Int J Clin Exp Med 2017;10(1):1651-1660
www.ijcem.com /ISSN:1940-5901/IJCEM0031494

Original Article

Development and nutritional validity of a novel Japanese diet score and its relation with health status

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Received April 29, 2016; Accepted August 6, 2016; Epub January 15, 2017; Published January 30, 2017

Abstract: The traditional Japanese diet (JD) had been widely regarded as healthy, but there is no appropriate and easy index to assess adherence to the JD pattern. The aim of this study was to develop a novel instrument to measure adherence to the JD and to examine its validity using food and nutrient intakes. A cross-sectional nutritional survey provided the data for construction of a novel JD score. A total of 1,048 subjects who were employees and university students, aged 18 to 68 years (645 men, 403 women), completed the 58-item brief-type self-administered diet history questionnaire. We constructed a new JD score focusing on 10 components: rice, soy-products, miso soup, fish, vegetables, vegetable pickles, seaweeds, green tea, Japanese confections (*wagashi*), and meat and meat products. Adherence to the JD was categorized as low (score 0-3), moderate (4-6), or high (7-10). There was no significant difference in JD score between men and women, but a greater adherence to JD was shown in older than in younger subjects. Subjects with a higher JD score were non-smokers, physically active, and consumed lower amounts of alcohol, whereas no difference was observed in JD score between subjects with and without obesity. Subjects with a higher JD score showed a higher intake of legumes, vegetables, fruits, and fish and a lower intake of meat and bread, which reflects the higher adherence to the JD pattern. A higher JD score was associated with a higher intake of polyunsaturated fatty acids, dietary fiber, potassium, calcium, magnesium, iron, vitamin D, folate, and vitamin C, and a lower intake of saturated acids, thus representing a healthy diet. Our novel JD score showed good validity and confirmed reasonable associations between the JD score and food and nutrient intakes.

Keywords: Diet quality, healthy diet, Japanese diet, nutrition

Introduction

The traditional Japanese diet (JD) had been widely regarded as healthy because the characteristic components, including fish, soy products, seaweeds, and pickled vegetables, have protective effects against cardio-metabolic risks [1]. It has been recognized that fish with high levels of polyunsaturated fatty acids have a beneficial effect on cardiovascular disease [2], mortality [3], and diabetes [4]. Soy products are a good source of plant protein and are rich in flavonoids, which have a protective effect against some types of cancers [5], diabetes [6], and cardiovascular diseases [7]. Miso soup (soy paste soup) is also preferentially drunk with meals in Japan, and an inverse association was observed between miso soup intake and cardiovascular mortality [8]. Seaweeds are frequently eaten in Japan, and they contain a large amount of fiber but are low in calories [9]. Japanese vegetable pickles (*Tsukemono*) have many positive effects on health, including providing a good supply of vitamins, minerals, and antioxidants, and encouraging the growth of probiotics in the gut [10]. Japanese people consume rice as major staple food. Intake of rice, which is a low-fat carbohydrate, is reported to be associated with a reduced risk of cardiovascular disease mortality in men [11], but if excessive amounts are consumed, it may have an unfavorable effect on diabetes risk [12]. The JD is also characterized by a high consumption of green tea. Green tea is high in antioxidants and is effective in reducing obesity, decreasing blood pressure and serum lipids, and preventing type 2 diabetes [13]. The JD is also characterized by an infrequent intake of red meat and processed meat. Red meat contains saturated fats and, if eaten in excess, can lead to obesity,

colon cancer, and cardiovascular disease [14]. The JD contains high levels of fiber, favorable fatty acids, and a variety of antioxidants, and the synergistic interactions of these items has a beneficial effect on health.

Recently, because of the complexity of human meals, "overall dietary quality" has emerged as an important approach investigating the relationship between diet and health [15, 16]. There are several ways to define dietary quality including a *posteriori* dietary pattern or a *priori* scoring system [17]. Advantages of these approaches are that they show stronger correlations with health outcomes than studying individual nutrients or foods components [15-17]. Several studies have reported associations of the JD pattern, extracted by factor component analysis or principal component analysis, with risk reduction for cardio-metabolic disease [18-22]. Although a *posteriori* dietary pattern analysis can capture habitual eating characteristics, this approach has some methodologic issues [23, 24]. For example, the defined dietary pattern is driven by the underlying dietary data from a selected study population, which may limit generalizability to other study populations. In addition, the statistical analyses needed in a *posteriori* dietary pattern analysis are too complicated for use in clinical practice.

