

Dietary patterns extracted from the current Japanese diet and their associations with sodium and potassium intakes estimated by repeated 24 h urine collection

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Abstract

Objective: To identify dietary patterns in the current Japanese diet and evaluate the associations between these patterns and Na and K intakes.

Design: Dietary patterns were extracted by factor analysis from the intakes of food groups assessed with a validated self-administrated diet history questionnaire. Na and K intakes and urinary Na:K were assessed by repeated 24 h urine collection.

Subjects: Healthy Japanese adults aged 20–69 years (353 men and 349 women).

Setting: Twenty study areas in twenty-three prefectures in Japan.

Result: Four dietary patterns were identified in each sex. After adjustment for several confounding factors, the 'Fish and vegetable' pattern was associated with higher urinary Na excretion, but the association was not significant ($P=0.37$ in men and $P=0.06$ in women). This pattern was also associated with higher K excretion in both sexes. The 'Noodle' pattern tended to be associated with higher urinary Na excretion ($P=0.17$ in men and $P=0.04$ in women) and higher Na:K ($P=0.02$ in men). The 'Meat, vegetable and oil' (in men)/'Meat and oil' (in women) and 'Bread and confectioneries' patterns were not associated with urinary Na excretion (in men) or were negatively associated (in women).

Conclusions: Contrary to the case in Western countries, the 'Fish and vegetable' and 'Noodle' patterns contributed to higher Na intake in Japan. Target foods for salt reduction should be set based on careful consideration of the relationships between dietary patterns and Na and K intakes in the target population.

Keywords
Dietary patterns
Sodium
Potassium
24 h urine collection
Japanese

Excess Na intake and insufficient K intake are well-known risk factors for hypertension and CVD⁽¹⁾. Since salt reduction is one of the most cost-effective means of reducing non-communicable diseases such as CVD⁽²⁾, population salt reduction programmes have been developed worldwide^(3,4). To promote these programmes effectively, the WHO recommends the evaluation and monitoring of Na consumption in each population and sources of Na in the diet⁽⁵⁾.

East Asian countries, including Japan, have higher Na intake and lower K intake than other countries^(6,7). Using precise assessment by 24 h urine collection⁽⁸⁾, we recently showed that the average intake of Na in Japan was still high and that of K was low⁽⁹⁾, and that many people did not meet the WHO recommendation^(10,11). High salt consumption from traditional Japanese seasonings and processed foods, such as soya sauce, *miso* (fermented soyabean paste), pickled vegetables and fish (including sea products), is considered to be the downside of the

Japanese diet^(12,13). Given the difference between the Japanese diet and the Western diet, with the latter including bread and meat products as major contributors to Na intake^(3,12), Japanese populations require a different salt reduction strategy. Since the dietary pattern approach can extract a number of different consumption patterns from overall diets in an analysed population⁽¹⁴⁾, this approach might clarify the difference in intake styles between the Japanese and Western diets and show what aspects of the current Japanese diet are associated with higher salt consumption.

The association between dietary patterns and Na intake has been investigated in Japanese people^(15–19), but these studies estimated Na intake by dietary assessment questionnaires in which measurement error cannot be ignored^(20,21). To date, only one British study has investigated the association between dietary patterns and Na intake using 24 h urinary collection⁽²²⁾, and no comparable research from Asian countries has yet appeared, including Japan.

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In the present study, we identified dietary patterns in the current Japanese diet and evaluated the associations between these patterns and Na and K intakes measured by repeated 24 h urine collection.

Methods

Study participants

Details of the study design and procedure have been described elsewhere⁽⁹⁾. Briefly, the study was based on data from a cross-sectional multicentre survey, conducted in February or March 2013, among healthy welfare facility staff aged 20–69 years from 199 facilities in twenty study areas in twenty-three prefectures in Japan. First, 199 dietitians working in these facilities were recruited to support the study as research dietitians. These dietitians recruited their co-workers as participants. They were not selected randomly but were volunteers. Exclusion criteria were: (i) licensed dietary or medical provider (e.g. dietitian, nurse or medical doctor); (ii) residence in the prefecture or prefecture adjacent to that in which the facility was located (workplace at the time of the study) commencing after 1 August 2012; (iii) under diet therapy prescribed by a doctor or dietitian at the time of the study or within 1 year before the study; (iv) pregnant or lactating women; and (v) history of educational admission for diabetes mellitus. In total, 791 individuals (395 men and 396 women) participated in the survey. Written informed consent was obtained from all participants.

Measurement schedule

All measurements were made in February or March 2013. Main examination items were semi-weighed diet records (DR; obtained from 392 participants), 24 h urine collection (two non-consecutive days), three questionnaires (two types of diet history questionnaire and one lifestyle questionnaire) and anthropometric measurements (body height and weight). First, four non-consecutive survey days for the DR were arranged. Then, two 24 h urine collections were planned before and after the four DR days. The questionnaire surveys were performed between the first urine collection and the first DR. The measurement schedule aimed to complete all measurements within 10 to 14 d and was arranged by the research dietitian and the participant him- or herself in consideration of the participant's work and private schedules.

Dietary assessment and food grouping

Dietary habits during the preceding month were assessed using a validated, self-administered diet history questionnaire (DHQ)^(23–25). Estimates of daily intake for 151 food and beverage items, energy and nutrients were calculated using an *ad hoc* computer algorithm for the DHQ, which was based on the *Standard Tables of Food Composition in Japan*⁽²⁶⁾. For most items, the intakes were

calculated based on the reported consumption frequency and portion size according to the semi-quantitative food frequency methodology. For seasonings used during cooking, the intakes were estimated according to the diet history method, using the qualitative and quantitative information (i.e. cooking method and frequency of the intake). Responses to the DHQ were checked at least twice for completeness, and when necessary were reviewed with the participants by trained survey staff (mostly dietitians) to ensure the accuracy and clarity of answers. After the exclusion of four items (nutritional supplement bars, artificial sweeteners, energy drinks and drinking-water), 147 food items in the DHQ were grouped into forty-one predefined food groups by adding food items within each group (see online supplementary material, Supplemental Table 1) to extract dietary patterns. We excluded the former three items because nutrient contents of these items were unclear, and the number of participants who consumed these items and the amount of intake were small in the present study. Similarly, drinking-water was excluded because accurate estimation for its intake by DHQ was thought to be difficult. Grouping was defined according to the culinary usage of the food items and the similarity of nutrient profiles, with some modification from a previous report⁽²⁷⁾ to ensure that the purposes of the present study were met. In this step, we particularly considered the Na content in each food. The following food groups in the previous report⁽²⁷⁾ were separated due to the difference in Na content: 'Confectioneries' was separated into 'Sweetened bun', 'Confectioneries (i.e. sweets)' and 'Savoury snacks'; 'Dairy products' was separated into 'Cheese' and 'Milk and yoghurt'; and 'Sea products' was separated into 'Salty sea products' (sea products including more than 4 g salt per 100 g of edible portion, such as salted fish eggs, boiled fish in soya sauce and salted fish guts) and 'Sea products' (other sea products). We also composed 'Salt', 'Japanese seasonings' and 'Western seasonings' groups from 'Salt-containing seasonings' and a part of 'Pulses (*miso*)' and 'Vegetable oils (salad dressings with oil and mayonnaise)⁽²⁷⁾ (Supplemental Table 1).

