Short Communication

Nutritional adequacy of four dietary patterns defined by cluster analysis in Japanese women aged 18-20 years

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Information on nutritional adequacy and inadequacy of dietary patterns is useful when making practical dietary recommendations. We examined nutritional inadequacy of dietary patterns among 3756 Japanese female dietetic students aged 18-20 years. Diet was assessed with a validated self-administered diet history questionnaire (DHQ). Dietary patterns were determined from intakes of 33 food groups summarized from 147 foods assessed with DHQ, by cluster analysis. Nutritional inadequacy for the selected 21 nutrients in each dietary pattern was examined using the reference values given in the Dietary Reference Intakes for the Japanese (DRIs) as the gold standard. Four dietary patterns identified were labeled 'fish and vegetables' (n=697), 'meat and eggs' (n=1008), 'rice' (n=1041), and 'bread and confectionaries' (n=1010) patterns. The 'fish and vegetables' pattern, characterized by high intakes of vegetables, potatoes, pulses, fruits, fish, and dairy products, showed significantly the lowest percentage of subjects with inadequate intakes for 15 nutrients, except for the highest prevalence in sodium. In contrast, 'bread and confectionaries' pattern, characterized by high intakes of bread, confectionaries, and soft drinks, showed the highest prevalence of inadequate intakes for nine nutrients. The median number of nutrients not meeting the DRIs as a marker of overall nutritional inadequacy was five in 'fish and vegetables' pattern. It was significantly lower than nine both in 'meat and eggs' and 'rice', and 10 in 'bread and confectionaries' patterns (p<0.001). A dietary pattern high in vegetables, fruits, fish, and some others showed better profile of nutritional adequacy except for sodium in young Japanese women.

Key Words: dietary patterns, cluster analysis, dietary reference intakes, nutritional adequacy, Japanese young women

INTRODUCTION

The dietary requirement for a nutrient is defined as an intake level that meets specified criteria for adequacy, thereby minimizing the risk of nutrient deficit or excess. Traditional nutritional assessment has therefore been focused on a detailed examination of nutrients. If nutrient intakes are inadequate or excessive, however, it is necessary to know which foods are mediating the nutrient supply so that the food supply and nutrition education programs can be directed effectively toward changing the dietary pattern.[1]

More recent evidence suggests that the dietary pattern approach, which looks at combinations of foods rather than the traditional single nutrient or food approach, is useful in examining the relationship between diet and several health outcomes.[2,3] Using this approach, several studies have evaluated the nutritional quality (adequacy or inadequacy) of nutrient intakes of dietary patterns by comparison with the country-specific recommended intake levels such as the Dietary Reference Intakes.[1,4-6] In a study of West African immigrants in Madrid,[4] two dietary patterns ('Healthier' and 'Western' patterns) were identified by cluster analysis, and the nutritional adequacy of each nutrient intake were examined by comparison with the WHO/FAO recommendation. Similar studies were conducted in Spain and Canada.[5,6] However, almost all these studies have been conducted among Western populations. No comparable study in Asian countries has been reported, including Japan, with their different subject characteristics and culture-specific dietary habits.

Here, we evaluated the nutritional inadequacy of dietary patterns identified by cluster analysis in a group of Japanese female dietetic students aged 18-20 years using the reference values given in the Dietary Reference Intakes for the Japanese (DRIs) as the gold standard.[7]

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Manuscript received 31 March 2010. Initial review completed 20 June 2010. Revision accepted 27 July 2010.

MATERIALS AND METHODS

Subjects and study procedures

This study was based on a self-administered questionnaire survey of a wide range of dietary and non-dietary behaviors among freshmen who enrolled in the dietetic course from 54 universities, colleges and technical schools in 33 of 47 prefectures in Japan (n=4679). The survey was conducted from April to May 2005. A detailed description of the study design and survey procedure has been published elsewhere.[8,9] The study protocol was approved by the Ethics Committee of the National Institute of Health and Nutrition, Japan. Participants indicated their informed consent by completing the survey questionnaires.

In total, 4394 students (4168 women and 226 men) completed two questionnaires on dietary habits and other lifestyle behaviors (response rate=93.9%). For the present analysis, we selected female participants aged 18-20 years (n=4060). We then excluded women who were in an institution where the survey was not conducted within two weeks of entry (n=98), those who reported extremely low or high energy intake (<850 or ≥3375 kcal/d, n=85), those who were currently receiving dietary counseling from a doctor or dietitian (n=105), and those with missing information on the variables used (n=20). As some participants were in more than 1 exclusion category, the final analysis comprised 3756 women in 53 institutions.

