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Adherence to the American Heart Association Recommended Healthy Diet and Prevalence of Metabolic Syndrome in Male Japanese Workers

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Abstract

Objective: The American Heart Association-recommended healthy diet (AHA-HD) is one of 7 ideal cardiovascular health metrics. Few studies have focused on use of the AHA-HD in Asian subjects. This study reports on the prevalence of adherence to the AHA-HD and examines the association between adherence to this diet and the risk for metabolic syndrome in male Japanese workers.

Design: A cross-sectional study provided data from 508 male workers, aged 25 to 63 years. Participants completed a 58-item brief-type, self-administered dietary history questionnaire. The AHA-HD score include 8 components (fruits and vegetables, fish, whole grains, salt, sugar-sweetened beverages, processed meat, legumes, and saturated fatty acids).

Results: The AHA-HD score of all subjects ranged from 0 to 7; no participant had a full score for all 8 components. The prevalence of metabolic syndrome was significantly lower in subjects with high adherence to AHA-HD (met ≥4 components) than in those with low adherence (21.8% vs. 30.1%, respectively). High adherence to the AHA-HD was significantly associated with a low prevalence of metabolic syndrome (OR, 0.64; 95%CI, 0.42-0.97; p=0.038) after adjustment for age, total energy intake, smoking habit, and alcohol drinking.

Conclusions: Improving adherence to the AHA-HD recommendations may be an effective approach to promoting better health. Achievement of eating behaviors that meet ≥4 components of the AHA-HD may lead to a reduction in the risk for metabolic syndrome.

Key words: American Heart Association-recommended healthy diet; Japan; metabolic syndrome; workers;

Introduction

Diet quality has emerged as an alternative to the traditional approach of using single nutrients or food groups to examine associations between diet and health, and several dietary quality scores have been proposed to assess healthy eating patterns [1, 2]. In 2010, the American Heart Association (AHA) published its strategic impact goal recommendations [3]. These recommendations proposed new dietary guidelines to reduce cardiovascular disease mortality by 20% and improve cardiovascular health by 20% by the year 2020 and beyond [3]. The committee defined a construct of ideal cardiovascular health, including 3 physiological risk factors and 4 healthy behaviors [3]. The AHA-recommended healthy diet (AHA-HD) is one of 7 ideal cardiovascular health metrics. The primary dietary recommendations include 5 components (fruits and vegetables, fish, whole grains, salt, and sugar-sweetened beverages), and secondary dietary recommendations include 3 additional components (processed meat, legumes, and saturated fatty acids). These recommendations are simple to determine compared with other indices and can be used easily in healthcare settings, especially in Western countries [4]. Application of this score in other populations requires certain adaptations, because dietary cultures and eating habits differ between Western and Asian countries. Although a traditional Japanese diet has been recognized as healthy [5, 6], dietary habits in Japan are changing from the traditional Japanese diet to an American-style diet or other less-healthy eating habits [7]. Thus, it is important to assess the contemporary diet in Japan using an American-style or a Westernized diet pattern score. In addition, the prevalence of metabolic syndrome among the Japanese population has increased in recent decades, especially in adult male workers [8]. However, there is little evidence that evaluates the association of adherence to the AHA-HD with the risk for metabolic syndrome. In a previous short report, we examined 7 metrics of ideal cardiovascular health and the risk for metabolic syndrome in Japanese subjects, but a precise analysis of the AHA-HD components was not performed [9]. The aim of this study was to report on adherence to the AHA-HD in male Japanese workers and to estimate the association between metabolic syndrome and increased adherence to this diet.

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Methods

Study participants

A total of 535 male workers were invited to participate in this cross-sectional study. Participants were recruited from a selected workplace (an electronic products factory) in Nara Prefecture, Japan. Of these, 8 persons refused to participate. The remaining 527 eligible subjects were chosen to answer the diet history questionnaire. Of these, we excluded 12 subjects who did not complete the diet history questionnaire and 7 subjects who had implausibly low or high estimated caloric intake (<800 or >4500 kcal per day). Finally, a total of 508 participants (mean age, 45.6 ± 7.1 years; range, 25 to 63 years) were included in the analysis. This study was performed in accordance with the Helsinki Declaration. Study protocols were approved by the Institutional Review Board of Kio University, and written informed consent was obtained from each participant.

Dietary assessment

The dietary assessment is described in detail elsewhere [10]. Briefly, using the 58-item brief self-administered diet history questionnaire (BDHQ) [11], participants were asked to choose 7 possible answers to indicate how often they had consumed specific foods during the past month (never, <1 time per week, once per week, 2-3 times per week, 4-6 times per week, once per day, and ≥2 times per day). Values for the intake of nutrients and energy were estimated based on the questionnaire and the corresponding food composition list in the Standard Tables of Food Composition in Japan [12].

