Original Article

Simple questions in salt intake behavior assessment: comparison with urinary sodium excretion in Japanese adults

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Background and Objectives: To clarify whether six conventional 'high-risk' behaviors toward excess salt intake captured by simple questions such as frequency of salty food consumption are related to actual salt intake. Also, to examine the relationship of nutrition knowledge, food label use, and food preparation with actual salt intake. **Methods and Study Design:** Study participants were 742 subjects (370 men and 372 women) aged 20-69 years from 20 areas of Japan. Salt intake and dietary knowledge/behavior were evaluated with two 24-hour urine collections and a questionnaire, respectively. Multivariable linear regression analyses by sex included sodium excretion as a dependent variable, each knowledge/behavior item as an independent variable, and with age, body mass index, education, and smoking as covariates. **Results:** Four 'high-risk' behaviors (frequency of miso soup and salty foods consumption, proportion of consumed noodle soup, and amount of seasoning/condiment use) were associated with higher sodium excretion in men (p for trend $\leq$0.04) and were marginally associated in women (p for trend $\leq$0.06). Combination of these behaviors elevated the odds ratios for excess salt intake (sodium excretion: >136 mmol/day). Most of the other nine dietary factors were not associated with sodium excretion. Interestingly, women who decided to purchase foods after referring to the salt/sodium content information on food label, had significant lower sodium excretion than other women (p for trend=0.03). **Conclusions:** High-risk behaviors toward excess salt intake captured by simple questions were actually related to excess salt intake. Specific and practical advice based on answers to these questions might contribute to salt reduction in Japanese population.

Key Words: sodium, 24-hour urine collection, behavior, questionnaire, Japanese

INTRODUCTION

Salt intake reduction is the key public health strategy for preventing hypertension and related diseases.[1-3] However, population salt intake in most countries exceeds the 5 g/day targeted by the World Health Organization (WHO) as the daily salt intake in adults to prevent non-communicable diseases.[4,5] Accordingly, there is a strong worldwide need for public health efforts aimed at developing effective strategies to reduce population salt intake. Japan is known as the one of the countries with the highest in salt intake. Although population salt intake in northern area of Japan was over 20 g/day in 1950s,[6] the National Nutrition Survey in Japan showed that the sodium intake of Japanese is decreasing, and reported a population mean sodium intake in 2012 of 4239 mg/day (184.3 mmol/day) for men and 3658 mg/day (159.0 mmol/day) for women, as estimated using a single-day household-based dietary record.[7,8] However, a nation-wide study conducted in 2013 reported sodium excretion of 206.0 mmol/day and 173.9 mmol/day for men and women, respectively, as estimated by 24-hour urine collection.[9] These results suggest that actual sodium intake in Japanese is higher than that reported by the National Nutrition Survey, and that intake might not have changed since the time of the INTERMAP study (late 1990s) and INTERSALT study (mid-1980s).[10,11]

This potentially unchanged trend of Japanese salt intake might be retained by the way of consuming salt. The major source of dietary salt was soy-sauce commonly added in daily meals of Japanese, while processed foods

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(including restaurant meal) and breads are major source salt in the United Kingdom and the United States.[12] Since salty seasonings including soy-sauce are added in many cooked meal commonly consumed, Japanese might feel it difficult to control their salt intake by not consuming particular salty foods. Inline of salt reduction strategies, health professionals should indicate effective and practical dietary behaviors to reduce salt intake of Japanese as evidence-based education. Actually, 'eat lightly-seasoned foods', 'use less soy-sauce and other salty condiment', and 'do not consume too much salty foods such as miso-soup and pickled (salted) foods' have been habitually used as practical messages to reduce salt intake in the clinical and educational settings. In addition, these messages have been turned into questions and commonly used to briefly grasp dietary habits leading to excess salt intake in these settings. However, unexpectedly, few studies confirmed whether these conventional questions are actually related to salt intake.

Here, we investigated the relationship of simple questions regarding dietary knowledge/behaviors related to sodium intake with sodium excretion measured by 24-hour urine collection which is considered a standard method to estimate sodium intake. We also aimed to discuss potential usefulness of these simple questions as educational tools for excess salt intake.

MATERIALS AND METHODS

Study subjects

The targeted population was 800 apparently healthy men and women aged 20-69 years from 20 areas of Japan. In each of these areas, we recruited 10 staff dietitians from local welfare facilities who agreed to participate in the study as study dietitians. These study dietitians then recruited their co-workers as study subjects. To ensure the uniformity of sex and age distribution between study areas, recruitment was managed such that each area included 8 subjects (4 men and 4 women) from each of five 10-year age groups (20-29, 30-39, 40-49, 50-59, and 60-69 years). Subject recruitment, study procedure and schedule are described in detail elsewhere.[9] Subjects were individually informed of the study objective and procedure by the study dietitians using oral explanation and detailed documents. A total of 791 subjects submitted written informed consent and participated in the study. The study was conducted from February to March 2013 in accordance with the guidelines laid down in the Declaration of Helsinki, and all procedures involving human subjects were approved by the Ethics Committee of the University of Tokyo, Faculty of Medicine (approval no. 10005, 7 January 2013).