Dietary assessment

Dietary habits during the preceding month were assessed using a self-administered diet history questionnaire (DHQ).[10-12] The DHQ is a structured 16-page questionnaire that asks about the consumption frequency and portion size of selected foods commonly consumed in Japan, general dietary behaviors, and usual cooking methods.[12] Estimates of daily intakes for foods (150 items in total), 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.[13] A detailed description of the methods used to calculate dietary intake and the validity of the DHQ have been published elsewhere.[10-12]

All self-administered dietary assessment could not avoid reporting errors, especially under- or over-reporting.[14,15] It may induce bias when comparing the reported nutrient intake levels and the corresponding DRI values because the latter does not consider this problem. In order to make this comparison practically possible, we adjusted the reported nutrient intakes to the energy-adjusted ones in the assumption that each subject takes her estimated energy requirement (EER) rather than her reported energy. We used the EER based on the reported physical activity level of each subject. The calculation method is as follows: Energy-adjusted nutrient intake (amount/d) = reported nutrient intake (amount/d) × EER (kcal/d) / observed energy intake (kcal/d).

Determination of nutritional quality

Inadequacy of nutrient intake was examined by comparing with each dietary reference value according to the Japanese DRIs.[7] Of the total 34 nutrients presented in the DRIs, 5 nutrients (biotin, chromium, molybdenum, selenium, iodine) were excluded from this study because of a lack of the food composition tables in Japan.

For the nutrients with EAR, namely protein, vitamin A expressed as retinol equivalent (RE), vitamin B_1, vitamin B_2, niacin expressed as niacin equivalent, vitamin B_6, vitamin B_{12}, folate, vitamin C, calcium, magnesium, zinc, and copper, the energy-adjusted intake levels below the EAR were considered as inadequate.[7] For iron, the probability approach[16,17] was used because the EAR cut-point method cannot be used due to the seriously skewed distribution of the requirement in menstruating women.[16-18] Assuming that an iron absorption rate was 15%,[7] energy-adjusted iron intake (mg/d) was converted to usable iron intake. Each individual's usable iron intake was adjusted by deducting the median amount of iron required for basal loss (0.77 mg).[18] The adjusted individual's usable iron intake was then log-transformed to improve normality of the distribution. The probability approach was applied using the log-normalized mean and standard deviation of the menstrual iron loss curve (-0.734 and 0.777, respectively)[18] and the log-normalized iron intake data adjusted for basal loss.The probability of inadequacy for iron more than 50% was considered as inadequate. In the Japanese DRIs, Tentative Dietary Goal for Preventing Life-style related Disease (DG) was given for total fat, saturated fatty acid (SFA), n-3 poly-unsaturated fatty acid (PUFA), cholesterol, carbohydrate, dietary fiber, and sodium expressed as salt-equivalent.[7] For these nutrients, the energy-adjusted intake levels outside the range of corresponding DG were considered as inadequate. For the nutrients with Adequate Intake (AI) such as n-6 PUFA, vitamin D, vitamin E, expressed as alpha-tocopherol, vitamin K, pantothenic acid, potassium, phosphorus, and manganese, the energy-adjusted intake levels at or above AI were considered as adequate.[7,16]

Assessment of lifestyle variables

Variables such as geographic area, living status, current smoking, and whether trying to lose weight were obtained from the other questionnaire designed for this survey. Current supplement use, physical activity level, and self-reported body height (cm) and weight (kg) were obtained from the DHQ. Body mass index was calculated as body weight (kg) divided by the square of body height (m^2).

Statistical analysis

First, 150 food items in the DHQ were classified into 33 predefined groups with similar nutrient profiles and culinary usage.[19] However, nutritional supplement bars, soup of noodle, and drinking water were difficult to group or rarely eaten, and were omitted from the study. To remove the extraneous effect of variables with large variances, we standardized intake of each energy-adjusted food group to a mean of zero and standard deviation of one.

Cluster analysis was performed using the FASTCLUS procedure in SAS.[20] This procedure applies the K-means method to classify subjects into a predetermined number of mutually exclusive groups by comparing Euclidean distances between each subject and each cluster center in an interactive process until no further changes occurred. To identify the optimal number of clusters, several runs were conducted varying the number of clusters from 2 to

6. The final cluster solution was selected by comparing the ratio of between-cluster variance to within-cluster variance divided by the number of clusters. Based on these determinations, we selected the four-cluster solution as the most appropriate.

The median differences in intakes of energy-adjusted food group and nutrient across clusters were examined by the Kruskal-Wallis test. To examine the nutritional inadequacy of nutrient intakes of each dietary pattern, we estimated the percentage of subjects whose intake was below the EAR or outside the range of DG. The nutrients set for AI were excluded from calculation of the prevalence of inadequacy because no firm conclusion can be drawn on inadequacy if usual intakes are less than AI.[7,16] The chi-square test was used to examine the difference of variables expressed as proportion such as lifestyle variables and the prevalence of inadequacy.

