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Diet quality and adherence to a healthy diet in Japanese male workers with untreated hypertension

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ABSTRACT

Objectives: As Japanese societies rapidly undergo Westernization, the prevalence of hypertension is increasing. We investigated the association between dietary quality and the prevalence of untreated hypertension in Japanese male workers. **Design and methods:** We conducted a cross-sectional study of 461 male workers who completed a brief food frequency questionnaire. Adherence to the WHO-based Healthy Diet Indicator, the American Heart Association 2006 Diet and Lifestyle Recommendations, the Dietary Approaches to Stop Hypertension diet, and Mediterranean style diet were assessed using 4 adherence indexes (HDI score, AI-84 score, DASH score, and MED score). Hypertension classes were classified into 3 categories: non-hypertension, untreated hypertension, and treated hypertension (i.e. taking anti-hypertensive medication). **Results:** The prevalence of untreated hypertension and treated hypertension were 22.3% and 8.7%, respectively. Subjects with untreated hypertension had significantly lower HDI and AI-84 scores compared with non-hypertension. DASH scores and MED scores across the 3 hypertension classes were comparable. After adjusting for age, energy intake, smoking habit, alcohol drinking, physical activity and salt intake, a low adherence to HDI and a lowest quartile of AI-84 score were associated with a significantly higher prevalence of untreated hypertension, with an odds ratio of 2.56 (95% CI 1.15-5.69, p=0.021) and 2.25 (1.12-4.52, p=0.023), respectively. **Conclusions:** A lower dietary quality was associated with increased prevalence of untreated hypertension in Japanese male workers. Our findings support a

potential beneficial impact of nutritional assessment using diet qualities.

Key Words: DASH diet, diet quality, Healthy Diet Indicator, Japanese, male workers, Mediterranean style diet

Abbreviations: AHA-DLR, American Heart Association 2006 Diet and Lifestyle Recommendations; AI-84 score, adherence index to the AHA-DLR; BDHQ, brief self-administered diet history questionnaire; BMI, body mass index; DASH, Dietary Approaches to Stop Hypertension; HDI, Healthy Diet Indicator; MED score, Mediterranean diet score; NHT, non-hypertension; UHT, untreated hypertension; THT, treated hypertension.

Strength and limitations:

Low diet quality was associated with a high prevalence of untreated hypertension in Japanese male workers.

The Healthy Diet Indicator, followed by the adherence index to the American Heart Association 2006 Diet and Lifestyle Recommendations, are easily applicable tools for assessing diet quality and seems to have advantages predicting untreated hypertension in Japanese men.

Many Japanese male workers were unlikely to follow the guidelines of the DASH diet or Mediterranean style diet.

INTRODUCTION

The prevalence of hypertension is increasing in Asian countries, and in Japan an estimated 23 million men have hypertension [1]. Several lifestyle factors are closely associated with blood pressure, and dietary habits play an important role in the development of this disease [2]. Hypertension is also one of most important health problems in male workers, because unhealthy dietary habits may be prevalent among this population [3]. Reasons for consuming an unhealthy diet in this group may include consumption of high-fat snacks, eating meat, and eating at fast-food restaurants. To prevent hypertension, it is important to identify diet qualities that are strongly associated with hypertension in this working population.

There is convincing evidence, mostly from Western countries, demonstrating the link between blood pressure status and individual nutrients or foods [4]. However, Asians' dietary habits differ from those of people in Western countries. Some cross-sectional studies showed an inverse association of fruits, vegetable, and milk protein intakes with the prevalence of hypertension in Asians population [5-7], but precise analyses of diet quality in subjects with untreated hypertension are sparse.

The dominant approach of nutritional epidemiology in the past has been to investigate the association between single nutrients or foods and the risk of disease; however, this approach is fraught with problems [8]. Recently, comprehensive approaches, such as the priori-defined methods from adherence to calculation of diet scores based on dietary guidelines, have been used to investigate the association between diet and disease: the WHO-based

Healthy Diet Indicator (HDI) [9], the 2005 Dietary Guidelines for the American Adherence Index [10], and the adherence index based on the American Heart Association 2006 Diet and Lifestyle Recommendations (AHA-DLR) [11]. Another method for identification of habitual dietary intakes is the adherence score to the appropriate dietary models, and some adherence scores have been proposed, including the Healthy Eating Index [12], adherence to the Dietary Approaches to Stop Hypertension (DASH) diet [13], and adherence to Mediterranean style diet [14]. Some studies have tried to identify the relation between these indexes and the risk of hypertension, but findings are not consistent [15-19]. In addition, little is known about the associations in Asians. The aim of this study was to determine whether dietary quality is associated with the risk of hypertension in male Japanese workers.

METHODS

Subjects

We conducted a cross-sectional study of 521 male workers at an electronic products factory (in Nara Prefecture, Japan) aged >30 years who underwent annual health examinations. We excluded participants with known diabetes or taking antidiabetic medication (n=10), who had implausibly low or high estimated caloric intake (<600 or >4500 kcal per day, n=3), or who had missing information for factors needed for statistical adjustment (n=18), leaving 490 participants. Study protocols were approved by the Institutional Review Board of Kio University and written informed consent was received from each participant.

Definition of hypertension classes

All participants were subjected to a physical examination assessing height, weight, and blood pressure. Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters. Trained nurses measured blood pressure in a seated position using a sphygmomanometer (OMRON Blood Pressure Monitor HEM-7081-IT, Omron Healthcare, Muko, Japan). The first measure was used, but if more than one measure was obtained, the mean of the last two measures were used. Subjects were classified as follows: non-hypertension (NHT; systolic blood pressure < 140 mm Hg and diastolic blood pressure < 90 mm Hg), untreated hypertension (UHT; defined as subjects not on medication for hypertension who met hypertension criteria), or treated hypertension (THT) defined as those with hypertension receiving antihypertensive medication. Because the purpose of the current study was to evaluate the dietary quality of UHT, borderline cases were omitted from analysis (n=27). Subjects were considered to be borderline cases if their systolic blood pressure ranged from140 to149 mm Hg and the diastolic blood pressure was below 90 mm Hg. This was done because under the annual health check setting, blood pressure readings are potentially overestimated; in addition we did not capture ambulatory blood pressure.

Dietary assessment

Habitual food consumption and nutrient intake were assessed using a brief self-administered diet history questionnaire (BDHQ) [20]. The questionnaire asks about the consumption frequency of 58 food and beverage items and requires that participant recall his dietary habits over a 1-month period. Participants were asked to choose 7 possible answers to indicate how often they had consumed various specified foods during the past month (never, <1 times per week, once a week, 2 to 3 times per week, 4 to 6 times per week, once-daily, 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. Estimates of nutrients and energy were calculated using an adhoc computer algorithm for the BDHQ that was based on the Standard Tables of Food composition in Japan (Japan Science and Technology Agency, 2010).