The American Heart Association healthy diet score (AHA-HDS)

We modified the original AHA-HD recommendations [3] to reflect cultural and dietary habits of Japanese subjects. The AHA-HDS includes 5 primary components (fruits and vegetables ≥400 g per day; fish intake ≥2 times per week with at least one of oily fish; fiber/carbohydrate ratio ≥0.1; salt intake <8 g per day; and sugar-sweetened beverages <2 times per week), plus 3 secondary components (processed meats <2 times per week; legumes ≥4 times per week; and saturated fatty acid intake <7% of total energy intake). Because measuring the precise amount of whole grain intake is difficult with the BDHQ, we used a fiber/carbohydrate ratio instead. Recommendations state that when choosing a whole grain food, a rule of >1 g of fiber per 10 g of carbohydrate should be used [13]. This recommendation comes from a report from the Harvard School of Public Health [13] and has been used in previous studies assessing the AHA-HD [14, 15]. Another modified point was the cutoff for salt intake. Because it is difficult to achieve the original AHA-HD criteria (sodium <2300 mg per day) in Japan, we used a value from a report of the Dietary Reference Intake for Japanese 2015 [16], which recommends <8 g of salt per day for men as a dietary goal for preventing lifestyle-related diseases. The AHA-HD was calculated as a dichotomous score, awarding 1 point for meeting the ideal definitions or 0 points for not meeting them, resulting in scores ranging from 0 to 8. The adherence to the AHA-HD was classified as high (met 4-8 components) and low (met 0-3 components).

Assessment of metabolic syndrome

Metabolic syndrome was defined according to the criteria of the International Diabetes Federation in conjunction with the National Heart, Lung, and Blood Institute, American Heart Association, World Heart Federation, International Atherosclerosis Society, and International Association for the Study of Obesity [17]. Subjects were defined as having metabolic syndrome if they had 3 or more of the following 5 components: waist circumference ≥85 cm [18]; high blood pressure (≥130 mmHg systolic, ≥85 mmHg diastolic, or current use of antihypertensive medicine); a high serum triglyceride level (≥150 mg/dL or specific treatment for this lipid abnormality); low high-density lipoprotein (HDL) cholesterol (<40 mg/dL); and high fasting glucose level (≥100 mg/dL).

Other variables

Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters, and overweight/obesity was defined as BMI ≥25 kg/m2. Smoking status (yes, no) and physical activity (persons who exercised at least 2 days a week, 30 minutes or more each time, were defined as active) was assessed using a self-reported questionnaire. In addition, alcohol consumption (for men) was assessed using the BDHQ and was classified as low (<10 g of ethanol per day), moderate (10 to 30 g per day), and high (>30 g per day).

Statistical analyses

Categorical variables were described as percentages and were compared by the chi-square test. Continuous variables between 2 groups were compared using Student's t-test. A binary logistic regression analysis was conducted to examine the association between adherence to the AHA-HD and the risk for metabolic syndrome. Three models were used. Model 1 was adjusted for age (years). Model 2 was adjusted for age (years), total energy intake (kcal/day), smoking (yes, no), and alcohol drinking (low, moderate, high). Model 3 was adjusted for model 2 components plus being physically active (yes, no). All statistical analyses were performed using SPSS version 21.0 (IBM Corp, Armonk, NY). P values <0.05 were considered statistically significant.

Results

Characteristics of subjects with or without metabolic syndrome

Characteristics and nutrient intakes of subjects with or without metabolic syndrome are shown in (Table 1). As expected, body weight, BMI, and waist circumference were significantly higher in participants with metabolic syndrome than in those without metabolic syndrome. Total energy intake and the proportion of energy intake from protein and carbohydrate were comparable between groups. Unexpectedly, the proportion of energy intake from fat was significantly lower in subjects with

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Table 1: Characteristics of subjects with or without metabolic syndrome

