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Original article

Prediction of high salt and low potassium intake behavior from urinary sodium and potassium excretion in Japan

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Summary. Salt reduction policies have been implemented worldwide and increased potassium intake is also recommended. However, simultaneous investigations of dietary behavior and sodium and/or potassium intake estimated by urinary excretion are sparse. This study aimed to predict high salt and low potassium intake based on dietary behaviors in Japan. The study was comprised of 2627 participants aged 20 to 74 years (Men%: 50%) living in Niigata City, Japan. Participants completed a questionnaire about dietary behaviors potentially relevant to salt and potassium intake. A casual urine specimen for estimating dietary salt and potassium intake per day was collected the same day. The relationship of estimated dietary salt and potassium intake to questionnaire responses was examined using analysis of covariance for age, gender, and body mass index. Twenty-eight items on the questionnaire revealed an association with dietary salt and/or potassium intake and were divided into 4 categories: related to both high salt and low potassium intake, only high salt intake, only low potassium intake, and both high potassium and high salt intake. Identified were 28 dietary behaviors that enabled the prediction of high salt and low potassium intake behavior and provided information for encouraging decreased salt intake and increased potassium intake among Japanese.

Key words: salt intake, potassium intake, dietary behavior, casual urine specimen, Japanese

Introduction

Reduction of dietary salt intake is encouraged throughout the world to prevent hypertension, which is quantitatively the most important risk factor for cardiovascular disease (1): systolic blood pressure above 140 mmHg causes 51% of stroke deaths and 45% of ischemic heart disease deaths (2). Hypertension is more common than other major risk factors, including cigarette smoking, high blood glucose, and dyslipidemia (2). Many countries have salt reduction policies with various goals set for daily salt intake (<5.8 g/d in the United States (3), 6 g/day in United Kingdom (4), and 8.0 g/day in men and 7.0 g/day in women in Japan (5)). Several countries reported the relationships of salt intake to dietary behavior using information from urinary sodium excretion (6-8).

In addition to salt reduction, increasing potassium intake is recommended, such as ≥3510 mg/day by the World Health Organization (9), since supplementation with potassium produces vasodilatation and increases the urinary excretion of sodium chloride (10). To more effectively prevent hypertension, it is necessary to implement nutritional policies and education that would include both reduction of salt intake and increased potassium intake. There has not been evi-

dence of the value of intakes of salt and potassium estimated by urinary excretion. However, there have been several previous randomized controlled trials of the effect of adjustments in both intake of salt and potassium on blood pressure (11).

To provide effective nutrition policies and evaluation systems in preventing hypertension, it is necessary to assess dietary behavior that affects both high salt and low potassium intake and either salt or potassium intake because multiple nutrients are usually ingested with diets that include salt and potassium (12, 13). Intake of food and nutrition is affected by the food environment, such as whether food consumed is from a fast food restaurant, a full-service restaurant, or is homemade (14). Thus, we aimed this study to predict dietary behavior related to high salt and low potassium intake from a simultaneous sampling of urine sodium and potassium excretion among Japan participants.

Methods

The study was comprised of 2627 participants, aged 20 to 74 years, living in Niigata City, Japan, led by a working group in Niigata prefecture that provided data analysis and made policy recommendations to create a nutrition policy and evaluation system. The activities involving the study participants were carried out in November 2015 and 2016. Participants were selected in all districts of Niigata City, including Kita, Akiha, Minami, Higashi, Chuo, Konan, Nishi, and Nishikan. Recruitment of participants was done by a stratified random sampling method to recruit nearly equal numbers of participants into each of the six strata defined by gender (men and women) and age groups (20-39 years, 40-59 years, and 60-74 years) for each of the 8 districts. Call for entry for participation in this survey was made by mail to 8560 people. Of these, 2627 participants (30.7%) were examined at the public health center nearest to his/her residence. The participants consisted of 1302 men and 1325 women (Men%: 49.6%), and number of participants aged 20-39 years, 40-59 years, and 60-74 years were 822, 948, and 857, respectively. Within one day, participants answered a questionnaire on dietary habits, provided a casual urine specimen on the day the questionnaire was collected using a urine receptacle while alone. They also underwent other assessments on the same day. The questionnaire on dietary habits and the urine receptacle were sent by mail at the same time. The protocol for the study was performed in accordance with the Declaration of Helsinki and the Ethical Guidelines for Medical and Health Research Involving Human Subjects of the Japanese Ministry of Health Labor and Welfare, and was approved by the ethics committee of the University of Niigata prefecture (#1406). After providing written informed consent, participants were enrolled in this study.

A casual urine specimen for estimating dietary salt and dietary potassium intake per day among participants was collected from each participant. All specimens were refrigerated at 4°C for 24 hours and frozen at -20°C within 7 days and analyzed at a clinical laboratory center in Niigata City. Na and K studies were conducted by emission flame photometry and Cr by the Jaffé method. Estimated sodium excretion from a casual urine specimen was validated with that of 24-h urinary (24HU) excretion. The obtained formulas for 24-h urinary sodium excretion (24HUNaV) and potassium (24HUKV) excretion were reported as follows (15): (i) PRCr (mg/day) = -2.04 x age + 14.89 x weight (kg) + 16.14 x height (cm) -2244.45; (ii) estimated 24HUNaV (mEq/day) = 21.98 x $XNa^{0.392}$; and (iii) estimated 24HUKV (mEq/day) = 7.59 x $XK^{0.431}$; where PRCr = predicted value of 24HUCr, SUNa = Na concentration in the spot voided urine, SUK = K concentration in the spot voided urine, SUCr = creatinine concentration in the spot voided urine, and XNa (or XK) = SUNa (or SUK)/SUCr x PRCr. These were reported to be useful formulas for estimating population mean levels of 1-day Na and K excretion ($r = 0.54$, $p < 0.01$, and $r = 0.56$, $p < 0.01$, respectively). Estimated 24HUNaV and 24HUKV were calculated to reflect dietary salt and potassium intake, respectively, by the following formula according to their atomic weights: dietary salt intake (g/day) = 24HUNaV (mEq/day)/1000 ÷ 23.3× 58.4, and dietary potassium intake (mg/day) = 24HUKV (mEq /day) ÷ 39.1.