In this context, the use of a *priori* dietary scores that measure adherence to a predefined healthy diet pattern has emerged as an alternative to a *posteriori* dietary pattern approach [25, 26]. The advantage of using a dietary score is that it allows a quick assessment of overall dietary quality and can compare findings across different cohorts. One of widely used indexes for a healthy diet is the Mediterranean diet (MD) score, which has been shown to be inversely associated with a lower mortality rate and a reduced risk of cancer, metabolic disease, and cardiovascular disease [27]. However, different food cultures exist across countries. For example, while the MD may be common in European countries, it is not generally followed in Japan [28]. Therefore, using the MD score as an index of a healthy diet is impractical in a Japanese population.

Over the past few decades, the Japanese lifestyle has become markedly more westernized, although it is not clear whether the traditional JD has been replaced by other dietary habits in most people. It seems that traditional JD habits still remain or are followed in the contemporary lifestyle. It is important to get a valid and easy assessment tool that can capture the JD pattern. In Japan, the most known nutrition icon is the "Japan Food Guide Spinning Top", which was developed by the Japanese Ministry of Health, Labor, and Welfare and Ministry of Agriculture, Forestry, and Fishery [29]. However, this guide does not assess the Japanese-style dietary pattern and cannot assess the level of adherence to the JD.

To the best of our knowledge, only two studies [30, 31] have attempted to use an index to assess adherence to the JD pattern, but the nutritional validation of these studies was sparse. The aim of this study was to develop a novel instrument to measure JD adherence and examine the validity and associations of the JD score with food and nutrient intakes.

Methods

Subjects

A total of 1,002 employees at eight work-place settings and 62 university students from the urban and suburban area of Nara Prefecture, Japan, were recruited in this study. Most employees were industrial workers, office workers, formal caregivers, or nursing staff. Of these, we excluded one subject who was older than 70 years, two subjects who did not complete the diet history questionnaire, 11 subjects who had implausibly low or high estimated caloric intake (<700 or >4500 kcal per day for men, <600 or >3500 kcal per day for women), and two subjects who had missing information for factors needed for statistical adjustment. Finally, a total of 1,048 participants aged 18 to 68 years (645 men, 403 women) were included in this analysis. Study protocols were approved by the Institutional Review Board of Kio University, and written informed consent was obtained from each participant.

Dietary assessment

Habitual food consumption and nutrient intake were assessed using the brief-type self-administered diet history questionnaire (BDHQ) [32, 33]. The BDHQ is a 4-page fixed-portion questionnaire, and food and beverage items con-

Table 1. Association of personal characteristics of study subjects with mean Japanese diet (JD) scores

	Number	JD score	*P* value
Gender			0.558
Men	645	4.17 ± 2.02	
Women	403	4.09 ± 2.08	
Age group (yrs)			<0.001
<20	33	3.76 ± 1.75	
20-29	118	3.86 ± 1.93	
30-39	215	4.04 ± 2.07	
40-49	392	3.95 ± 2.08	
50-59	241	4.47 ± 1.96	
60+	49	5.35 ± 1.93	
BMI class (kg/m^2)			0.448
<20	193	4.12 ± 2.08	
20-24.9	564	4.09 ± 2.03	
25-29.9	248	4.17 ± 2.02	
30+	43	4.60 ± 2.14	
Obesity			0.323
Yes	291	4.24 ± 2.04	
No	757	4.10 ± 2.04	
Smoking status*			0.002
Yes	445	3.81 ± 2.03	
No	539	4.26 ± 2.05	
Physically active*			<0.001
Yes	445	4.43 ± 2.04	
No	539	3.91 ± 2.03	
Alcohol intake†			<0.001
No or low	670	4.34 ± 2.03	
Moderate	148	4.22 ± 2.09	
High	230	3.50 ± 1.93	
Hypertension‡			0.464
Yes	241	4.05 ± 2.09	
No	805	4.16 ± 2.03	
Diabetes‡			0.266
Yes	22	3.64 ± 2.06	
No	1024	4.15 ± 2.04	