Twenty-four-hour urine collection

Two non-consecutive 24-hour urine collections were conducted during the study period, scheduled according to subject convenience. At the start time of collection, subjects were asked to excrete and discard urine. They were then asked to collect all subsequent urine until the finish time of collection the next day. As a final collection, they were asked to excrete and collect the last urine at the same time that the first urine had been discarded the previous day. Subjects recorded the start and finish times of urine collection. They also approximated and recorded the volume of any urine they failed to collect. This approximated volume was added to the collected urine volume, and the total was then used to calculate the adjusted 24-hour urinary volume based on the recorded start and finish times. This adjustment method has been validated using the para-aminobenzoic acid (PABA) check method.[13] After collection, a portion of the urine was refrigerated in the dark until transfer to the analyzing laboratory (LSI Medience Corporation, Tokyo, Japan). Urinary sodium and potassium concentrations were analyzed using the electrode method, and urinary creatinine concentration was analyzed using the enzyme method. Twenty-four-hour urinary excretion was calculated as urinary excretion (mmol/day) = urinary concentration (mmol/L) × adjusted 24-hour urinary volume (L). The completeness of the 24-hour urine collection was evaluated with Joossen's criteria: when observed creatinine excretion was between 60% and 140% of the expected amount, the collection was regarded as appropriate.[14]

Questionnaire about dietary behavior

The dietary knowledge/behavior of subjects was investigated by a self-administered questionnaire. We categorized 15 questions into the four groups of 'Salt intake behavior', 'Knowledge about salt', 'Food label use', and 'Food preparation'. Details of the questionnaire are shown in Table 1.

Questions in the category of 'Salt intake behavior' asked about dietary habits or behaviors which were directly related to salt intake. These dietary behaviors were deemed to cause high salt intake. Moreover, these behaviors might have arisen from the subjects' preference for salty foods.[15] Regarding noodle soup, proportion of consumed noodle soup (not consumption frequency) was asked, because more than 95% of participants in this study habitually have noodle with soup once or more times per week (data not shown). In addition, medical or public health professional in Japan often encourage people to eat less noodle soup (but, sometimes they do not encourage to reduce frequency of noodle with soup consumption), but effectiveness of this message had not been confirmed yet. In the 'Knowledge about salt' group, subjects were asked to answer whether they had knowledge about foods with a high salt content and diseases which were potentially induced by excess salt intake. Further, 'Food label use' was considered a health-conscious behavior based on appropriate dietary knowledge and preference for healthy diet.[16] We asked them about their habitual food label use for both general nutritional information (energy, carbohydrate, protein, and total fat) and salt/sodium content. Lastly, in the 'Food preparation' group, the answers for these questions might have partially reflected the subjects' dietary environment and whether they were accustomed to cooking.[17,18]

These questions were selected from several prior studies and two validated diet assessment questionnaires, the self-administered Dietary History Questionnaire (DHQ) and Brief-type self-administered Dietary History Questionnaire (BDHQ).[19-22]

Table 1. Summary of questionnaire about dietary knowledge/behaviors

Category	Question	Response
1) Salt intake behavior		
Degree of salty food intake		
1. Frequency of miso soup consumption	How many bowls of miso soup do you eat in a day?	<1, 1, 2≤ bowls
2. Proportion of consumed noodle soup	How much soup do you eat when you eat noodles with soup?	0-39%, 40-79%, 80-100%
3. Frequency of salty foods consumption†	How many times do you eat salty foods (salt 4g or more/ food 100g)in a week?	<3, 3-6, 7≤ times
4. Awareness of saltiness of home-made dishes	Are foods cooked at home saltier than those served in restaurants?	Less salty, similar, salty
Discretionary salt use		
5. Frequency of seasoning/condiment use	How often do you use seasonings/condiments to foods at the table?	Never or rarely, sometimes, often
6. Amount of seasoning/condiment use	How much seasonings/condiments do you add to foods at the table?	Little, moderate, much
2) Knowledge about salt		
7. Salty foods	Do you have knowledge about foods with high salt content?	A few, some, several or many
8. Diseases induced by excess intake of salt‡	Check all diseases which are induced by excess intake of salt.	≤4, 5, 6, 7≤ correct answers
3) Food label use		
Checking food label		
9. Checking food labels while shopping	Do you check food labels while shopping?	Rarely, sometimes, often or always
10. Checking salt/sodium content	Do you check salt/sodium content on food labels while shopping?	Rarely, sometimes, often or always
Food choice based on food label information		
11. Influence of food label information on purchase	Do you choose foods by food label information?	Rarely, sometimes, often or always
12. Influence of salt/sodium content on purchase	Do you decide to purchase foods or not by salt/sodium content?	Rarely, sometimes, often or always
4) Food preparation		
13. Daily food purchase	Do you purchase daily foods by yourself?	Rarely, sometimes, often, always
14. Cooking at home	How many times do you cook at home per week?	≤1, 2-3, 4-5, 6≤ times
15. Dining out	How many times do you eat out per week?	<1, 1-3, 4-7≤ times

†Salty foods (4 g salt or more /100 g foods) include fish roe, *tsukudani* (foods boiled with soy sauce and sugar), *shiokara* (salted fish guts), *umeboshi* (salted Japanese apricots), and pickled vegetables (pickled with salt).
‡Diseases included in choices are hypertension, hyperlipidemia, diabetes, renal dysfunction, heart failure, liver dysfunction, stomach cancer, and lung cancer. Hypertension, renal dysfunction, heart failure, and stomach cancer are classified as 'induced diseases'. The number of diseases with correct classifying was counted.