Heathy Diet Indicator (HDI score)

The HDI score consists of 7 nutrients and one food group component including saturated fatty acid (SFA), poly-saturated fatty acid (PSFA), cholesterol, protein, fiber, free sugar, sodium, and fruits and vegetables [9]. When intake was within the recommended range according to WHO guidelines [21], a score of one was assigned; otherwise a score of zero was used. This resulted in scores ranging from 0 to 8 (Supplemental Table 1). We considered that a HDI score <4 represented low adherence.

Adherence index to the AHA-DLR (AI-84 score)

We proposed an adherence index to the AHA-DLR modified from the original index developed by Bhupathiraju et al. [11]. The modified adherence index we used was reported elsewhere [22]. Briefly, the index includes 10 components: (1) consuming a diet rich in fruit and vegetables, (2) choosing a variety of fruit and vegetables, (3) choosing whole-grain products, (4) consuming oily fish, (5) consuming an appropriate range of total fat, (6) limiting intake of saturated fat, (7) reducing dietary cholesterol, (8) minimizing intake of beverages and foods with added sugars, (9) consuming low- or no-salt foods, and (10) consuming alcohol in moderation. In addition, we used a simple scoring system (Supplemental Table 2). Participants who reported adhering to recommended levels received the maximum points (4, 5, 6, or 10 points for each component) that could be assigned. If the intermediate target was met, 2, 3, or 5 points for each component was assigned. Finally, the adherence index (namely AI-84) was calculated as the sum of these 10 components with a possible score of 0 to 84. A higher score on the AI-84 indicates better adherence to the recommendations, and a low adherence to AHA-DLR was defined as 18 points or lower (the lowest quartile of AI-84 score).

The DASH score

We determined a DASH score based on foods and nutrients in accordance with the DASH diet [13] focusing on 8 components: high intake of vegetable, fruits, legumes, whole grain, and low-fat dairy products, and low intake of meats and processed meats, sweetened beverages, and sodium. Accordance with each target is given a score of 1, and the total DASH score was generated by summing the points (range 0-8) (Supplemental Table 1). Higher total scores indicated better adherence. We considered that a DASH score <3 represented a low adherence to the DASH diet.

The Mediterranean style diet score (MED score)

According to the position in the updated MED pyramid [23], we constructed the MED score focusing on 11 components: vegetable, fruits, grains, legumes, fish, red meat and processed meat, dairy products, eggs, poultry, alcohol, and the ratio of monosaturated fatty acid (MUFA) to saturated fatty acid (SFA) (Supplemental Table 1). Values of 0 or 1 were assigned to each components. For alcohol intake, a value of 1 was assigned to men who consumed 10-30 g per day. For the MUFA/SFA ratio, a value of 1 was assigned to subjects whose ratio was above 1.5. We considered that a MED score <5 represented low adherence to the MED.

Other variables

A self-reported questionnaire was used to assess current smoking status (yes, no) and physical activity (active, sedentary). According to the National Health and Nutrition Survey in Japan, regular exercise is defined as exercising at least 2 days a week, 30 minutes or more each time: thus a subject who reported physical activity that met this definition was considered active.

Statistical analysis

Data are presented as means ± SD or as percentages. Differences in mean values of continuous variables between groups with and without hypertension were tested using the student t test; percentages were compared using chi-square analysis. Linear trends of dietary quality parameters across hypertension classes were assessed by analysis of variance. To evaluate the risk of UHT, we chose to exclude THT subjects in order to evaluate whether the adherence to dietary quality indexes has an impact on hypertension by avoiding the potential confounding effect because THT subjects might have changed their diet upon medical advice. The odds ratios (ORs) and 95% confidence intervals (CIs) of having UHT were calculated by logistic regression analysis. 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

After excluding borderline cases, a total of 461 subjects were included in analysis. The mean age of men in this study was 45.5 ± 7.1 years (range 30-62 years), the prevalence of UHT was 22.3%, and the prevalence of THT was 8.7%. Characteristics and nutrient intakes of subjects among hypertension classes are shown in Table 1. As expected, age and BMI were significantly higher in participants with hypertension than in those without. Subjects without hypertension were significantly more active. Total energy intake and salt intake were comparable between groups. Subjects with UHT had significantly lower HDI score and AI-84 score compared with the NHT group (4.19 ± 1.24 vs. 4.58 ± 1.17, p=0.01; 24.4 ± 9.9 vs. 27.1 ± 9.8, p=0.031; respectively). On the other hand, DASH scores and MED scores across the 3 hypertension classes were comparable.

Table 1. Subject characteristics and diet quality scores according to hypertension class

	NHT	UHT	THT	p
n	318	103	40	
Age (years)	44.7 ± 6.9	46.7 ± 6.7	50.2 ± 6.7	<0.001
BMI (kg/m^2)	23.7 ± 3.0	26.1 ± 3.5	24.8 ± 3.9	<0.001
Smoking (%)	26	23	23	0.821
Active (%)	47	30	50	0.008
SBP (mm Hg)	121.9 ± 11.1	150.1 ± 14.2	139.0 ± 14.7	<0.001
DBP (mm Hg)	74.9 ± 8.4	96.9 ± 8.8	87.3 ± 8.5	<0.001
Total energy intake (kcal)	1926 ± 557	1963 ± 553	1877 ± 489	0.684
Salt intake (g/1000 kcal)	5.88 ± 1.36	5.96 ± 1.31	5.57 ± 1.32	0.277
HDI score	4.58 ± 1.17	4.19 ± 1.24	4.35 ± 1.08	0.014
AI-84 score	27.1 ± 9.8	24.4 ± 9.9	27.7 ± 9.3	0.031
DASH score	2.44 ± 1.31	2.38 ± 1.19	2.73 ± 1.28	0.339
MED score	5.27 ± 1.49	5.40 ± 1.73	5.43 ± 1.37	0.682

Data were mean ± SD, or %.

NHT, non-hypertension; UHT, untreated hypertension; THT, treated hypertension; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; HDI, Healthy Diet Indicator; AI-84, adherence index to the American Heart Association 2006 Diet and Lifestyle Recommendation; DASH score, Dietary Approaches to Stop Hypertension score; MED score, Mediterranean diet score.