To assess the overall nutritional inadequacy of each

Table 1. Daily energy-adjusted intake of 33 food groups (g/d) assessed with a self-administered diet history questionnaire across the four dietary patterns identified among 3756 Japanese women aged 18-20 years †

Food group	All (*n* = 3756)		Dietary pattern‡							
			Fish and vegetables (*n* = 697)		Meat and eggs (*n* = 1008)		Rice (*n* = 1041)		Bread and confectionaries (*n* = 1010)	
Rice	276	(201, 362)	252	(188, 328)	241	(187, 297)	401*	(338, 472)	221	(165, 284)
Bread	42	(21, 69)	32	(15, 55)	38	(20, 58)	27	(12, 46)	73*	(49, 100)
Noodles	55	(25, 95)	49	(23, 83)	59	(28, 95)	54	(23, 96)	59	(27, 102)
Potatoes	22	(15, 34)	35*	(23, 54)	24	(16, 36)	18	(12, 27)	20	(14, 28)
Nuts	0	(0, 1)	1*	(0, 2)	0	(0, 2)	0	(0, 1)	0	(0, 2)
Pulses	30	(16, 53)	62*	(39, 86)	28	(16, 47)	28	(16, 48)	21	(12, 34)
Sugar	10	(7, 14)	13*	(10, 16)	10	(8, 13)	8	(6, 11)	10	(7, 14)
Confectioneries	73	(51, 102)	62	(43, 83)	72	(52, 95)	57	(40, 76)	109*	(82, 144)
Butter	0	(0, 1)	0	(0, 1)	1*	(0, 2)	0	(0, 1)	0	(0, 1)
Vegetable oil	22	(16, 29)	22	(16, 28)	29*	(23, 36)	18	(14, 23)	19	(14, 25)
Fruits	36	(19, 67)	61*	(35, 110)	33	(19, 58)	29	(15, 53)	35	(19, 65)
Green and yellow vegetables	62	(37, 98)	127*	(96, 171)	64	(44, 90)	49	(28, 73)	44	(28, 69)
White vegetables	82	(55, 118)	147*	(109, 194)	89	(66, 117)	67	(45, 95)	62	(42, 90)
Pickled vegetables	5	(2, 13)	11*	(4, 22)	5	(3, 13)	5	(2, 12)	4	(2, 10)
Mushrooms	6	(4, 15)	19*	(11, 31)	7	(4, 15)	5	(3, 9)	5	(3, 9)
Seaweeds	7	(4, 17)	21*	(13, 34)	7	(4, 14)	6	(4, 15)	5	(3, 10)
Alcoholic beverages	0	(0, 0)	0	(0, 0)	0	(0, 0)	0	(0, 0)	0	(0, 0)
Fruit and vegetable juice	26	(0, 82)	26	(0, 95)	26	(0, 82)	15	(0, 58)	38*	(0, 101)
Japanese and Chinese tea	431	(178, 737)	557*	(323, 908)	426	(201, 740)	416	(163, 738)	360	(140, 630)
Tea	16	(0, 58)	21*	(0, 75)	20	(0, 64)	0	(0, 31)	19	(0, 61)
Coffee and cocoa	0	(0, 63)	12	(0, 73)	13	(0, 58)	0	(0, 42)	22*	(0, 94)
Soft drinks	17	(0, 70)	7	(0, 36)	25	(3, 80)	12	(0, 51)	36*	(4, 93)
Dairy products	98	(37, 179)	127*	(57, 203)	84	(34, 155)	92	(30, 183)	105	(39, 188)
Fish	22	(14, 34)	34*	(23, 53)	24	(16, 37)	20	(12, 28)	18	(10, 26)
Shellfish	11	(6, 16)	14*	(9, 20)	13	(7, 18)	9	(4, 14)	9	(5, 14)
Sea products	12	(7, 21)	20*	(12, 31)	14	(9, 23)	10	(6, 17)	9	(5, 15)
Chicken	12	(8, 21)	14	(9, 24)	18*	(10, 28)	10	(7, 14)	10	(7, 15)
Beef and pork	33	(22, 49)	32	(22, 46)	50*	(36, 67)	26	(18, 36)	26	(19, 38)
Processed meat	6	(3, 11)	6	(3, 11)	9*	(5, 15)	5	(3, 9)	5	(3, 8)
Eggs	29	(12, 48)	36	(16, 51)	39*	(23, 55)	25	(10, 46)	21	(8, 37)
Miso soup	83	(24, 150)	121	(66, 177)	66	(18, 122)	125*	(50, 206)	45	(3, 102)
Other soup	0	(0, 8)	0	(0, 9)	0	(0, 8)	0	(0, 0)	0	(0, 8)
Salt-containing seasonings	12	(9, 17)	17*	(13, 23)	15	(11, 19)	10	(8, 13)	10	(7, 14)

*The highest median values.
† Values are medians (interquartile ranges). Intakes of food group were energy-adjusted as follows: energy-adjusted intake (g/d) = observed intake (g/d) × Estimated Energy Requirement (kcal/d)/observed energy intake (kcal/d).
‡ All food group intakes were significantly different across the four dietary patterns ($p < 0.001$; Kruskal-Wallis test).