All participants completed a questionnaire on dietary behavior potentially relevant to salt and/or potassium intake. This questionnaire was comprised of 36 questions developed from an empirical perspective

gained from interviews with registered dietitians associated with public administrations or medical services. Construction of the questionnaire and possible responses are shown in Table 2. The questionnaire was based on the frequency of healthy eating behavior (No. 1-5), intake of salty food (No. 6-15), and potassium-rich food (No. 7-9, 15, and 16), as well as behavior related to salt restriction (No. 17-20, 32, 33, and 36) and increased potassium intake (No. 17, 18, 21, 23-30, and 36). The questionnaire also elicited information on the participant's knowledge related to salt restriction (No. 34 and 35) and increased potassium intake (No. 22, 31, and 35). Height and weight of all participants were measured by trained healthcare professionals including doctors, nurses, and dietitians. Accuracy of the entire instrument was provided based on the Japanese Measurement Act.

Participants' characteristics were described as mean ± SD or percentages. Differences in salt and potassium intake between the major characteristics according to gender, age, and body mass index (BMI), household composition, and smoking status were examined by t-tests or linear regression analysis. Multiple linear regression analyses were used for examining the relationships of salt and potassium intake to each answer to the questionnaire regarding dietary behavior potentially relevant to salt and/or potassium intake. Data were then examined after adjustment for gender, age (20-39, 40-59, 60-70 years), BMI (<18.5, 18.5-24.9, ≥ 25.0 kg/m^2), household composition (1 person, 2 persons from 1 generation, 2 generations, >2 generations), and smoking status (Yes, Quit, Never). The associations were presented as linear regression coefficients (B) and p-values. All p-values are two-sided, and the significance level is 0.05. All statistical analyses were carried out using SPSS Statistics 23 (IBM, New York, NY, USA).

Results

Characteristics of participants

Daily salt and potassium intake according to the characteristics of the 2627 participants are shown in Table 1. Participants' mean age was 49.1 years, mean BMI was 22.6 kg/m^2, and 49.6% were men. Mean daily salt intake was 10.0 and 9.5 g in men and women, respectively (p<0.001). Participants with higher salt intake included significantly more men and those of an older age, with a high BMI, and who had quit

Table 1. Characteristics of participants who completed a questionnaire on dietary habits and who underwent spot collection of urine.

		Salt intake (g/day)						Potassium intake (g/day)				
		N	Mean	±	SD	B	p	Mean	±	SD	B	p
Gender	Men	1302	10.0	±	2.4	-	< 0.001	1644.1	±	365.1	-	0.287
	Women	1325	9.5	±	2.2			1659.4	±	374.5		
Age group	20-39 years	822	9.4	±	2.3			1545.4	±	376.7		
	40-59 years	948	10.0	±	2.3	0.2	< 0.001	1651.9	±	358.6	104.2	< 0.001
	60-74 years	857	9.9	±	2.2			1753.9	±	346.4		
Household composition	1 person	195	9.9	±	2.5			1674.9	±	389.8		
	2 persons from 1 generation	545	9.9	±	2.3	-0.1	0.22	1723.2	±	363.0	-31.5	< 0.001
	2 generations	1408	9.7	±	2.3			1625.7	±	364.6		
	>2 generations	479	9.8	±	2.3			1638.2	±	374.7		
BMI	<18.5 kg/m^2	229	8.9	±	2.3			1504.5	±	379.0		
	18.5-24.9 kg/m^2	1872	9.6	±	2.2	0.2	< 0.001	1651.0	±	368.0	95.6	< 0.001
	≥ 25.0 kg/m^2	526	10.6	±	2.3			1718.9	±	354.2		
Smoking	Yes	467	9.9	±	2.4			1603.6	±	356.0		
	Quit	514	10.1	±	2.2	-0.2	0.004	1678.1	±	332.9	19.9	0.032
	Never	1646	9.6	±	2.3			1657.3	±	383.5		

Table 2. Dietary salt intake and responses to the questionnaire on dietary habits potentially relevant to salt and/or potassium intakes

			Sodium intake			
No. Questionnaire items	**Answer**	**n**	**Mean**	**[95% CI]**	**B**	**p**
1. Frequency of alcohol consumption	Daily	524	10.1	[9.8-10.3]		
	5-6 times/week	212	9.8	[9.5-10.1]		
	3-4 times/week	211	9.9	[9.6-10.2]		
	1-2 times/week	257	9.6	[9.4-9.9]	-0.1	0.001
	1-3 times/month	260	9.7	[9.5-10.0]		
	Rarely	560	9.8	[9.6-10.0]		
	Never	603	9.5	[9.3-9.7]		
2. No. meals/day consisting of a staple food, main dish, and side dishes	3 times/day	737	9.6	[9.4-9.8]		
	2 times/day	1027	9.8	[9.7-9.9]	0.1	0.033
	1 time/day	863	9.9	[9.7-10.0]		
3. Makes oneself gorge on a meal	Usually	1345	9.9	[9.8-10.0]		
	Sometimes	958	9.7	[9.6-9.8]	-0.2	< 0.001
	Really	324	9.4	[9.1-9.6]		
4. Frequency of ≥2 different staples foods	≥ 3 times/week	269	10.1	[9.8-10.4]		
	1-2 times/week	753	10.1	[9.9-10.2]	-0.3	< 0.001
	< 1 time/week	1605	9.6	[9.5-9.7]		
5. Consumption of 1-dish meals	≥ 3 times/week	62	10.3	[9.8-10.9]		
	1-2 times/week	1444	9.8	[9.7-9.9]	-0.1	0.108
	< 1 time/week	1121	9.7	[9.6-9.8]		
6. Consumption of noodles	≥ 3 times/week	408	10.1	[9.9-10.3]		
	1-2 times/week	1586	9.8	[9.7-9.9]	-0.4	< 0.001
	< 1 time/week	633	9.4	[9.2-9.6]		
7. Quantity of soup consumed when eating noodles	Total volume	518	10.3	[10.1-10.5]		
	1/2	795	9.9	[9.7-10.1]	-0.4	< 0.001
	1/3	698	9.8	[9.6-9.9]		
	very little	616	9.1	[9.0-9.3]		
8. No. servings of soups	≥ 3 servings/day	143	10.0	[9.6-10.4]		
	2 servings/day	761	10.0	[9.9-10.2]	-0.2	< 0.001
	1 serving/day	1346	9.7	[9.6-9.8]		
	< 1 serving/day	377	9.5	[9.3-9.7]		
9. No. servings of simmered dishes	≥ 4 servings/day	135	9.7	[9.4-10.1]		
	2-3 servings/day	833	9.8	[9.7-10.0]	0.0	0.406
	1 serving/day	1212	9.8	[9.6-9.9]		
	< 1 serving/day	447	9.7	[9.5-9.9]		
10. Consumption of salt-cured fish eggs	≥ 1 times/day	173	10.1	[9.7-10.4]		
	1 time/2 days	431	10.2	[10.0-10.4]	-0.3	< 0.001
	< 1 time/2 days	2023	9.6	[9.5-9.7]		
11. Consumption of salted fish	≥ 1 times/day	254	10.0	[9.7-10.2]		
	1 time/2 days	972	9.9	[9.7-10.0]	-0.2	0.008
	< 1 time/2 days	1401	9.7	[9.5-9.8]		
12. Consumption of processed meat products	≥ 1 time/day	404	9.9	[9.6-10.1]		
	1 time/2 days	1456	9.8	[9.6-9.9]	0.0	0.534
	< 1 times/2 days	767	9.8	[9.6-9.9]		