Table 2 shows the diet quality related to having UHT in the logistic regression analysis when the THT subjects were excluded from the analysis. In the unadjusted model, low adherence to HDI was significantly associated with a higher prevalence of UHT with an OR of 2.63 (95% CI 1.22-5.71, p=0.014) and a lowest quartile AI-84 score was significantly associated with a higher prevalence of UHT with an OR of 1.98 (95% CI 1.04-3.78, p=0.038). After adjusting for age, total energy intake, smoking habit, alcohol drinking, physical activity and salt intake (model 2), low adherence to HDI was significantly associated with the prevalence UHT with an OR of 2.56 (95% CI 1.15-5.69, p=0.021), and a lowest quartile of AI-84 score was significantly associated with a higher prevalence of UHT with an OR of 2.25 (95% CI 1.12-4.52, p=0.023). As expected, being obese was a significant positive influencing factor on UHT. In the fully adjusted model (model 3), low adherence to HDI remained significantly associated with UHT. On the other hand, low adherence to DASH and MED scores were not associated with UHT in any model tested.

Table 2. Crude and multivariate-adjusted odds ratios of the prevalence untreated hypertension for the low adherence to dietary quality scores

	OR	95%CI	p
HDI score (unadjusted)	2.63	1.22-5.71	0.014
(Model 1)	2.73	1.25-5.95	0.011
(Model 2)	2.56	1.15-5.69	0.021
(Model 3)	2.31	1.02-5.19	0.044
AI-84 score (unadjusted)	1.98	1.04-3.78	0.038
(Model 1)	2.11	1.10-4.07	0.025
(Model 2)	2.25	1.12-4.52	0.023
(Model 3)	1.69	0.84-3.37	0.139
DASH score (unadjusted)	0.91	0.58-1.43	0.690
(Model 1)	0.86	0.55-1.35	0.513
(Model 2)	0.87	0.54-1.39	0.559
(Model 3)	0.92	0.57-1.49	0.745
MED score (unadjusted)	1.04	0.64-1.69	0.885
(Model 1)	0.98	0.60-1.61	0.947
(Model 2)	0.97	0.58-1.61	0.967
(Model 3)	1.09	0.65-1.83	0.740

Model 1 was adjusted for age. Model 2 was adjusted for age, total energy intake, smoking habit (yes/no), alcohol drinking (yes/no), physically active (yes/no), and salt intake. Model 3 was additionally adjusted for obesity status (yes/no).

DISCUSSION

The use of an adherence index to either established dietary recommendations or adequate dietary models has emerged as an alternative to the traditional approach for examining associations between diet and health [24]. The present study revealed that lower adherence to the WHO-HDI and AHA-DLR were associated with a significantly increased prevalence of UHT in Japanese male workers. In this study, we used 4 adherence indexes to assess dietary quality. The first index we used in this study, the HDI, was originally created by Haijbregts et al [9] as a tool to assess compliance with the WHO's dietary guidelines for the prevention of chronic disease [25]. Because the WHO provided updated guidelines in 2002 [21], we adapted the new criteria in this study. The HDI has been used worldwide and described as a very strong tool for assessing the dietary quality [26]. The HDI has been studied in relation to all-cause mortality [9, 27], overall cancer risk [28], and cardiovascular disease risk [29], but risk for hypertension was not investigated. In the present study, using the HDI score created by the updated WHO guidelines, low adherence to the HDI was significantly associated with a risk of UHT. Being overweight is an important risk factor for hypertension. It is worth noting that, in the present study, the association of HDI with UHT remained significant after adjustment for multiple confounders, including obesity.

The second index, the AI-84, was developed by a study group at Tufts University [11]. The adherence index is aimed at examining the association between dietary behaviors and cardiovascular disease risk. To the best of our knowledge, no study has assessed the adherence index to the AHA-DLR among subjects with UHT. We used the AI-84, with minor and simpler modifications, and examined the association between healthy dietary habits and the prevalence of hypertension in male Japanese workers. In the present study, we showed that a low AI-84 score was associated with a significantly higher prevalence of UHT after adjusting for confounding factors for hypertension such as smoking, alcohol drinking, salt intake and physical activity. However, it became nonsignificant after additional adjustment for obesity. It has been recognized that different populations have unique dietary patterns with varying effects on the risk for chronic diseases. Although traditional Japanese dietary habits differ from Caucasians or other ethnic populations, the contemporary diet of most Japanese adults resembles the Westernized diet. Meat, white bread, refined grains, fast food, and soft drinks have become typical features of the contemporary diet in Japan. Therefore, we believe that it is reasonable to adapt and use the AI-84 even in a Japanese population.

The third index, the DASH score, measures an adherence to a dietary pattern that was rich in fruits, vegetable, whole grain, legumes and low-fat dairy products and reduced intake of red/processed meat, sweets, and sodium. The dietary pattern has demonstrated beneficial effects on lower blood pressure in intervention studies [13]. However, little is known about the habitual adherence to the DASH diet in adults with or without hypertension. Using data from the National Health and Nutrition

Examination Survey, Mellen et al. [17] reported the Americans with hypertension had lower adherence with the DASH diet than normotensive Americans. Harrington et al. [30] also reported an inverse association between DASH score and systolic blood pressure in a population study of middle-aged men and women conducted in Ireland. In the present study, however, we showed little evidence of a relation between a habitual DASH diet and a lower risk for hypertension in Japanese male workers. This result contradicts previous reports [17, 30]. These different findings might be explained by several reasons. It is well documented that Japanese people prefer salty food such as miso-soup, salty fish, and pickles. In this study, salt intake was comparable between the 3 hypertension groups (NHT, UHT and THT; Table 1) and each groups had a high consumption of salt so that only 1.1% of study subjects maintained the recommended intake of 9 g per day (data not shown). In addition, Japanese people are less likely consume low-fat dairy products. Low-fat dairy products, which are a common component of the DASH diet, have been shown to reduce blood pressure. However, only 27.5% of our study subjects consumed low-fat milk (data not shown). Therefore, we were not surprised at the lack of association between adherence to the DASH diet and UHT. The results of the current study show that Japanese male workers consumed a diet that did not adhere to DASH.

