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Food sources of dietary sodium in the Japanese adult population: the international study of macro-/micronutrients and blood pressure (INTERMAP)

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Abstract

Purpose—It is often reported that Na intake levels are higher in Japan than in western countries. Detailed analysis of food intake and its association with Na intake are necessary for supporting further decreases in Na consumption in Japan. We investigated the association between Na and food intake by food group using data from the Japanese participants of the INTERMAP Study.

Method—Results from the Japanese participants of the INTERMAP Study who did not use antihypertensive medication and/or consume a reduced Na diet were used (531 men and 518 women, aged 40–59 years), obtained from four 24-h dietary recalls and two 24-h urine collections from each participant. We developed a classification system with 46 food group classifications;

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Compliance with ethical standards

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Conflict of interest None.

food consumption and Na intake from these groups were compared across quartiles of participants determined by 24-h urinary Na excretion per unit of body weight (UNa/BW).

Results—Average daily Na intake from Japanese high-Na foods was 2552 mg/day. Participants with a higher UNa/BW consumed a significantly greater amount of high-Na Japanese foods, such as salted fish ($P = 0.001$) and miso soup ($P < 0.001$). They also had greater amount of rice ($P = 0.001$). Participants with lower UNa/BW consumed a significantly greater amount of western foods, such as bread ($P < 0.001$) and milk and dairy products ($P < 0.001$).

Conclusions—Detailed analyses of various Japanese and western food intakes in addition to Na intake were performed. These results can be used to help draw up effective programs for the reduction in Na intake and prevention of prehypertension/hypertension in the Japanese population.

Keywords

Sodium intake; Food intake; 24-h urine; Japanese diet; Population study

Introduction

Excess sodium (Na) intake is one of the important modifiable lifestyle factors that contribute to elevated blood pressure (BP) and cardiovascular diseases (CVD). Observational studies have demonstrated that higher Na intake was associated with elevated BP [1, 2]. Direct associations with Na intake were also shown with coronary heart disease (CHD), stroke, and some non-cardiovascular diseases [3–5]. Clinical trials have provided evidence for the detrimental effect of Na on BP in both hypertensive and normotensive individuals [6, 7]. Based on these findings, Na reduction policies for prevention and control of hypertension have moved forward in many countries in the last several decades [8]. The prevalence of hypertension is high in Japan, at a level similar to other developed countries, although both prevalence of hypertension and average BP level have decreased largely [9, 10]. The prevalence was reported to be 46.1 % in adults 20 years of age and older by the National Health and Nutrition Survey Japan (NHNSJ) in 2012 [11].

Higher Na intake in Japan than in western countries has been repeatedly reported in previous studies [1, 12–14], which is attributable to habitual consumption of traditional high-Na Japanese foods, e.g., soy sauce, miso, and salted fish [15]. In a study performed in the 1950s using 24-h urine collection, average salt (NaCl) intake was estimated to be 17–27 g/day, varying among local regions [16]. Average salt intake has since decreased and was reported to be an average of 10.2 g/day in adults according to the NHNSJ 2012 [11]. During this period, westernization of diet has been observed, including increased consumption of bread, meat, milk, and dairy products [17]. However, this decrease has plateaued in recent years, and in a recent study using 24-h urine collection, average salt intake was estimated to be 12.1 and 10.2 g/day in men and women, respectively [18]. These recent average Na intake levels remain higher than the targeted Na intake value of 8 g/day of salt, according to Health Japan 21 (second edition), a 10-year national health promotion campaign [19].

The INTERMAP Study is an ongoing international cooperative study on macro-/micronutrient intake and blood pressure in Japan, People's Republic of China, the UK, and

the USA [20], with data on dietary intake of each participant from four 24-h recalls and two timed 24-h urine collections. Here, we utilized the results of the Japanese participants of the INTERMAP Study to investigate the differences in both Na intake by food group and total food group consumption between participants with higher and lower Na intake, assessed by 24-h urinary Na excretion per unit of body weight. Foods were classified into groups based on whether they were Japanese or western foods. The results may shed light on the association of Japanese and western foods with Na intake and may be useful for drawing up effective programs for the reduction in Na intake and prevention of prehypertension/hypertension in the Japanese population.

Methods

Detailed methods of the INTERMAP Study have been previously described [20, 21]. In brief, participants visited clinics four times on two pairs of consecutive days, approximately two to three weeks apart. Anthropometrics, BP measurements, and medical and lifestyle data were collected, including four in-depth 24-h dietary recalls and two timed 24-h urine specimens (Fig. 1).

Participants

Participants were men and women aged 40–59 years recruited by four research centers in Japan. Each sample was representative of a defined population; both the general population and workforce samples were included. Individuals were selected randomly from lists that included all eligible people of the population. In factories, the population lists included both manual and clerical workers. The four populations were as follows: factory workers from Toyama in central Japan (149 men and 150 women), factory workers from Sapporo in northern Japan (149 men and 148 women), residents of Aito town, central Japan (130 men and 129 women), and factory workers from Wakayama, central Japan (146 men and 144 women). The ethical committees of the Shiga University of Medical Science, Sapporo Medical University, Kanazawa Medical University, and Wakayama Medical University approved the study protocol. Written informed consent was obtained from all participants.