(Continued)

Table 2. (continued) Dietary salt intake and responses to the questionnaire on dietary habits potentially relevant to salt and/or potassium intakes

		Sodium intake				
No. Questionnaire items	**Answer**	**n**	**Mean**	**[95% CI]**	**B**	**p**
13.Consumption of fish paste products (e.g. Kamaboko, chikuwa)	≥ 1 time/day	112	9.9	[9.5-10.3]		
	1 time/2 days	1144	9.8	[9.7-10.0]	-0.1	0.141
	< 1 time/2 days	1371	9.7	[9.6-9.8]		
14. Consumption of salty snacks	≥ 1 times/day	653	9.9	[9.7-10.0]		
	1 time/2 days	862	9.7	[9.6-9.9]	-0.1	0.195
	< 1 time/2 days	1112	9.7	[9.6-9.9]		
15. Consumption of pickled vegetables	≥ 1 times/day	433	10.2	[9.9-10.4]		
	1 times/2 days	1082	9.8	[9.7-9.9]	-0.3	< 0.001
	< 1 times/2 days	1112	9.6	[9.4-9.7]		
16. No. vegetable side dishes	≥ 5 servings/day	324	9.6	[9.3-9.8]		
	3-4 servings/day	1022	9.7	[9.6-9.9]	0.1	0.041
	< 2 serving/day	1281	9.8	[9.7-10.0]		
17. Frequency of eating out	≥ 4 times/week	103	9.9	[9.4-10.3]		
	2-3 times/week	598	9.8	[9.6-10.0]	-0.1	0.538
	<2 times/week	1926	9.8	[9.7-9.9]		
18. Frequency of using delicatessen food	≥ 4 times/week	422	9.9	[9.7-10.1]		
	2-3 times/week	1043	9.8	[9.7-9.9]	-0.1	0.035
	<2 times/week	1162	9.7	[9.5-9.8]		
19. Attempts use of dashi flavor, broth, the stock and the natural taste of food	trying actively	514	9.7	[9.5-9.8]		
	trying a little	715	10.0	[9.8-10.1]	0.0	0.837
	not trying much	830	9.7	[9.5-9.8]		
	not trying at all	568	9.7	[9.6-9.9]		
20. Prefers strong-tasting meals	Yes	980	10.0	[9.9-10.2]	-0.4	< 0.001
	No	1647	9.6	[9.5-9.7]		
21 Prefers eating vegetables	Prefers	1587	9.8	[9.7-9.9]		
	Prefers relatively	752	9.7	[9.5-9.9]	0.0	0.695
	Prefers a little	263	9.8	[9.5-10.1]		
	Does not prefer	25	9.6	[8.8-10.5]		
22. Ability to cook vegetable side dishes	Being able	1366	9.8	[9.6-9.9]		
	Being relatively able	648	9.7	[9.5-9.9]	0.0	0.568
	Being relatively unable	307	9.9	[9.6-10.2]		
	Being unable	306	9.8	[9.5-10.1]		
Importance of the following points for buying and eating vegetables:						
23. freshness	Very important	1400	9.7	[9.6-9.9]		
	Quite important	1101	9.8	[9.7-9.9]	0.0	0.911
	Not so important	93	9.8	[9.3-10.2]		
	Not at all important	33	9.4	[8.6-10.2]		
24. Seasonal foods	Very important	749	9.7	[9.5-9.9]		
	Quite important	1376	9.8	[9.7-9.9]	0.1	0.128
	Not so important	401	9.8	[9.6-10.0]		
	Not at all important	101	10.1	[9.7-10.6]		
25. Reasonable prices	Very important	1465	9.8	[9.7-9.9]		
	Quite important	1005	9.7	[9.6-9.9]	-0.1	0.136
	Not so important	110	9.6	[9.2-10.0]		
	Not at all important	47	9.5	[8.8-10.1]		

Table 2. (continued) Dietary salt intake and responses to the questionnaire on dietary habits potentially relevant to salt and/or potassium intakes