The forth index, the MED score, is widely known for its use in assessing the habitual intakes of a MED. Several indexes that attempt to evaluate the level of adherence to this diet pattern have been proposed [31]. Some of these indexes are simple, while others are more complicated. Many studies reported the associations of the MED with decreased all-cause mortality [14], improvements in cardiovascular risk [32], or lower incidence of metabolic syndrome [33]. However, little is known about the association of this index with hypertension. In the Seginien Universided de Navarra study, conducted in Spain, adherence to the MED was not associated with the incidence of hypertension during 4.2 years follow-up [18]. In a sample of the ATTICA study, which included subjects living in s metropolitan area in Athens, the MED score was significantly lower in hypertensives compared with normotensives [16]. A cross-sectional study conducted in a Spanish population reported that the diet of hypertensive individuals has a low accordance with Mediterranean dietary patterns [19]. In the present study, the habitual Mediterranean style diet was not associated with UHT. These different findings might be explained by several reasons. It is well documented that Japanese people eat a high amount of fish. We speculate that the high consumption of fish in this study population negated any association between a low adherence to a Mediterranean style diet and the prevalence of hypertension. As for the original MED pattern, olive oil must be used as the main cooking fat. In contrast, consumption of olive oil is low in Japan and the food frequency questionnaire (BDHQ) used in this study could not calculate the amount of olive oil consumed. Instead of olive oil consumption, we used an indirect assessment of the MUFA/SFA ratio, which was contained in the traditional Mediterranean score proposed by Trichopoulou et al. [14]. The MED has also been characterized by low-to-moderate consumption of wine, usually red wine, but many Japanese men prefer other alcoholic beverages such as beer, sake (Japanese rice wine), or sho-chu (Japan's distilled alcoholic beverage) as their drink of choice. A very low drinking rate of wine were observed in our study subjects (12.3%, data not shown).

This study has several limitations. First, as a cross-sectional study, the present analysis cannot prove a causal relationship between the dietary quality indexes and the prevalence of hypertension. Second, our results showed this association only among male workers at one factory. Our findings may not be generalizable to women or to other male populations in different work areas. Third, although it is known that chronic stress at work is associated with hypertension, the present study did not evaluate these issues. Despite these limitations, the main strength of our study was the use of comprehensive measures of adherence to current dietary recommendations or dietary models based on usual intakes estimated from a brief food frequency questionnaire, which can be used easily in clinical practice and public health areas. This approach of assessing a dietary quality index has merit in that it allows information regarding food and nutrient consumption to be combined into a single useful indicator. In addition, we evaluated the risk of hypertension by avoiding the potential confounding effect of the THT group. For hypertensive patients undergoing medical treatment, lifestyle interventions including dietary counseling, nutritional education and clinician's advice may influence their healthy dietary choice. We consider it likely that their dietary habits might be better and that the result of dietary quality scores may be affected if the THT group was included in the logistic regression analysis. This is an interesting finding, because all of dietary quality scores in the THT group tended to be high compared with the UHT group (Table 1).

In conclusion, lower adherence to the WHO-HDI and AHA-DLR were associated with a significantly increased prevalence of UHT in this study group of Japanese male workers. From a public health perspective, changes in dietary habits are probably one of the most important strategies for preventing hypertension. Assessing dietary quality and improving compliance with nutritional recommendations may help reduce the burden of hypertension.

Contribution statement

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

Disclosures

None.

Conflict of interest statement

All the authors declare no conflict of interest.

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Supplemental Table 1. Scoring system of HDI, DASH score and Mediterranean score

Index	Nutrient or food intake	Scoring criteria for 1 point	0 point
HDI	Saturated fatty acid (%E)	<10	≥10
	Polysaturated fatty acid (%E)	6 - 10	<6, >10
	Cholesterol (mg/d)	<300	≥300
	Protein (%E)	10 - 15	<10, >15
	Dietary fiber (g/d)	≥19	<19
	Free sugar (%E)	<10	≥10
	Sodium (g/d)	<9	≥9
	Fruits and vegetable (g/d)	≥400	<400
DASH diet	Vegetable (SV/d)	≥4	<4
	Fruits (SV/d)	≥3	<3
	Legumes (g/d)	≥70	<70
	Whole-grain (%)	≥25	<25
	Low-fat dairy products (times/w)	≥5	<5
	Meats/processed meats (times/w)	<5	≥5
	Sweet	<8.6	≥8.6
	Sodium (g/d)	<9	≥9
Mediterranean diet	Vegetable (SV/d)	≥5	<5
	Fruits (SV/d)	≥2	<2
	Legume (g/d)	≥50	<50

	Cereals (SV/d)	3 -6.9	<3, >7
	Fish (g/d)	≥30	<30
	Dairy products (SV/d)	1.5 - 2.5	<1.5, >2.5
	Meat/processed meat (times/w)	<4	≥4
	Eggs (times/w)	2 - 3	<2, >3
	Poultry (times/w)	2 - 3	<2, >3
	Alcohol (g/d)	10 - 30	<10, >30
	MUFA/SFA	≥1.5	<1.5

Abbreviations were: DASH, Dietary Approaches to Stop Hypertension; HDI, Healthy Diet Indicator; MUFA, monosaturated fatty acid; SFA, saturated fatty acid; SV, serving.

Supplemental Table 2. Scoring system of AI-84

Items	Non-adherence	intermediate	Good adherence
Vegetable (SV/d)	<3 (0)	3 – 4.9 (3)	≥5 (5)
Fruits (SV/d)	<1 (0)	1 – 1.9 (3)	≥2 (5)
Variety in fruits and vegetable #	<10 (0)	10 – 14 (5)	≥15 (10)
Whole grain (%)	0 (0)	10 (2), 25 (5)	≥50 (10)
Oily fish (times/w)	0 (0)	1 (3)	≥2 (10)
Total fat (%E)	>35 (0)	<25 (2)	25 - 35 (4)
Saturated fat (%E)	>7.0 (0)	3.5 - 7.0 (3)	<3.5 (6)
Cholesterol (mg/d)	>300 (0)	150 - 300 (2)	<150 (4)
Added sugar (kcal/d)	≥150 (0)	100-149 (2),	<50 (10)

		50-99 (5)	
Salt (g/d)	>9 (0)	6-9 (5)	<6 (10)
Alcohol	≥2 drinks/d (0)	Nondrinker(5)	Adequate (10)

Each point of score in parenthesis.

number of 16 different vegetables consumed per week

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	P1-2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	P2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	P3-5
Objectives	3	State specific objectives, including any prespecified hypotheses	P5
Methods			
Study design	4	Present key elements of study design early in the paper	P5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	P5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	P5-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	P6-9, Supplemental table 1 and 2
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	P6-9
Bias	9	Describe any efforts to address potential sources of bias	N/A
Study size	10	Explain how the study size was arrived at	N/A
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	P9-10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	P9-10
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	P5
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	N/A
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	P10
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	P11, Table 1
		(b) Indicate number of participants with missing data for each variable of interest	N/A
Outcome data	15*	Report numbers of outcome events or summary measures	P12-13, Table2
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	P12-13, Table2
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	P14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	P17-18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	P18-19
Generalisability	21	Discuss the generalisability (external validity) of the study results	P18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	P19

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Diet quality and adherence to a healthy diet in Japanese male workers with untreated hypertension

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Diet quality and adherence to a healthy diet in Japanese male workers with untreated hypertension