Table 2. Subject characteristics across the four dietary patterns identified among 3756 Japanese women aged 18-20 years†

	All (n = 3756)	Dietary pattern				p-value‡
		Fish and vegetables (n = 697)	Meat and eggs (n = 1008)	Rice (n = 1041)	Bread and confectionaries (n = 1010)	
Age (years)	18.1 ± 0.3	18.1 ± 0.3	18.1 ± 0.3	18.1 ± 0.4	18.1 ± 0.3	0.77
Body height (cm)	157.9 ± 5.3	157.8 ± 5.4	157.7 ± 5.2	157.8 ± 5.4	158.1 ± 5.4	0.30
Body weight (kg)	52.2 ± 7.6	51.8 ± 7.3	52.2 ± 7.8	52.4 ± 7.6	52.4 ± 7.8	0.35
Body mass index (kg/m^2)	21.0 ± 2.8	20.8 ± 2.7	21.0 ± 2.9	21.1 ± 2.8	20.9 ±2.8	0.33
Geographic area (%)						
Hokkaido and Tohoku	10.0	10.6	7.0	13.4	8.9	<0.001
Kanto	34.6	36.3	34.6	31.4	36.6	
Hokuriku and Tokai	13.7	14.8	12.9	15.7	11.6	
Kinki	20.0	18.9	22.6	15.2	23.1	
Chugoku and Shikoku	10.5	6.7	10.4	12.2	11.6	
Kyushu	11.3	12.6	12.4	12.2	8.2	
Living status (%)						
Living alone	5.9	3.2	4.2	7.8	7.4	<0.001
Living with family	88.8	92.0	91.0	86.9	86.2	
Living with others	5.4	4.9	4.9	5.3	6.3	
Current smoker (%)	1.4	0.6	1.8	0.9	2.1	0.02
Current dietary supplement user (%)	18.3	24.7	17.2	14.2	19.4	<0.001
Subjects trying to lose weight (%)	35.6	45.3	36.0	28.5	35.7	<0.001
Physical activity level (%)§						
Level I (low)	62.2	47.1	59.8	72.8	64.1	<0.001
Level II (moderate)	35.8	49.2	37.6	26.4	34.6	
Level III (high)	2.0	3.7	2.6	0.8	1.4	

† Values are mean ± standard deviation or percentage of subjects.
‡ For continuous variables, ANOVA was used; for categorical variables, chi-square test was used to test differences across the dietary patterns.
§ Categorization was according to the Dietary Reference Intakes for Japanese, 2010 (reference 7).

subject, we counted the number of nutrients which did not meet the DRIs among 14 and 7 nutrients with EAR and DG, respectively.[5,6] The nutrients with AI were excluded from this analysis because of the reason mentioned above. Therefore, this number ranged from 0 (meeting all the 21 DRIs) to 21 (meeting none of the 21 DRIs).

All statistical analyses were performed using SAS v. 9.1 (SAS Institute Inc., Cary, NC, USA). A two-sided p-value of 0.05 was considered significant.

RESULTS

Four clusters of dietary pattern were identified (Table 1). We descriptively labeled them as 'fish and vegetables', 'meat and eggs', 'rice' and 'bread and confectionaries' patterns, based on the food groups predominant in each cluster. The 'fish and vegetables' pattern was characterized by higher median intakes of potatoes, nuts, pulses, sugar, fruits, green and yellow vegetables, white vegetables, pickled vegetables, mushrooms, seaweeds, Japanese and Chinese tea, dairy products, fish, shellfish, sea products, and salt-containing seasonings other than those in the other three patterns. The 'meat and eggs' pattern was characterized by higher median intakes of chicken, beef and pork, processed meat, eggs, butter, and vegetable oil. The 'rice' pattern was characterized by higher median intakes of rice and miso soup. The 'bread and confectionaries' pattern was characterized by higher median intakes of bread, confectioneries, fruit and vegetable juice, coffee and cocoa, and soft drinks.

Table 2 shows the subject characteristics for lifestyle variables across the four dietary patterns. The subjects in the 'fish and vegetables' pattern were more likely to be non-smokers, supplement users, physically active, lived with family members, and tried to lose weight than those in other patterns. The subjects in the 'rice' pattern were likely to be few supplement users, physically inactive, and not trying to lose weight. The subjects in the 'bread and confectionaries' pattern were more likely to be current smokers and lived with someone other than their family members.

Table 3 shows median of the energy-adjusted nutrient intakes and the prevalence of subjects who did not meet

Table 3. Daily energy-adjusted nutrient intakes assessed with a self-administered diet history questionnaire and prevalence of subjects with inadequate nutrient intakes compared with Dietary Reference Intakes (DRIs) for the Japanese, 2010, using the cut-point method across the four dietary patterns identified among 3,756 Japanese women aged 18-20 years†