			Sodium intake			
No. Questionnaire items	**Answer**	**n**	**Mean**	**[95% CI]**	**B**	**p**
26. Local products	Very important	442	9.6	[9.4-9.8]		
	Quite important	1007	9.7	[9.6-9.9]	0.1	0.175
	Not so important	799	9.9	[9.8-10.1]		
	Not at all important	379	9.7	[9.5-9.9]		
27. Safety	Very important	1329	9.8	[9.7-9.9]		
	Quite important	1033	9.7	[9.6-9.8]	0.0	0.904
	Not so important	217	10.1	[9.8-10.4]		
	Not at all important	48	9.5	[8.8-10.1]		
28. Preference of oneself and one's family	Very important	1072	9.8	[9.6-9.9]		
	Quite important	1337	9.8	[9.6-9.9]	0.0	0.943
	Not so important	166	9.8	[9.4-10.1]		
	Not at all important	52	9.7	[9.1-10.3]		
29. Time and effort for cooking	Very important	435	9.7	[9.5-9.9]		
	Quite important	1271	9.8	[9.7-9.9]	0.0	0.854
	Not so important	697	9.8	[9.6-9.9]		
	Not at all important	224	9.6	[9.4-9.9]		
30. Health effects	Very important	804	9.7	[9.6-9.9]		
	Quite important	1350	9.8	[9.6-9.9]	0.0	0.474
	Not so important	389	9.9	[9.6-10.1]		
	Not at all important	84	9.8	[9.3-10.2]		
31. Number of vegetable side dishes per day considered for health	Don't know	142	9.6	[9.2-10.0]		
	1-2 servings/day	250	10.1	[9.8-10.4]		
	3-4 servings/day	1155	9.8	[9.6-9.9]	-0.1	0.213
	5-6 servings/day	810	9.7	[9.6-9.9]		
	≥ 7 servings/day	270	9.6	[9.3-9.9]		
32. Trying to reduce salt intake	Trying actively	261	9.3	[9.1-9.6]		
	Trying a little	1049	9.7	[9.5-9.8]	0.2	< 0.001
	Not trying much	1051	9.9	[9.8-10.1]		
	Not trying at all	266	10.0	[9.7-10.2]		
33. Knowing the amount of salt intake per day desirable for health	Yes	1238	9.7	[9.6-9.8]	-0.2	0.060
	No	1389	9.8	[9.7-10.0]		
34. Recognizing one's salt intake as moderate	A little	86	9.0	[8.5-9.4]		
	Relatively small	212	9.6	[9.3-9.9]		
	Moderate	873	9.6	[9.4-9.7]	0.3	< 0.001
	Relatively great	1250	9.9	[9.8-10.0]		
	Very great	206	10.3	[10.0-10.6]		
35. Knowing that potassium is highly involved in vegetables and fruits and promotes urinary sodium excretion	Yes	1170	9.6	[9.5-9.8]	0.2	0.015
	No	1457	9.9	[9.7-10.0]		
36. Checks nutrition facts when buying food and eating out	Checks actively	200	9.5	[9.2-9.9]		
	Checks a little	787	9.8	[9.6-9.9]		
	Not checks much	671	9.7	[9.6-9.9]	0.1	0.201
	Not checks at all	918	9.8	[9.7-10.0]		
	Don't know	51	9.7	[9.1-10.3]		

Analyses were conducted by analysis of covariance for gender, age group, household composition, BMI (<18.5, 18.5-24.9, ≥ 25.0), and smoking status.

smoking (p<0.001, <0.001, <0.001, and 0.004, respectively). There were no significant trends in household composition among values for salt intake. As to daily potassium intake, mean consumption by men and women were 1644.1 mg and 1659.4 mg, respectively (p= 0.287). Potassium intake differed significantly according to gender, age group, household composition, and smoking status.

Dietary salt intake and responses to the questionnaire

The association between dietary salt intake according to responses to the questionnaire on dietary behaviors potentially relevant to urinary values for salt and/or potassium intake is shown in Table 2. Sixteen of the 36 items on the questionnaire showed relationships with high salt intake per day, and 15 of these 16 items were questions relevant to healthy eating behavior, salty food intake, and behavior and knowledge related to salt restriction. Those 15 were high frequency of alcohol consumption (p = 0.001), small number of meals consisting of a staple food, main dish, and side dishes per day (p= 0.033), high frequency of making oneself gorge on a meal (p <0.001), high frequency of having ≥2 different staple foods per meal (p <0.001), high frequency of having noodles (p < 0.001), large quantity of soup consumed when eating noodles (p <0.001), large number of soups per day (p <0.001), high frequency of having salt-cured fish eggs per day (p <0.001), high frequency of having salted fish per day (p =0.008), high frequency of having pickled vegetables per day (p <0.001), high frequency of using delicatessen food (p =0.035), preference for strong-tasting meals (p <0.001), not trying to reduce salt intake (p <0.001), estimating one's own salt intake as more than moderate (p <0.001), and not knowing that vegetables and fruits have high levels of potassium, which and promotes urinary sodium excretion (p = 0.015). The remaining 1 item was a question about potassium-rich food intake, and a small number of vegetable side dishes per day was significantly associated with high dietary salt intake (p =0.041).

Potassium intake and responses to the questionnaire

As for low potassium intake, an association was shown for potassium intake in 23 of the 36 items (Table 3). These 23 items included not only questions related to healthy eating behavior, potassium-rich food intake, and behavior and knowledge related to increased potassium intake but also those related to salty food intake and knowledge and behavior related to salt restriction. These items included low frequency of alcohol consumption (p <0.001), small number of meals consisting of a staple food, main dish, and side dishes per day (p <0.001), low frequency of making oneself gorge on a meal (p =0.016), and high frequency of having ≥2 different staple foods per meal (p <0.001) as healthy eating behavior. A small quantity of soup consumed when eating noodles (p =0.015), small number of soups per day (p <0.001), small number of simmered dishes per day (p <0.001), low frequency of having pickled vegetables per day (p = 0.035), and a small number of vegetable side dishes per day (p <0.001) indicated intake of potassium-rich food. Five of these 6 items were also items relevant to salty food intake. As to behavior and knowledge relevant to increased potassium intake, the following apply: high frequency of using delicatessen food (p =0.006), not preferring to eat vegetables (p <0.001), being unable to cook vegetable side dishes (p = 0.001), not considering freshness important when buying and eating vegetables (p = 0.001), seasonal foods (p = 0.005), local products (p = 0.008), safety (p = 0.006), and health effects (p <0.001), not knowing that a small number of vegetable side dishes per day is important for health (p = 0.001), not knowing that potassium is highly involved in vegetables and fruits and promotes urinary sodium excretion (p <0.001), and not checking nutrition facts when buying food and eating out (p <0.001). Not trying to use dashi flavor, broth, stock, and the natural taste of food (p <0.001), not trying to reduce salt consumption (p = 0.001), not knowing the amount of desirable salt intake per day for health, and self evaluation of one's salt intake as less than moderate (p = 0.004) were items involving behavior and knowledge related not to increased potassium intake but to restriction of salt intake.

