p for trend <0.0001). A linear regression model analysis adjusted for age, sex, body mass index, hypertension, diabetes, hypercholesterolemia and chronic kidney disease revealed that daily salt intake was associated with the frequency of intake of miso soup ($p<0.0001$) and Japanese pickles ($p<0.0001$) in all age groups, except those ≥ 80 years of age.

Conclusion These findings suggest that reducing the consumption of miso soup and Japanese pickles may be an effective approach for decreasing the level of dietary salt intake in the general Japanese population, although not in octogenarians or nonagenarians.

Key words: education, health communication, linear model

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Introduction

Reducing dietary salt intake is an important public health strategy for preventing and treating hypertension and cardiovascular disease (1-4). Although excess salt intake is a global public health issue, individual countries must develop strategies tailored to the dietary habits of their populations.

Japan is among the many countries with a high salt intake problem (5, 6). Although a marked decrease in the levels of salt intake has been achieved within the past several decades

in Japan, there still is room for improvement. In fact, the 2012 National Health and Nutrition Survey of Japan (NHNS) reported a mean daily salt intake of 11.3 g and 9.6 g in adult men and women, respectively (7). These values are higher than the recommended value of <6 g per day (4).

Reducing the frequency of intake of miso soup, a popular traditional Japanese dish, as well as Japanese pickles, is often advised in various healthcare settings to decrease the salt intake. Both dishes have long been considered major contributors to dietary sodium. In fact, a previous study revealed that miso soup and Japanese pickles accounted for

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Figure 1. Chart of subject selection for this study. Of the 9,003 participants who underwent health examinations in 2013, 8,821 were included in the analysis.

17.1% and 12.4% of total sodium intake, respectively, establishing these two dishes as the top contributors among 197 common Japanese dishes (8). However, that study used data collected in 1996-1997, and there is no evidence linking the frequency of intake of miso soup and Japanese pickles to salt intake based on current data.

Recently, Japan has seen drastic changes in the dietary habits of its citizens due to the Westernization of dietary and lifestyle factors. This phenomenon has resulted in a decrease in the consumption of traditional Japanese dishes, and possibly a reduction in the effect of these dishes on sodium intake. If there is no association between daily salt intake and the consumption of miso soup or Japanese pickles, reducing the intake of these foods may not be an effective dietary approach and thus should not be recommended in the health-care setting.

With these questions in mind, we used existing health examination data obtained from a local government office to determine the frequency of intake of miso soup and Japanese pickles according to categories of age and evaluated the associations with the estimated 24-hour urinary sodium excretion (an indicator of daily salt intake) in the general population.

Materials and Methods

Study participants and design

A cross-sectional study was performed among the adult residents of Sado City using health examination data obtained in 2013. Sado City, which is located on an island in the Sea of Japan off the coast of Niigata Prefecture, represents one of the most rapidly aging areas in Japan. The details of the health examination survey are described elsewhere (9, 10). In brief, the participants completed a self-administered questionnaire regarding their smoking, alcohol consumption, exercise and dietary habits. Questions regarding the frequency of intake of miso soup and Japanese pickles were included in the questionnaire independently.

Trained staff measured the height, weight and blood pressure of each participant, after which serum and spot urine samples were collected. Measurements of the urinary sodium and creatinine concentrations in the spot urine samples are not evaluated as mandatory items on the health examinations, although they were assessed independently in Sado City. Of the 9,003 participants (age range, 19-97 years) who underwent health examinations in 2013, 8,821 were included in the analysis, excluding 182 individuals with missing information for lifestyle factors (Fig. 1). The anonymity of all study participants was maintained, and the study was conducted in compliance with the Declaration of Helsinki and according to Japanese privacy protection laws and ethical guidelines for epidemiological studies published by the Ministry of Education, Science and Culture and the Ministry of Health, Labour and Welfare. The ethics committee of Niigata University Hospital approved the study protocol (No. 1787).