Data collection

BP of the seated participant was measured twice/visit (for a total of eight times) with a random zero sphygmomanometer after at least 5 min of rest. Height and weight were measured twice at first and third visits (for a total of four times) (Fig. 1). Height was measured without shoes. Weight was measured with light clothing and shoes off. Self-reported heights and weights were not acceptable. Using a questionnaire, trained observers inquired about physical activity, smoking status, previous medical history of cerebro-cardiovascular diseases, use of medication, and use of any special diet. Two questions were used to determine whether the participant followed a reduced Na diet. The first question was “are you following any special diet?” If answered yes, he/she was asked whether he/she was following various specified types of diet, among them a reduced Na diet.

Dietary assessment

Four in-depth 24-h dietary recalls were conducted with each participant, one at each of the four visits, by specially trained dietary interviewers. Prior to the data collection, in cooperation with the INTERMAP international nutritionist, a Japanese nutritionist supervising the national Japanese dietary data collection (termed the “country nutritionist”) trained all interviewers and certified that they had the appropriate skills to conduct dietary interviews and process dietary data using computers. Standardized quality control procedures were utilized to ensure the quality of dietary data throughout data collection. Details of the procedures for assessing dietary intake of individual participants are described elsewhere [21] and are briefly summarized here. Standardized sets of food models were used in all four research centers. Participants were asked to report all foods and beverages, except for water, consumed within 24 h prior to the interview. The INTERMAP Food Table Japan (IFTJ), an integrated food composition table based on the Standard Tables for Food Composition in Japan, 4th edition, was used to code foods and calculate nutrient intake [22]. Because some codes for common high-Na foods were not included in the 4th Standard Table, they were added to the IFTJ prior to the survey, e.g., miso soup (standard dilution of miso paste), soup for Japanese/Chinese noodles (standard dilution of soy sauce, salt, etc.). When participants reported intake of certain Japanese pickles not included in the IFTJ, the Japanese country nutritionist assigned a new food code upon request, so that the interviewer could use the new code specifically for those pickles, rather than using codes for the component vegetables and salt. New food codes for certain types of salted fish were also assigned. For condiments used during cooking, standard recipes were used, e.g., to estimate soy sauce, salt, sugar, with reliance on a computer program specifically designed for the INTERMAP survey in Japan. To aid in quantification of discretionary use of condiments, participants were asked to recreate their use of soy sauce and/or salt on an electric balance.

The Nutrition Coordinating Center in Minnesota, in cooperation with the Japanese country nutritionist, was responsible for completion of the food database of the nutrient composition of all foods consumed by INTERMAP participants, and for assuring the quality of the dietary data.

Urine collection and urinary Na and K measurements

Each participant provided two 24-h urine collections, with start and end times recorded at the research center; measurements included urinary volume, Na, K, and creatinine. Urinary values per 24 h were calculated as the product of urinary concentration and timed volume, standardized to 24 h.

Food groups

To explore the association of food consumption with Na intake, 2508 food codes used in the dietary recalls were classified into 46 groups (Table 1). When developing the 46 food groups, the following aspects of the foods were taken into account: whether Na was added (processed foods with/ without added Na), and whether the food was an indigenous Japanese food (including Chinese food) or a western food brought to Japan. Vegetables were grouped according to cooking procedure: boiled/stewed vegetables (relatively Japanese style), or raw/ stir fried vegetables (relatively western style). The 46 food groups were grouped into seven

non-overlapping categories: starchy foods, protein foods, vegetables, soups, condiments, dairy products and snacks, and beverages.

Data analysis

Participants taking antihypertensive medication ($n = 71$) and/or consuming a reduced Na diet ($n = 36$) were excluded from the analyses; thus, 1049 participants (531 men and 518 women) were included in this study. Using the whole dietary recall of these participants (4196 recalls), the sum of the Na (mg) and sum of the amount of food consumed (g) for each food group were calculated. Average Na content (mg/100 g) was calculated as the sum of Na contained (mg) divided by the sum of the amount of food consumed (100 g) for each food group. Daily food (g) and Na (mg) intakes of each of the 46 food groups by each participant were calculated from the four 24-h dietary recalls data, divided by four. Energy intake excluding alcohol [total energy minus alcohol (g) $\times$ 7.1] was used to calculate Na/food intake per 1000 kcal of total energy intake of the participant, because alcoholic beverages contain virtually no Na, but contribute to energy intake. Using total energy including alcohol leads to lower calculated caloric densities especially for heavy drinkers.