Summary of questionnaire items of dietary habits related to both dietary salt and potassium intake

Table 4 summarizes the questionnaire items for dietary habits related to dietary salt and potassium intakes. A total of 28 of 36 items were related to dietary

Table 3. Dietary potassium intake and responses to the questionnaire on dietary habits potentially relevant to salt and/or potassium intakes

No. Questionnaire items	Answer	n	Mean	[95%CI]	B	p
1. Frequency of alcohol consumption	Daily	524	1694.4	[1662.1-1726.7]		
	5-6 times/week	212	1696.5	[1648.5-1744.6]		
	3-4 times/week	211	1742.8	[1694.8-1790.9]	-16.7	< 0.001
	1-2 times/week	257	1627.9	[1584.3-1671.4]		
	1-3 times/month	260	1645.1	[1601.3-1688.9]		
	Rarely	560	1625.5	[1595.7-1655.3]		
	Never	603	1604.8	[1576.0-1633.7]		
2. No. meals/day consisting of a staple food, main dish, and side dishes	3 times/day	737	1685.5	[1659.3-1711.7]		
	2 times/day	1027	1666.8	[1645.0-1688.6]	-40.7	< 0.001
	1 time/day	863	1605.3	[1581.1-1629.5]		
3. Makes oneself gorge on a meal	Usually	1345	1665.0	[1645.5-1684.4]		
	Sometimes	958	1649.0	[1626.3-1671.7]	-25.5	0.016
	Really	324	1605.8	[1565.5-1646.0]		
4. Frequency of ≥2 different staple foods	≥ 3 times/week	269	1651.0	[1608.0-1694.0]		
	1-2 times/week	753	1644.4	[1618.6-1670.2]	5.0	0.638
	< 1 time/week	1605	1655.5	[1637.8-1673.1]		
5. Consumption of 1-dish meals	≥ 3 times/week	62	1714.1	[1624.6-1803.5]		
	1-2 times/week	1444	1646.3	[1627.8-1664.9]	0.4	0.978
	< 1 time/week	1121	1655.5	[1634.3-1676.6]		
6. Consumption of noodles	≥ 3 times/week	408	1657.4	[1622.2-1692.5]		
	1-2 times/week	1586	1653.0	[1635.4-1670.7]	-6.3	0.585
	< 1 time/week	633	1645.3	[1617.0-1673.5]		
7. Quantity of soup consumed when eating noodles	Total volume	518	1659.7	[1627.8-1691.7]		
	1/2	795	1676.8	[1651.8-1701.7]	-17.3	0.015
	1/3	698	1648.9	[1622.3-1675.6]		
	very little	616	1616.4	[1587.4-1645.4]		
8. No. servings of soups	≥ 3 servings/day	143	1694.7	[1635.8-1753.7]		
	2 servings/day	761	1687.2	[1661.7-1712.6]	-34.6	< 0.001
	1 serving/day	1346	1637.7	[1618.6-1656.8]		
	< 1 serving/day	377	1614.6	[1578.4-1650.9]		
9. No. servings of simmered dishes	≥ 4 servings/day	135	1722.2	[1661.1-1783.3]		
	2-3 servings/day	833	1683.4	[1658.6-1708.1]	-37.4	< 0.001
	1 serving/day	1212	1636.2	[1616.0-1656.4]		
	< 1 serving/day	447	1614.3	[1580.3-1648.2]		
10. Consumption of salt-cured fish	≥ 1 times/day	173	1625.2	[1571.6-1678.8]		
	1 time/2 days	431	1652.3	[1618.2-1686.5]	10.2	0.403
	< 1 time/2 days	2023	1654.0	[1638.4-1669.6]		
11. Consumption of salted fish eggs	≥ 1 times/day	254	1659.4	[1615.4-1703.3]		
	1 time/2 days	972	1672.0	[1649.2-1694.8]	-19.8	0.065
	< 1 time/2 days	1401	1636.5	[1617.5-1655.5]		
12. Consumption of processed meat products	≥ 1 time/day	404	1631.3	[1596.1-1666.4]		
	1 time/2 days	1456	1655.6	[1637.2-1674.0]	10.0	0.359
	< 1 times/2 days	767	1655.6	[1630.0-1681.2]		
13. Consumption of fish paste products (eg. Kamaboko, chikuwa)	≥ 1 time/day	112	1596.0	[1529.8-1662.2]		
	1 time/2 days	1144	1667.9	[1647.1-1688.7]	-6.4	0.598
	< 1 time/2 days	1371	1643.0	[1624.0-1662.0]		
14. Consumption of salty snacks	≥ 1 times/day	653	1646.4	[1618.9-1673.9]		
	1 time/2 days	862	1663.9	[1640.0-1687.8]	-2.0	0.824
	< 1 time/2 days	1112	1645.6	[1624.5-1666.8]		

(Continued)

Table 3. (continued) Dietary potassium intake and responses to the questionnaire on dietary habits potentially relevant to salt and/or potassium intakes