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ABSTRACT

Objectives: As Japanese societies rapidly undergo Westernization, the prevalence of hypertension is increasing. We investigated the association between dietary quality and the prevalence of untreated hypertension in Japanese male workers. **Design and methods:** We conducted a cross-sectional study of 433 male workers who completed a brief food frequency questionnaire. Adherence to the WHO-based Healthy Diet Indicator, the American Heart Association 2006 Diet and Lifestyle Recommendations, the Dietary Approaches to Stop Hypertension diet, and Mediterranean style diet were assessed using 4 adherence indexes (HDI score, AI-84 score, DASH score, and MED score). Hypertension classes were classified into 3 categories: non-hypertension, untreated hypertension, and treated hypertension (i.e. taking anti-hypertensive medication). **Results:** The prevalence of untreated hypertension and treated hypertension were 22.4% and 8.5%, respectively. Subjects with untreated hypertension had significantly lower HDI and AI-84 scores compared with non-hypertension. DASH scores and MED scores across the 3 hypertension classes were comparable. After adjusting for age, energy intake, smoking habit, alcohol drinking, physical activity and salt intake, a low adherence to HDI and a lowest quartile of AI-84 score were associated with a significantly higher prevalence of untreated hypertension, with an odds ratio of 3.33 (95% CI 1.39-7.94, p=0.007) and 2.23 (1.09-4.53, p=0.027), respectively. **Conclusions:** A lower dietary quality was associated with increased prevalence of untreated hypertension in Japanese male workers. Our findings support a

potential beneficial impact of nutritional assessment using diet qualities.

Key Words: DASH diet, diet quality, Healthy Diet Indicator, Japanese, male workers, Mediterranean style diet

Abbreviations: AHA-DLR, American Heart Association 2006 Diet and Lifestyle Recommendations; AI-84 score, adherence index to the AHA-DLR; BDHQ, brief self-administered diet history questionnaire; BMI, body mass index; DASH, Dietary Approaches to Stop Hypertension; HDI, Healthy Diet Indicator; MED score, Mediterranean diet score; NHT, non-hypertension; UHT, untreated hypertension; THT, treated hypertension.

Strength and limitations:

Low diet quality was associated with a high prevalence of untreated hypertension in Japanese male workers.

The Healthy Diet Indicator, followed by the adherence index to the American Heart Association 2006 Diet and Lifestyle Recommendations, are easily applicable tools for assessing diet quality and seems to have advantages predicting untreated hypertension in Japanese men.

Many Japanese male workers were unlikely to follow the guidelines of the DASH diet or Mediterranean style diet.

INTRODUCTION

The prevalence of hypertension is increasing in Asian countries, and in Japan an estimated 23 million men have hypertension [1]. Several lifestyle factors are closely associated with blood pressure, and dietary habits play an important role in the development of this disease [2]. Hypertension is also one of most important health problems in male workers, because unhealthy dietary habits may be prevalent among this population [3]. Reasons for consuming an unhealthy diet in this group may include consumption of high-fat snacks, eating meat, and eating at fast-food restaurants. To prevent hypertension, it is important to identify diet qualities that are strongly associated with hypertension in this working population.

There is convincing evidence, mostly from Western countries, demonstrating the link between blood pressure status and individual nutrients or foods [4]. However, Asians' dietary habits differ from those of people in Western countries. Some cross-sectional studies showed an inverse association of fruits, vegetable, and milk protein intakes with the prevalence of hypertension in Asians population [5-7], but precise analyses of diet quality in subjects with untreated hypertension are sparse.

The dominant approach of nutritional epidemiology in the past has been to investigate the association between single nutrients or foods and the risk of disease; however, this approach is fraught with problems [8]. Recently, comprehensive approaches, such as the priori-defined methods from adherence to calculation of diet scores based on dietary guidelines, have been used to investigate the association between diet and disease: the WHO-based

Healthy Diet Indicator (HDI) [9], the 2005 Dietary Guidelines for the American Adherence Index [10], and the adherence index based on the American Heart Association 2006 Diet and Lifestyle Recommendations (AHA-DLR) [11]. Another method for identification of habitual dietary intakes is the adherence score to the appropriate dietary models, and some adherence scores have been proposed, including the Healthy Eating Index [12], adherence to the Dietary Approaches to Stop Hypertension (DASH) diet [13], and adherence to Mediterranean style diet [14]. Although the benefit of the DASH or Mediterranean dietary pattern were related to the reduction of hypertension risk [15, 16], there is still a certain controversy about these associations. In addition, little is known about the associations in Asians. The aim of this study was to determine whether dietary quality is associated with the risk of hypertension in male Japanese worker.

METHODS

Subjects

We conducted a cross-sectional study of 521 male workers at an electronic products factory (in Nara Prefecture, Japan) aged >30 years who underwent annual health examinations. We excluded participants with known diabetes (n=10) or chronic kidney disease (stage ≥3, n=29), who had implausibly low or high estimated caloric intake (<600 or >4500 kcal per day, n=3), or who had missing information for factors needed for statistical adjustment (n=21), leaving 458 participants. Study protocols were approved by the Institutional Review Board of Kio University and written informed consent was received from each participant.

Definition of hypertension classes

All participants were subjected to a physical examination assessing height, weight, and blood pressure. Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters. Trained nurses measured blood pressure in a seated position using a sphygmomanometer (OMRON Blood Pressure Monitor HEM-7081-IT, Omron Healthcare, Muko, Japan). The first measure was used, but if more than one measure was obtained, the mean of the last two measures were used. Subjects were classified as follows: non-hypertension (NHT; systolic blood pressure < 140 mm Hg and diastolic blood pressure < 90 mm Hg), untreated hypertension (UHT; defined as subjects not on medication for hypertension who met hypertension criteria), or treated hypertension (THT) defined as those with hypertension receiving antihypertensive medication. In addition, subjects were considered to be borderline cases if their systolic blood pressure ranged from140 to149 mm Hg and the diastolic blood pressure was below 90 mm Hg. These borderline cases were omitted from analysis (n=25), because the purpose of the current study was to evaluate the dietary quality of UHT. This was done because under the annual health check setting, blood pressure readings are potentially overestimated; in addition we did not capture ambulatory blood pressure.

Dietary assessment

Habitual food consumption and nutrient intake were assessed using a brief self-administered diet history questionnaire (BDHQ) [17, 18]. The BDHQ is a 4-page fixed-portion questionnaire, and food and beverage items contained 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 [19]. The questionnaire asks about the consumption frequency of 58 food and beverage items and requires that participant recall his dietary habits over a 1-month period. Participants were asked to choose 7 possible answers to indicate how often they had consumed various specified foods during the past month (never, <1 times per week, once a week, 2 to 3 times per week, 4 to 6 times per week, once-daily, 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 obtained questionnaire and the corresponding food composition list in the Standard Tables of Food Composition in Japan [20].