Twenty-four-hour urine collection

Twenty-four-hour urine collection was performed twice on two non-consecutive days during the study period to measure Na and K excretion. A detailed description of the procedure for 24 h urine collection has been published elsewhere⁽⁹⁾. Briefly, participants were asked to collect all urine voided during a 24 h period and to record the time of the start and end of the collection period. They were also asked to estimate the volume of any missing urine specimens. The 24 h urine volume was adjusted by the self-reported collection time of the start and end of the collection period and missing urine volume. This adjustment method has been validated using the *p*-aminobenzoic acid check method⁽²⁸⁾. Samples of collected urine were transferred to

LSI Medicine Corporation (Tokyo, Japan) and analysed for urinary Na and K concentration using the electrode method. Creatinine levels were analysed by the enzyme test. A JCA-BM6050 clinical chemistry analyser (JEOL Limited) was used to determine the concentrations of Na, K and creatinine. An IatroQ CRE(A) II chemical reagent kit (LSI Medicine Corporation) was also used to determine the concentration of creatinine. Excretion of Na and K was calculated as: total 24 h excretion (mmol/d) = adjusted volume of 24 h urine (ml/d) \times concentration (mmol/ml). Na:K was calculated by dividing excreted Na (mg/d) by K (mg/d). This differs from the Na:K ratio recommended by WHO of 1.0 which is a molar ratio⁽¹⁰⁾. We have therefore not compared our values with the WHO recommendation in the present paper.

Other measurements

Body height and weight were measured to the nearest 0.1 cm and 0.1 kg, respectively, with the participant wearing light clothing and no shoes, by the research dietitians or medical staff in the welfare facilities. BMI was calculated as body weight divided by the square of body height (kg/m²). Blood pressure was then measured twice by research dietitians, nurses or the participants themselves using sphygmomanometers in the welfare facilities. The average of the two measurements was used as the participant's representative blood pressure value⁽²⁹⁾. Information on participant background and lifestyle was collected by a questionnaire, which included twenty-one questions about the participant's occupation, family structure, education, smoking habit, medical history, current medication use and physical activity level (estimated by summing the products of exercise duration and the metabolic equivalent of task (MET) value for each activity⁽³⁰⁾).

Statistical analysis

All analyses were performed using the statistical software package SAS version 9.4. We analysed men and women separately, because differences in dietary pattern between sexes were reported previously⁽³¹⁾. For analysis, we selected 760 participants (384 men and 376 women) whose 24 h urine collection was considered to be completed at least once, as assessed by calculating the ratio of observed to expected creatinine excretion according to the equation of Jossens *et al.*^(28,32). If the observed creatinine excretion of a urine collection was within 60 to 140% of the expected value, the collection was considered to be successful^(28,32). When both collections were considered successful, the average of the two excretion values of urine collection was used as representative; when only one collection was considered successful, its value was used as representative. We then excluded those who did not answer the DHQ (n 1). We also excluded participants with severe under- or over-reporting for energy intake as follows: participants with reported energy intake less than half the energy

requirement for the lowest physical activity category according to the *Dietary Reference Intakes for Japanese, 2015*⁽³³⁾ or participants with reported energy intake equal to or more than 1.5 times the energy requirement for the highest physical activity category, respectively (n 12). We further excluded participants who were currently receiving dietary counselling from a doctor or dietitian (n 45). Finally, the total number of individuals in the analysis was 353 men and 349 women.

Factor analysis to derive dietary patterns based on the forty-one predefined food groups was conducted using the FACTOR PROCEDURE function of the SAS software. Intakes of these food groups (g/d) were examined by the DHQ, log-transformed to achieve normality and then adjusted for total energy intake by the residual method⁽⁸⁾. The factors were rotated by orthogonal transformation (Varimax rotation function in SAS) to achieve a simpler structure with greater interpretability. The number of factors was determined by the eigenvalue (>1.0), scree plots and the interpretability of the combination of food groups on the factors. A factor solution with four factors was found to be reasonable and meaningful for both men and women (see online supplementary material, Supplemental Table 2). The proportion of variance explained by each factor was calculated by dividing the sum of the square of the respective factor loading by the number of variables. The factor scores of each dietary pattern for each participant were calculated by summing the intakes of food groups weighted by their factor score loadings. The validity of dietary patterns derived from the DHQ has been reported previously⁽²⁷⁾.

The factor score for each dietary pattern was categorized into quintiles and general characteristics were compared between these categories. The Mantel-Haenszel χ^2 test was used for categorical variables. For continuous variables, a linear regression analysis was conducted to assess trend associations, using factor scores (continuous) as independent variables. To investigate associations between factor scores (quintiles) for dietary patterns and urinary Na and K excretions and Na:K, multivariate-adjusted means of Na and K excretion in each quintile were calculated by adjusting for age and weight (model 1). We further adjusted for residential block (six categories), education (high school or less and other, some college, university or more) and smoking (never, past and current) in model 2. Regarding Na:K, multivariate-adjusted means were calculated by adjusting for age (model 3) and further adjusting for residential block, education and smoking (model 4), respectively. Trends of association in factor score quintiles were assessed by a linear regression model which included Na and K excretions or Na:K as a dependent variable and factor scores (continuous), age, body weight, residential block, education and smoking as independent variables. Energy-adjusted mean by the residual method of food group intake and Na intake from each food group, and its contribution as Na source to total Na intake in participants of the highest

quintile, were calculated for each dietary pattern to show key foods which characterize Na intake in each dietary pattern. A two-sided P value of <0.05 was considered statistically significant.

Results

In factor analysis, four factors were extracted for each sex and labelled according to those food groups with high loadings (see online supplementary material, Supplemental Table 2). For men, factors were labelled 'Fish and vegetable' (high positive loadings on fish, sea products (e.g. dried fish, canned tuna and fish paste products), green and yellow vegetables, fruits, other vegetables, etc.), 'Meat, vegetable and oil' (positive loadings on vegetable oil, beef and pork, salt, chicken, other vegetables, potatoes, green and yellow vegetables, processed meat, etc.), 'Noodle' (positive loadings on noodle soup, Japanese, Chinese and instant noodles and pasta) and 'Bread and confectioneries' (positive loadings on sweetened buns, bread, confectioneries, savoury snacks, etc. and negative loading on alcoholic beverages). For women, factors were labelled 'Fish and vegetable' (high positive loadings on other vegetables, green and yellow vegetables, salt, potatoes, fish, etc.), 'Meat and oil' (positive loadings on beef and pork, vegetable oil, chicken and processed meat and negative loadings on fruits and pulses), 'Noodle' (same as men) and 'Bread and confectioneries' (positive loadings on bread, sweetened buns, confectioneries, fatty spreads and tea and negative loadings on rice and *miso* soup). The total explained variance of dietary patterns was 26.0% for men and 22.4% for women, respectively.