Data are mean ± SD. *Data on smoking status and physical activity were missing for 64 subjects. †Alcohol consumption was categorized as low (men <10 g per day, women <5 g per day), moderate (men 10-30 g per day, women 5-15 g per day), and high (men >30 g per day, women >15 g per day). ‡Data on self-reported hypertension and diabetes were missing for 2 subjects.

tained in the BDHQ were selected from foods commonly consumed in Japan, mainly from a food list used in the National Health and Nutritional Survey of Japan [34]. The questionnaire asks about the consumption frequency of 58 food and beverage items and requires that participants recall their dietary habits over a 1-month period. Participants were asked to choose seven possible answers to indicate how often they had consumed specific foods during the past month (never, <1 times per week, once perweek, 2 to 3 times per week, 4 to 6 times per week, once per day, and more than 2 times per day). Combined with standard serving sizes, the intake frequencies were converted into the average daily intake for each food item. Values for the intake of nutrients and energy were estimated based on the food items asked about on the questionnaire and the corresponding food composition list in the Standard Tables of Food Composition in Japan [35].

Japanese diet score

The JD score was developed by building on evidence from previous studies [18-22] that extract the JD pattern using principal component analysis, and the items scored were selected based on the fact that they captured 10 key foods traditionally consumed in Japan. One point was given to subjects who met criteria for: 1) consumption of three or more bowls of rice per day; 2) consumption of soy and soyproducts (except for miso soup) five or more times per week; 3) everyday intake of miso soup; 4) consumption of fish five or more times per week; 5) consumption of 300 grams or more of vegetables (except for potato and legumes) per day; 6) consumption of vegetable pickles two or more times per week; 7) consumption of seaweeds two or more times per week; 8) everyday drinking of green tea; 9) consumption of Japanese confections (*wagashi*) one to three times per week; and 10) consumption of meat and meat products less than three times per week. The JD score was calculated as the sum of these 10 components with a possible score of 0 to 10. A higher score indicated better adherence to the traditional JD. Adherence to JD was categorized as low (score 0-3), moderate (score 4-6), or high (score 7-10).

Other variables

Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters, and subjects were classified by BMI category (BMI <20, 20-24.9, 25-29.9, >30 kg/m^2). Obesity was defined as BMI >25 kg/m^2. A self-reported questionnaire was used to assess current smoking status (yes, no),

Table 2. Food intake by the adherence levels to the Japanese diet (JD)

Food	JD score 0-3 (n=419)	JD score 4-6 (n=489)	JD score 7-10 (n=140)	P
Grain (g/day)	549 ± 199	557 ± 190	541 ± 182	0.945
Rice (g/day)	377 ± 182	388 ± 175	359 ± 175	0.247
Bread (g/day)	66 ± 45	58 ± 39	45 ± 29	<0.001
Others (g/day)	106 ± 80	111 ± 89	102 ± 73	0.954
Legumes (g/day)	44 ± 35	67 ± 46	88 ± 45	<0.001
Vegetables (g/day)	222 ± 118	304 ± 139	401 ± 152	<0.001
Fruits (g/day)	98 ± 110	123 ± 124	142 ± 129	<0.001
Fish (g/day)	71 ± 37	97 ± 53	121 ± 60	<0.001
Meat (g/day)	100 ± 47	90 ± 46	87 ± 42	0.001
Dairy (g/day)	155 ± 146	144 ± 122	145 ± 117	0.251
Eggs (g/day)	47 ± 36	51 ± 32	52 ± 27	0.054

Data are mean ± SD.

physical activity (active, sedentary), hypertension (yes, no), and diabetes (yes, no). Alcohol consumption (frequency and daily consumption) was evaluated by BDHQ information and was categorized as low (men, <10 g per day; women, <5 g per day), moderate (men, 10-30 g per day; women, 5-15 g per day), and high (men, >30 g per day; women >15 g per day).