Outcomes

The primary outcome measurement was the estimated daily salt intake based on the daily sodium excretion level, as sodium is mostly excreted in the urine. The level of daily sodium excretion was estimated in the spot urine tests using the method described by Tanaka et al. (11), which is recommended by the Japanese Society of Hypertension (12). The estimated sodium excretion (mEq/day) was multiplied by 0.0585 to convert the values to the daily salt intake level (g/day) (13).

Frequency of intake of miso soup and Japanese pickles

In order to assess the frequency of intake of miso soup and Japanese pickles, the following question was included in the self-administered questionnaire: 'How many times a day do you have miso soup or Japanese pickles?' The responses included 'not daily,' 'one bowl per day' and 'two or more bowls per day' for the intake of miso soup and 'not daily,' 'once or twice per day' and 'three times or more per day' for the intake of Japanese pickles.

Covariates

Body mass index (BMI) was calculated by dividing the patient's weight (kg) by the square of their height (m). Diabetes mellitus was defined as the use of insulin or oral antidiabetic medications or an HbA1c level of $\geq 6.5\%$ or both. Hypertension was defined as a systolic blood pressure (SBP) of ≥ 140 mmHg and/or diastolic blood pressure (DBP) of ≥ 90 mmHg and/or the use of antihypertensive medications. Hypercholesterolemia was defined as the use of cholesterol-lowering medications, a low-density lipoprotein cholesterol (LDL-C) level of ≥ 140 mg/dL or both. Chronic kidney disease (CKD) was defined as the detection of proteinuria on a urinalysis, a glomerular filtration rate (GFR) of ≥ 60 mL/min/1.73 m² or both (14). Proteinuria was defined as a dipstick urinalysis score of 1+ or greater (equivalent to ≥ 30 mg/

Table 1. Participant Characteristics Stratified by Age

Characteristics ¹	Total (n=8,821)	Age group				p for trend
		< 60 [n=1,696 (19.2%)]	60 – 69 [n=2,657 (30.1%)]	70 - 79 [n=3,049 (34.6%)]	≥ 80 [n=1,419 (16.1%)]	
Estimated salt intake, g/day	9.4 (2.4)	9.8 (2.4)	9.8 (2.3)	9.2 (2.3)	8.3 (2.3)	<0.0001
Age, years	67.3 (13.6)	44.8 (10.7)	65.1 (2.5)	74.2 (2.9)	83.4 (3.1)	<0.0001
Men, n (%)	3,956 (44.8)	700 (41.3)	1,222 (46.0)	1,346 (44.1)	688 (48.5)	0.002
Body mass index, kg/m ²	23.1 (3.4)	23.2 (4.1)	23.4 (3.4)	23.1 (3.1)	22.5 (3.1)	<0.0001
Systolic blood pressure, mmHg	127 (18)	120 (17)	128 (17)	129 (17)	130 (18)	<0.0001
Diastolic blood pressure, mmHg	74 (11)	73 (12)	76 (11)	73 (10)	71 (10)	<0.0001
Antihypertensive medication, n (%)	3,415 (38.7)	167 (9.8)	904 (34.0)	1,510 (49.5)	834 (58.8)	<0.0001
Hypertension, n (%)	4,488 (50.9)	347 (20.5)	1,292 (48.6)	1,847 (60.6)	1,002 (70.6)	<0.0001
LDL cholesterol, mg/dL	116 (28)	115 (30)	121 (29)	115 (27)	110 (25)	<0.0001
Triglycerides, mg/dL	111 (77, 161)	103 (67, 160)	118 (81, 172)	112 (81, 157)	104 (76, 148)	0.87
HDL cholesterol, mg/dL	56 (14)	59 (15)	57 (15)	55 (14)	53 (13)	<0.0001
Cholesterol-lowering medication, n (%)	1,706 (19.3)	108 (6.4)	561 (21.1)	717 (23.5)	320 (22.6)	<0.0001
Hypercholesterolemia, n (%)	3,145 (35.7)	422 (24.9)	1,127 (42.4)	1,143 (37.5)	453 (31.9)	0.003
Hemoglobin A1c, %	5.8 (0.6)	5.6 (0.7)	5.9 (0.7)	5.9 (0.6)	5.9 (0.5)	<0.0001
Antidiabetic medication, n (%)	645 (7.3)	52 (3.1)	214 (8.1)	261 (8.6)	118 (8.3)	<0.0001
Diabetes, n (%)	1,003 (11.4)	83 (4.9)	342 (12.9)	397 (13.0)	181 (12.8)	<0.0001
Creatinine, mg/dL	0.70 (0.24)	0.65 (0.18)	0.68 (0.29)	0.70 (0.22)	0.76 (0.24)	<0.0001
eGFR, mL/min/1.73 m ²	79.4 (20.3)	94.3 (21.7)	80.6 (17.5)	75.3 (17.8)	68.1 (17.6)	<0.0001
Proteinuria, n (%)	443 (5.0)	73 (4.3)	117 (4.4)	145 (4.8)	108 (7.6)	<0.0001
Chronic kidney disease, n (%)	1,467 (16.6)	101 (6.0)	332 (12.5)	537 (17.6)	497 (35.0)	<0.0001