The mean of the two 24-h urinary Na excretion values (UNa, mg/24 h) divided by body weight (BW, kg) (UNa/ BW, mg/24 h/kg) for each participant was calculated. Participants were divided into quartiles according to UNa/BW, men and women separately. Spearman's correlation coefficient between dietary Na intake (mg/1000 kcal) and UNa/ BW quartile was calculated. To explore any association between diet and salt intake among those with higher and lower Na intake, Na intake per 1000 kcal of total energy intake from each of the 46 food groups (mg/1000 kcal) was compared among the quartiles of UNa/BW, men and women combined. Intake of each of the 46 food groups per 1000 kcal of total energy intake (g/1000 kcal) was also compared among the quartiles.

All eight readings of SBP/DBP were used to calculate the average SBP/DBP of each participant. For height and weight, means of four measurements were used in the analyses. The P value was calculated to examine the linear relationship among the UNa/BW quartiles, analyzed as a continuous variable. Two-tailed significance level was set at $P < 0.05$. SPSS statistics version 21.0 (IBM Corporation, Tokyo, Japan) was used for all analyses.

Results

Data from 531 men and 518 women were analyzed. The average Na content (mg/100 g) and average daily Na intake (mg/day) for each food group consumed in the dietary survey are shown in Table 1. Traditional Japanese food with added Na had particularly high levels of Na content, e.g., 2192 mg/100 g for salted/canned fish and 1814 mg/100 g for Japanese pickles. As to Na intake per day, bread (161 mg/day) in the starchy food category, salted/canned fish (396 mg/day) in the protein foods category, Japanese pickles (543 mg/day) in the vegetable category, miso soup (325 mg/day) in the soup category, and soy sauce (806 mg/day) in the condiment category were the top contributors within their categories (Table 1). The average Na intake from Japanese high-Na foods (i.e., salted/canned fish, fish cakes, Japanese pickles, miso soup, soup for use with noodles, soy sauce, low-salt soy sauce, and miso paste) totaled 2552 mg/day.

Characteristics by UNa/BW quartile are shown in Table 2. Those in the highest UNa/BW quartile were older ($P = 0.001$), lower in BMI ($P = 0.001$), and DBP ($P = 0.029$) than those in the lower quartile. Dietary intakes of protein ($P = 0.017$), carbohydrate ($P = 0.032$), and Na ($P < 0.001$) were significantly higher in the higher quartiles. Spearman's correlation coefficient between dietary Na intake (mg/1000 kcal) and UNa/BW quartile was 0.332 ($P < 0.001$) (data not shown). Intakes of total fat, saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), and Keys lipid scores [23] were significantly higher in the lower quartiles ($P < 0.001$ for all variables).

With participants stratified by UNa/BW quartiles, Na intake per 1000 kcal of total energy intake from each food groups is shown in Table 3. Intakes of Na from Japanese high-Na foods were significantly higher in the higher UNa/BW quartiles; P was less than 0.001 for salted/canned fish, Japanese pickles, and miso soup. However, Na intakes from bread ($P < 0.001$), milk, and other dairy products ($P = 0.001$) were significantly higher in the lower quartiles. Na intake from each food group per day (mg/day) for participants stratified by quartiles of UNa/BW is shown in Online Table 1. The trends across quartiles were similar to those values per 1000 kcal.

Table 4 gives food consumption data by UNa/BW quartiles. The foods that demonstrated a positive association between Na intake and UNa/BW quartiles in Table 3 showed a similar trend between consumption amount and UNa/BW quartiles. In addition, intakes of rice ($P = 0.001$), boiled/stewed vegetables ($P < 0.001$), and potatoes ($P < 0.001$) were significantly higher in the higher quartiles; these foods contain almost no Na. Average intake of rice was 169 g/1000 kcal and 195 g/1000 kcal for the lowest and the highest quartile, respectively. Intakes of bread ($P < 0.001$), milk and other dairy products ($P < 0.001$), ice cream ($P < 0.001$), other soft drinks ($P = 0.016$), and sports drinks ($P = 0.048$) were significantly higher in the lower quartiles. Average intake of bread was 20 g/1000 kcal and 13 g/1000 kcal for the lowest and the highest quartile, respectively, and for milk and dairy products, it was 68 g/1000 kcal and 47 g/1000 kcal for the lowest and the highest quartile, respectively.

Discussion

The main findings of the present study on the association of estimated Na intake with food consumption in middle-aged Japanese adults were that the contribution of Japanese foods with a high content of added Na, e.g., salted fish, Japanese pickles, miso soup, and soy sauce, to total Na intake was high in the study population, and that intake of these foods was higher in participants with higher UNa/BW. Contributions of western foods to total Na intake, e.g., bread, milk, and other dairy products, were small; participants in the lower quartiles consumed these foods in higher quantities than those in the higher quartiles.