Heathy Diet Indicator (HDI score)

The HDI score consists of 8 nutrients and one food group component including carbohydrate, saturated fatty acid (SFA), poly-saturated fatty acid (PSFA), cholesterol, protein, fiber, free sugar, sodium, and fruits and vegetables [9]. When intake was within the recommended range according to WHO guidelines [21], a score of one was assigned; otherwise a score of zero was used. This resulted in scores ranging from 0 to 9 (Supplemental Table 1).

We considered that a HDI score <4 represented low adherence.

Adherence index to the AHA-DLR (AI-84 score)

We proposed an adherence index to the AHA-DLR modified from the original index developed by Bhupathiraju et al. [11]. The modified adherence index we used was reported elsewhere [22]. Briefly, the index includes 10 components: (1) consuming a diet rich in fruit and vegetables, (2) choosing a variety of fruit and vegetables, (3) choosing whole-grain products, (4) consuming oily fish, (5) consuming an appropriate range of total fat, (6) limiting intake of saturated fat, (7) reducing dietary cholesterol, (8) minimizing intake of beverages and foods with added sugars, (9) consuming low- or no-salt foods, and (10) consuming alcohol in moderation. In addition, we used a simple scoring system (Supplemental Table 2). Participants who reported adhering to recommended levels received the maximum points (4, 5, 6, or 10 points for each component) that could be assigned. If the intermediate target was met, 2, 3, or 5 points for each component was assigned. Finally, the adherence index (namely AI-84) was calculated as the sum of these 10 components with a possible score of 0 to 84. A higher score on the AI-84 indicates better adherence to the recommendations, and a low adherence to AHA-DLR was defined as 18 points or lower (the lowest quartile of AI-84 score).

The DASH score

We determined a DASH score based on foods and nutrients in accordance with the DASH diet [13] focusing on 8 components: high intake of vegetable, fruits, legumes, whole grain, and low-fat dairy products, and low intake of meats and processed meats, sweetened beverages, and sodium. Accordance with each target is given a score of 1, and the total DASH score was generated by summing the points (range 0-8) (Supplemental Table 1). Higher total scores indicated better adherence. We considered that a DASH score <3 represented a low adherence to the DASH diet.

The Mediterranean style diet score (MED score)

According to the position in the updated MED pyramid [23], we constructed the MED score focusing on 11 components: vegetable, fruits, grains, legumes, fish, red meat and processed meat, dairy products, eggs, poultry, alcohol, and the ratio of monosaturated fatty acid (MUFA) to saturated fatty acid (SFA) (Supplemental Table 1). Values of 0 or 1 were assigned to each components. For alcohol intake, a value of 1 was assigned to men who consumed 10-30 g per day. For the MUFA/SFA ratio, a value of 1 was assigned to subjects whose ratio was above 1.5. We considered that a MED score <5 represented low adherence to the MED.

Other variables

A self-reported questionnaire was used to assess current smoking status (yes, no) and physical activity (active, sedentary). According to the National Health and Nutrition Survey in Japan, regular exercise is defined as exercising at least 2 days a week, 30 minutes or more each time: thus a subject who reported physical activity that met this definition was considered active.

Statistical analysis

Data are presented as means ± SD or as percentages. Differences in mean values of continuous variables between groups with and without hypertension were tested using the student t test; percentages were compared using chi-square analysis. Linear trends of dietary quality parameters across hypertension classes were assessed by analysis of variance. To evaluate the risk of UHT, we chose to exclude THT subjects in order to evaluate whether the adherence to dietary quality indexes has an impact on hypertension by avoiding the potential confounding effect because THT subjects might have changed their diet upon medical advice. The odds ratios (ORs) and 95% confidence intervals (CIs) of having UHT were calculated by logistic regression analysis. 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

After excluding borderline cases (n=25), a total of 433 subjects were included in analysis. The mean age of men in this study was 45.3 ± 7.0 years (range 30-62 years), the prevalence of UHT was 22.4%, and the prevalence of THT was 8.5%. Characteristics and nutrient intakes of subjects among hypertension classes are shown in Table 1. As expected, age and BMI were significantly higher in participants with hypertension than in those without. Subjects without hypertension were significantly more active. Total energy intake and salt intake were comparable between groups. Subjects with UHT had significantly lower HDI score and AI-84 score compared with the NHT group (4.12 ± 1.24 vs. 4.59 ± 1.16; 24.6 ± 10.1 vs. 27.3 ± 9.8; respectively). On the other hand, DASH scores and MED scores across the 3 hypertension classes were comparable.

Table 1. Subject characteristics and diet quality scores according to hypertension class

	NHT	UHT	THT	p
n	299	97	37	
Age (years)	44.4 ± 6.8	46.4 ± 6.7	50.1 ± 6.4	<0.001
BMI (kg/m^2)	23.7 ± 3.0	26.1 ± 3.6	24.5 ± 3.7	<0.001
Smoking (%)	26.1	24.7	24.3	0.949
Active (%)	47.2	29.9	48.6	0.009
SBP (mm Hg)	121.1 ± 11.0	150.3 ± 14.0	139.9 ± 14.6	<0.001
DBP (mm Hg)	74.9 ± 8.4	96.4 ± 8.3	87.2 ± 8.8	<0.001
Total energy intake (kcal)	1923 ± 540	1978 ± 560	1871 ± 489	0.535
Salt intake (g/1000 kcal)	5.86 ± 1.33	5.91 ± 1.26	5.63 ± 1.35	0.530
HDI score	4.59 ± 1.16	4.12 ± 1.24	4.27 ± 1.02	0.002
AI-84 score	27.3 ± 9.8	24.6 ± 10.1	27.7 ± 8.8	0.045

DASH score	2.45 ± 1.31	2.38 ± 1.21	2.70 ± 1.13	0.423
MED score	5.24 ± 1.45	5.41 ± 1.78	5.51 ± 1.35	0.427

Data were mean ± SD, or %.

NHT, non-hypertension; UHT, untreated hypertension; THT, treated hypertension; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; HDI, Healthy Diet Indicator; AI-84, adherence index to the American Heart Association 2006 Diet and Lifestyle Recommendation; DASH score, Dietary Approaches to Stop Hypertension score; MED score, Mediterranean diet score.