Abbreviations: LDL: low-density lipoprotein, HDL: high-density lipoprotein, eGFR: estimated glomerular filtration rate. Definitions of clinical characteristics are described in the text.

¹ Numbers in the table represent means (standard deviation) for continuous variables, except for triglycerides (median and interquartile range), and numbers (percentages) for categorical variables.

dL) based on the poor level of discrimination between negative and trace positive dipstick readings (15). The estimated GFR was calculated using the Japanese equation (16).

Statistical analysis

The mean estimated salt intake was calculated according to age (<30, 30-39, 40-49, 50-59, 60-69, 70-79 and ≥80 years) and the frequency of intake of miso soup and Japanese pickles. Differences in variables across age categories were examined using an analysis of variance (ANOVA) and compared with Dunnett's multiple comparison test. The middle category of age (50-59 years) was used as the reference category. Descriptive statistics for the clinical characteristics across the categories of miso soup and Japanese pickles intake were compared using the chi-square test for categorical data and an ANOVA or the Kruskal-Wallis test for continuous variables. The p values for trends were determined using the chi-square test for trends and Jonckheere-Terpstra test for nominal and ordinal variables, respectively. Pearson and Spearman correlation coefficients were calculated to evaluate relationships between the variables.

Multiple linear regression analyses were performed to assess the relationship between the estimated salt intake and the frequency of intake of miso soup and Japanese pickles after adjusting for *a priori* identified covariates, including age, sex, BMI, hypertension (yes/no), diabetes (yes/no), hypercholesterolemia (yes/no) and CKD (yes/no). The results

were reported using the categories of miso soup or Japanese pickles intake as continuous variables, since the categorical analysis yielded similar results. Multicollinearity was assessed using the variance inflation factor, with a variance inflation factor of >10 considered to be indicative of serious multicollinearity and a value of >4.0 suggesting a cause for concern. Interactions were constructed based on the variables included in the final main effects model according to the levels of statistical and clinical significance. Subgroup analyses were performed to assess the robustness of the main results. First, sex-stratified subgroup analyses were performed to establish whether sex had any effect on the relationship. Second, an age-stratified analysis was performed, as the age distribution of the study participants was dispersed.

All tests were two-tailed, with a p value of <0.05 considered to be statistically significant. All statistical analyses were performed using the SPSS for Windows statistical package (Version 18.0, SPSS, Chicago, USA) and EZR (Saitama Medical Center, Jichi Medical University), a graphical user interface for R (The R Foundation for Statistical Computing) (17).