We divided the participants into quintiles by the factor score of each dietary pattern. Sample characteristics are presented for the lowest (Q1) and highest (Q5) quintiles of each pattern (Table 1 for men and Table 2 for women). Participants in the higher quintiles of the 'Fish and vegetable' pattern were older, whereas the opposite association was seen with the other patterns. The 'Fish and vegetable' pattern was negatively associated with smoking in both sexes and with drinking only in women. The 'Meat and oil' pattern was negatively associated with systolic blood pressure in women, but this association disappeared after adjustment for age and body weight (data not shown).

Multivariable-adjusted means for urinary Na and K excretions and Na:K across quintiles of all four dietary patterns are shown in Tables 3 (men) and 4 (women). For men, after controlling for confounding factors, higher factor score for the 'Fish and vegetable' pattern was significantly associated with higher urinary K excretion (P for trend = 0.008) and lower urinary Na:K (P for trend = 0.04). The mean urinary K excretion in the participants in the highest quintile of the 'Fish and vegetable' pattern was 5.8 mmol/d (227 mg/d) higher than those in the lowest quintile. Urinary Na excretion was higher in quintiles with

a higher factor score for the 'Fish and vegetable' pattern, but the relationship was not significant (211.6 *v.* 205.0 mmol/d (12.4 *v.* 12.0 g/d as salt) in the highest *v.* the lowest quintile, respectively). Higher factor score for the 'Meat, vegetable and oil' pattern was associated with neither urinary Na and K excretions nor Na:K. Higher factor score for the 'Noodle' pattern was significantly associated with lower urinary K excretion and higher Na:K (P for trend = 0.04 and 0.02, respectively). The mean urinary K excretion of participants in the highest quintile for the 'Noodle' pattern was 3.2 mmol/d (125 mg/d) lower than those in the lowest quintile. Urinary Na excretion was higher in quintiles with a higher factor score for the 'Noodle' pattern, but again the relationship was not significant (216.4 *v.* 193.4 mmol/d (12.7 *v.* 11.3 g/d as salt) in the highest *v.* the lowest quintile, respectively).

For women, the direction of associations was similar to that in men but the number of statistically significant associations was larger in women. Higher factor score for the 'Fish and vegetable' pattern was marginally or significantly associated with higher urinary Na and K excretions after adjustment for covariates (P for trend = 0.06 and 0.013, respectively). Actually, the mean Na and K excretions in the highest quintile for this pattern were 13.6 mmol/d (0.8 g/d as salt) and 6.3 mmol/d (246 mg/d) higher than those in the lowest quintile, respectively. For the 'Meat and oil' pattern, lower Na and K excretions were associated with a higher factor score (P for trend = 0.006 and <0.0001 , respectively). The mean Na and K excretions in the highest quintile for this pattern were 17.1 mmol/d (1.0 g/d as salt) and 9.0 mmol/d (352 mg/d) lower than those in the lowest quintile. In addition, higher Na excretion was significantly associated with a higher factor score for the 'Noodle' pattern (187.0 *v.* 163.8 mmol/d (10.9 *v.* 9.6 g/d as salt) in the highest *v.* the lowest quintile, respectively) and a lower score for the 'Bread and confectioneries' pattern (168.3 *v.* 180.6 mmol/d (9.8 *v.* 10.6 g/d as salt) in the highest *v.* the lowest quintile, respectively). These two patterns were not significantly related with urinary K excretion or Na:K.

The mean food group intake and mean and proportion of Na intake from each food group in the highest quintile (Q5) of each dietary pattern are shown in online supplementary material, Supplemental Table 3 (men) and Supplemental Table 4 (women), respectively. Among all dietary patterns, seasonings (salt and Japanese and Western seasonings) were the largest contributor to Na intake. Additionally, mean food group intake and the proportion of Na intake from each food group differed among the different dietary patterns.

Discussion

In the current study we identified four dietary patterns in the current Japanese diet and showed a number of

Table 1 Sample characteristics for the lowest (Q1) and highest (Q5) quintiles of four dietary patterns identified for 353 Japanese men*

	Sample characteristics for the lowest (Q1) and highest (Q5) quintiles of four dietary patterns identified for 353 Japanese men*																									
	'Fish and vegetable'							'Meat, vegetable and oil'					'Noodle'					'Bread and confectioneries'								
	All (n 353)		Q1 (n 70)		Q5 (n 70)			P value†	Q1 (n 70)		Q5 (n 70)			P value†	Q1 (n 70)		Q5 (n 70)			P value†	Q1 (n 70)		Q5 (n 70)		P value†	
Mean or n	SD or %	Mean or n	SD or %	Mean or n	SD or %	Mean or n	SD or %		Mean or n	SD or %	Mean or n	SD or %	Mean or n		SD or %	Mean or n	SD or %	Mean or n	SD or %		Mean or n	SD or %	Mean or n	SD or %		Mean or n
Age (years), mean and SD	44.2	13.7	34.8	10.3	55.9	11.2	<0.0001	47.6	14.4	38.5	11.7	<0.0001	46.2	13.2	42.3	14.6	0.02	46.2	13.8	42.3	13.3	0.27				
Age group (years), n and %																										
20–29	70	19.8	31	44.3	2	2.9	<0.0001	15	21.4	20	28.6	0.0001	9	12.9	21	30.0	0.04	13	18.6	14	20.0	0.32				
30–39	77	21.8	18	25.7	9	12.9		6	8.6	19	27.1		16	22.9	13	18.6		9	12.9	19	27.1					
40–49	68	19.3	14	20.0	8	11.4		16	22.9	17	24.3		17	24.3	10	14.3		17	24.3	14	20.0					
50–59	67	19.0	4	5.7	11	15.7		13	18.6	9	12.9		10	14.3	13	18.6		15	21.4	13	18.6					
60–69	71	20.1	3	4.3	40	57.1		20	28.6	5	7.1		18	25.7	13	18.6		16	22.9	10	14.3					
Body height (cm), mean and SD	170.1	5.9	171.2	5.8	168.4	5.3	0.003	169.9	6.5	169.9	5.2	0.60	169.2	5.3	169.8	6.4	0.17	169.7	5.6	170.5	4.8	0.51				
Body weight (kg), mean and SD	68.9	10.9	69.6	11.2	67.1	9.7	0.27	67.7	9.3	70.9	12.1	0.04	67.8	10.8	70.1	11.4	0.35	69.2	10.6	71.4	12.6	0.40				
BMI (kg/m ²), mean and SD	23.8	3.4	23.7	3.7	23.6	3.1	0.90	23.4	3.0	24.5	3.9	0.06	23.7	3.3	24.3	3.4	0.69	24.0	3.1	24.5	4.0	0.48				
SBP (mmHg), mean and SD	127	14	126	13	129	14	0.30	129	14	126	14	0.55	129	14	129	13	0.57	127	15	129	14	0.73				
DBP (mmHg), mean and SD	80	11	80	11	81	10	>0.999	81	11	78	10	0.52	81	11	81	11	0.45	78	11	82	10	0.25				
PAL (MET × h), mean and SD	37.8	5.9	38.9	6.2	36.1	4.8	0.0005	38.3	5.8	38.4	5.9	0.96	37.9	6.7	38.2	5.7	0.62	37.4	6.9	37.9	6.1	0.70				
Energy (kJ/d), mean and SD	9548	2205	9473	2853	9694	2146	>0.999	9669	2791	9862	2113	>0.999	9577	2561	9000	2109	>0.999	9904	2360	9883	1954	>0.999				
Energy (kcal/d), mean and SD	2282	574	2264	682	2317	513	>0.999	2311	667	2357	505	>0.999	2289	612	2151	504	>0.999	2367	564	2362	467	>0.999				
Residential block, n and %																										
Hokkaido and Tohoku	55	15.6	13	18.6	15	21.4	0.12	18	25.7	7	10.0	0.0004	6	8.6	15	21.4	0.002	18	25.7	7	10.0	0.50				
Kanto	71	20.1	12	17.1	18	25.7		17	24.3	15	21.4		11	15.7	23	32.9		10	14.3	18	25.7					
Hokuriku and Tokai	35	9.9	6	8.6	9	12.9		9	12.9	5	7.1		10	14.3	7	10.0		6	8.6	9	12.9					
Kinki	56	15.9	13	18.6	8	11.4		9	12.9	6	8.6		15	21.4	7	10.0		8	11.4	11	15.7					
Chugoku and Shikoku	66	18.7	12	17.1	9	12.9		8	11.4	17	24.3		18	25.7	4	5.7		8	11.4	18	25.7					
Kyushu and Okinawa	70	19.8	14	20.0	11	15.7		9	12.9	20	28.6		10	14.3	14	20.0		20	28.6	7	10.0					
Education, n and %																										
High school or less and other	87	24.7	15	21.4	19	27.1	0.03	22	31.4	7	10.0	0.02	22	31.4	10	14.3	0.006	21	30.0	10	14.3	0.06				
Some college	100	28.3	33	47.1	10	14.3		17	24.3	20	28.6		20	28.6	17	24.3		20	28.6	25	35.7					
University or more	166	47.0	22	31.4	41	58.6		31	44.3	43	61.4		28	40.0	43	61.4		29	41.4	35	50.0					
Smoking, n and %																										
Non-smoker	112	31.7	27	38.6	24	34.3	0.048	21	30.0	19	27.1	0.49	23	32.9	23	32.9	0.15	17	24.3	29	41.4	0.0002				
Past smoker	115	32.6	9	12.9	28	40.0		17	24.3	27	38.6		29	41.4	15	21.4		20	28.6	22	31.4					
Current smoker	126	35.7	34	48.6	18	25.7		32	45.7	24	34.3		18	25.7	32	45.7		33	47.1	19	27.1					
Alcohol drinking, n and %																										
Current drinker	269	76.2	47	67.1	60	85.7	0.008	50	71.4	55	78.6	0.48	54	77.1	53	75.7	0.33	63	90.0	36	51.4	<0.0001				