Table 2 shows the diet quality related to having UHT in the logistic regression analysis when the THT subjects were excluded from the analysis. After adjustment for age, low adherence to HDI was significantly associated with a higher prevalence of UHT with an OR of 3.70 (95% CI 1.58-8.66, p=0.003) and a lowest quartile AI-84 score was significantly associated with a higher prevalence of UHT with an OR of 2.12 (95% CI 1.09-4.14, p=0.027). After adjusting for age, total energy intake, smoking habit, alcohol drinking, physical activity and salt intake (model 2), low adherence to HDI was significantly associated with the prevalence UHT with an OR of 3.33 (95% CI 1.39-7.94, p=0.007), and a lowest quartile of AI-84 score was significantly associated with a higher prevalence of UHT with an OR of 2.23 (95% CI 1.09-4.53, p=0.027). As expected, being obese was a significant positive influencing factor on UHT. In the fully adjusted model (model 3), low adherence to HDI remained significantly associated with UHT. On the other hand, low adherence to DASH and MED scores were not associated with UHT in any model tested.

Table 2. Crude and multivariate-adjusted odds ratios of the prevalence untreated hypertension for the low adherence to dietary quality scores

	OR	95%CI	p
HDI score (unadjusted)	3.63	1.56-8.41	0.003
(Model 1)	3.70	1.58-8.66	0.003
(Model 2)	3.33	1.39-7.94	0.007
(Model 3)	3.05	1.25-7.40	0.014
AI-84 score (unadjusted)	1.97	1.02-3.79	0.044
(Model 1)	2.12	1.09-4.14	0.027
(Model 2)	2.23	1.09-4.53	0.027
(Model 3)	1.90	0.91-3.90	0.086
DASH score (unadjusted)	0.88	0.55-1.39	0.580
(Model 1)	0.83	0.52-1.32	0.429
(Model 2)	0.83	0.51-1.36	0.466
(Model 3)	0.89	0.54-1.47	0.651
MED score (unadjusted)	0.98	0.60-1.61	0.927
(Model 1)	0.92	0.56-1.52	0.750
(Model 2)	0.92	0.55-1.54	0.737
(Model 3)	0.97	0.57-1.66	0.922

Model 1 was adjusted for age. Model 2 was adjusted for age, total energy intake, smoking habit (yes/no), alcohol drinking (yes/no), physically active (yes/no), and salt intake. Model 3 was additionally adjusted for obesity status (yes/no).

DISCUSSION

The use of an adherence index to either established dietary recommendations or adequate dietary models has emerged as an alternative to the traditional approach for examining associations between diet and health [24]. The present study revealed that lower adherence to the WHO-HDI and AHA-DLR were associated with a significantly increased prevalence of UHT in Japanese male workers. In this study, we used 4 adherence indexes to assess dietary quality. The first index we used in this study, the HDI, was originally created by Haijbregts et al [9] as a tool to assess compliance with the WHO's dietary guidelines for the prevention of chronic disease [25]. Because the WHO provided updated guidelines in 2002 [21], we adapted the new criteria in this study. The HDI has been used worldwide and described as a very strong tool for assessing the dietary quality [26]. The HDI has been studied in relation to all-cause mortality [9, 27], overall cancer risk [28], and cardiovascular disease risk [29], but risk for hypertension was not investigated. In the present study, using the HDI score created by the updated WHO guidelines, low adherence to the HDI was significantly associated with a risk of UHT. Being overweight is an important risk factor for hypertension. It is worth noting that, in the present study, the association of HDI with UHT remained significant after adjustment for multiple confounders, including obesity.

The second index, the adherence index to the AHA-DLR, was developed by a study group at Tufts University [11]. The index is aimed at examining the association between dietary behaviors and cardiovascular disease risk. To the best of our knowledge, no study has assessed the adherence index to the AHA-DLR among subjects with UHT. We developed the AI-84 score [22], with minor and simpler modifications for the original index, and examined the association between healthy dietary habits and the prevalence of hypertension in male Japanese workers. In the present study, we showed that a low AI-84 score was associated with a significantly higher prevalence of UHT after adjusting for confounding factors for hypertension such as smoking, alcohol drinking, salt intake and physical activity. However, it became nonsignificant after additional adjustment for obesity. It has been recognized that different populations have unique dietary patterns with varying effects on the risk for chronic diseases. Although traditional Japanese dietary habits differ from Caucasians or other ethnic populations, the contemporary diet of most Japanese adults resembles the Westernized diet. Meat, white bread, refined grains, fast food, and soft drinks have become typical features of the contemporary diet in Japan. Therefore, we believe that it is reasonable to adapt and use the AI-84 even in a Japanese population.

The third index, the DASH score, measures an adherence to a dietary pattern that was rich in fruits, vegetable, whole grain, legumes and low-fat dairy products and reduced intake of red/processed meat, sweets, and sodium. The dietary pattern has demonstrated beneficial effects on lower blood pressure in intervention studies [13]. However, little is known about the habitual adherence to the DASH diet in adults with or without hypertension. Using data from the National Health and Nutrition Examination Survey, Mellen et al. [30] reported the Americans with hypertension had lower adherence with the DASH diet than normotensive Americans. Harrington et al. [31] also reported an inverse association between DASH score and systolic blood pressure in a population study of middle-aged men and women conducted in Ireland. In the present study, however, we showed little evidence of a relation between a habitual DASH diet and a lower risk for hypertension in Japanese male workers. This result contradicts previous reports [30, 31]. These different findings might be explained by several reasons. It is well documented that Japanese people prefer salty food such as miso-soup, salty fish, and pickles. In the present study, salt intake was comparable between the 3 hypertension groups (NHT, UHT and THT; Table 1) and each groups had a high consumption of salt so that only 1.1% of study participants maintained the recommended intake of 9 g per day (data not shown). In addition, Japanese people are less likely consume low-fat dairy products. Low-fat dairy products, which are a common component of the DASH diet, have been shown to reduce blood pressure. However, only 21.6% of our study subjects consumed low-fat milk (data not shown). Therefore, we were not surprised at the lack of association between adherence to the DASH diet and UHT. The results of the current study show that Japanese male workers consumed a diet that did not adhere to DASH.

The forth index, the MED score, is widely known for its use in assessing the habitual intakes of a MED. Several indexes that attempt to evaluate the level of adherence to this diet pattern have been proposed [32]. Some of these indexes are simple, while others are more complicated. Many studies reported the associations of the MED with decreased all-cause mortality [14], improvements in cardiovascular risk [33], or lower incidence of metabolic syndrome [34]. However, little is known about the association of this index with hypertension. A cross-sectional study in Canary Islands showed that subjects in the high adherence to MED presented 70% lower prevalence of high blood pressure [35]. Another cross-sectional study conducted in a Spanish population reported that the diet of hypertensive individuals has a low accordance with Mediterranean dietary patterns [36]. In a sample of the ATTICA study, which included subjects living in a metropolitan area in Athens, the MED score was significantly lower in hypertensives compared with normotensives [37]. In a population-based survey conducted in Sicily, an association between a higher adherence to the MED and lower likelihood of being hypertensive were observed [38]. In the present study, the habitual Mediterranean style diet was not associated with UHT. These different findings might be explained by several reasons. It is well documented that Japanese people eat a high amount of fish. We speculate that the high consumption of fish in this study population negated any association between a low adherence to a Mediterranean style diet and the prevalence of hypertension. As for the original MED pattern, olive oil must be used as the main cooking fat. In contrast, consumption of olive oil is low in Japan and the food frequency questionnaire (BDHQ) used in this study could not calculate the amount of olive oil consumed. Instead of olive oil consumption, we used an indirect parameter of the MUFA/SFA ratio, which was contained in the traditional Mediterranean score proposed by Trichopoulou et al. [14]. The MED has also been characterized by low-to-moderate consumption of wine, usually red wine, but many Japanese men prefer other alcoholic beverages such as beer, sake (Japanese rice wine), or sho-chu (Japan's distilled alcoholic beverage) as their drink of choice. A very low drinking rate of wine were observed in our study subjects (11.7%, data not shown).