Table 2. Participant Characteristics according to Daily Intake Frequency of Miso Soup

Characteristics ¹	Intake frequency of miso soup			p for trend
	Not daily [n=936 (10.6%)]	One bowl per day [n=3,486 (39.5%)]	Two or more bowls per day [n=4,399 (49.9%)]	
Estimated salt intake, g/day	9.0 (2.4)	9.3 (2.4)	9.5 (2.4)	<0.0001
Age, years	61.7 (15.2)	65.7 (14.3)	69.7 (12.1)	<0.0001
Men, n (%)	387 (41.3)	1,416 (40.6)	2,153 (54.4)	<0.0001
Body mass index, kg/m ²	23.6 (3.7)	23.1 (3.5)	23.0 (3.3)	<0.0001
Systolic blood pressure, mmHg	126 (18)	127 (18)	127 (18)	0.03
Diastolic blood pressure, mmHg	74 (11)	73 (11)	74 (11)	0.32
Antihypertensive medication, n (%)	323 (34.5)	1,347 (38.6)	1,745 (51.1)	0.008
Hypertension, n (%)	448 (47.9)	1,752 (50.3)	2,288 (52.0)	0.01
LDL cholesterol, mg/dL	120 (30)	117 (28)	114 (27)	<0.0001
Triglycerides, mg/dL	114 (78, 163)	112 (77, 164)	109 (77, 158)	0.05
HDL cholesterol, mg/dL	57 (14)	57 (15)	55 (14)	<0.0001
Cholesterol-lowering medication, n (%)	167 (17.8)	704 (20.2)	835 (19.0)	0.94
Hypercholesterolemia, n (%)	375 (40.1)	1,310 (37.6)	1,460 (33.2)	<0.0001
Hemoglobin A1c, %	5.8 (0.8)	5.8 (0.6)	5.8 (0.6)	0.11
Antidiabetic medication, n (%)	71 (11.0)	268 (7.7)	306 (7.0)	0.27
Diabetes, n (%)	117 (12.5)	406 (11.6)	480 (10.9)	0.12
Creatinine, mg/dL	0.71 (0.44)	0.69 (0.22)	0.70 (0.2)	0.94
eGFR, mL/min/1.73 m ²	81.4 (21.9)	79.8 (21.0)	78.6 (19.3)	<0.0001
Proteinuria, n (%)	58 (6.2)	191 (5.5)	194 (4.4)	0.006
Chronic kidney disease, n (%)	153 (16.3)	586 (16.8)	728 (16.5)	0.97
Intake frequency of Japanese pickles				<0.001
Not daily	516 (55.1)	1,055 (30.3)	828 (18.8)	
Once or twice per day	318 (34.0)	1,951 (56.0)	2,054 (46.7)	
Three times or more per day	102 (10.9)	480 (13.8)	1,517 (34.5)	

Abbreviations: LDL: low-density lipoprotein, HDL: high-density lipoprotein, eGFR: estimated glomerular filtration rate. Definitions of clinical characteristics are described in the text.

¹ Numbers in the table represent means (standard deviation) for continuous variables, except for triglycerides (median and interquartile range), and numbers (percentages) for categorical variables.

Results

Patient characteristics

Table 1 summarizes the characteristics of the 8,821 participants. The mean (standard deviation) salt excretion was estimated to be 9.4 (2.4) g. Of the subjects, 44.8% were men and 50.9% were hypertensive, with 3,415 (76.1%) participants receiving antihypertensive medications. Of the 1,419 patients ≥80 years of age, 1,002 (70.6%) were hypertensive, with 834 (83.2%) receiving antihypertensive medications.

Tables 2 and 3 show the participants' characteristics according to the frequency of intake of miso soup and Japanese pickles. The mean salt intake slightly increased with an increasing frequency of intake of miso soup and Japanese pickles (p for trend <0.0001). The participants with a higher frequency of intake of miso soup were older and had higher SBP and LDL-C values and lower BMI, triglyceride, high-density lipoprotein cholesterol (HDL-C) and eGFR values as well as a reduced prevalence of proteinuria. Men were more likely to consume miso soup. The participants with a higher frequency of intake of Japanese pickles were older and had

higher SBP, triglyceride and HbA1c values and lower DBP, LDL-C, HDL-C and eGFR values in addition to a higher prevalence of CKD.