SBP, systolic blood pressure; DBP, diastolic blood pressure; PAL, physical activity level; MET, metabolic equivalent of task.

*The factors were standardized by continuous variables, and each participant had a score for each factor.

†A linear trend test and the Mantel–Haenszel χ^2 test were used for continuous and categorical variables, respectively.

Table 2 Sample characteristics for the lowest (Q1) and highest (Q5) quintiles of four dietary patterns identified for 349 Japanese women*

	'Fish and vegetable'								'Meat and oil'					'Noodle'					'Bread and confectioneries'				
	All (n 349)		Q1 (n 69)		Q5 (n 70)†		P value‡	Q1 (n 69)		Q5 (n 70)†		P value‡	Q1 (n 69)		Q5 (n 70)†		P value‡	Q1 (n 69)		Q5 (n 70)†		P value‡	
	Mean or n	SD or %	Mean or n	SD or %	Mean or n	SD or %		Mean or n	SD or %	Mean or n	SD or %		Mean or n	SD or %	Mean or n	SD or %		Mean or n	SD or %	Mean or n	SD or %		Mean or n
Age (years), mean and SD	44.3	13.3	40.8	13.0	47.9	14.3	0.0001	52.6	12.5	38.9	10.8	<0.0001	48.8	13.6	44.6	13.7	0.002	49.1	12.7	41.8	12.8	0.002	
Age group (years), n and %																							
20–29	68	19.5	18	26.1	13	18.6	0.003	8	11.6	18	25.7	<0.0001	10	14.5	15	21.4	0.03	9	13.0	17	24.3	0.002	
30–39	70	20.1	15	21.7	8	11.4		4	5.8	19	27.1		9	13.0	9	12.9		6	8.7	15	21.4		
40–49	76	21.8	17	24.6	13	18.6		8	11.6	23	32.9		12	17.4	18	25.7		18	26.1	17	24.3		
50–59	68	19.5	10	14.5	16	22.9		21	30.4	6	8.6		14	20.3	16	22.9		15	21.7	12	17.1		
60–69	67	19.2	9	13.0	20	28.6		28	40.6	4	5.7		24	34.8	12	17.1		21	30.4	9	12.9		
Body height (cm), mean and SD	157.4	5.4	157.3	5.5	156.5	5.4	0.22	156.9	6.3	157.5	4.9	0.14	156.6	6.0	158.1	5.3	0.14	156.4	5.7	158.1	6.0	0.37	
Body weight (kg), mean and SD	55.6	9.7	55.9	10.8	54.6	7.3	0.97	55.8	11.8	55.2	8.3	0.45	56.1	10.8	55.6	9.5	0.93	54.2	9.7	56.3	9.4	0.35	
BMI (kg/m ²), mean and SD	22.4	3.6	22.6	3.8	22.3	2.7	0.52	22.6	4.2	22.2	2.9	0.83	22.9	4.2	22.2	3.4	0.53	22.1	3.6	22.5	3.2	0.56	
SBP (mmHg), mean and SD	119	16	118	16	120	15	0.20	125	19	116	14	0.0003	120	17	122	15	0.74	123	14	118	13	0.09	
DBP (mmHg), mean and SD	76	11	76	10	77	12	0.12	78	11	75	9	0.16	75	9	78	11	0.69	77	10	76	10	0.71	
PAL (MET × h), mean and SD	38.4	6.3	38.4	7.0	39.1	5.4	0.16	38.5	6.0	39.3	7.0	0.98	39.1	6.3	38.0	5.5	0.53	38.5	5.7	37.8	5.9	0.95	
Energy (kJ/d), mean and SD	7598	1862	7489	2163	7719	1490	0.97	7590	1866	7489	1657	0.92	7686	1757	7627	1824	0.95	7326	1833	7401	1606	0.94	
Energy (kcal/d), mean and SD	1816	445	1790	517	1845	356	0.97	1814	446	1790	396	0.92	1837	420	1823	436	0.95	1751	438	1769	384	0.94	
Residential block, n and %																							
Hokkaido and Tohoku	46	13.2	13	18.8	7	10.0	0.14	12	17.4	5	7.1	0.0001	6	8.7	14	20.0	0.014	13	18.8	5	7.1	0.052	
Kanto	75	21.5	16	23.2	14	20.0		24	34.8	10	14.3		16	23.2	19	27.1		13	18.8	16	22.9		
Hokuriku and Tokai	34	9.7	5	7.2	5	7.1		6	8.7	5	7.1		4	5.8	6	8.6		10	14.5	7	10.0		
Kinki	57	16.3	14	20.3	10	14.3		10	14.5	13	18.6		12	17.4	6	8.6		4	5.8	15	21.4		
Chugoku and Shikoku	71	20.3	9	13.0	18	25.7		10	14.5	19	27.1		18	26.1	14	20.0		14	20.3	16	22.9		
Kyusyu and Okinawa	66	18.9	12	17.4	16	22.9		7	10.1	18	25.7		13	18.8	11	15.7		15	21.7	11	15.7		
Education, n and %																							
High school or less and other	140	40.1	29	42.0	34	48.6	0.52	38	55.1	26	37.1	0.012	37	53.6	28	40.0	0.13	38	55.1	16	22.9	0.008	
Some college	145	41.6	27	39.1	26	37.1		24	34.8	32	45.7		26	37.7	30	42.9		23	33.3	44	62.9		
University or more	64	18.3	13	18.8	10	14.3		7	10.1	12	17.1		6	8.7	12	17.1		8	11.6	10	14.3		
Smoking, n and %																							
Non-smoker	269	77.1	44	63.8	61	87.1	0.003	57	82.6	54	77.1	0.93	54	78.3	52	74.3	0.44	49	71.0	56	80.0	0.37	
Past smoker	34	9.7	10	14.5	6	8.6		4	5.8	7	10.0		4	5.8	6	8.6		9	13.0	7	10.0		
Current smoker	46	13.2	15	21.7	3	4.3		8	11.6	9	12.9		11	15.9	12	17.1		11	15.9	7	10.0		
Alcohol drinking, n and %																							
Current drinker	190	54.4	47	68.1	31	44.3	0.002	40	58.0	39	55.7	0.93	33	47.8	44	62.9	0.07	41	59.4	34	48.6	0.13	