In addition to high-Na Japanese foods, participants with higher UNa/BW consumed more foods without Na, including rice, boiled/stewed vegetables, potatoes, sugar, and sweeteners. These findings indicate that consumption of traditional Japanese-style diets with rice and high-Na Japanese foods [salted fish, Japanese pickles, miso soup, salty side dishes cooked with soy sauce, and sugar (*teriyaki* flavor)] all contribute to excess Na intake in Japan. A reduction in Na content in high-Na Japanese foods should be effective in decreasing Na

intake in the Japanese population. There was no association between the consumption of tofu, unsalted fish, unsalted meat, and eggs with UNa/BW. Participants in the lower quartiles consumed more western foods, e.g., bread, milk, and other dairy products. Na intake is generally higher in Asian countries than in western countries [14], as observed in this Japanese study population. Westernization of the diet in Japan may have partially contributed to Na reduction in the last several decades.

Participants in the higher Una/BW quartile tended to be older, lower in BMI, and had more traditional Japanese style diets. Higher Na intake level in older people has been often reported in the NHNSJ. In the 2012 NHNSJ, average salt intake was 9.8 and 10.8 g/day for participants in their 20 and 50 s, respectively [11]. Consumption of meat and bread has been higher in younger participants, and consumption of rice, fish, and Japanese pickles has been higher in older participants according to the NHNSJ. Adolescents have tended to more favor westernized foods than the elderly. This difference between generations may have partially contributed to the decrease in Na intake observed in younger generations. Although this trend may result in a decrease in Na intake to some extent, current Na intake levels in Japanese adolescents remain higher compared with those of western countries [14], and well over the target value in Japan (8 g/day of salt) [19], as well as the WHO's recommended value (5 g/day) [24]. Comprehensive efforts to reduce Na intake level in the Japanese population are required, for both decreasing the Na content of manufactured foods and for education of the public on the harmful effects of excess Na intake.

The Japanese has been enjoying one of the highest longevities in the world since mid-1980s [25]: Average life expectancy was 80.21 and 86.61 years for men and women, respectively, in 2013 [26]. However, it was lower than in western developed countries only several decades ago [27]. Nutrition status in Japan was poor in the 1950s; percent energy intake from protein was approximately 13 % and was as low as 7 % for fat [17]. Furthermore, daily salt intake exceeded 20 g/day in some local area in Japan [16]. In the 1960s, the stroke mortality rate in Japan was the highest in the world, while CHD mortality was quite low [25, 28]. Stroke mortality has declined since 1965, coinciding with decreases in BP levels and Na intake levels [9, 25, 28]. The average SBP for men aged 60–69 declined approximately 15 mmHg between 1965 and 1990, and the prevalence of severe hypertension, defined as SBP 180 mmHg, was 21 % in 1965 and 4 % in 1990. Furthermore, age-adjusted stroke mortality decreased by approximately 80 % during this period [25]. Following the economic growth of this period, westernization of the diet has resulted in increased intakes of protein and fat [17]. However, present average macronutrient intake status in Japan still differs from western countries. In the NHNSJ 2012, intake of total fat (25.8 % kcal) and SFA (6.9 % kcal) by the Japanese was shown to be lower than in developed western countries, and vegetable protein intake (6.9 % kcal) was higher [11]; these levels were similar to those of the DASH diet [6]. Furthermore, the Japanese INTERMAP participants showed a higher intake of marine-derived n-3 PUFA (0.5 % kcal) [29]. These aspects may have contributed to the prevention of rises in obesity and serum total cholesterol levels [30], and may maintain higher high-density lipoprotein cholesterol levels [29]. The recent prevalence of overweight and obese (BMI ≥ 25.0 kg/m²) Japanese adults was reported to be 28.9 and 17.6 % for men and women, respectively, much lower than in western countries [31]. Average serum total

cholesterol level has increased, but the value for middle-aged men has not exceeded 200 mg/dL [11, 25].

Under these circumstances, increase in CHD mortality is not evident in Japan [28]. The declining trend in BP level has plateaued recently, and the average Na intake level remains high in Japan [25]. With further prevention/management of hypertension, there may be room for further decrease in the incidence/mortality rate of stroke. In Japan, stroke is the most significant cause of impairment in the ability to perform activities in daily living (ADL) [32, 33], for which hypertension is the most important risk factor [34]. Despite the increase in average life expectancy, the burden of nursing care is rapidly increasing [35]. The contribution of high-Na intake in CVD deaths was reported to be greater than high BMI [36]. Thus, a further decrease in average Na intake level is important for the prevention and control of prehypertension/hypertension, stroke, and disability in Japan.

Na reduction, while maintaining the basic aspects of the Japanese diet, may help prevent prehypertension/hypertension and CVD. Consuming appropriate amounts of western foods/dishes may also aid in the reduction in Na intake to some degree. However, it is important to keep in mind that people consuming a western-style diet may also suffer from hypertension. Increases in the intake of energy, total fat, and SFA may increase the risk of obesity, BP, and serum total cholesterol levels in Japan. Furthermore, caution must be taken to avoid excess intake of soft drinks, high fat dairy products, as well as salty cured meat.