Assessment of healthy behaviors

To evaluate the JD score in relation to health status, we constructed a Healthy 5 score, which is intended to measure healthy lifestyle, based on being non-obese, not smoking, being physically active, no or low/moderate alcohol use, and high adherence to the JD (JD score ≥7) as healthy dietary habits. Values of 0 or 1 were assigned to each item, and scores ranged from 0 to 5. Higher scores represented more healthy behaviors.

Statistical analysis

Data are presented as means ± SD or as percentages. The JD score between groups were assessed by the student t-test for continuous variables or the chi-square test for categorical variables. Differences of food or nutritional parameters across the JD adherence categories were assessed by one-way analysis of variance. Linear trends across the categories of JD adherence were also evaluated by modeling the score as a continuous variable, and correlations between various food and nutrient intakes and JD adherence were assessed using Pearson's correlation coefficient. Logistic regression analysis was applied to evaluate the risk of having self-reported hypertension and diabetes. *P* values <0.05 were considered statistically significant. All statistical analyses were performed using the SPSS statistical version 21.0 (IBM Corp, Armonk, NY).

Results

The mean age of subjects was 42.6 ± 11.4 years (range, 18-68 years). The mean BMI was 23.2 ± 3.6 years (range, 15.8-42.0 kg/m^2), and the prevalence of obesity (BMI >25.0 kg/m^2) was 27.8%. The mean JD score was 4.14 ± 2.04 (range, 0-10) and scores were normally distributed (data not shown). There were no significant differences in JD scores between men and women (**Table 1**). There was significant positive association between the mean JD score and age groups. No significant difference was observed in mean JD score between subjects with and without obesity. After stratifying subjects by BMI, no apparent trend association between JD score and BMI categories was observed. Subjects with a higher JD score were more likely to be non-smokers, physically active, and consume lower amounts of alcohol. No difference was observed in mean JD score between subjects with and without self-reported hypertension, as well as subjects with and without self-reported diabetes.

When subjects were classified by JD adherence categories, only 13.4% of subjects showed high adherence to the JD, whereas 40.0% showed low adherence. Mean daily consumption for food components was evaluated across the JD adherence categories (**Table 2**). Subjects who had a high JD score, consistent with a more traditional JD pattern, reported diets high in legumes, vegetables, fruits, and fish, and low in meat. When grain intakes were subdivided into rice, bread, and others, a negative association was observed between JD adherence and bread.

Nutrient intakes were evaluated across the JD adherence categories to confirm nutritional

Table 3. Nutrient intake by adherence levels to the Japanese diet (JD)

Nutrient	JD score 0-3 (n=419)	JD score 4-6 (n=489)	JD score 7-10 (n=140)	P
Energy (kcal/day)	1,624 ± 498	1,981 ± 568	2,257 ± 654	<0.001
Protein (%E)	13.3 ± 2.4	14.7 ± 2.6	15.9 ± 2.6	<0.001
Fat (%E)	25.9 ± 6.2	25.7 ± 5.5	25.9 ± 5.0	0.722
Carbohydrate (%E)	53.5 ± 8.4	54.5 ± 7.7	54.4 ± 6.8	0.096
SFA (%E)	7.09 ± 2.26	6.77 ± 1.83	6.64 ± 1.64	0.006
MUFA (%E)	9.54 ± 2.41	9.29 ± 2.18	9.18 ± 2.02	0.050
PUFA (%E)	6.13 ± 1.48	6.31 ± 1.39	6.54 ± 1.32	0.002
M/S ratio	1.40 ± 0.27	1.40 ± 0.28	1.41 ± 0.22	0.615
Dietary fiber (g/day)	11.3 ± 3.2	14.1 ± 4.0	17.0 ± 4.4	<0.001
Sucrose (g/day)	18.5 ± 11.6	18.4 ± 10.8	17.6 ± 10.9	0.515
Salt (g/day)	13.0 ± 3.3	13.9 ± 3.6	14.2 ± 3.2	<0.001
Potassium (mg/day)	2,566 ± 664	3,034 ± 854	3,520 ± 827	<0.001
Calcium (mg/day)	528 ± 199	625 ± 207	723 ± 206	<0.001
Magnesium (mg/day)	265 ± 57	308 ± 67	351 ± 70	<0.001
Iron (mg/day)	7.8 ± 2.0	9.5 ±2.1	10.9 ± 2.3	<0.001
Vitamin D (μg/day)	11.5 ± 6.2	16.0 ± 8.5	20.2 ±10.9	<0.001
Folate (μg/day)	328 ± 123	410 ± 132	492 ± 140	<0.001
Vitamin C (mg/day)	100 ± 48	134 ± 58	165 ± 64	<0.001