SBP, systolic blood pressure; DBP, diastolic blood pressure; PAL, physical activity level; MET, metabolic equivalent of task.

*The factors were standardized continuous variables, and each participant had a score for each factor.

†For PAL, the fifth quintile (Q5) comprised sixty-nine participants.

‡A linear trend test and the Mantel–Haenszel χ^2 test were used for continuous and categorical variables, respectively.

Table 3 Multivariate-adjusted means and SE for urinary sodium and potassium excretion and sodium:potassium by quintile of each dietary pattern for 353 Japanese men

	Quintile category of dietary pattern										P value*
	Q1 (n 70)		Q2 (n 71)		Q3 (n 71)		Q4 (n 71)		Q5 (n 70)		
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	
'Fish and vegetable'											
Na excretion (mmol/d)											
Model 1†	205.7	7.7	202.1	7.2	195.8	7.3	207.1	7.3	212.8	8.0	0.32
Model 2‡	205.0	7.8	205.0	7.3	195.9	7.2	206.0	7.4	211.6	8.1	0.37
K excretion (mmol/d)											
Model 1†	47.1	1.8	50.7	1.7	49.7	1.7	52.4	1.7	55.1	1.9	0.0004
Model 2‡	48.3	1.8	51.4	1.7	49.9	1.7	51.4	1.7	54.1	1.9	0.008
Na:K											
Model 3§	2.7	0.1	2.5	0.1	2.4	0.1	2.4	0.1	2.4	0.1	0.006
Model 4	2.7	0.1	2.5	0.1	2.4	0.1	2.5	0.1	2.4	0.1	0.04
'Meat, vegetable and oil'											
Na excretion (mmol/d)											
Model 1†	212.9	7.3	203.2	7.2	210.1	7.2	200.4	7.2	196.8	7.4	0.14
Model 2‡	213.3	7.4	203.3	7.2	208.7	7.3	200.2	7.2	198.0	7.5	0.20
K excretion (mmol/d)											
Model 1†	49.8	1.7	52.5	1.7	50.1	1.7	50.2	1.7	52.5	1.8	0.35
Model 2‡	50.4	1.8	52.3	1.7	50.9	1.7	49.6	1.7	51.8	1.8	0.64
Na:K											
Model 3§	2.6	0.1	2.4	0.1	2.6	0.1	2.5	0.1	2.3	0.1	0.04
Model 4	2.6	0.1	2.4	0.1	2.5	0.1	2.5	0.1	2.4	0.1	0.15
'Noodle'											
Na excretion (mmol/d)											
Model 1†	196.5	7.3	199.3	7.2	206.0	7.2	206.6	7.2	215.1	7.3	0.32
Model 2‡	193.4	7.3	203.2	7.3	205.0	7.1	205.5	7.2	216.4	7.4	0.17
K excretion (mmol/d)											
Model 1†	52.1	1.7	53.3	1.7	51.9	1.7	48.8	1.7	49.0	1.7	0.04
Model 2‡	51.9	1.7	53.4	1.7	52.1	1.7	49.0	1.7	48.7	1.8	0.04
Na:K											
Model 3§	2.4	0.1	2.3	0.1	2.5	0.1	2.6	0.1	2.7	0.1	0.051
Model 4	2.3	0.1	2.3	0.1	2.6	0.1	2.4	0.1	2.7	0.1	0.02
'Bread and confectioneries'											
Na excretion (mmol/d)											
Model 1†	198.0	7.2	200.8	7.2	218.5	7.3	204.2	7.2	201.8	7.3	0.99
Model 2‡	201.3	7.3	202.9	7.2	217.7	7.3	204.1	7.3	197.3	7.4	0.50
K excretion (mmol/d)											
Model 1†	48.1	1.7	51.8	1.7	53.3	1.7	52.4	1.7	49.4	1.7	0.47
Model 2‡	49.4	1.7	52.2	1.7	53.5	1.7	51.6	1.7	48.3	1.7	0.74
Na:K											
Model 3§	2.5	0.1	2.4	0.1	2.5	0.1	2.4	0.1	2.6	0.1	0.61
Model 4	2.5	0.1	2.4	0.1	2.4	0.1	2.5	0.1	2.5	0.1	0.77

*A linear trend test was used for the trend test.

†Adjusted for age and body weight.

‡Further adjusted for residential block (Hokkaido and Tohoku; Kanto; Hokuriku and Tokai; Kinki; Chugoku and Shikoku; Kyushu and Okinawa), education (high school or less and other, some college, university or more) and smoking (none, past, current).

§Adjusted for age.

||Further adjusted for residential block, education and smoking.