In these Japanese INTERMAP participants, only a small percentage of participants ($n = 36$, 3.1 %) reported partaking in a reduced Na diet. Na reduction has been widely recommended for several decades in Japan. In the NHNSJ 2000, about one-third of the male and half of the female middle-aged participants answered that they were conscious of Na content when they chose foods/dishes [37]. However, the actual number of people consuming a reduced Na diet may have been fewer. We have previously reported that there was only a modest difference in 24-h urinary Na excretion (approximately 1 g NaCl equivalent) between those reporting a reduced Na diet and the remaining Japanese INTERMAP participants [38]. This difference may become even smaller for those only conscious of the need of Na reduction and not actively partaking in such a diet. Thus, these results emphasize the importance of a population-based approach for further Na reduction. A decrease in Na content of a wide variety of manufactured foods is necessary to achieve this. Recent UK experience merits attention: Goals were set for reduction in Na added in processed foods, and level of Na intake (estimated with use of 24-h urine collection) was successively decreased [39, 40]. Until recently, Japanese regulations required Na content, not NaCl equivalent, to be labeled on manufactured foods [41]. However, a legal revision in 2015 now requires NaCl equivalents to be on the labels [42]. Labels clearly showing NaCl content may help those who want to reduce their Na intake from manufactured foods by choosing lower Na foods.

Average salt intake per day has decreased around two grams according to NHNSJ data collected by semi-weighed dietary records [17], from 12.1 g per capita in 1985 to 10.2 g in 2010 [11]. However, this trend differs from studies using 24-h urine collection in Japan; estimated daily salt intakes were 11.6 and 10.3 g for men and women, respectively, in the 1980s [1], a similar level in the 1990s [13, 43], and 12.1 and 10.2 g in a 2013 study [18].

There are limitations to this study. We used the Na content of foods listed in the ITFJ, which is based on the Standard Tables for Food Composition in Japan, 4th edition, to calculate Na intake. For use of condiments during cooking, we used standard recipes including soy sauce, salt, and sugar, without confirming the amounts of condiments actually used. Thus, there may be differences between Na content in the foods consumed and the true content.

In summary, these data demonstrated that people with higher Na intake consumed greater amounts of Japanese foods both with and without added Na. People with lower Na intake consumed a more westernized diet, with more consumption of bread, milk, and other dairy products. In conclusion, a decrease in Na content of high-Na Japanese foods and a moderate increase in consumption of appropriate western-type foods may be effective in reducing salt intake for the prevention and control of prehypertension/ hypertension and cardiovascular diseases in Japan.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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For the INTERMAP Cooperative Research Group.

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First pair of visits

First visit	Voiding, start of first 24-hour urine collection Blood pressure measured twice Height and weight measured twice Questionnaire 24-hour dietary recall
Second visit	Voiding, end of first 24-hour urine collection Blood pressure measured twice 24-hour dietary recall

(Two to three weeks)

Second pair of visits

Third visit	Voiding, start of second 24-hour urine collection Blood pressure measured twice Height and weight measured twice 24-hour dietary recall
Fourth visit	Voiding, end of second 24-hour urine collection Blood pressure measured twice 24-hour dietary recall

Fig. 1.

Data collection for INTERMAP Study

Table 1

Forty-six food groups, the Japanese INTERMAP Food Table for investigation of the association of food group consumption with salt intake

Food group	Description	Number of food codes	Average Na content ^a (mg/100 g)	Na intake (mg/day/participant)	
				Mean	(SD)
<i>Starchy foods</i>					
Rice		22	2	7	(5)
Noodles (Japanese/Chinese)	Without soup	30	150	86	(178)
Bread		16	526	161	(182)
Pasta, macaroni	Without sauce	2	170	8	(23)
Other grain		36	39	2	(8)
<i>Protein foods</i>					
Fish, not salted		408	182	86	(83)
Salted/canned fish		181	2192	396	(428)
Fish cakes		15	999	134	(172)
Meat, not salted		419	57	21	(18)
Ham, sausage, bacon		64	1127	111	(150)
Hamburgers		17	465	5	(39)
Eggs		19	146	49	(42)
Tofu	Tofu, fried tofu, etc.	16	10	5	(11)
Soy beans, other legumes	Cooked soy beans and other legumes	28	76	4	(16)
<i>Vegetables</i>					
Vegetables, boiled/stewed	Usually served as a Japanese dish	165	14	14	(14)
Vegetables, raw/grilled/stir fried	Usually served as a non-Japanese dish	187	18	15	(52)
Japanese pickles	Salted vegetables and “tsukudami” (mushroom/sea algae cooked strong with soy sauce)	121	1814	543	(505)
Sea algae	Not salted	27	384	21	(52)
Potatoes	Cooked potatoes, chips not included	33	4	2	(2)
Mushrooms		55	7	1	(2)
<i>Soups</i>					
Miso soup		5	318	325	(262)
Soup for use with noodles (Japanese/Chinese)		12	618	264	(305)