Other measurements

Body height and weight were measured to the nearest 0.1 cm and 0.1 kg, respectively, while wearing light clothes without shoes. Body mass index (BMI) was calculated as weight (kg) divided by the square of body height (m). Blood pressure was measured twice and mean systolic and diastolic blood pressures were calculated. Demographic and social characteristics were investigated by questionnaire.

Statistical analysis

Before analysis, we excluded those who failed the two 24-h urine collections (n=31), those with an inappropriate intervals of urine collection (<3 d; n=8), those who reported using diuretics (n=7), and those with renal dysfunction (n=3), leaving 742 subjects (n=370 in men and n=372 in women) for analysis. Subjects who did not answer particular questions of the questionnaire about dietary knowledge/behavior were excluded from any analyses concerning that question.

We carried out univariate and multivariate linear regression analysis to examine the relationship between the dietary knowledge/behaviors and 24-hour sodium excretion. As sodium excretions significantly differ between men and women, subsequent analyses were performed with stratification by sex. We included sodium excretion in the models as the dependent variable and each questioned dietary knowledge/behavioras an independent variable. Linear trends were examined by assigning responses to each question with a sequential integer in the order of the lowest to highest response category (e.g. rarely=1, sometimes=2, and often/always=3 for questions included in 'food label use'). We included age, BMI, and surrogate variables for socioeconomic status (education and smoking status)[23-26] in the model as possible confounders. We established crude and two adjusted models (Model 1 and Model 2) to examine linear trends. Model 1 was adjusted for age (continuous), and Model 2 for age (continuous), BMI (continuous), education (university education and equivalent or not), and smoking status (current, former, or non-smoker). We then estimated the adjusted mean of sodium excretion for each response category in all models.

Regarding dietary behaviors significantly associated with sodium excretion in both sexes, we additionally performed multivariate logistic regression analysis and then calculated adjusted odds ratios for higher sodium intake (>136 mmol/day (=8 g/day of salt) of daily sodium excretion) to examine whether combinations of 'high-risk' behavior additively or synergistically increase a risk of excess salt intake. Combinations of categories for two dietary behaviors were included in the model as dummy variables, and sex, age, BMI, education, and smoking status were included as covariates. Adjusted odds ratios were then calculated for each combination using the combination of two lowest categories as a reference. To secure enough participants in all combinations of categories, we did not stratify the subjects by sex. Interaction between sex and four dietary behaviors selected for this analysis was not observed. *P* values <0.05 were considered statistically significant. All statistical analyses were conducted using SAS (version 9.3, SAS Institute Inc, Cary, NC, USA).

Table 2. Characteristics of study participants (n=742)

	Men (n=370) Mean±SD, or n (%)	Women (n=372) Mean±SD, or n (%)	All (n=742) Mean±SD, or n (%)
Age (year)	44±13	45±13	44±13
Age distribution, n (%)			
20-29	75 (20)	71 (19)	146 (20)
30-39	82 (22)	76 (20)	158 (21)
40-49	76 (21)	77 (21)	153 (21)
50-59	70 (19)	73 (20)	143 (19)
60-69	66 (18)	75 (20)	141 (19)
Body height (cm)	170±5.8	157±5.4	164±8.5
Body weight (kg)	69.2±11.0	55.8±9.4	62.5±12.2
Body mass index (kg/m^2)	23.9±3.4	22.5±3.5	23.2±3.5
24-hour urine collection			
Volume (ml/day)	1,707±655	1,543±553	1,625±611
Sodium excretion (mmol/day)	206±63.6	174±54.1	190±61.2
Potassium excretion (mmol/day)	51.6±15.5	47.2±14.7	49.4±15.3
Creatinine excretion (mmol/day)	13.3±2.5	8.7±1.7	11.0±3.1
Educational status, n (%)			
University education or equivalent	178 (48.1)	64 (17.2)	242 (32.6)
Others	192 (51.9)	308 (82.8)	500 (67.4)
Smoking status, n (%)			
Current smoker	128 (34.6)	51 (13.7)	179 (24.1)
Former smoker	124 (33.5)	38 (10.2)	162 (21.8)
Non smoker	118 (31.9)	283 (76.1)	401 (54.0)
Blood pressure (mmHg)			
Systolic	127±14.0	120±15.8	123±15.4
Diastolic	79.9±11.4	75.9±10.6	77.9±11.1
Past history or current treatment, n (%)			
Hypertension	57 (15.4)	36 (9.7)	93 (12.5)
Hyperlipidemia	29 (7.8)	32 (8.6)	61 (8.2)
Diabetes mellitus	17 (4.6)	7 (1.9)	24 (3.2)

RESULTS

Subject characteristics are shown in Table 2. Population mean of 24-hour urinary sodium excretion was 206 mmol/day in men and 174 mmol/day in women. After the exclusions of participants, age and sex distributions were well balanced.