Table 4 Multivariate adjusted means and SE for urinary sodium and potassium excretion and sodium:potassium by quintile of each dietary pattern for 349 Japanese women

	Quintile category of dietary pattern										P value*
	Q1 (n 69)		Q2 (n 70)		Q3 (n 70)		Q4 (n 70)		Q5 (n 70)		
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	
'Fish and vegetable'											
Na excretion (mmol/d)											
Model 1†	165.7	6.0	166.8	5.9	172.4	5.9	179.2	5.9	181.2	5.9	0.04
Model 2‡	166.8	6.1	166.3	5.9	173.1	5.9	178.7	6.0	180.4	6.0	0.06
K excretion (mmol/d)											
Model 1†	44.0	1.7	44.7	1.6	49.5	1.6	47.8	1.6	50.5	1.6	0.011
Model 2‡	44.4	1.7	44.3	1.6	49.5	1.6	47.6	1.6	50.7	1.6	0.013
Na:K											
Model 3§	2.3	0.1	2.3	0.1	2.1	0.1	2.3	0.1	2.2	0.1	0.53
Model 4	2.3	0.1	2.4	0.1	2.1	0.1	2.3	0.1	2.2	0.1	0.55
'Meat and oil'											
Na excretion (mmol/d)											
Model 1†	184.7	6.2	171.9	5.9	167.4	5.9	173.2	6.0	168.3	6.0	0.007
Model 2‡	185.0	6.3	171.4	6.0	167.4	6.0	173.8	6.0	167.9	6.1	0.006
K excretion (mmol/d)											
Model 1†	52.5	1.7	48.4	1.6	47.0	1.6	45.8	1.6	42.9	1.6	<0.0001
Model 2‡	52.4	1.7	48.4	1.6	46.9	1.6	45.5	1.6	43.4	1.7	<0.0001
Na:K											
Model 3§	2.2	0.1	2.1	0.1	2.2	0.1	2.4	0.1	2.4	0.1	0.09
Model 4	2.2	0.1	2.1	0.1	2.2	0.1	2.4	0.1	2.4	0.1	0.14
'Noodle'											
Na excretion (mmol/d)											
Model 1†	163.6	6.0	168.7	5.9	169.7	5.9	175.9	5.9	187.4	5.9	0.003
Model 2‡	163.8	6.0	169.3	6.0	169.5	5.9	175.7	5.9	187.0	5.9	0.003
K excretion (mmol/d)											
Model 1†	45.3	1.7	46.8	1.6	46.2	1.6	49.5	1.7	48.7	1.6	0.08
Model 2‡	45.9	1.7	46.8	1.7	46.2	1.6	49.2	1.6	48.4	1.6	0.20
Na:K											
Model 3§	2.2	0.1	2.2	0.1	2.2	0.1	2.3	0.1	2.4	0.1	0.25
Model 4	2.2	0.1	2.2	0.1	2.2	0.1	2.3	0.1	2.4	0.1	0.10
'Bread and confectioneries'											
Na excretion (mmol/d)											
Model 1†	181.5	6.0	176.8	5.9	179.0	5.9	158.9	5.9	169.3	5.9	0.02
Model 2‡	180.6	6.1	176.6	5.9	181.6	5.9	158.4	5.9	168.3	6.0	0.02
K excretion (mmol/d)											
Model 1†	47.5	1.7	49.1	1.6	47.8	1.6	44.8	1.6	47.4	1.7	0.41
Model 2‡	47.2	1.7	48.7	1.6	48.2	1.7	45.0	1.6	47.4	1.7	0.48
Na:K											
Model 3§	2.4	0.1	2.2	0.1	2.3	0.1	2.1	0.1	2.2	0.1	0.13
Model 4	2.4	0.1	2.2	0.1	2.3	0.1	2.1	0.1	2.2	0.1	0.08

*A linear trend test was used for trend test.

†Adjusted for age and body weight.

‡Further adjusted for residential block (Hokkaido and Tohoku; Kanto; Hokuriku and Tokai; Kinki; Chugoku and Shikoku; Kyushu and Okinawa), education (high school or less and other, some college, university or more) and smoking (none, past, current).

§Adjusted for age.

||Further adjusted for residential block, education and smoking.

associations between these patterns and urinary Na and K excretions and Na:K. To our knowledge, the present study is the first to precisely investigate the associations between dietary patterns and Na and K intakes measured by 24 h urine collection in a non-Western country.

The 'Fish and vegetable' pattern was similar to the 'Japanese', 'Vegetable' or 'Healthy' pattern, or 'Fish and vegetable' pattern found in previous Japanese studies^(15–17,27). These dietary patterns were characterized by high intakes of fish and vegetables and were most comparable to the so-called traditional Japanese pattern. The high Na intake in these patterns was due to the high intake of salty foods such as salted fish and sea products, pickled vegetables, *miso* soup and salt-containing seasonings, regardless of the statistical method used to identify these dietary patterns^(15–17,27). The present study reconfirmed these findings by precise Na intake assessment using repeated 24 h urinary collection. The 'Meat, vegetable and oil' pattern in men and 'Meat and oil' pattern in women were most closely comparable to the 'Western'⁽²⁷⁾ or 'Animal Food'⁽¹⁵⁾ pattern in previous Japanese studies. In the present study, the 'Meat, vegetable and oil' pattern was not associated with either Na or K intake in men. In women, the 'Meat and oil' pattern was associated with lower Na and K intakes and Na:K was not associated with this pattern. A unique aspect of this dietary pattern was the sex difference in food intake characteristics; factor loadings on salty foods (such as fish products, pickled vegetables and *miso* soup), salt-containing seasonings and K-rich foods (such as fruits, vegetables, potatoes and pulses) were lower in women than in men (see online supplementary material, Supplemental Table 3). This difference might explain why this pattern was associated with lower urinary Na and K excretions in women, whereas no clear association was observed in men. Although the reason for these results is unclear, gender differences in beliefs about the healthfulness of meat might affect the characteristics of the dietary patterns. In previous research more men identified meat as the component of 'a healthy diet' than women^(34,35). Therefore, men with higher meat intake might be more health-conscious than other men and also include more fruits, vegetables, potatoes and pulses in their diet. By contrast, meat intake could not be a marker of health consciousness in women. This might explain why women with higher meat intake had stable or less intake of 'healthy' foods such as fruits or vegetables⁽³⁶⁾. The characteristics of the 'Meat, vegetable and oil' pattern in men might be relatively similar to those of the 'Fish and vegetable' pattern, which had been considered 'Health-conscious' pattern in a previous study⁽²²⁾, whereas the 'Meat and oil' pattern in women might be different from so-called 'healthy' pattern. The 'Bread and confectioneries' pattern was comparable to the 'Westernized breakfast' pattern, which was associated with a lower Na intake in a previous Japanese study⁽¹⁶⁾. Similarly, this pattern was not associated with

either Na or K intake in men and was negatively associated with Na intake in women in the present study. A second unique finding in our study was the higher Na intake and lower (in men) or almost stable (in women) K intake in the 'Noodle' pattern. The reason for these results was the higher loadings of noodle and noodle soup and negative (in men) or almost null (in women) loadings for vegetables, potatoes and pulses.

The current study also showed that there was a clear association between age and dietary pattern. Older people had high score for the 'Fish and vegetables' pattern, whereas younger people had higher score for the 'Meat, vegetable and oil'/'Meat and oil', 'Noodle' and the 'Bread and confectioneries' patterns. The present study was conducted under cross-sectional design, preventing any direct mention of secular trend in dietary patterns. Nevertheless, this association between age and dietary pattern might have reflected nutrition transition⁽³⁷⁾ in Japan and suggests that an effective salt reduction programme should consider the different contributions of particular processed foods to salt intake between generations.