No. Questionnaire items	Answer	n	Mean	[95%CI]	B	p
15. Consumption of pickled vegetables	≥ 1 times/day	433	1671.7	[1637.1-1706.3]		
	1 times/2 days	1082	1662.8	[1641.4-1684.2]	-21.1	0.039
	< 1 times/2 days	1112	1633.4	[1611.8-1655.1]		
16. No. vegetable side dishes	≥ 5 servings/day	324	1752.0	[1712.6-1791.3]		
	3-4 servings/day	1022	1666.8	[1644.7-1688.8]	-64.0	< 0.001
	< 2 serving/day	1281	1614.6	[1594.6-1634.6]		
17. Frequency of eating out	≥ 4 times/week	103	1622.7	[1552.8-1692.5]		
	2-3 times/week	598	1650.1	[1621.0-1679.2]	9.3	0.486
	<2 times/week	1926	1653.9	[1637.8-1670.0]		
18. Frequency of using delicatessen food	≥ 4 times/week	422	1625.3	[1590.9-1659.6]		
	2-3 times/week	1043	1638.3	[1616.7-1660.0]	26.5	0.006
	<2 times/week	1162	1673.6	[1653.0-1694.2]		
19. Attempts use of dashi flavor, broth, the stock and the natural taste of food	trying actively	514	1694.2	[1663.2-1725.3]		
	trying a little	715	1677.7	[1651.5-1703.9]	-28.8	< 0.001
	not trying much	830	1626.2	[1601.9-1650.6]		
	not trying at all	568	1618.3	[1588.7-1648.0]		
20. Prefers strong-tasting meals	Yes	980	1633.8	[1610.9-1656.6]	28.8	0.054
	No	1647	1662.6	[1645.1-1680.1]		
21 Prefers eating vegetables	Prefers	1587	1688.7	[1670.9-1706.4]		
	Prefers relatively	752	1603.0	[1577.5-1628.6]	-60.6	< 0.001
	Prefers a little	263	1571.7	[1527.7-1615.7]		
	Does not prefer	25	1625.8	[1486.1-1765.5]		
22. Ability to cook vegetable side dishes	Being able	1366	1680.0	[1660.3-1699.7]		
	Being relatively able	648	1621.2	[1593.7-1648.7]	-25.9	0.001
	Being relatively unable	307	1641.2	[1600.3-1682.1]		
	Being unable	306	1601.7	[1559.5-1643.9]		
Importance of the following points for buying and eating vegetables:						
23. freshness	Very important	1400	1663.7	[1644.9-1682.4]		
	Quite important	1101	1651.3	[1630.2-1672.4]	-37.0	0.001
	Not so important	93	1545.0	[1472.2-1617.8]		
	Not at all important	33	1469.6	[1347.6-1591.6]		
24. Seasonal foods	Very important	749	1676.3	[1650.7-1702.0]		
	Quite important	1376	1653.3	[1634.4-1672.2]	-26.0	0.005
	Not so important	401	1605.0	[1569.7-1640.4]		
	Not at all important	101	1636.2	[1565.9-1706.5]		
25. Reasonable prices	Very important	1465	1649.3	[1630.8-1667.8]		
	Quite important	1005	1660.3	[1637.9-1682.7]	-3.9	0.713
	Not so important	110	1638.3	[1571.4-1705.2]		
	Not at all important	47	1582.3	[1479.7-1684.9]		
26. Local products	Very important	442	1665.3	[1631.6-1698.9]		
	Quite important	1007	1673.2	[1651.0-1695.3]	-20.6	0.008
	Not so important	799	1635.0	[1610.1-1659.9]		
	Not at all important	379	1615.0	[1578.4-1651.5]		
27. Safety	Very important	1329	1662.4	[1643.1-1681.6]		
	Quite important	1033	1651.3	[1629.5-1673.0]	-26.9	0.006
	Not so important	217	1630.6	[1582.6-1678.5]		
	Not at all important	48	1469.4	[1368.3-1570.6]		

Table 3. (continued) Dietary potassium intake and responses to the questionnaire on dietary habits potentially relevant to salt and/or potassium intakes

No. Questionnaire items	Answer	n	Mean	[95%CI]	B	p
28. Preference of oneself and one's family	Very important	1072	1643.7	[1622.2-1665.2]		
	Quite important	1337	1667.1	[1648.0-1686.3]	-6.8	0.513
	Not so important	166	1612.1	[1557.7-1666.5]		
	Not at all important	52	1553.3	[1456.0-1650.7]		
29. Time and effort for cooking	Very important	435	1626.6	[1592.9-1660.4]		
	Quite important	1271	1665.5	[1645.9-1685.2]	-0.1	0.988
	Not so important	697	1649.3	[1622.7-1676.0]		
	Not at all important	224	1630.8	[1583.9-1677.7]		
30. Health effects	Very important	804	1676.8	[1652.0-1701.5]		
	Quite important	1350	1657.6	[1638.6-1676.6]	-38.4	< 0.001
	Not so important	389	1606.2	[1570.4-1642.1]		
	Not at all important	84	1531.7	[1455.1-1608.3]		
31. Number of vegetable side dishes	Don't know	142	1629.2	[1570.3-1688.1]		
per day considered for health	1-2 servings/day	250	1628.6	[1584.3-1673.0]	23.5	0.001
	3-4 servings/day	1155	1634.6	[1613.9-1655.3]		
	5-6 servings/day	810	1666.9	[1642.1-1691.7]		
	≥ 7 servings/day	270	1713.9	[1671.1-1756.7]		
32. Trying to reduce salt intake	Trying actively	261	1677.2	[1633.1-1721.2]		
	Trying a little	1049	1680.1	[1658.1-1702.0]	-31.4	0.001
	Not trying much	1051	1628.2	[1606.3-1650.0]		
	Not trying at all	266	1609.2	[1565.5-1652.9]		
33. Knowing the amount of salt intake	Yes	1238	1682.7	[1662.6-1702.7]	58.3	< 0.001
per day desirable for health	No	1389	1624.4	[1605.5-1643.3]		
34. Recognizing one's salt intake	A little	86	1517.0	[1441.0-1593.1]		
as moderate	Relatively small	212	1625.3	[1577.1-1673.4]	23.6	0.004
	Moderate	873	1654.8	[1631.1-1678.6]		
	Relatively great	1250	1660.2	[1640.4-1680.0]		
	Very great	206	1671.9	[1622.6-1721.1]		
35. Knowing that potassium is highly involved in	Yes	1170	1688.1	[1667.4-1708.7]	-65.3	< 0.001
vegetables and fruits and promotes urinary sodium excretion	No	1457	1622.7	[1604.3-1641.2]		
36. Checks nutrition facts	Checks actively	200	1670.4	[1620.6-1720.1]		
when buying food and eating out	Checks a little	787	1701.6	[1676.3-1726.9]	-34.0	< 0.001
	Not checks much	671	1651.8	[1624.8-1678.9]		
	Not checks at all	918	1608.3	[1584.8-1631.8]		
	Don't know	51	1594.7	[1496.5-1693.0]		

Analyses were conducted by analysis of covariance for gender, age group, household composition, BMI (<18.5, 18.5-24.9, ≥ 25.0), and smoking status.

salt and/or potassium intakes and were divided into 4 categories as related to both high salt and low potassium intake, only to high salt intake, only to low potassium intake, and to both high potassium and high salt intake. However, 11 of the 28 items were inconsistent with registered dietitians' initial expectations regarding the relationship to salt and/or potassium intake.