Multivariate linear regression analyses of the relationships of dietary knowledge/behaviors with urinary sodium excretion in men and women are described in Table 3. Regarding 'salt intake behavior' in men, higher sodium excretion was significantly associated with frequency of miso soup and salty foods consumption, and the proportion of consumed noodle soup (*p* for trend ≤0.03 in all models), as well as more frequent and higher amount of discretionary seasoning/condiment use (*p* for trend ≤0.04 in all models). However, a significant relationship was not observed between sodium excretion and the awareness of saltiness of home-made dishes even after adjustment for covariates (*p* for trend ≥0.44 in all models). In women, higher sodium excretion was significantly associated with frequency of miso soup and salty foods consumption regardless of adjustment for covariates (*p* for trend <0.02 in all models), while the relationships with proportion of consumed noodle soup and amount of seasoning/condiment used were marginal after adjustment for all covariates (*p* for trend=0.06 in Model 2 for these two behaviors). In contrast to for men, awareness of the saltiness of home-made dishes in women was significantly associated with higher sodium excretion (*p* for trend ≤0.03 in all models), and the frequency of seasoning/condiment use was not (*p* for trend ≥0.32 in all models).

In the 'knowledge about salt' group, no significant relationships were found in either sex regardless of adjustment for covariates (*p* for trend ≥0.22, and ≥0.16 in all questions and models for men and women, respectively).

Regarding 'food label use', women sometimes (40%) and often/always (33%) checked food labels for general nutrients more frequently than men (sometimes, 29%; and often/always, 11%). However, a smaller percentage of men and women sometimes (10% in men and 24% in women) and often/always (6% in men and 9% in women) checked salt/sodium content on food labels. Moreover, only 20% of the study population sometimes and often/always decided to purchase foods with reference to salt/sodium content information (Sometimes: 6% of men and 20% of women; Often/always: 6% of men and 8% of women; in total, 20% of study population). Checking food labels was not associated with sodium excretion in either sex regardless of whether or not the labeled information was about salt/sodium. However, the sodium excretion of subjects who were more influenced by food labeling about salt/sodium content on purchase was significantly lower after adjustment for covariates in women (*p* for trend=0.03 in Model 2), but not in men (*p* for trend=0.35 in Model 2).

Around 70% of women always purchased foods and 65% of women cooked at home six or more times per week. In contrast, 14% of men always purchased foods, and 7% of men cooked at home six or more times per week. No behaviors included in 'food preparation' were significantly associated with sodium excretion in men or women regardless of adjustment for covariates.

Since four dietary behaviors (frequency of miso soup and salty foods consumption, proportion of consumed noodle soup, and amount of seasoning/condiment use) were associated with sodium excretion in both sexes, we then performed multivariate logistic regression analysis including these dietary behaviors. Combinations of high-risk dietary behaviors and adjusted odds ratios are shown in Table 4. In all combinations of dietary behaviors, each behavior independently increased the risk of higher sodium intake (>136 mmol/day of sodium excretion) and their additive effect was also observed. In other words, the risk of excess sodium intake was elevated when participants have several 'high risk' behaviors at the same time.

DISCUSSION

We investigated the relationship of dietary knowledge/behaviors related to salt intake with 24-hour urinary sodium excretion. Higher frequency of salty food consumption and greater and more frequent discretionary seasonings/condiments use were associated with higher sodium excretion in men, and were marginally related in women. These 'high-risk' dietary behaviors actually increased the risk of higher sodium intake, which was defined by sodium excretion of >136 mmol/day. The degree of knowledge about salty foods and diseases induced by excess intake of salt were not associated with sodium excretion. Only 8% of female participants often/always decided whether to buy a certain food based on label information about salt/sodium content, and these women had significantly lower sodium excretion than other women. Our results suggested that these questions about salt intake behaviors are useful for health professionals to briefly assess the behavior relating to excess salt intake, and these behaviors can be good targets for use in salt reduction programs. In addition, using salt/sodium information on food label for purchasing foods might be a marker of knowledge and attitude toward salt reduction in the Japanese female population. Encouragement for food choice based on food label about salt/sodium content may become a good means to improve dietary knowledge, attitude, and behavior toward salt reduction.

Frequency of salty food consumption and higher amount of discretionary seasonings/condiments use were associated with higher sodium excretion, suggesting that specific suggestions to reduce salty food intake might be useful to reduce salt intake. On the other hand, efforts to reduce salt intake should therefore begin with knowledge about the salt content of frequently consumed foods. The INTERMAP study showed that the major sources of salt intake in Japan are soy sauce, salted vegetables, miso soup, fish, other soup, and salt added to cooked or restaurant meals.[12] However, the degree of knowledge about salty foods and about diseases related to excess salt intake was not associated with sodium excretion in either men or women. One possible reason was that the question which assessed the degree of knowledge about salty foods merely asked the subject about his or herself-impression of their knowledge, and did not ask about specific knowledge of salty foods. In addition, the relationship between better knowledge and health-conscious behaviour might be modified by preference for salty taste.[15] It is

Table 3. The linear relationship between dietary behaviors related to salt intake and 24-hour urinary sodium excretion (mmol/day) in Japanese men (n=370) and women (n=372)