Our present results differed from those of previous Western studies, in which the patterns with high loadings for bread and meat products were positively associated with high Na intake whereas those with high loadings for fish and vegetables were not^(22,38). This difference might be explained by the different contribution of each food group to total Na intake. Given that the DHQ has lower validity in estimating salt intake in men than women⁽²³⁾, we first attempted to compare the contribution of each food group as an Na source to total Na intake in women. In the previous British study⁽²²⁾, the proportion of Na intake in total women from bread or bacon/ham and sausages was 20.7% or 9.3%. These values should have been higher in those who had a higher factor score for the 'Bread, spread and cheese' or 'Meat products, chips and eggs' or 'Red meat and alcohol' pattern because these dietary patterns were characterized by a higher intake of these foods. In the present study, the contribution of bread or total meat to Na intake in the highest quintile of the 'Bread and confectioneries' pattern or the 'Meat and oil' pattern was lower than in the British study (8.1% or 4.1%). On the contrary, the proportions of Na intake from fish, vegetable or sauce (the factor loadings of these foods were high in the 'Health-conscious' pattern) in the British study⁽²²⁾ were lower than their counterparts in the present study; namely, the proportions of Na intake from seafood, vegetables (including green and yellow, other and pickled vegetables) and Japanese and Western seasonings in the highest quintile of the 'Fish and vegetable' pattern (4.6, 4.2 and 5.3% in British women *v.* 6.6, 5.8 and 17.6% in Japanese women, respectively). Similar tendencies were seen in men. England and many other Western countries have targeted bread and/or processed foods such as meat products for salt reduction due to their major contribution

to salt intake⁽³⁾, and this strategy has reduced the population average salt intake in England⁽³⁹⁾. However, our present study suggests that targeting these foods for salt reduction might be less effective in Japan. Additionally, any recommendation for a dietary pattern characterized by higher fish and vegetable intakes, which was considered as 'health-conscious' in the previous study⁽²²⁾ and was most comparable to the so-called traditional Japanese diet, should be done carefully because this dietary pattern is associated with high salt intake in Japan.

The major strength of the present study is its precise assessment of Na and K intakes using two 24 h urine collections, which is considered the gold standard⁽⁸⁾. In previous Japanese studies^(15–19), evaluation of Na and K intakes was conducted by dietary assessment questionnaires which were shown to include reporting error^(20,21). In the British study, Na intake was also assessed by 24 h urine collection, but only a single collection was made⁽²²⁾. It has been reported that the accuracy of a single 24 h urine collection was insufficient to estimate habitual Na and K intakes⁽⁸⁾. We also identified dietary patterns using the DHQ, in which the validity of dietary patterns was previously reported⁽²⁷⁾. Most dietary pattern studies use dietary assessment questionnaires that have not been validated at the dietary pattern level, but rather at the food and/or nutrient intake level(s). A further strength was that we first attempted to show the Na intake for each food group and the contribution to Na intake to each dietary pattern. Gibson and Ashwell⁽²²⁾ also presented the proportion of Na intake from individual food groups, but did not show the major Na source for each dietary pattern. This information is necessary to the development of effective salt reduction programmes for individual populations.

Several limitations of the present study also warrant mention. First, the participants were not randomly selected from the general Japanese population, but were volunteers, and possibly health-conscious⁽⁹⁾. Random sampling was not feasible because of the burden of multiple 24 h urine collection. Nevertheless, the participants' general characteristics were compatible with the results of national surveys^(40,41). Second, standardization of 24 h urine collection was difficult because the research areas were located throughout the whole of Japan. We therefore attempted to standardize the procedure as already described⁽⁹⁾. Third, the factor analysis itself also had limitations, in that the procedures arose from arbitrary decisions. These decisions might have affected both the results and their interpretation. We therefore attempted to derive dietary patterns by using similar steps in the objective decision-making process as used in previous studies, namely eigenvalues, scree plots and interpretability. Finally, as mentioned above, the validity of the DHQ for Na intake estimation was lower in men than women (Pearson correlation coefficient was $r=0.14$ in men and $r=0.23$ in women)⁽²³⁾. In the present study, the

Pearson correlation coefficient of dietary Na intake estimated by the DHQ (energy-adjusted by the residual method) and urinary Na excretion per body weight was very low in men ($r=0.03$ in men and $r=0.20$ in women, respectively; data not shown). Although the reason for this is unknown, men might report their dietary intakes less accurately than women, because men are generally less conscious about their dietary intake than women⁽⁴²⁾. Since women are usually in charge of meal preparation in Japan, men might not comprehend the amount of seasonings used in meal preparation⁽⁴³⁾. However, the validity of the DHQ for food group intake estimation was sufficient (median Spearman correlation coefficient was 0.44)⁽²⁴⁾. We therefore consider that the intake of foods in each dietary pattern was estimated precisely even in men, and that their contribution to total Na intake should have been measured in a similar manner to that in women.

Conclusion

We identified four dietary patterns among Japanese adults. The 'Fish and vegetable' pattern as well as the 'Noodle' pattern contributed to higher Na intake. The 'Fish and vegetable' pattern was simultaneously associated with higher K intake. Given that similar dietary patterns derived from Japan and the UK had different influences on Na intake, target foods for salt reduction should be set based on careful consideration of the relationships between major dietary patterns and Na and K intakes in the target population.

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Supplementary material

To view supplementary material for this article, please visit <http://dx.doi.org/10.1017/S1368980016000641>