Data are mean ± SD. MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; M/S, monounsaturated fatty acids to saturated fatty acids ratio.

validity (**Table 3**). A higher JD score was associated with a higher intake of protein, polyunsaturated fatty acids, dietary fiber, potassium, calcium, magnesium, iron, vitamin D, folate, and vitamin C and a lower intake of saturated fats.

To evaluate this score in relation to health status, associations of the Healthy 5 score, which include JD adherence as one component, with a prevalence ratio of self-reported hypertension and diabetes was assessed (**Table 4**). A higher Healthy 5 score (≥3 points) was significantly associated with a lower prevalence of hypertension (odds ratio, 0.55; 95% confidence interval, 0.40-0.76; P<0.001) after adjusting for age and sex. A 1-point increase in Healthy 5 score was also related to a risk reduction for having hypertension. The risk for diabetes was not associated with the Healthy 5 score in any model.

Discussion

This is the first study to investigate the validity of a novel JD score in comparison with food and nutrient intakes. About 50-60 years ago, the incidence of cardiovascular disease was very low in Japan [36]. This may be partly attributed to the good dietary habits in Japan [37]. Over the past few decades, however, the Japanese lifestyle has become more westernized. To date, unhealthy dietary habits have become more prevalent, and switching from a traditional JD to a westernized dietary pattern may play an important role in increases in obesity, metabolic diseases, and cardiovascular disease. However, traditional dietary habits have not been clarified in contemporary lifestyle. Studying these newer dietary patterns has become important in the field of nutritional epidemiology.

Previous studies have examined the health impact of individual foods characterized by the traditional JD [1]. However, because people consume meals consisting of a variety of foods with complex combinations of nutrients, the effect of a single food or a specific nutrient on health may be difficult to determine. In this context, an assessment of dietary patterns, instead of isolated foods or nutrients, has been proposed to evaluate the balance between protective and harmful components of the diet [15-17].

Recently, several studies identified a JD pattern by factor component analysis or principal component analysis [18-22]. Mizoue et al. [18] reported that the JD pattern was characterized by frequent intake of soybean products, vegetables, fish, seaweed, pickles, and green tea. They reported that the JD pattern is positively associated with impaired glucose tolerance in Japanese men. Shimazu et al. [19] reported that the JD pattern was characterized by frequent intake of soybean products, vegetables, fish, seaweed, green tea, and fruits, and that the JD was associated with a decreased risk of cardiovascular disease mortality in Japanese men and women aged 40-79 years. Okubo et al. [20] found a positive association of the traditional JD, characterized by high intake of rice,

Table 4. Association of increase in Healthy 5 score (including JD adherence as one component) with having disease risk*

Participants with likelihood of having disease†	Models	OR (95% CI)	*p* value
Hypertension	Healthy 5 score ≥3‡	0.55 (0.40-0.76)	<0.001
	Healthy 5 score per 1-point increase‡	0.73 (0.62-0.85)	<0.001
Diabetes	Healthy 5 score ≥3‡	0.83 (0.34-2.03)	0.677
	Healthy 5 score per 1-point increase‡	0.96 (0.63-1.47)	0.858

*A Healthy 5 score is based on being non-obese, not smoking, being physically active, no or low/moderate alcohol use, and high adherence to the JD (JD score ≥7). †Subjects with missing data for smoking habit, physical activity status, or self-reported hypertension and diabetes were excluded; data represents 984 subjects. ‡Adjusted for age and sex. OR, odds ratio; CI, confidence interval.