This study has several limitations. First, as a cross-sectional study, the present analysis cannot prove a causal relationship between the dietary quality indexes and the prevalence of hypertension. Second, our results showed this association only among male workers at one factory. Our findings may not be generalizable to women or to other male populations in different work areas. Third, although it is known that chronic stress at work is associated with hypertension, the present study did not evaluate these issues. Finally, tea (including green tea) and soy foods are widely consumed in Asian countries. Although legumes is a component of both Mediterranean and DASH diet scores, these indexes cannot estimate individual intake of different types of legumes. Effects of tea and soy intakes were not evaluated by the dietary scores used in this study.

Despite these limitations, the main strength of our study was the use of comprehensive measures of adherence to current dietary recommendations or dietary models based on usual intakes estimated from a brief food frequency questionnaire, which can be used easily in clinical practice and public health areas. This approach of assessing a dietary quality index has merit in that it allows information regarding food and nutrient consumption to be combined into a single useful indicator. In addition, we evaluated the risk of hypertension by avoiding the potential confounding effect of the THT group. For hypertensive patients undergoing medical treatment, lifestyle interventions including dietary counseling, nutritional education and clinician's advice may influence their healthy dietary choice. We consider it likely that their dietary habits might be better and that the result of dietary quality scores may be affected if the THT group was included in the logistic regression analysis. This is an interesting finding, because all of dietary quality scores in the THT group tended to be high compared with the UHT group (Table 1).

In conclusion, lower adherence to the WHO-HDI and AHA-DLR were associated with a significantly increased prevalence of UHT in this study group of Japanese male workers. From a public health perspective, changes in dietary habits are probably one of the most important strategies for preventing hypertension. Assessing dietary quality and improving compliance with nutritional recommendations may help reduce the burden of hypertension.

Contribution statement

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

Disclosures

None.

Conflict of interest statement

All the authors declare no conflict of interest.

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Supplemental Table 1. Scoring system of HDI, DASH score and Mediterranean score

Index	Nutrient or food intake	Scoring criteria for 1 point	0 point
HDI	Carbohydrate (%E)	55 - 75	<55, >75
	Saturated fatty acid (%E)	<10	≥10
	Polysaturated fatty acid (%E)	6 - 10	<6, >10
	Cholesterol (mg/d)	<300	≥300
	Protein (%E)	10 - 15	<10, >15
	Dietary fiber (g/d)	≥19	<19
	Free sugar (%E)	<10	≥10
	Sodium (g/d)	<9	≥9
	Fruits and vegetable (g/d)	≥400	<400
DASH diet	Vegetable (SV/d)	≥4	<4
	Fruits (SV/d)	≥3	<3
	Legumes (g/d)	≥70	<70
	Whole-grain (%)	≥25	<25
	Low-fat dairy products (times/w)	≥5	<5
	Meats/processed meats (times/w)	<5	≥5
	Sweet	<8.6	≥8.6
	Sodium (g/d)	<9	≥9
Mediterranean diet	Vegetable (SV/d)	≥5	<5
	Fruits (SV/d)	≥2	<2

	Legume (g/d)	≥50	<50
	Cereals (SV/d)	3 -6.9	<3, >7
	Fish (g/d)	≥30	<30
	Dairy products (SV/d)	1.5 - 2.5	<1.5, >2.5
	Meat/processed meat (times/w)	<4	≥4
	Eggs (times/w)	2 - 3	<2, >3
	Poultry (times/w)	2 - 3	<2, >3
	Alcohol (g/d)	10 - 30	<10, >30
	MUFA/SFA	≥1.5	<1.5

Abbreviations were: DASH, Dietary Approaches to Stop Hypertension; HDI, Healthy Diet Indicator; MUFA, monosaturated fatty acid; SFA, saturated fatty acid; SV, serving.

Supplemental Table 2. Scoring system of AI-84

Items	Non-adherence	intermediate	Good adherence
Vegetable (SV/d)	<3 (0)	3 – 4.9 (3)	≥5 (5)
Fruits (SV/d)	<1 (0)	1 – 1.9 (3)	≥2 (5)
Variety in fruits and vegetable #	<10 (0)	10 – 14 (5)	≥15 (10)
Whole grain (%)	0 (0)	10 (2), 25 (5)	≥50 (10)
Oily fish (times/w)	0 (0)	1 (3)	≥2 (10)
Total fat (%E)	>35 (0)	<25 (2)	25 - 35 (4)
Saturated fat (%E)	>7.0 (0)	3.5 - 7.0 (3)	<3.5 (6)
Cholesterol (mg/d)	>300 (0)	150 - 300 (2)	<150 (4)

Added sugar (kcal/d)	≥150 (0)	100-149 (2), 50-99 (5)	<50 (10)
Salt (g/d)	>9 (0)	6-9 (5)	<6 (10)
Alcohol	≥2 drinks/d (0)	Nondrinker(5)	Adequate (10)

Each point of score in parenthesis.

number of 16 different vegetables consumed per week

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	P1-2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	P2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	P3-5
Objectives	3	State specific objectives, including any prespecified hypotheses	P5
Methods			
Study design	4	Present key elements of study design early in the paper	P5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	P5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	P5-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	P6-9, Supplemental table 1 and 2
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	P6-9
Bias	9	Describe any efforts to address potential sources of bias	N/A
Study size	10	Explain how the study size was arrived at	N/A
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	P9-10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	P9-10
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	P5
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	N/A
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	P10
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	P11, Table 1
		(b) Indicate number of participants with missing data for each variable of interest	N/A
Outcome data	15*	Report numbers of outcome events or summary measures	P12-13, Table2
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	P12-13, Table2
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	P14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	P17-18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	P18-19
Generalisability	21	Discuss the generalisability (external validity) of the study results	P18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	P19

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.