References

- O'Donnell M, Mente A, Rangarajan S *et al.* (2014) Urinary sodium and potassium excretion, mortality, and cardiovascular events. *N Engl J Med* **371**, 612–623.
- Neal B (2007) *The Effectiveness and Costs of Population Interventions to Reduce Salt Consumption*. Geneva: WHO.
- Webster J, Trieu K, Dunford E *et al.* (2014) Target salt 2025: a global overview of national programs to encourage the food industry to reduce salt in foods. *Nutrients* **6**, 3274–3287.
- He FJ & MacGregor G (2009) A comprehensive review on salt and health and current experience of worldwide salt reduction programmes. *J Hum Hypertens* **23**, 363–384.
- World Health Organization (n.d.) Population sodium reduction strategies. <http://www.who.int/dietphysicalactivity/reducingsalt/en/> (accessed September 2015).
- Intersalt Cooperative Research Group (1988) INTERSALT: an international study of electrolyte excretion and blood pressure: results for 24h urinary sodium and potassium excretion. *Br Med J* **297**, 319–328.
- Zhou BF, Stamler J, Dennis B *et al.* (2003) Nutrient intakes of middle-aged men and women in China, Japan, United Kingdom, and United States in the late 1990s: the INTERMAP study. *J Hum Hypertens* **17**, 623–630.
- Willett W (editor) (2013) *Nutritional Epidemiology*, 3rd ed. New York: Oxford University Press.
- Asakura K, Uechi K, Sasaki Y *et al.* (2014) Estimation of sodium and potassium intakes assessed by two 24 h urine collections in healthy Japanese adults: a nationwide study. *Br J Nutr* **112**, 1195–1205.
- World Health Organization (2012) *Guideline: Sodium Intake for Adults and Children*. Geneva: WHO.
- World Health Organization (2012) *Guideline: Potassium Intake for Adults and Children*. Geneva: WHO.
- Anderson CA, Appel LJ, Okuda N *et al.* (2010) Dietary sources of sodium in China, Japan, the United Kingdom, and the United States, women and men aged 40 to 59 years: the INTERMAP study. *J Am Diet Assoc* **110**, 736–745.
- Tsugane S & Sawada N (2014) The JPHC study: design and some findings on the typical Japanese diet. *Jpn J Clin Oncol* **44**, 777–782.
- Newby PK & Tucker KL (2004) Empirically derived eating patterns using factor or cluster analysis: a review. *Nutr Rev* **62**, 177–203.
- Shimazu T, Kuriyama S, Hozawa A *et al.* (2007) Dietary patterns and cardiovascular disease mortality in Japan: a prospective cohort study. *Int J Epidemiol* **36**, 600–609.
- Akter S, Nanri A, Pham NM *et al.* (2013) Dietary patterns and metabolic syndrome in a Japanese working population. *Nutr Metab (Lond)* **10**, 30.
- Maruyama K, Iso H, Date C *et al.* (2013) Dietary patterns and risk of cardiovascular deaths among middle-aged Japanese: JACC Study. *Nutr Metab Cardiovasc Dis* **23**, 519–527.
- Okubo H, Sasaki S, Murakami K *et al.* (2010) Nutritional adequacy of four dietary patterns defined by cluster analysis in Japanese women aged 18–20 years. *Asia Pac J Clin Nutr* **19**, 555–563.
- Okubo H, Miyake Y, Sasaki S *et al.* (2011) Nutritional adequacy of three dietary patterns defined by cluster analysis in 997 pregnant Japanese women: the Osaka Maternal and Child Health Study. *Public Health Nutr* **14**, 611–621.
- Huang Y, Van Horn L, Tinker LF *et al.* (2014) Measurement error corrected sodium and potassium intake estimation using 24-hour urinary excretion. *Hypertension* **63**, 238–244.
- Murakami K, Sasaki S, Uenishi K *et al.* (2012) The degree of misreporting of the energy-adjusted intake of protein, potassium, and sodium does not differ among under-, acceptable, and over-reporters of energy intake. *Nutr Res* **32**, 741–750.
- Gibson S & Ashwell M (2011) Dietary patterns among British adults: compatibility with dietary guidelines for salt/sodium, fat, saturated fat and sugars. *Public Health Nutr* **14**, 1323–1336.
- Sasaki S, Yanagibori R & Amano K (1998) Validity of a self-administered diet history questionnaire for assessment of sodium and potassium: comparison with single 24-hour urinary excretion. *Jpn Circ J* **62**, 431–435.
- Kobayashi S, Murakami K, Sasaki S *et al.* (2011) Comparison of relative validity of food group intakes estimated by comprehensive and brief-type self-administered diet history questionnaires against 16 d dietary records in Japanese adults. *Public Health Nutr* **14**, 1200–1211.
- Kobayashi S, Honda S, Murakami K *et al.* (2012) Both comprehensive and brief self-administered diet history questionnaires satisfactorily rank nutrient intakes in Japanese adults. *J Epidemiol* **22**, 151–159.
- Agency Science and Technology (2010) *Standard Tables of Food Composition in Japan*, 5th revision. Tokyo: National Printing Bureau (in Japanese).
- Okubo H, Murakami K, Sasaki S *et al.* (2010) Relative validity of dietary patterns derived from a self-administered diet history questionnaire using factor analysis among Japanese adults. *Public Health Nutr* **13**, 1080–1089.
- Murakami K, Sasaki S, Takahashi Y *et al.* (2008) Sensitivity and specificity of published strategies using urinary creatinine to identify incomplete 24-h urine collection. *Nutrition* **24**, 16–22.
- McAlister FA & Straus SE (2001) Evidence based treatment of hypertension. Measurement of blood pressure: an evidence based review. *BMJ* **322**, 908–911.
- Ainsworth BE, Haskell WL, Herrmann SD *et al.* (2011) 2011 compendium of physical activities: a second update of codes and MET values. *Med Sci Sports Exerc* **43**, 1575–1581.
- Northstone K (2012) Dietary patterns: the importance of sex differences. *Br J Nutr* **108**, 393–394.
- Knuiman JT, Hautvast JG, van der Heyden L *et al.* (1986) A multi-centre study on completeness of urine collection in 11 European centres. I. Some problems with the use of creatinine and 4-aminobenzoic acid as markers of the completeness of collection. *Hum Nutr Clin Nutr* **40**, 229–237.
- Hishida A & Sasaki S (2014) *Dietary Reference Intakes for Japanese, 2015*. Tokyo: Daiichishuppan (in Japanese).
- Beardsworth A, Bryman A, Keil T *et al.* (2002) Women, men and food: the significance of gender for nutritional attitudes and choices. *Br Food J* **104**, 470–491.
- Pomerleau J, McKee M, Robertson A *et al.* (2001) Dietary beliefs in the Baltic Republics. *Public Health Nutr* **4**, 217–225.
- Okubo H, Sasaki S, Murakami K *et al.* (2011) The ratio of fish to meat in the diet is positively associated with favorable intake of food groups and nutrients among young Japanese women. *Nutr Res* **31**, 169–177.
- Popkin BM (2006) Global nutrition dynamics: the world is shifting rapidly toward a diet linked with noncommunicable diseases. *Am J Clin Nutr* **84**, 289–298.
- Schulze MB, Hoffmann K, Kroke A *et al.* (2001) Dietary patterns and their association with food and nutrient intake in the European Prospective Investigation into Cancer and Nutrition (EPIC)–Potsdam study. *Br J Nutr* **85**, 363–373.
- Sadler K, Nicholson S, Steer T *et al.* (2011) *National Diet and Nutrition Survey – Assessment of Dietary Sodium in*

- Adults (aged 19 to 64 years) in England, 2011*. London: Department of Health.
40. Ministry of Education, Culture, Sports Science and Technology of Japan (2015) Tairyoku, Undo-Noryoku Chosa (Survey for Physical and Motor Fitness). http://http://www.mext.go.jp/a_menu/sports/kodomo/zencyo/1342657.html (accessed September 2015).
 41. Cancer Control and Health Promotion Division, Health Service Bureau, Ministry of Health Labour and Welfare of Japan (2012) The National Health and Nutrition Survey in Japan (in Japanese). http://www.e-stat.go.jp/SG1/estat/GL08020101.do?_toGL08020101_&tstatCode=000001041744&requestSender=dsearch (accessed September 2015).
 42. Lau C, Glümer C, Toft U *et al.* (2008) Identification and reproducibility of dietary patterns in a Danish cohort: the Inter99 study. *Br J Nutr* **99**, 1089–1098.
 43. Statistic Bureau Ministry of Internal Affairs and Communications (2011) Survey on Time Use and Leisure Activities. <http://www.stat.go.jp/english/data/shakai/> (accessed January 2016).