Five question items involved relationships with both high salt and low potassium intake; of these 5 items there was 1 item that was expected to indicate healthy eating behavior (No. 2), 1 item expected to indicate behavior for both salt restriction and increased potassium intake (No. 18), 1 item expected to indicate knowledge on both salt restriction and increased potassium intake (No. 35), 1 item expected to be only related to knowledge on salt restriction (No. 32), and

Table 4. Summary of questionnaire items of dietary habits related with dietary salt and potassium intakes

No. Questionnaire items	Type of question
Items related to both high salt and low potassium intakes	
2. No. meals/day consisting of a staple food, main dish, and side dishes	HE
16. Small number of vegetable side dishes	PI
18. High frequency of using delicatessen food	SB, PB
32. Trying to reduce salt intake	SB
35. Knowing that potassium is highly involved in vegetables and fruits and promotes urinary sodium excretion	SK, PK
Items related with only high salt intake	
4. Frequency of having ≥2 different staple foods	HE
6. Consumption of noodles	SI
10. Consumption of salt-cured fish eggs	SI
11. Consumption of salted fish	SI
20. Prefers strong-tasting meals	SB
Items related with only low potassium intake	
9. No. servings of simmered dishes	SI, PI
19. Attempts use of dashi flavor, broth, the stock and the natural taste of food	SB
21. Prefers eating vegetables	PB
22. Ability to cook vegetable side dishes	PK
Not considering the following points to be important for buying and eating vegetables:	
23. Freshness	PB
24. Seasonal foods	PB
26. Local products	PB
27. Safety	PB
30. Health effects	PB
31. No. vegetable side dishes per day considered for health	PK
33. Knowing the amount of salt intake per day desirable for health	SB
36. Checks nutrition facts when buying food and eating out	SB, PB
Items related with both high potassium and high salt intake	
1. Frequency of alcohol consumption	HE
3. Makes oneself gorge on a meal	HE
7. Quantity of soup consumed when eating noodles	SI
8. No. servings of soups	SI, PI
15. Consumption of pickled vegetables	SI
34. Recognizing one's salt intake as moderate	SK

Abbreviations: HE, healthy eating behavior; SI, salty food intake; PI, potassium-rich food intake, SB, behavior for salt restriction; PB, behavior for increased potassium intake; SK, knowledge for salt restriction; PK, knowledge for increased potassium intake.

1 item expected to be only related to intake of potassium-rich food (No. 16). Five items involved only high salt intake and these items were anticipated to be about healthy eating behavior (No. 4), salty food intake (No.6, 10, and 11), and behavior for salt restriction (No. 20). There were 12 items only related to low potassium intake: 6 of the 12 items were the questions expected to indicate behavior for increased

potassium intake (No. 21, 23, 24, 26, 27, and 30), 2 were expected to indicate knowledge about increased potassium intake (No. 22 and 31), 2 were expected to indicate behavior regarding salt restriction (No. 19 and 33), 1 was expected to indicate intake of both salty and potassium-rich food (No. 9), and 1 was expected to indicate behavior about both salt restriction and increased potassium intake (No. 36). Six items related to both high potassium and high salt intake were found. Of these, 2 items were anticipated to involve healthy eating behavior (No. 1 and 3), 2 items anticipated salty food intake (No. 7 and 15), 1 item was anticipated to involve intake of both salty and potassium-rich food (No. 8), 1 item was about potassium-rich food intake (No. 32), and 1 item was anticipated to indicate knowledge about salt restriction (No. 15).

Discussion

Dietary salt reduction and increasing potassium intake are encouraged worldwide for reduction of blood pressure to decrease the incidence of cardiovascular disease such as stroke and coronary heart disease. These challenges are especially important for Japan as Japan has the highest dietary salt intake among developed countries (16). However, simultaneous investigations of salt and/or potassium intake and dietary behavior relating to high salt and low potassium intake are sparse. Our current study addressed this issue with the cooperation of Niigata city, Japan. Our findings can contribute to developing evidence-based education on reducing salt intake and increasing potassium intake for Japanese people.

Our results showed that a total of 28 of 36 items on the questionnaire developed from an empirical perspective gained from registered dietitians associated with public administrations or medical services were related to dietary salt and/or potassium intake. Given that the majority of items were related to salt and/or potassium intake, it was reasonable to assume that the questionnaire generally followed the lines of questionnaires used in previous dietary education to reduce salt intake. However, results that were inconsistent with registered dietitians' initial expectations regarding the relationship with salt and/or potassium intake were obtained for 11 of the 28 items. Because of this, attention should be paid when providing information based on these items to participants in community salt reduction interventions so as not to mislead them. However, the majority of the questionnaire items were relevant to salt and/or potassium intake.

Among the five questionnaire items categorized as "Items related to both high salt and low potassium intakes", "Small number of vegetable side dishes per day" (item No. 16) and "Not trying to reduce salt intake" (item No. 32) had initially been expected to be related to "potassium-rich food intake" and "behavior for salt restriction", respectively. Regarding item No. 16, a previous report demonstrated that individuals who consumed vegetables infrequently and in small quantities had a low level of health awareness, including awareness of salt reduction (17), suggesting that low vegetable consumption and associated unhealthy eating habits in terms of salt intake may have led to low potassium intake as well as high salt intake. Similarly, individuals who do not engage in reducing salt intake tend to eat vegetables less frequently and in small quantities (17). This may explain the relationship of item No. 32 with both high salt and low potassium intake. In summary, individuals who report eating a small number of vegetable side dishes and those who report not trying to reduce salt intake are likely to adopt other unhealthy eating habits in terms of salt and potassium intakes, highlighting the importance of encouraging this group of individuals to acquire the knowledge and skills to reduce salt intake in their daily lives through educational interventions.