Nutrient	Reference value‡	All (*n* = 3756)			Dietary pattern: Fish and vegetables (*n* = 697)			Meat and eggs (*n* = 1008)			Rice (*n* = 1041)			Bread and confectionaries (*n* = 1010)			*p*-value¶¶
		Median	IQR	Prevalence of inadequacy (%)§	Median	IQR	(%)§	Median	IQR	(%)§	Median	IQR	(%)§	Median	IQR	(%)§	
Energy intake	1700 kcal	1736	(1459, 2054)	-	1809	(1513, 2106)	-	1872*	(1604, 2203)	-	1560	(1345, 1807)	-	1765	(1468, 2087)	-	-
Nutrient with DG																	
Total fat	20-30% of energy	29.5	(25.6, 33.3)	51.4	29.7	(26.8, 33.0)	50.2	33.8*	(30.9, 36.7)	81.9	25.2	(22.0, 28.4)	27.3	29.3	(25.8, 32.5)	46.8	<0.001
SFA	4.5-7.0% of energy	8.1	(6.8, 9.5)	73.1	7.8	(6.7, 9.1)	70.7	9.0*	(7.9, 10.2)	91.0	6.8	(5.7, 8.1)	52.3	8.4	(7.1, 10.1)	78.3	<0.001
n-3 PUFA	≥1.8 g	2.3	(1.9, 2.8)	21.1	2.8*	(2.4, 3.3)	3.2	2.7	(2.4, 3.1)	2.4	2.0	(1.7, 2.4)	35.2	2.0	(1.6, 2.3)	37.5	<0.001
Cholesterol	<600 mg	284	(208, 370)	1.3	325	(251, 402)	1.9	345*	(476, 412)	2.4	240	(170, 320)	0.8	243	(188, 314)	0.2	<0.001
Carbohydrate	50-70% of energy	55.8	(51.4, 60.3)	20.4	54.2	(50.9, 58.0)	21.7	50.6	(47.4, 53.7)	44.2	60.5*	(57.1, 64.3)	7.6	57.2	(53.5, 60.8)	9.1	<0.001
Dietary fiber	≥17 g	11.0	(9.1, 13.5)	90.8	16.2*	(14.1, 18.7)	57.1	10.6	(9.0, 12.3)	99.1	10.0	(8.3, 11.7)	98.8	10.4	(8.9, 12.2)	97.6	<0.001
Sodium (salt-equivalent)¶	<7.5 g	9.5	(8.0, 11.2)	81.6	11.5*	(10.1, 13.4)	96.8	10.1	(8.9, 11.5)	90.1	8.6	(7.3, 10.1)	72.3	8.6	(7.4, 9.9)	72.1	<0.001
Nutrient with EAR																	
Protein	40 g	59.2	(52.5, 66.3)	1.4	69.9*	(63.1, 76.4)	0	62.6	(57.6, 68.8)	0.6	54.3	(48.7, 59.8)	2.3	55.0	(49.5, 60.2)	2.4	<0.001
Vitamin A††	450 μg RE	419	(294, 605)	55.9	658*	(507, 977)	15.4	432	(326, 606)	55.3	340	(244, 477)	71.4	358	(255, 492)	68.7	<0.001
Vitamin B_1	0.9 mg	0.71	(0.61, 0.83)	84.7	0.85*	(0.77, 0.96)	63.7	0.76	(0.68, 0.87)	80.5	0.62	(0.54, 0.71)	93.8	0.65	(0.57, 0.74)	94.2	<0.001
Vitamin B_2	1.0 mg	1.19	(0.99, 1.42)	25.9	1.46*	(1.27, 1.7)	3.3	1.21	(1.06, 1.42)	17.9	1.07	(0.87, 1.27)	40.6	1.11	(0.93, 1.30)	34.5	<0.001
Niacin ‡‡	9 mg NE	22.0	(18.9, 25.6)	0	26.9*	(24.2, 30.3)	0	24.0	(21.6, 26.9)	0	19.5	(17.2, 22.0)	0	19.8	(17.6, 22.1)	0	-

IQR = interquartile ranges, DG = tentative dietary goal for preventing life-style related disease, SFA = saturated fatty acids, PUFA = poly-unsaturated fatty acids, EAR = estimated average requirement, RE = retinol equivalents, NE = niacin equivalents, AI = adequate intake.

*The highest median values.

† Values are medians (interquartile ranges). Nutrients expressed as amount per day were energy-adjusted by using the following equation: energy-adjusted intake (unit/d) = observed intake (unit/d) × Estimated Energy Requirement (EER, kcal/d) / observed energy intake (kcal/d). All nutrient intakes were significantly different across the dietary patterns ($P < 0.001$; Kruskal-Wallis test).

‡ Dietary reference intakes (units/d) for non-pregnant Japanese females aged 18-29 years old. The EER of physical activity level I, II, and III are 1700, 1950, and 2250 kcal/d, respectively.

§ Percentage of subjects whose intake was outside the range of DG or below the EAR. Each energy-adjusted nutrient intake (unit/d) was compared with each DRI value (unit/d), using the cut-point method. Nutrients with AI were not examined.

¶ Considering the convenience of the use, the DG of sodium are expressed as salt-equivalent [salt (g) = 58.5/23 × sodium (g)] (reference 7).

†† 1 μgRE = retinol (μg) + beta-carotene (μg) × 1/12 + alpha-carotene (μg) × 1/24 + beta-cryptoxantin (μg) × 1/24 + other provitamin A carotenoides (μg) × 1/24 (reference 7).

‡‡ Niacin equivalents were computed as niacin (mg) + protein (mg)/6000 according to the Dietary Reference Intake for the Japanese, 2010 (reference 7).

§§ Probability approach was used to assess inadequacy for iron intake.

¶¶ Chi-square test was used to test differences of the prevalence of subjects with inadequate nutrient intake across the dietary patterns.