Food group	Description	Number of food codes	Average Na content ^a (mg/100 g)	Na intake (mg/day/participant)	
				Mean	(SD)
Soup, western style	Corn soup, consommé soup, powder type included	4	1512	26	(64)
Curry sauce, stew		9	778	66	(133)
Other prepared foods		36	635	69	(129)
<i>Condiments</i>					
Soy sauce	Soy sauce used during cooking, and discretionary	36	5906	806	(508)
Low-salt soy sauce		6	2146	42	(121)
Miso paste	Miso, served as miso paste	7	4046	42	(87)
Mirin	Japanese sweet condiment	1	0	0	(0)
Salt	Salt and salt with monosodium glutamate used during cooking, and discretionary	4	31,691	397	(272)
Worcestershire sauce, ketchup		10	2201	60	(91)
Dressing, mayonnaise		11	1061	50	(56)
Fats and oils	Vegetable oil, e.g., soybean oil, canola oil, corn oil, margarine	26	97	10	(22)
Spices		17	1063	10	(17)
Vinegar		4	297	8	(10)
Sugar and sweeteners		23	1	0	(0)
<i>Dairy products and snacks</i>					
Milk and other dairy products	Butter included	73	74	80	(77)
Sweets	Sweet snacks, Japanese and western style	106	114	32	(45)
Salty snacks	Salty snacks, chips, Japanese and western style	52	350	25	(48)
Ice cream		8	79	2	(9)
Fruit	Fresh, canned, and juice	114	2	2	(4)
<i>Beverages</i>					
Tea	Japanese/Chinese/British tea	21	2	11	(21)
Coffee, cocoa		9	14	11	(27)
Alcoholic beverages		42	3	5	(9)
Sport drinks		3	35	4	(20)
Other soft drinks	Canned coffee, fruit flavored juice, etc.	8	22	3	(12)
		2508			

^a Average Na content was calculated from the sum of Na intake divided by the total food consumption for each food group from the four 24-h dietary recalls of all participants

Table 2

Characteristics of participants stratified by quartiles of 24-h urinary sodium (Na) excretion per unit of body weight (BW) (mg/24 h/kg), Japanese men and women aged 40–59, INTERMAP Japan Study

	Q1		Q2		Q3		Q4		Trend <i>P</i>
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Number of participants	261		263		263		262		
Men, %	50.6		50.6		50.6		50.8		
Urinary Na per BW (mg/24 h/kg)	51.8	6.9	67.4	4.4	80.7	4.8	102.1	12.9	<0.001
Urine volume per BW (ml/24 h/kg)	19.7	8.5	23.7	7.1	26.0	7.4	29.9	7.9	<0.001
Age (years)	47.9	5.2	49.2	5.3	49.0	4.9	50.2	5.4	<0.001
Body weight (kg)	62.8	10.1	61.2	10.4	60.9	9.9	59.4	9.8	<0.001
Body mass index (kg/m ²)	23.7	2.9	23.3	2.9	23.4	2.7	22.9	2.6	0.005
Systolic blood pressure (mmHg)	116.6	14.4	117.0	13.2	116.1	12.8	115.0	12.8	0.126
Diastolic blood pressure (mmHg)	73.6	10.6	73.7	9.8	73.2	10.0	71.7	10.0	0.029
<i>Nutrient intake</i>									
Total energy (kcal/day)	1963	440	2059	437	2045	431	2129	474	<0.001
Energy from foods (kcal/day)	1860	379	1948	378	1934	388	2008	432	<0.001
Alcohol (g/day)	15.4	22.8	15.2	21.9	15.9	22.1	17.2	23.1	0.299
Total protein (%kcal)	16.7	2.8	16.6	2.4	17.1	2.8	17.0	2.8	0.017
Total fat (%kcal)	26.8	4.8	26.8	5.1	26.3	5.0	25.3	5.0	<0.001
Total SFA (%kcal)	7.3	1.8	7.1	1.7	6.8	1.8	6.5	1.7	<0.001
Total MUFA (%kcal)	9.7	2.1	9.8	2.3	9.6	2.2	9.0	2.1	<0.001
Total PUFA (%kcal)	6.7	1.6	6.7	1.5	6.8	1.4	6.7	1.5	0.767
Total n-3 PUFA (%kcal)	1.4	0.4	1.4	0.4	1.4	0.4	1.5	0.4	0.021
Total n-6 PUFA (%kcal)	5.3	1.4	5.3	1.3	5.4	1.2	5.2	1.3	0.295
Carbohydrate (%kcal)	56.7	5.6	56.7	5.7	56.7	6.2	57.9	6.1	0.032
Cholesterol (mg/1000 kcal)	206	70	208	72	212	76	210	77	0.456
Keys lipid score	32.5	6.7	32.0	6.3	31.2	7.0	30.8	6.9	<0.001
Na (mg/1000 kcal)	2245	476	2350	453	2506	504	2685	585	<0.001