	Men (n=370)				Women (n=372)			
	n (%)	Crude	Model 1†	Model 2‡	n (%)	Crude	Model 1†	Model 2‡
		Mean±SE	Adjusted mean±SE	Adjusted mean±SE		Mean±SE	Adjusted mean±SE	Adjusted mean±SE
1) Salt intake behavior								
Salty food intake								
1. Frequency of miso-soup consumption (bowls/day)		p=0.001	p=0.002	p<0.001		p=0.02	p=0.001	p=0.01
<1	84 (23)	191±6.9	192±6.9	192±6.7	115 (31)	166±5.1	165±5.0	160±5.8
1	140 (38)	203±5.3	203±5.3	202±5.2	152 (41)	173±4.4	175±4.3	170±5.6
2 ≤	146 (39)	218±5.2	218±5.2	219±5.0	105 (28)	183±5.3	183±5.2	177±5.9
2. Proportion of consumed noodle soup§		p=0.003	p=0.005	p=0.03		p=0.02	p=0.03	p=0.06
0-39%	83 (22)	195±6.9	195±6.9	198±6.7	177 (48)	168±4.0	169±4.0	164±5.2
40-79%	103 (28)	198±6.2	199±6.2	200±6.0	121 (32)	175±4.9	175±4.9	169±5.9
80-100%	183 (50)	217±4.6	217±4.7	215±4.5	74 (20)	187±6.3	185±6.2	177±6.7
3. Frequency of salty foods consumption¶ (times/week)		p=0.003	p=0.006	p<0.001		p<0.001	p<0.001	p<0.001
<3	175 (48)	200±4.7	200±4.9	198±4.6	183 (49)	158±3.8	160±3.9	156±5.1
3-6	93 (25)	201±6.5	201±6.5	200±6.2	92 (24)	184±5.4	183±5.4	176±6.2
7≤	101 (27)	225±6.2	224±6.5	228±6.2	97 (26)	194±5.3	192±5.4	185±6.1
4. Awareness of saltiness of home-made dishes††		p=0.54	p=0.49	p=0.44		p=0.03	p=0.01	p=0.01
Less salty	235 (64)	206±4.1	206±4.1	207±4.0	221 (59)	170±3.6	170±3.6	164±4.8
Similar	96 (26)	204±6.5	204±6.5	200±6.3	106 (29)	174±5.2	175±5.2	172±6.3
Salty	38 (10)	217±10.3	217±10.3	224±10.1	45 (12)	192±8.0	192±7.9	185±8.1
Discretionary salt use								
5. Frequency of seasonings/condiments use		p=0.005	p=0.007	p<0.001		p=0.32	p=0.37	p=0.64
Never or rarely	64 (17)	200±7.8	200±7.8	197±7.5	86 (23)	176±5.8	176±5.8	174±6.3
Sometimes	135 (37)	195±5.4	195±5.4	195±5.1	171 (46)	167±4.1	168±4.1	162±5.2
Often	170 (46)	219±4.8	219±4.8	220±4.6	115 (31)	182±5.0	182±5.0	175±6.0
6. Amount of seasonings/condiments use		p=0.04	p=0.03	p=0.04		p=0.04	p=0.02	p=0.06
Little	110 (30)	199±6.0	198±6.0	199±5.8	156 (42)	169±4.3	167±4.3	164±5.3
Moderate	206 (56)	207±4.4	208±4.4	208±4.2	194 (52)	176±3.9	177±3.8	170±5.2
Much	53 (14)	221±8.7	221±8.7	219±8.4	22 (6)	194±11.5	193±11.4	188±11.2

p-values (are for trend) <0.05 is considered statistically significant.
†Multi-variable regression analysis adjusted for age (years, continuous).
‡Multi-variable regression analysis adjusted for age (years, continuous), body mass index (kg/m^2, continuous), education (university education and equivalent, or not), and smoking status (current, former, or never).
§Proportion of consumed noodle soup when participants eat noodles with soup.
¶Salty foods (4 g salt or more/100 g foods) include fish roe, *tsukudani* (foods boiled with soy sauce and sugar), *shiokara* (salted fish guts), *umeboshi* (salted Japanese apricots), and pickled vegetables (pickled with salt).
††Comparison with restaurant dish.
‡‡Diseases included in choices were hypertension, hyperlipidemia, diabetes, renal dysfunction, heart failure, liver dysfunction, stomach cancer, and lung cancer. Hypertension, renal dysfunction, heart failure, and stomach cancer are classified as induced diseases. Correct classification of disease produced a score.

Table 3. The linear relationship between dietary behaviors related to salt intake and 24-hour urinary sodium excretion (mmol/day) in Japanese men (n=370) and women (n=372) (cont.)