Table 3. Daily energy-adjusted nutrient intakes assessed with a self-administered diet history questionnaire and prevalence of subjects with inadequate nutrient intakes compared with Dietary Reference Intakes (DRIs) for the Japanese, 2010, using the cut-point method across the four dietary patterns identified among 3,756 Japanese women aged 18-20 years† (con.)

Nutrient	Reference value‡	All (*n* = 3756)			Dietary pattern: Fish and vegetables (*n* = 697)			Meat and eggs (*n* = 1008)			Rice (*n* = 1041)			Bread and confectionaries (*n* = 1010)			*p*-value¶¶
		Median	IQR	Prevalence of inadequacy (%)§	Median	IQR	(%)§	Median	IQR	(%)§	Median	IQR	(%)§	Median	IQR	(%)§	
Vitamin B_6	1.0 mg	0.90	(0.75, 1.09)	64.5	1.20*	(1.08, 1.38)	13.2	0.97	(0.85, 1.09)	57.7	0.79	(0.68, 0.92)	84.0	0.76	(0.66, 0.90)	86.4	<0.001
Vitamin B_{12}	2.0 µg	5.1	(3.7, 6.9)	4.5	7.2*	(5.5, 9.5)	0.7	5.8	(4.4, 7.4)	1.2	4.4	(3.2, 5.7)	7.4	4.2	(3.0, 5.6)	7.4	<0.001
Folate	200 µg	256	(206, 321)	22.3	383*	(331, 443)	0.1	259	(217, 303)	15.9	227	(185, 273)	33.1	225	(186, 275)	32.9	<0.001
Vitamin C	85 mg	78	(57, 106)	57.3	120*	(100, 145)	10.8	79	(62, 100)	57.4	65	(50, 84)	75.7	68	(51, 90)	70.3	<0.001
Calcium	550 mg	446	(345, 570)	71.9	590*	(492, 718)	39.6	417	(343, 513)	81.4	394	(299, 513)	81.0	432	(343, 548)	75.5	<0.001
Magnesium	230 mg	204	(176, 241)	68.8	268*	(241, 301)	14.9	202	(181, 226)	78.3	190	(165, 217)	81.6	189	(165, 216)	83.5	<0.001
Iron §§	8.5 mg	6.4	(5.4, 7.5)	80.0	8.4*	(7.5, 9.4)	50.5	6.6	(5.9, 7.3)	80.6	5.8	(5, 6.6)	89.4	5.8	(5.0, 6.5)	90.1	<0.001
Zinc	7 mg	7.2	(6.5, 8)	41.6	8.2*	(7.5, 8.9)	11.8	7.6	(7.0, 8.4)	27.2	7.1	(6.5, 7.7)	47.1	6.5	(6.0, 7.1)	71.1	<0.001
Copper	0.6 mg	1.00	(0.90, 1.14)	0.3	1.22*	(1.10, 1.34)	0	0.96	(0.87, 1.06)	0	1.02	(0.93, 1.13)	0	0.92	(0.83, 1.02)	0.7	0.01
Nutrient with AI																	
n-6 PUFA	9 g	11.0	(9.4, 12.7)	-	12.0	(10.5, 13.6)	-	12.8*	(11.4, 14.4)	-	9.6	(8.4, 11.0)	-	10.1	(8.7, 11.4)	-	<0.001
Vitamin D	5.5 µg	5.4	(3.8, 7.4)	-	8.2*	(6.1, 10.6)	-	5.9	(4.5, 7.8)	-	4.6	(3.5, 6.2)	-	4.3	(3.2, 5.7)	-	<0.001
Vitamin E	6.5 mg	7.5	(6.2, 8.8)	-	9.5*	(8.2, 10.7)	-	8.4	(7.4, 9.3)	-	6.2	(5.3, 7.1)	-	6.8	(5.9, 7.8)	-	<0.001
Vitamin K	60 µg	218	(149, 314)	-	394*	(305, 511)	-	227	(176, 289)	-	191	(132, 263)	-	161	(117, 224)	-	<0.001
Pantothenic acid	5 mg	5.3	(4.7, 6.2)	-	6.5*	(5.8, 7.3)	-	5.4	(4.9, 6.1)	-	4.9	(4.3, 5.7)	-	4.9	(4.4, 5.6)	-	<0.001
Potassium	2000 mg	1873	(1565, 2226)	-	2532*	(2254, 2851)	-	1894	(1679, 2131)	-	1638	(1409, 1911)	-	1709	(1477, 1995)	-	<0.001
Phosphorus	900 mg	881	(764, 1017)	-	1070*	(971, 1191)	-	902	(816, 998)	-	804	(708, 926)	-	811	(715, 925)	-	<0.001
Manganese	3.5 mg	3.4	(2.6, 4.4)	-	4.2*	(3.3, 5.2)	-	3.2	(2.5, 4.1)	-	3.6	(2.9, 4.7)	-	2.9	(2.3, 3.7)	-	<0.001

IQR = interquartile ranges, DG = tentative dietary goal for preventing life-style related disease, SFA = saturated fatty acids, PUFA = poly-unsaturated fatty acids, EAR = estimated average requirement, RE = retinol equivalents, NE = niacin equivalents, AI = adequate intake.