Energy from foods was calculated as total energy minus energy from alcohol consumption (g) $\times$ 7.1 (kcal/g)

Keys lipid score was calculated as $1.35 \times (2S - P) + 1.5 \times C^{1/2}$, where S is the percent of calories from SFA, P is the percent of calories from PUFA, and C is dietary cholesterol (mg/1000 kcal)

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SFA saturated fatty acids, *MUFA* monounsaturated fatty acids, *PUFA* polyunsaturated fatty acids

Table 3

Sodium intake per 1000 kcal of total energy intake (mg/1000 kcal) from the 46 food groups, participants stratified by quartiles of 24-h urinary sodium excretion per body weight (mg/24 h/kg), men and women, aged 40–59, INTERMAP Japan Study

Food group	Q1		Q2		Q3		Q4		Trend P	Total	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		Mean	SD
Starchy foods											
Rice	3	2	4	2	4	2	4	4	0.001	4	2
Noodles (Japanese/Chinese)	46	120	32	65	41	73	58	114	0.101	44	96
Bread	105	110	98	95	66	78	68	81	<0.001	84	93
Pasta, macaroni	4	10	5	13	4	11	4	11	0.982	4	11
Other grain	1	3	1	4	1	5	1	4	0.460	1	4
Protein foods											
Fish, not salted	48	57	50	49	48	51	52	48	0.527	50	52
Salted/canned fish	177	203	199	217	193	205	256	250	<0.001	206	221
Fish cakes	59	81	69	83	69	84	77	89	0.015	68	84
Meat, not salted	10	9	11	8	11	9	10	7	0.358	11	8
Ham, sausage	52	64	63	84	60	76	50	69	0.696	57	74
Hamburgers	2	16	3	19	5	30	1	13	0.971	3	20
Eggs	27	25	25	19	25	19	24	18	0.088	25	20
Tofu	2	5	3	6	2	5	3	7	0.101	3	6
Soy beans, other legumes	3	10	2	5	2	7	2	9	0.871	2	8
Vegetables											
Vegetables, boiled/stewed	6	6	7	7	8	7	8	7	0.002	7	7
Vegetables, raw/grilled/stir fried	6	21	7	18	8	27	10	33	0.074	8	25
Japanese pickles	230	214	278	255	341	278	443	356	<0.001	323	291
Sea algae	11	29	11	33	11	28	10	21	0.910	11	28
Potatoes	1	1	1	1	1	1	1	1	0.006	1	1
Mushrooms	0	2	0	1	0	1	0	1	0.204	0	1
Soups											
Miso soup	131	126	156	120	181	133	212	150	<0.001	170	136
Soup for use with noodles (Japanese/Chinese)	128	166	137	154	155	158	130	152	0.584	138	157

Food group	Q1		Q2		Q3		Q4		Trend <i>P</i>	Total	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		Mean	SD
Soup, western style	12	33	15	29	14	34	16	37	0.243	14	34
Curry sauce, stew	34	72	36	68	30	63	36	69	0.960	34	68
Other manufactured foods	32	65	37	68	39	66	32	59	0.917	35	65
<i>Condiments</i>											
Soy sauce	369	242	413	242	432	243	453	265	<0.001	417	250
Low-salt soy sauce	19	45	23	65	25	69	17	47	0.897	21	58
Miso paste	13	29	21	46	24	47	28	51	<0.001	22	44
Mirin	0	0	0	0	0	0	0	0	0.180	0	0
Salt	198	127	212	132	215	140	196	130	0.926	205	133
Worcester sauce, ketchup	26	39	33	50	30	43	32	45	0.279	30	44
Dressing, mayonnaise	24	27	30	33	26	30	23	28	0.554	26	29
Fats and oils	5	9	7	13	5	11	4	9	0.130	5	11
Spices	4	7	6	11	5	8	5	8	0.698	5	8
Vinegar	4	7	4	5	4	4	5	6	0.355	4	6
Sugar and sweeteners	0	0	0	0	0	0	0	0	0.614	0	0
<i>Dairy products and snacks</i>											
Milk and other dairy products	48	43	43	36	38	39	38	36	0.001	42	39
Sweets	19	26	18	24	14	19	16	20	0.027	17	22
Salty snacks	14	29	12	22	12	22	13	21	0.708	13	24
Ice cream	2	7	1	5	1	3	1	3	<0.001	1	5
Fruit	1	2	1	2	1	3	1	1	0.497	1	2
<i>Beverages</i>											
Tea	5	7	6	18	5	12	6	12	0.507	6	13
Coffee, cocoa	6	16	4	11	5	11	6	13	0.986	5	13
Alcoholic beverages	3	5	3	4	3	4	3	5	0.643	3	5
Sport drinks	3	15	2	6	1	5	1	7	0.066	2	9
Other soft drinks	2	7	2	7	1	5	1	4	0.005	2	6