	Men (n=370)				Women (n=372)			
	n (%)	Crude	Model 1†	Model 2‡	n (%)	Crude	Model 1†	Model 2‡
		Mean±SE	Adjusted mean±SE	Adjusted mean±SE		Mean±SE	Adjusted mean±SE	Adjusted mean±SE
2) Knowledge about salt								
7. Salty foods		*p*=0.22	*p*=0.32	*p*=0.40		*p*=0.36	*p*=0.95	*p*=0.55
A few	95 (26)	212±6.4	213±6.5	213±6.3	31 (8)	177±9.7	183±9.8	175±9.9
Some	206 (56)	196±4.4	196±4.4	197±4.2	177 (48)	169±4.1	170±4.0	163±5.3
Several or many	68 (18)	229±7.6	228±7.6	225±7.4	162 (44)	178±4.2	176±4.3	172±5.4
8. Diseases induced by excess intake of salt‡‡		*p*=0.59	*p*=0.44	*p*=0.78		*p*=0.24	*p*=0.48	*p*=0.16
≤4 correct answers	69 (19)	208±7.7	209±7.7	207±7.5	46 (12)	171±8.0	173±8.0	168±8.4
5 correct answers	97 (26)	207±6.5	207±6.5	206±6.2	99 (27)	170±5.5	170±5.4	163±6.1
6 correct answers	109 (29)	209±6.1	209±6.1	209±5.9	90 (24)	174±5.7	174±5.7	168±6.2
7≤ correct answers	95 (26)	202±6.5	201±6.6	204±6.3	137 (37)	178±4.6	177±4.6	175±5.8
3) Food label use								
Checking food label								
9. Checking food labels while shopping		*p*=0.51	*p*=0.44	*p*=0.71		*p*=0.70	*p*=0.56	*p*=0.86
Rarely	221 (60)	205±4.3	205±4.3	206±4.1	99 (27)	172±5.4	173±5.4	167±6.4
Sometimes	105 (29)	205±6.2	205±6.2	205±6.0	151 (40)	178±4.4	178±4.4	170±5.4
Often or always	42 (11)	215±9.8	216±9.9	212±9.6	121 (33)	170±4.9	169±4.9	167±5.8
10. Checking salt/sodium content		*p*=0.73	*p*=0.69	*p*=0.90		*p*=0.53	*p*=0.28	*p*=0.22
Rarely	310 (84)	206±3.6	206±3.6	207±3.5	250 (67)	175±3.4	176±3.4	171±4.8
Sometimes	36 (10)	204±10.6	205±10.6	200±10.3	90 (24)	170±5.7	169±5.7	161±6.5
Often or always	22 (6)	213±13.6	214±13.6	213±13.1	32 (9)	173±9.6	170±9.5	167±9.4
Food choice based on food label information								
11. Influence of food label information on purchase		*p*=0.79	*p*=0.69	*p*=0.86		*p*=0.61	*p*=0.45	*p*=0.62
Rarely	245 (66)	206±4.1	205±4.1	206±3.9	130 (35)	176±4.8	177±4.7	170±5.7
Sometimes	87 (24)	207±6.9	208±6.8	205±6.6	136 (37)	173±4.7	173±4.6	168±5.6
Often or always	36 (10)	208±10.6	209±10.7	209±10.3	105 (28)	172±5.3	172±5.3	167±6.1
12. Influence of salt/sodium content on purchase		*p*=0.25	*p*=0.24	*p*=0.35		*p*=0.08	*p*=0.03	*p*=0.03
Rarely	324 (88)	205±3.5	205±3.5	205±3.4	267 (72)	176±3.3	176±3.3	172±4.7
Sometimes	23 (6)	220±13.3	219±13.3	214±12.9	75 (20)	176±6.2	175±6.2	166±7.0
Often or always	21 (6)	216±13.9	217±13.9	216±13.4	29 (8)	152±10.0	147±10.0	150±9.8

p-values (are for trend) <0.05 is considered statistically significant.
†Multi-variable regression analysis adjusted for age (years, continuous).
‡Multi-variable regression analysis adjusted for age (years, continuous), body mass index (kg/m^2, continuous), education (university education and equivalent, or not), and smoking status (current, former, or never).
§Proportion of consumed noodle soup when participants eat noodles with soup.
¶Salty foods (4 g salt or more/100 g foods) include fish roe, *tsukudani* (foods boiled with soy sauce and sugar), *shiokara* (salted fish guts), *umeboshi* (salted Japanese apricots), and pickled vegetables (pickled with salt).
††Comparison with restaurant dish.
‡‡Diseases included in choices were hypertension, hyperlipidemia, diabetes, renal dysfunction, heart failure, liver dysfunction, stomach cancer, and lung cancer. Hypertension, renal dysfunction, heart failure, and stomach cancer are classified as induced diseases. Correct classification of disease produced a score.

Table 3. The linear relationship between dietary behaviors related to salt intake and 24-hour urinary sodium excretion (mmol/day) in Japanese men (n=370) and women (n=372) (cont.)

	Men (n=370)				Women (n=372)			
	n (%)	Crude	Model 1†	Model 2‡	n (%)	Crude	Model 1†	Model 2‡
		Mean±SE	Adjusted mean±SE	Adjusted mean±SE		Mean±SE	Adjusted mean±SE	Adjusted mean±SE
4) Food preparation								
13. Daily food purchase		*p*=0.28	*p*=0.38	*p*=0.17		*p*=0.78	*p*=0.31	*p*=0.44
Rarely	145 (39)	217±5.2	216±5.3	218±5.1	16 (4)	176±13.6	184±13.6	183±13.4
Sometimes	103 (28)	192±6.2	192±6.2	195±6.0	51 (14)	168±7.6	176±7.9	164±8.2
Often	69 (19)	202±7.6	203±7.7	198±7.4	40 (11)	180±8.6	185±8.6	180±8.6
Always	53 (14)	211±8.7	211±8.7	210±8.3	264 (71)	174±3.3	171±3.4	167±4.8
14. Cooking at home (times/week)		*p*=0.80	*p*=0.88	*p*=0.53		*p*=0.69	*p*=0.21	*p*=0.44
≤1	254 (69)	207±4.0	207±4.0	209±3.9	43 (12)	161±8.2	172±8.7	165±9.5
2-3	60 (16)	207±8.2	208±8.3	202±8.0	40 (11)	178±8.5	186±8.7	179±8.9
4-5	30 (8)	199±11.7	201±11.8	199±11.3	46 (12)	192±7.9	195±7.8	180±9.2
6≤	24 (7)	209±13.0	208±13.0	208±12.5	243 (65)	172±3.4	168±3.6	165±4.8
15. Dining out (times/week)		*p*=0.95	*p*=0.99	*p*=0.61		*p*=0.92	*p*=0.39	*p*=0.89
<1	126 (34)	209±5.6	208±5.7	210±5.5	155 (42)	173±4.4	170±4.4	168±5.5
1-3	130 (35)	203±5.6	204±5.6	204±5.4	140 (38)	176±4.6	178±4.6	172±5.7
4-7≤	113 (31)	208±6.0	209±6.0	207±5.7	77 (20)	172±6.2	175±6.1	165±6.7