All five items in the "Items related to only high salt intake" category had been expected by registered dietitians experienced in community nutrition to be related to healthy eating behaviors or salt intake. This result may support the validity of their expectations and indicates that nutritional strategies focusing on these items should continue to be implemented in the future.

Among the 12 items categorized as "Items related to only low potassium intake", "Small number of simmered dishes per day" (item No. 9) had initially been believed to be related to "Behavior for both salt restriction and increased potassium intake", while "Not trying to use dashi flavor, broth, stock and the natural taste of

food" (item No. 19) and "Not knowing the amount of desirable salt intake per day for health" (item No. 33) were initially believed to be related to "Behavior for salt restriction only", and "Not checking nutrition facts when buying food and eating out" (item No. 36) had been believed to be related to "Behavior for both salt restriction and increased potassium intake". Regarding item No. 9, since simmered dishes are often prepared with vegetables and traditionally high-salt seasonings, such as soy sauce and *miso* (18), we hypothesized when designing the questionnaire that the consumption of simmered dishes would increase both potassium and salt intakes. However, it was found that the consumption of simmered dishes was significantly related only to potassium intake in this questionnaire. This may be because the use of those seasoning products has decreased in the last 20 years, as reported in the National Health and Nutrition Survey in Japan (19-20), and that foreign food cultures, including the use of Western seasonings and spices with a relatively low salt content, have become popular (21). In the present study, a significant relationship with the consumption of simmered dishes was only observed for potassium intake, a parameter associated with vegetable consumption. With respect to item No. 19, stocks and broths were reported to enhance the perceived taste and flavor of low-salt diets because of their umami substance contents (22). On that basis, we hypothesized that the effective use of stocks and broths in meals would reduce salt intake. However, this study failed to detect a significant relationship between not making good use of stocks, broths, or the natural flavors of foods and salt intake. Thus, it is recommended that ways to make stocks and broths in participants' homes be assessed, and that appropriate methods for their preparation be promoted through cooking classes and other activities. A possible reason for the significant relationship with high potassium intake is that stocks and broths are often used in soups and simmered dishes, which are commonly prepared with vegetables (18). Thus, individuals who do not use stocks and broths are likely to have a low-vegetable, i.e., low-potassium, diet.

Knowing appropriate healthy levels of daily salt intake (item No. 33) would logically be expected to be related to salt intake, and referring to food labels when purchasing food or making eating-out decisions (item No. 36) to salt and potassium intake. However, these items were found to be related only to potassium intake. The results suggest that individuals who recognize appropriate levels of daily salt intake may have a high level of awareness about healthy diets, such as those rich in vegetables (17), but may fail to take action to reduce salt intake. Taken together, these results, particularly those for items No. 19, 33, and 36, demonstrate that Japanese people have not yet fully adopted effective food preparation and food purchasing skills needed to successfully reduce salt intake in a sustained manner. To address this issue, future efforts should focus not only on continuously raising awareness and knowledge of salt intake among the population, but also on providing long-term educational interventions, such as cooking classes and role-playing activities simulating food purchasing situations through a population-based approach.

Six items were identified as "Items related to high potassium and high salt intake at the same time". With respect to "Frequency of alcohol consumption" (item No. 1), given that alcohol consumption itself is a risk factor for hypertension (23), and that salt intake has a more direct impact on blood pressure elevation than potassium intake (10), it is still reasonable to recommend reducing alcohol consumption. Regarding frequency of "Making oneself gorge on a meal" (item No. 3), it is assumed that both salt and potassium intakes would increase with increases in food intake. Similarly, as for "Quantity of soup consumed when eating noodles" (item No. 7) and "Number of soups per day" (item No. 8), the use of salt and high-salt seasonings in noodle soup (the soup in soup-based noodle dishes) and soup dishes (18), and leaching of nutrients, including potassium, from ingredients into the soup in these dishes (24) may be responsible for the concomitant increase in salt and potassium intakes. In terms of "Frequency of having pickled vegetables per day" (item No. 15), pickled vegetables can be a source of both potassium and salt, due to the potassium content of their major ingredients (24). Since the prevention of hypertension is more strongly affected by salt than by potassium intake (10), it is still necessary to promote recommended eating practices, including not eating until feeling completely full, limiting the consumption of noodle soup and soup dishes, and reducing the

consumption of pickles. As for "considering one's own salt intake as more than moderate" (item No. 34), individuals who are already aware of their high salt intake should be encouraged to translate this awareness into action, with a key focus on reducing salt intake, which is more effective in lowering blood pressure than increasing potassium intake.

The present study had several limitations. First, the participants were all residents of Niigata city in Japan. It has been reported that many countries have regional differences in dietary habits and nutritional intake including salt and potassium intakes (25-27). Additional research in other prefectures is of importance for nationwide salt reduction policies. Second, this study included only participants aged 20 years or older. A proper lifestyle, which includes proper dietary habits, is the basis for healthy status in childhood and tends to persist throughout life (28, 29). Further studies involving minors are required in the future. Another limitation is that estimated dietary salt and potassium intakes were obtained from a casual urine specimen. However, estimated sodium and potassium excretions from a casual urine specimen were validated with that of 24-h urinary excretion with significant correlations ($r = 0.54$, $p < 0.01$, and $r = 0.56$, $p < 0.01$, respectively.) (15) and its use has been reported in a number of epidemiological studies (30, 31).

Conclusion

In conclusion, we clarified that 28 out of the 36 dietary behaviors on the questionnaire gained from an empirical perspective of registered dietitians related to dietary behavior were associated with dietary salt and potassium intake in cooperation with Niigata city in Japan. Additionally, these items were composed of 4 categories: items related with both high salt and low potassium intakes, only high salt intake, only low potassium intake, and both high potassium and high salt intake. On the other hand, some items were inconsistent with registered dietitians' initial expectations regarding the relationship with salt and/or potassium intake. These findings would contribute to developing evidence based on the value of reducing salt intake and increasing potassium intake for Japanese people. Based on our current findings, education in regions and/or individuals according to specific dietary habits and development of an effective program related to high salt intake and low potassium intake are needed for successful prevention of hypertension including dietary salt reduction and increasing potassium intake.

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