Table 4

Consumption of each food group per 1000 kcal of total energy intake (g/1000 kcal, participants stratified by quartiles of 24-h urinary sodium excretion per body weight (mg/24 h/kg, men and women, aged 40–59 years, INTERMAP Japan Study)

Food group	Q1		Q2		Q3		Q4		Trend P	Total	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		Mean	SD
Starchy foods											
Rice	169	86	186	84	186	84	195	91	0.001	184	87
Noodles (Japanese/Chinese)	28	42	28	31	32	33	32	40	0.122	30	37
Bread	20	21	19	18	13	15	13	15	<0.001	16	18
Pasta, macaroni	2	6	3	8	3	6	2	7	0.983	3	7
Other grain	2	3	3	4	2	3	3	3	0.837	3	3
Protein foods											
Fish, not salted	23	22	25	18	25	20	25	20	0.246	24	20
Salted/canned fish	8	9	9	9	9	9	12	11	<0.001	9	10
Fish cakes	6	8	7	8	7	8	8	9	0.010	7	8
Meat, not salted	18	14	20	14	19	15	17	12	0.471	18	14
Ham, sausage	5	6	6	7	5	6	4	6	0.447	5	6
Hamburgers	1	4	1	4	1	5	0	2	0.492	1	4
Eggs	18	12	17	11	17	12	17	11	0.406	17	12
Tofu	25	24	27	23	27	20	27	24	0.457	26	23
Soy beans, other legumes	4	15	2	4	3	7	3	6	0.872	3	9
Vegetables											
Vegetables, boiled/stewed	43	33	51	37	52	36	56	39	<0.001	51	37
Vegetables, raw/grilled/stir fried	46	37	45	30	43	32	42	30	0.160	44	32
Japanese pickles	11	10	13	13	16	13	21	16	<0.001	15	14
Sea algae	3	8	3	4	3	4	3	5	0.562	3	5
Potatoes	20	18	23	18	22	20	26	22	<0.001	23	20
Mushrooms	4	4	4	5	5	5	4	5	0.069	4	5
Soups											
Miso soup	41	39	49	38	57	42	66	47	<0.001	53	42
Soup for use with noodles (Japanese/Chinese)	19	28	22	25	27	28	22	27	0.065	22	27

Food group	Q1		Q2		Q3		Q4		Trend P	Total	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		Mean	SD
Soup, western style	1	3	1	5	1	4	1	5	0.505	1	4
Curry sauce, stew	5	11	5	10	4	9	4	10	0.491	4	10
Other manufactured foods	5	8	5	9	6	9	5	8	0.518	5	8
<i>Condiments</i>											
Soy sauce	6.2	4.1	7.0	4.1	7.3	4.1	7.7	4.5	<0.001	7.1	4.2
Low-salt soy sauce	0.9	2.3	1.1	3.1	1.2	2.9	0.8	2.1	0.548	1.0	2.6
Miso paste	0.4	0.8	0.5	1.1	0.6	1.1	0.7	1.2	0.001	0.5	1.1
Mirin	0.9	1.2	1.1	1.4	1.0	1.3	1.1	1.3	0.368	1.0	1.3
Salt	0.6	0.4	0.7	0.6	0.7	0.5	0.6	0.5	0.732	0.6	0.5
Worcester sauce, ketchup	1.2	1.8	1.5	2.2	1.3	1.9	1.4	2.0	0.400	1.4	2.0
Dressing, mayonnaise	2.2	2.3	2.8	2.9	2.5	2.7	2.2	2.4	0.593	2.4	2.6
Fats and oils	5.3	3.3	5.7	3.4	5.3	3.0	5.1	3.3	0.238	5.3	3.2
Spices	0.4	0.5	0.4	0.7	0.6	1.4	0.5	0.8	0.114	0.5	0.9
Vinegar	1.3	2.4	1.4	1.8	1.2	1.5	1.6	1.9	0.341	1.4	1.9
Sugar and sweeteners	4.8	3.5	5.3	3.4	5.6	3.9	5.8	3.9	0.001	5.4	3.7
<i>Dairy products and snacks</i>											
Milk and other dairy products	68	66	57	51	54	53	47	49	<0.001	57	56
Sweets	15	17	16	15	13	14	14	15	0.286	15	15
Salty snacks	4	7	3	4	4	5	4	5	0.832	4	5
Ice cream	3	8	2	6	1	4	1	4	<0.001	2	6
Fruit	52	52	56	49	58	50	53	48	0.591	55	50
<i>Beverages</i>											
Tea	232	177	226	172	228	178	238	194	0.696	231	180
Coffee, cocoa	45	75	36	54	40	64	39	73	0.413	40	67
Alcoholic beverages	104	177	99	135	95	146	102	164	0.817	100	156
Sport drinks	8	43	6	19	4	13	4	19	0.048	5	26
Other soft drinks	10	25	7	18	6	14	6	17	0.016	7	19