p-values (are for trend) <0.05 is considered statistically significant.
†Multi-variable regression analysis adjusted for age (years, continuous).
‡Multi-variable regression analysis adjusted for age (years, continuous), body mass index (kg/m^2, continuous), education (university education and equivalent, or not), and smoking status (current, former, or never).
§Proportion of consumed noodle soup when participants eat noodles with soup.
¶Salty foods (4 g salt or more/100 g foods) include fish roe, *tsukudani* (foods boiled with soy sauce and sugar), *shiokara* (salted fish guts), *umeboshi* (salted Japanese apricots), and pickled vegetables (pickled with salt).
††Comparison with restaurant dish.
‡‡Diseases included in choices were hypertension, hyperlipidemia, diabetes, renal dysfunction, heart failure, liver dysfunction, stomach cancer, and lung cancer. Hypertension, renal dysfunction, heart failure, and stomach cancer are classified as induced diseases. Correct classification of disease produced a score.

Table 4. Adjusted odds ratio and 95% confidence interval for high sodium intake in different condition defined by combination of high risk dietary behaviors in Japanese adults (n=742).

	Frequency of miso soup consumption† (bowls/day)			Frequency of salty foods consumption‡ (times/day)		
	1<	1	2≤	< 3	3-6	7 ≤
Frequency of salty foods consumption‡ (times/week)						
<3	Reference (n=84/117)§	1.38 (0.75,2.56) (n=103/134)	2.10 (1.07,4.23)* (n =88/107)			
3-6	1.98 (0.83,5.16) (n=41/49)	2.10 (0.99,4.63) (n=66/79)	4.52 (1.60,16.3)* (n =53/57)			
7 ≤	4.83 (1.48,21.9)* (n=30/33)	2.53 (1.16,5.85)* (n =68/79)	3.41 (1.47,8.75)* (n=78/86)			
Proportion of consumed noodle soup¶						
0-39%	Reference (n=62/87)	1.01 (0.52,1.95) (n=73/105)	3.26 (1.36,8.55)* (n=60/68)	Reference (n=89/129)	1.64 (0.79,3.56) (n=52/65)	1.77 (0.83,3.98) (n=54/66)
40-79%	1.20 (0.55,2.70) (n=49/63)	2.14 (1.01,4.72)* (n =80/94)	1.69 (0.75,3.96) (n=55/67)	1.14 (0.62,2.08) (n=89/117)	3.47 (1.34,10.9)* (n=52/57)	2.48 (1.04,6.64)* (n=43/50)
80-100%	2.36 (0.86,7.70) (n=44/49)	2.38 (1.01,5.98)* (n =84/93)	2.55 (1.14,6.01)* (n=104/115)	1.76 (0.89,3.63) (n=97/112)	2.09 (0.86,5.68) (n=56/63)	7.24 (2.35,31.9)* (n=79/82)
Amount of seasoning/condiment use††						
Little	Reference (n=62/85)	1.07 (0.53,2.14) (n=72/99)	1.94 (0.89,4.37) (n=68/82)	Reference (n=101/138)	0.88 (0.42,1.87) (n=43/59)	1.74 (0.80,3.99) (n=58/69)
Moderate	1.67 (0.80,3.51) (n=82/101)	2.18 (1.09,4.35)* (n=137/162)	2.37 (1.13,5.05)* (n=120/137)	1.13 (0.65,1.95) (n =144/187)	4.37 (1.91,11.4)* (n=100/107)	2.68 (1.28,6.02)* (n=95/106)
Much	1.19 (0.26,8.56) (n=11/13)	2.51 (0.73,11.8) (n=28/31)	Infinity‡‡(5.33,infinity)* (n=31/31)	2.59 (0.81,11.6) (n=30/33)	2.16 (0.51,15.1) (n=17/19)	Infinity‡‡ (2.58,infinity)* (n=23/23)

†Number of bowls of miso soup consumed in a day.
‡Salty foods (4 g salt or more /100 g foods) include fish roe, *tsukudani* (foods boiled with soy sauce and sugar), *shiokara* (salted fish guts), *umeboshi* (salted Japanese apricots), and pickled vegetables (pickled with salt).
§Number of participants is indicated as '(n=participants with high sodium intake/ all participants in that category)'.
¶Proportion of consumed noodle soup when participants eat noodles with soup.
††Amount of seasoning/condiment participants add to food at table.
‡‡Odds ratio could not be calculated and approached infinity because daily sodium excretion of all participants in these category was ≥136 mmol/day.
* $p<0.05$ (based on profile likelihood-based 95% confidence interval). Adjusted odds ratio and 95% confidence interval for high sodium intake (≥136 mmol/day of sodium excretion) were calculated by logistic regression model included age (year, continuous), sex (men or women), body mass index (kg/m^2, continuous), education (university education and equivalent, or not, categorical), and smoking status (current, former, or never smoker, categorical) as covariates.

also possible that the subjects had knowledge about salty foods but were unable to link that knowledge to how to reduce salt intake practically in daily life. If so, specific behavioral recommendations (e.g. 'reduce miso soup intake' or 'do not use soy sauce at the table') might be effective. Although the relationship between knowledge and sodium excretion remains unclear, our results suggested that specific behavioral suggestions for salt reduction might be useful, and better than food education limited to the salt contents of daily foods.