Fig. 2 shows the distribution of salt intake stratified by age. The mean salt intake increased with age up to 50-59 years and then decreased thereafter. The ANOVA with Dunnett's multiple comparison post-test revealed that the mean salt intake was significantly lower in the age categories of <30 (p=0.01), 70-79 (p<0.0001) and ≥80 (p<0.0001) than in the 50-59 category.

As shown in Fig. 3, the older participants were more likely to consume miso soup and Japanese pickles than the younger participants (p for trend <0.0001). The frequency of intake for both miso soup and Japanese pickles was correlated with each other (Spearman correlation coefficient, 0.29; p<0.0001).

Associations between the frequency of intake of miso soup and Japanese pickles and daily salt intake

The frequency of intake of miso soup (Fig. 4a, p<0.0001) and Japanese pickles (Fig. 4b, p<0.0001) was associated with daily salt intake according to the linear regression model after adjusting for age, sex, BMI, hypertension, dia-

Table 3. Participant Characteristics according to Daily Intake Frequency of Japanese Pickles

Characteristics ¹	Intake frequency of Japanese pickles			p for trend
	Not daily [n=2,399 (27.2%)]	Once or twice per day [n=4,323 (49.0%)]	Three times or more per day [n=2,099 (23.8%)]	
Estimated salt intake, g/day	9.2 (2.4)	9.4 (2.4)	9.5 (2.5)	<0.0001
Age years	61.5 (16.4)	67.5 (12.3)	73.4 (9.4)	<0.0001
Men, n (%)	1,073 (44.7)	1,927 (48.7)	956 (45.5)	0.60
Body mass index, kg/m ²	23.2 (3.7)	23.1 (3.3)	23.1 (3.2)	0.60
Systolic blood pressure, mmHg	126 (19)	127 (18)	128 (17)	<0.0001
Diastolic blood pressure, mmHg	74 (12)	74 (11)	73 (11)	0.002
Antihypertensive medication, n (%)	772 (32.2)	1,704 (39.4)	939 (44.7)	<0.0001
Hypertension, n (%)	1,083 (45.1)	2,220 (51.4)	1,185 (56.5)	<0.0001
LDL cholesterol, mg/dL	117 (29)	116 (28)	114 (27)	0.003
Triglycerides, mg/dL	107 (72, 161)	111 (78, 160)	115 (82, 162)	<0.0001
HDL cholesterol, mg/dL	58 (15)	57 (15)	54 (13)	<0.0001
Cholesterol-lowering medication, n (%)	343 (14.3)	905 (20.9)	458 (21.8)	<0.0001
Hypercholesterolemia, n (%)	785 (32.7)	1,602 (37.1)	758 (36.1)	0.01
Hemoglobin A1c, %	5.8 (0.7)	5.8 (0.6)	5.9 (0.6)	<0.0001
Antidiabetic medication, n (%)	161 (6.7)	326 (7.5)	158 (7.5)	0.28
Diabetes, n (%)	258 (10.8)	487 (11.3)	258 (12.3)	0.11
Creatinine, mg/dL	0.70 (0.33)	0.69 (0.20)	0.70 (0.21)	0.74
eGFR, mL/min/1.73 m ²	82.5(22.4)	79.2 (19.7)	76.4 (18.3)	<0.0001
Proteinuria, n (%)	139 (5.8)	205 (4.7)	99 (4.7)	0.09
Chronic kidney disease, n (%)	376 (15.7)	695 (16.1)	396 (18.9)	0.005
Frequency of miso soup consumption				<0.0001
Not daily	516 (21.5)	318 (7.4)	102 (4.9)	
One bowl per day	1,055 (44.0)	1,951 (45.1)	480 (22.9)	
Two or more bowls per day	828 (34.5)	2,054 (47.5)	1,517 (72.3)	

Abbreviations: LDL: low-density lipoprotein, HDL: high-density lipoprotein, eGFR: estimated glomerular filtration rate

Definitions of the clinical characteristics are described in the text.