miso soup, and soy products, with an increased risk for obesity among young women. Guo et al. [21] also reported that the JD was characterized by a higher intake of soy products, miso soup, vegetables, fish, seaweed, and green tea and was associated with increased serum adiponectin levels in Japanese adult men. They suggested that the JD was associated with higher serum adiponectin concentrations, which are protective against diabetes and cardiovascular disease. Akter et al. [22] reported that the JD was characterized by soy products, vegetable, green tea, fruits, and mushrooms, and did not find any association of the JD with metabolic syndrome in a Japanese working population. Although there is no consensus on the definition of the JD, the principal aspects are thought to be represented by a high consumption of rice, fish, soy products, vegetables, and seaweed and a low consumption of meat. Based on past studies [18-22], we constructed a novel 10-item JD score. We also assessed its validity regarding whether the JD score actually represents a higher intake of specific foods traditionally consumed in Japan. In the present study, a higher JD score was associated with a higher intake of legumes, vegetables, fruits, and fish and a lower intake of meat and bread, which reflect a higher level of adherence to the JD. In addition, a higher JD score was associated with a higher intake of desirable nutrients such as polyunsaturated fatty acids, dietary fiber, potassium, calcium, magnesium, iron, vitamin D, folate, and vitamin C, and a lower intake of unfavorable nutrients, such as saturated fatty acids; this eating pattern represents a healthy diet.

When creating the JD score, we did not incorporate "fruits" into our score. However, a Mediterranean diet score includes fruits as one important component, because fruits have antioxidant effects that are associated with a reduced risk for cardiovascular disease and cancer [38]. Japanese people commonly consume a variety of fruits such as citrus fruits, apples, strawberries, bananas, grapes, peaches, and persimmons. Of these, some are characteristic of the JD, but others are not. In addition, the fruit supply may change depending on the season. It is possible that seasonal variations in types of fruits consumed may lead to bias in evaluations of dietary quality. Because it is difficult to define a typical Japanese style eating habit for fruits, we omitted fruits from our JD score. Nevertheless, in the present results, a positive association of fruit intake with adherence to the JD was observed. We also did not incorporate "dairy products" into our JD score. Although the Mediterranean diet recommends less frequent intake of whole-fat dairy products [39], the Dietary Approaches to Stop Hypertension (DASH) diet promotes the consumption of fat-free or low-fat dairy products [40]. There is no consensus regarding adequate amounts or types of dairy products to promote better health in humans. In the past, dairy consumption in Japan has been shown to be much lower than in Mediterranean and western countries [37]. Currently, however, dairy consumption in Japan has rapidly grown as the traditional diet has become more westernized. Evidence from several studies in Japan [18-22] indicated that a high consumption of dairy products was not recognized as being part of the typical JD. Thus, we omitted dairy products from our study. In addition, our JD score does not include alcohol consumption, although most of MD scores consider alcohol intake, especially wine during meals. Some studies showed that the effect of wine on stroke risk reduction was stronger than that of other alcohol beverages [41], suggesting that wine

polyphenols have an additional antioxidant effect. It is important to note that Japanese men commonly consume several kind of alcoholic beverages such as sake (Japanese rice wine), beer, or sho-chu (Japanese distilled alcohol beverage), but the proportion of wine drinkers is relatively low. In addition, the proportion of alcohol drinkers is much lower in Japanese women than in Japanese men. For this reason, we omitted alcohol consumption from our JD score. Additionally, we did not include olive oil or nuts as part of our score. These foods are the main components of the MD, but their consumption in Japan is low.

Alternatively, we included some unique items within our JD score, including the consumption of green tea. Drinking green tea is a common habit in Japan. Green tea is high in antioxidants, and there is increasing evidence that it is beneficial for the prevention of diabetes, hypertension, and cancer [13, 42, 43]. Indeed, many studies conducted in Japan [18, 19, 21, 22] recognized that green tea is an important component of a typical JD pattern. Another item that is part of the JD is miso-soup. Miso soup, which is made from fermented soybeans, is commonly taken with meals in the Japanese dietary culture. It has a high level of protein, monounsaturated fatty acids, and polyunsaturated fatty acids and is a good source of fiber, potassium, calcium, magnesium, iron, and vitamin C. It also contains isoflavones. The health benefits of miso soup include a reduced risk for osteoporosis, a lower risk for cancer, and maintenance of a healthy digestive tract [44]. Another unique item included in our JD score was Japanese confections (*wagashi*). Preferences for sweets differ between people living in western countries and Japan. The beneficial effects of *wagashi* may be attributable to the use of adzuki beans (red beans) in these confections; the red beans are prepared by boiling and then sweetened into “red bean paste”. Adzuki beans contain relatively high amounts of plant protein, fiber, and polyphenols, and a lower fat content compared with western-style confectionaries [45]. This might contribute to weight loss and stabilization of cholesterol levels [45]. Although the updated MD pyramid [39] includes a low intakes of sweets, we thought it prudent to include the intake of *wagashi* in our JD score.