*The highest median values.

† Values are medians (interquartile ranges). Nutrients expressed as amount per day were energy-adjusted by using the following equation: energy-adjusted intake (unit/d) = observed intake (unit/d) × Estimated Energy Requirement (EER, kcal/d) / observed energy intake (kcal/d). All nutrient intakes were significantly different across the dietary patterns ($P < 0.001$; Kruskal-Wallis test).

‡ Dietary reference intakes (units/d) for non-pregnant Japanese females aged 18-29 years old. The EER of physical activity level I, II, and III are 1700, 1950, and 2250 kcal/d, respectively.

§ Percentage of subjects whose intake was outside the range of DG or below the EAR. Each energy-adjusted nutrient intake (unit/d) was compared with each DRI value (unit/d), using the cut-point method. Nutrients with AI were not examined.

¶ Considering the convenience of the use, the DG of sodium are expressed as salt-equivalent [salt (g) = 58.5/23 × sodium (g)] (reference 7).

†† 1 µgRE = retinol (µg) + beta-carotene (µg) × 1/12 + alpha-carotene (µg) × 1/24 + beta-cryptoxantin (µg) × 1/24 + other provitamin A carotenoides (µg) × 1/24 (reference 7).

‡‡ Niacin equivalents were computed as niacin (mg) + protein (mg)/6000 according to the Dietary Reference Intake for Japanese, 2010 (reference 7).

§§ Probability approach was used to assess inadequacy for iron intake.

¶¶ Chi-square test was used to test differences of the prevalence of subjects with inadequate nutrient intake across the dietary patterns.

the DRIs across the four dietary patterns. The 'fish and vegetables' pattern had significantly the highest intakes of n-3 PUFA, dietary fiber, protein, and all vitamins and minerals described here compared to the other dietary patterns. The 'fish and vegetables' pattern showed significantly the lowest percentage of subjects who did not meet the DG or EAR among the four dietary patterns, namely dietary fiber and all 14 nutrients set for EAR. However, this pattern showed significantly the highest percentage of subjects who did not meet the DG in sodium. The median intakes of all 8 nutrients set for AI were above the recommended AI levels.

The 'meat and eggs' pattern had significantly the highest intakes of energy, total fat, SFA, cholesterol, and n-6 PUFA, but significantly the lowest intake of carbohydrate. Median intakes of all nutrients except for potassium and manganese were above the recommended AI levels, and the prevalence of inadequacy for n-3 PUFA was significantly the lowest among four dietary patterns. However, the prevalence of inadequacy was significantly the highest for total fat, SFA, carbohydrate, and dietary fiber. On the other hand, both the 'rice' and 'bread and confectionaries' patterns showed significantly lower intakes of most vitamins and minerals, and the significantly higher prevalence of subjects who did not meet the EAR than the other two dietary patterns. The median intakes of most nutrients examined did not reach the corresponding AI values. However, the 'rice' pattern showed significantly the lowest prevalence of inadequacy in terms of total fat, SFA, and carbohydrate set for DG among the four dietary patterns.

A significant difference of overall nutritional inadequacy was observed among four dietary patterns: the median numbers (interquartile ranges) of nutrients not meeting EAR or DG were 5.0 (3.0-6.0) in the 'fish and vegetables' pattern, 9.0 (7.0-10.0) in the 'meat and eggs' pattern, 9.0 (7.0-11.0) in the 'rice' pattern, and 10.0 (8.0-11.0) in the 'bread and confectionaries' pattern (p <0.001).

DISCUSSION

To our knowledge, this is the first report to examine the nutritional inadequacy of dietary patterns using cluster analysis by comparing the scientifically-determined indices such as DRIs in an Asian population. The main finding of the present study was that the women in the 'fish and vegetables' pattern had better profiles with lower prevalence of inadequacy for many essential micronutrients than those with the other dietary patterns.

Almost all studies on dietary patterns and dietary quality have been conducted in Western populations. The results were largely consistent with the present study.[1,4-6] In the Seguimiento Universidad de Navarra cohort study,[5] nutritional adequacy of two major dietary patterns ('Mediterranean' and 'Western') identified by factor analysis were examined by comparing 15 individual nutrient intakes of each dietary pattern with the DRIs. The 'Mediterranean' dietary pattern, characterized by higher intakes of fruits and vegetables, fish, legumes, and low-fat dairy, was associated with a lower prevalence of inadequacy for the intake of zinc, iodine, vitamin E, magnesium, iron, vitamin B_1, vitamin A, selenium, vitamin C, and folic acid.[6] Additionally, a higher adherence to that 'Mediterranean' pattern resulted in significantly lower number of nutrients which did not meet the DRIs. In contrast, a higher adherence to the 'Western' dietary pattern, characterized by higher intakes of red and processed meat, eggs, and some others, showed the opposite.[5] Similar findings were shown in the Canadian study,[6] the 'health-conscious' pattern correlated positively with the number of nutrients which satisfied the recommended levels. In accordance with these previous studies, dietary pattern high in vegetables, fruits, pulses, fish, and dairy products have a greater capacity to meet recommended dietary intake levels, notwithstanding that the dietary patterns in each study were determined by different analytic methods and that subjects were characterized by culture-specific dietary habits.