¹ Numbers in the table represent means (standard deviation) for continuous variables, except for triglycerides (median and interquartile range), and numbers (percentages) for categorical variables.

betes, hypercholesterolemia and CKD. A sex-stratified subgroup analysis revealed similar results; however, an age-stratified subgroup analysis showed no associations in the oldest age category (i.e., ≥80 years).

Discussion

The present study investigated associations between the frequency of intake of miso soup and Japanese pickles and daily salt intake using health examination data obtained from a local government office. Consequently, we found the frequency of intake of miso soup and Japanese pickles to be independently associated with the estimated daily salt intake in a general Japanese population; however, these associations were not observed in octogenarians or nonagenarians. Our findings suggest that an approach in reducing the consumption of these dishes may be effective for decreasing dietary salt intake in the general population, although not in octogenarians and nonagenarians.

The present results also showed a clear decrease in the frequency of intake of miso soup and Japanese pickles with decreasing age, suggesting that younger generations are more prone to change their dietary habits, e.g., from Japanese to Western-style foods, compared to older generations.

This is a key finding that may have important public health implications, as public health workers often give nutritional education based on the nutritional content of common dishes and recipes (8). In this context, our findings regarding differences in dietary habits according to age provide valuable insight.

In the current study, no associations observed between the frequency of intake of miso soup and Japanese pickles and daily salt intake among the individuals ≥80 years of age. Although the reasons for this finding are unclear, the high prevalence of hypertension in this age group may be a contributing factor. Of the 1,419 participants ≥80 years of age, 1,002 (70.6%) were hypertensive, with 834 (83.2%) receiving antihypertensive medications. As hypertensive individuals, especially those on medication, are more concerned about their salt intake and would likely have more opportunities to receive dietary instructions regarding salt reduction, most subjects in this age group are expected to know that miso soup and Japanese pickles are high in salt. Therefore, individuals who frequently eat these dishes in this age group may attempt to reduce their salt intake by changing to mild-cured foods, decreasing the serving size or reducing the intake of salt from other dishes, with the result that the above association may disappear. Our findings clearly demon-

strated the existence of age-dependent associations between the frequency of intake of miso soup and Japanese pickles and daily salt intake, which provides further valuable insight.

Figure 2. Estimated salt intake stratified by age. Upper horizontal line, 75th percentile; lower horizontal line, 25th percentile; horizontal bar within the box, median; upper horizontal bar, 90th percentile; lower horizontal bar, 10th percentile. Circles represent outliers. The mean (SD) salt intake increased with age from 9.4 (2.5) g at <30 years to 9.8 (2.4) g at 30-39 years, 9.7 (2.4) g at 40-49 years and 10.0 (2.4) g at 50-59 years and then decreased from 9.8 (2.3) g at 60-69 years to 9.2 (2.3) g at 70-79 years and 8.3 (2.3) g at ≥80 years.

Little has been published regarding the association between dietary salt intake and the consumption of miso soup or Japanese pickles, although Japanese dietary habits have become substantially more Westernized over the past few decades. A previous study using data collected in 1996-1997 reported that miso soup and Japanese pickles are the top two contributors of dietary sodium, accounting for 17.1% and 12.4% of total sodium intake, respectively, among 197 common Japanese dishes (8). Japanese pickles include pickled cucumber (3.6%), pickled radish (2.9%), pickled plum (2.8%), pickled vegetables (1.3%), pickled eggplant (1.0%) and pickled Chinese cabbage (0.8%). Although the present study did not collect information concerning other dishes, the percent contributions of these foods to the total sodium intake may also differ from that observed in this previous report. In Western countries, especially the United Kingdom and United States, processed foods, such as breads, cereals and grains, are significant contributors to dietary sodium (18). The contribution of processed foods to the total sodium intake in Japan may also be large among individuals whose dietary habits are Westernized. Reexamining nutritional sources based on present dietary trends is necessary in order to properly characterize dietary patterns in the general population and provide appropriate nutritional education in the healthcare setting.