In the present results, some unintended findings were observed between the JD adherence and food or nutrient intakes. First, there was no significant difference in rice consumption among subjects with low, moderate, and high JD adherence scores. This finding indicates that eating rice is still part of the contemporary Japanese lifestyle. Second, protein intake was positively associated with increases in JD adherence scores. It seems reasonable that legumes (soy and soy-products) and fish intakes would be higher with increasing JD adherence scores despite the fact that meat intake was lower. Third, although this is a reasonable finding, JD adherence was positively associated with salt intake. This finding could be due to high consumption of miso soup, salty fish, and Japanese pickles, which contain high sodium levels and are preferably eaten in Japan.

The strength of the present study is that we developed a novel JD score that can be used to capture traditional Japanese eating habits. The design of the JD score permits an assessment of JD adherence without the need to estimate precise nutrient intakes. Most items included on the JD score can be determined by a simple and semi-quantitative questionnaire using frequency category (daily frequency or weekly frequency). For consumption of rice and miso soup, usual amounts were determined (bowls or cups per day). For vegetable intake, the amount of the foods in grams (g per day) were needed. In addition, although our JD score was based on food groups, it was positively associated with the intake of healthy nutrients such as polyunsaturated fatty acids, dietary fiber, potassium, calcium, magnesium, iron, vitamin D, folate, and vitamin C. The score was also inversely related to intakes of unhealthy nutrients such as saturated fatty acids. Therefore, our results indicate that the JD score has adequate nutritional validity. Second, in the current study, the Healthy 5 score, which included JD adherence as one component of a healthy diet, was significantly associated with the risk for hypertension. Subjects who met at least three of the Healthy 5 score’s item had a lower risk of having hypertension when compared with less healthy subjects.

This study has several limitations. First, the JD score included only 10 items to get a rough classification, that is, high, moderate, or low

adherence to the JD pattern. Although it is a simple and quick assessment tool, misclassification of food items must be considered. Second, because we did not measure plasma biomarkers such as lipids or vitamin levels, validation analysis between JD score and plasma biomarkers could not be confirmed. Third, we used self-reported data for diabetes and hypertension, which might be biased. In addition, in our sample population, the prevalence of self-reported diabetes was very low. We did not find a clear association between diabetes and the Healthy 5 score. This was largely explained by a low statistical power, due to the small number of subjects with diabetes. Fourth, this study was conducted only among adult employees and university students; the lack of a randomly selected sample could lead to selection bias. Although the geographic characteristics of our study sample are similar to a general Japanese population living in an urban or suburban area setting, we did not include study subjects in rural communities, such as farm workers, who might be more likely to adhere to the JD. Further investigations including subjects with a wider range of occupations is needed. In the present study, we included university students as study subjects. Generally young adults tend to select unhealthy foods and consume a high-fat diet, snacks and soft drinks, or a low variety of foods. Only about 6% of the younger group, including both university students and young employees, showed high adherence to the JD. Therefore, the eating habits of young people are thought to differ from the traditional JD pattern compared with results with the older age group.

In conclusion, the present study has shown good validity of the novel JD score by confirming reasonable associations with food and nutrient intakes. Currently, the JD has been recognized as a healthy diet worldwide, and the need to promote it to populations other than Japanese subjects has been emphasized. The use of the JD score in clinical practice or research may help promote healthier eating habits.

Disclosure of conflict of interest

None.

Authors' contribution

MK designed the study, researched the data and wrote the manuscript. KK contributed to the data collection and the discussions.

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