Cluster analysis is useful for focusing attention on groups with good or poor nutritional status. The women in the 'fish and vegetables' pattern met the DRIs for many nutrients examined. However, almost all women (96.8%) in this pattern did not meet the DG of sodium owing to high intakes of pickled vegetable, salty fish, and salt-containing seasonings. For women in the 'rice' and 'bread and confectionaries' patterns, intakes of almost all nutrients were lower than the average intakes of the entire sample of women in this study. In addition, the number of nutrients not meeting the DRIs was significantly higher for these two patterns of women than for the women in the 'fish and vegetables' and 'meat and eggs' patterns. The reason for this nutrient inadequacy might be related to socio-economic factors[21,22] and lifestyle behaviors.[23,24] Compared to women in the 'fish and vegetables' and 'meat and eggs' patterns, more women in the 'rice' and 'bread and confectionaries' patterns were current smokers, dietary supplement non-users, physically inactive, and lived alone or with someone except for family.

Several limitations of the present study warrant mention. First, the participants were selected female dietetic students, and not a random sample of Japanese people. Moreover, because they were freshmen enrolled in dietetic courses, they were likely highly health-conscious. Second, although we used a validated dietary assessment questionnaire,[10-12] its ability to estimate total food and nutrient intakes remains a concern. Therefore, incompleteness of assessment could not be ruled out. Third, we used energy-adjusted nutrient intakes made comparison possible with the DRI values considering possible under- or over-reporting of the nutrient intakes. However, scientific justification of this energy-adjustment is scarce. Fourth, we could not include nutrient intake from dietary supplements into the analysis because of the lack of a reliable composition data for dietary supplements in Japan. Fifth, the number of nutrients which did not meet the DRIs was counted equally to evaluate overall inadequacy of nutrient intakes of each dietary pattern. Although the contribution to the total nutritional quality might be different across nutrients, the evidence to determine the weighting coefficients of each nutrient was insufficient at the present time. The results should therefore be interpreted very cautiously. Finally, the reliability of the DRIs of individual nutrients is dependent on the state of the science for each nutrient.[7] Some degree of misclassification of participants by adequacy of nutrient intake is, therefore, unavoidable.

In summary, nutritional inadequacy of four dietary patterns identified by the cluster analysis was examined in young Japanese women. A dietary pattern high in vegetables, mushrooms, potatoes, pulses, fruits, fish, and shellfish showed better profile of overall nutrient intakes except for sodium. Further evaluation of nutritional adequacy of dietary patterns based on the DRIs as reference values in various Japanese populations is required.

ACKNOWLEDGEMENTS

This work was supported in part by a Grant-in-Aid for JSPS Fellows (21-3370) from the Japan Society for the Promotion of Science; and the Ministry of Health, Labor and Welfare, Comprehensive Research on Cardiovascular and Life-style Related Diseases.

AUTHOR DISCLOSURES

None of the authors has any personal or financial conflict of interest to declare.

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Short Communication

Nutritional adequacy of four dietary patterns defined by cluster analysis in Japanese women aged 18-20 years

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由群集分析訂定之四種飲食型態在日本 18-20 歲女性之營養適足性

當要建立實用的飲食建議時，飲食型態的營養適足與否的相關資訊是很有用的。作者檢驗日本 3756 位年齡 18-20 歲，修習膳療學的女學生，其飲食型態的營養不適當情形。飲食評估是使用自我填寫的個人飲食歷史問卷(DHQ)，此問卷做過效度評估。飲食型態是以 DHQ 所列的 147 項食物中，歸納出的 33 組食物群之攝取量，藉由群集分析決定的。以日本的營養素建議攝取量(DRIs)評估飲食型態中選定的 21 種營養素攝取量是否適當。共計確認四種飲食型態：魚類和蔬菜(n=697)、肉類和蛋類(n=1008)、米類(n=1041)、麵包和糕點類(n=1010)。魚類和蔬菜的飲食型態之特色是高攝取量的蔬菜、馬鈴薯、豆類、水果、魚類和奶製品，其參與者的 15 種營養素攝取不適當的百分率明顯最低，除了鈉攝取過多的盛行率是最高的。相較之下，麵包和糕點的飲食型態之特色是攝取高量的麵包、糕點類和非酒精性飲料，其參與者的 9 種營養素攝取不當的盛行率最高。將攝取量不符合 DRIs 的營養素項目之中位數做為整體營養不適的判斷標準，結果魚類和蔬菜組的中位數是 5，顯著低於其他三種飲食型態(p <0.001)，因為肉類和蛋類組及米類組的中位數是 9，麵包和糕點類組的中位數是 10。對日本的年輕女性而言，高攝取量的蔬菜、水果、魚類等的飲食型態，除了鈉以外，有較佳的營養適足性。

關鍵字：飲食型態、群集分析、營養素建議攝取量、營養適足、日本年輕女性