In the present study, the mean estimated salt intake was 9.4 g per day, which is lower than that reported in the 2012 NHNS (i.e., 11.3 g and 9.6 g per day for men and women, respectively) (7). This discrepancy may be due to differences in measurement methods, as the 2012 NHNS obtained data for the estimated salt intake based on dietary records,

Figure 3. Associations between the frequency of intake of (a) miso soup and (b) Japanese pickles by age. The frequency of intake of miso soup and Japanese pickles increased with age (p for trend <0.0001).

Figure 4. Forest plots of the changes in the estimated salt intake for each 1-category increment in the frequency of intake of (A) miso soup and (B) Japanese pickles. The data are based on multivariable linear regression models, adjusted for the following covariates (except for variables used to define subgroups in each case): age (years), sex, body mass index, hypertension, diabetes, hypercholesterolemia and chronic kidney disease. Changes in the estimated salt intake associated with a 1-category increase in the frequency of intake of (A) miso soup (i.e., not daily vs. one bowl per day or one bowl per day vs. two or more bowls per day) and (B) Japanese pickles (i.e., not daily vs. once or twice per day or once or twice per day vs. three times or more per day). CI: confidence interval

whereas the present study used spot urine samples.

Despite these differences in measurement methods, both studies found the highest estimated salt intake to be among middle-aged and older individuals. In the present study, the mean estimated salt intake was higher in the subjects between 30 and 69 years of age than in those under 30 or over 70 years of age. The 2012 NHNS also reported a mean salt intake of 11.0, 10.7, 11.1, 11.8, 11.8 and 11.1 in men 20-29, 30-39, 40-49, 50-59, 60-69 and ≥70 years of age and 8.8, 9.0, 9.1, 10.1, 10.2 and 9.8 in women 20-29, 30-39, 40-49, 50-59, 60-69 and ≥70 years of age, respectively (7). These results suggest that the development of a strategy targeting this age group should be considered, given the differences in dietary habits according to age.

There are some limitations associated this study worth noting. First, data regarding the frequency of intake of miso soup and Japanese pickles were self-reported and thus may not be accurate. In addition, the portion size and concentration of sodium in miso soup and Japanese pickles were not evaluated due to the lack of this information. A recent study reported that a higher number of bowls of miso soup consumed per day is associated with a lower sodium concentration in miso soup, whereas no association was noted between the number of bowls consumed daily and the 24-hour urinary sodium excretion in 143 individuals 40-69 years of age living in the metropolitan Tokyo area (19). Hence, it may be beneficial to discuss the effects of these dishes from the perspective of frequency as well as quantity. However,

since consuming these dishes less frequently is often advised as part of public health education, our findings offer practical insight for health professionals. Second, the salt intake levels were estimated using spot urine, rather than 24-hour urine, samples. Third, as all of the study participants underwent annual physical checkups, there may have been selection bias in the study population. Finally, despite performing adjustments for potential confounding factors, the presence of residual confounding is possible. For example, the data were not adjusted for indicators of the socioeconomic status, such as the level of education and household income (20), due to the lack of available data.

To the best of our knowledge, this study is the first to report the influence of the frequency of intake of miso soup and Japanese pickles on daily salt intake. In addition, although the generalizability of our findings may be limited, the relatively homogenous nature of the cohort (i.e., all study participants lived on the same small island), which helped reduce to confounding effects, is another strength of this study.

In conclusion, in the present study, the frequency of intake of miso soup and Japanese pickles clearly increased with age and was associated with daily salt intake in a general Japanese population, although not in those ≥ 80 years of age. These findings suggest that the development of an approach to reducing the frequency of consumption of miso soup and Japanese pickles with the goal of decreasing dietary salt intake may be effective in the general population, but not in octogenarians or nonagenarians. It is necessary to examine nutritional sources based on common dishes and recipes in order to accurately characterize dietary patterns in the Japanese population and thus provide appropriate nutritional education in the healthcare setting.

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