On the other hand, habitual food choice by reference to salt/sodium information on the food label was associated with low sodium excretion in women, suggesting not only knowledge but also attitude might indirectly contribute to salt reduction by supporting better behavior. In this study, only 6% of men and 8% of women often/always purchased foods using label information on salt content. This proportion is markedly lower than that reported in other countries.[16,27-29] According to study done by Okuda et al, this low percentage of label use might be as the result of having insufficient practical knowledge/attitude toward salt and its reduction.[30] Okuda et al reported that although subjects were interested in food education, only 25.5% could convert 1,000 mg of sodium to the correct saltequivalent.[30] In Japan, labeling of nutritional information for processed foods is not mandatory, and the label must show sodium content, not salt, even when food labeling is provided. Nevertheless, women in the present study who often/always choose foods using the salt content information on food labels excreted less sodium than other women. As Grimes et al showed, subjects who have intention to reduce dietary salt tend to look at the food labels and then purchase the foods,[16] our results suggested women who use sodium information on the label may have practical knowledge (e.g. necessity of salt reduction, to see information about 'sodium' content on the label for 'salt' reduction) and a positive attitude toward salt reduction. In other words, questions about food label use for salt/sodium content might be useful to briefly assess whether they have sufficient practical knowledge/attitude for salt reduction. Furthermore, if these practical knowledge and attitudes were greater in women than in men, promoting salt reduction in women would have a potential to reduce the salt intake of men and children cohabitating with them. Women often take the role of preparing and cooking meals for their family, and other family members might also be able to reduce and maintain a low salt intake.

Our results are consistent with an earlier study in Japan which showed a positive relationship between self-reported frequency of salty food intake and daily sodium excretion estimated with spot urine method.[31]Many studies have investigated knowledge, attitudes, and behavior concerning salt intake.[19,27,28,32] However, the study done by Land et al only evaluated these relationships using salt intake, as measured by 24-hour urine collection.[32]Our results were consistent with their results since the degree of knowledge about salt intake was not associated with sodium excretion.[32]

Our study had several strengths. First, we evaluated individual salt intake by measuring two 24-hour urinary sodium excretions. Since two urine collections corrected a within-individual variation of sodium excretion, the value of 'sodium excretion' in this study reflected habitual intake more precisely than studies using single urine collection. Sodium loss due to sweating was likely minimized because the survey was conducted during the winter, which might have helped increase the accuracy of sodium excretion measurement. Second, sample size was large compared with similar studies using 24-hour urine collections.[15,32] We were able to investigate differences in dietary behavior and their association with sodium excretion in detail, because each response category for the questions included sufficient participants for analysis. Finally, similar numbers of men and women were recruited from a wide range of age categories (20s-60s) and study areas (23 of 47 prefectures in Japan). Our study results might therefore be widely useful in the development of salt reduction strategies for Japanese adult populations.

Several limitations of our study also warrant mention. First, recruitment was not via a random sampling of the Japanese population. Although the study protocol included two 24-h urine collections, response rate was high (86.7%).[9] This suggested that our study population might have been more cooperative and health-conscious than the general population. Nevertheless, our study population had similar characteristics to a representative population of Japan, as mentioned in our previous study.[9] Second, we included participants with disease conditions or under medication. This might have caused under- or overestimation of sodium excretion. Notwithstanding this, they were sufficiently healthy to work in welfare facilities. Moreover, measured sodium excretion remained consistent even when we excluded subjects with complications or taking medicines.[9] Third, due to the nature of cross-sectional study, we were unable to detect sufficient causality between dietary knowledge/behavior and sodium excretion. It is possible that subjects with higher sodium intake tend to suffer from hypertension and accordingly receive more nutrition education about sodium intake. If so, subjects with higher sodium intake would have more knowledge about sodium and other nutrients, which would have in turn attenuated the likely relationship between higher nutrition knowledge and lower sodium intake. Therefore, even if there was reverse causality, it is safe to say that the relationship observed in this study definitely existed. Fourth, there are no general methods for evaluating dietary knowledge and behaviors about salt.[33] Therefore, we adopted questions from earlier studies as well as parts of a validated dietary history questionnaire to allow comparison with other studies,[19-22] albeit that the validity of the questionnaire was not confirmed. Lastly, we cannot deny the possibility of other potential confounders which were not considered in this study despite our adoption of confounders in accordance with several earlier studies.[23-26]

In conclusion, high-risk behaviors toward excess salt intake captured by the conventional simple questions were actually related to excess salt intake. Specific and practical advice based on answers for these questions might contribute to salt reduction in the Japanese population. The potential of this approach in other Asian countries having similar dietary culture with Japan should be examined. On the other hand, the questionnaire used in this study did not include a sufficient number or type of question to evaluate the impact of dietary environment, behaviors, and attitude on salt intake. Additional studies using more comprehensive questionnaires could shed further light on undiscovered viewpoints to effective education for salt reduction.

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