	Without metabolic syndrome	With metabolic syndrome	p
N	372	136	
Age (years)	45.2 ± 7.3	46.6 ± 6.4	0.042
Body weight (kg)	62.9 ± 10.7	77.4 ± 10.7	0.001
BMI (kg/m2)	23.7 ± 3.8	26.1 ± 2.5	0.001
Smoking (%)	23.9	28.7	0.276
Moderate alcohol (%)	20.4	16.9	0.376
Physically active (%)	47.8	25.7	0.001
Waist (cm)	84.1± 9.0	91.7 ± 6.1	0.001
SBP (mmHg)	127 ± 16	140 ± 15	0.001
DBP (mmHg)	78 ± 12	88 ± 10	0.001
Triglycerides (mg/dL)	109 ± 65	194 ± 85	0.001
HDL-cholesterol (mg/dL)	60 ± 13	51 ± 12	0.001
Fasting glucose (mg/dL)	92 ± 10	102 ± 22	0.001
Total energy intake (kcal)	1979 ± 550	1878 ± 535	0.067
Protein (%E)	14.0 ± 2.5	13.6 ± 2.4	0.065
Fat (%E)	25.2 ± 5.5	24.0 ± 5.3	0.034
Carbohydrate (%E)	54.0 ± 8.0	54.6 ± 8.6	0.458

Data are mean ± SD or %.
BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; HDL, high-density lipoprotein.

metabolic syndrome than those without. Among lifestyle factors, the proportion of subjects who were physically active was significantly higher in those without metabolic syndrome than those with.

Distributions of AHA-HDS

The AHA-HDS of all subjects ranged from 0 to 7; no participant had a full score for all 8 components. A high adherence rate (met ≥4 components) was seen in 32.4% of subjects with metabolic syndrome and 42.5% of subjects without metabolic syndrome (p=0.039) (Table 2). The total AHA-HDS tended to be lower in subjects with metabolic syndrome than in subjects without metabolic syndrome, but differences were not significant (3.01 ± 1.34 vs. 3.21 ± 1.43, respectively; p=0.150).

Table 2: Distribution of AHA-HDS scores

Number of Components	All subjects (n=508)	Without metabolic syndrome (n=372)	With metabolic syndrome (n=136)
0	11 (2.2%)	10 (2.7)	1 (0.7)
1	51 (10.0)	32 (8.6)	19 (14.0)
2	101 (19.9)	75 (20.2)	26 (19.1)
3	143 (28.1)	97 (26.1)	46 (33.8)
4	117 (23.6)	91 (24.5)	26 (19.1)
5	62 (12.2)	49 (13.2)	13 (9.6)
6	18 (3.5)	14 (3.8)	4 (2.9)
7	5 (1.0)	4 (1.1)	1 (0.7)
8	0 (0)	0 (0)	0 (0)

Data are n (%).
AHA-HDS, American Heart Association-recommended healthy diet score.

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Percentage of subjects meeting each component of the AHA-HD

With respect to the individual components of the AHA-HD recommendations, subjects were most likely to meet the ideal recommendations for saturated fatty acids, processed meat intake, and sugar-sweetened beverages, followed by fish intake and fruit and vegetable intake. Salt intake was least like to meet ideal guidelines, followed by fiber/carbohydrate ratio (representing high intakes of whole grain) (Table 3). Contrary to expectations, only sugar-sweetened beverage components were significantly lower in subjects with metabolic syndrome than in those without metabolic syndrome. Other components did not differ significantly between subjects with and without metabolic syndrome.

Table 3: Percentage of subjects meeting the different AHA-HD recommendations

	All subjects	Without metabolic syndrome	With metabolic syndrome	p[a]
Fruits and vegetables ≥400 g/day	46.3	47.3	43.4	0.433
Fish ≥2 times/week*	47.2	47.3	47.1	0.960
Fiber/carbohydrate ≥0.1	10.8	12.1	7.4	0.128
Salt <8 g/day	0.8	0.5	1.5	0.293
Sugar sweetened beverages <2 times/week	52.0	55.6	41.9	0.006
Processed meat <2 times/week	60.2	59.4	62.5	0.529
Legumes ≥4 times/week	35.0	36.8	30.1	0.163
Saturated fatty acid <7% of total energy	63.2	61.8	66.9	0.294

AHA-HDS, American Heart Association-recommended healthy diet score.

[a] P values indicate difference between subjects with and without metabolic syndrome.

* At least 1 oily fish.

Adherence to the AHA-HD and metabolic syndrome components

The prevalence of metabolic syndrome was significantly lower in subjects with high adherence to AHA-HD recommendations than in subjects with low adherence to AHA-HD recommendations. Among each component of metabolic syndrome, the prevalence of abdominal obesity, high triglycerides, and low HDL cholesterol levels were significantly lower in subjects with high adherence to the AHA-HD than in subjects with low adherence to the AHA-HD (Table 4).

Table 4: Metabolic syndrome component between low adherers and high adherers in AHA-HD

Components	Low adherence to AHA-HD (0-3 components)	High adherence to AHA-HD (4-8 components)	P
Metabolic syndrome	30.1%	21.8%	0.039
Abdominal obesity	35.9	25.3	0.013
High blood pressure	54.2	55.0	0.877
High triglycerides	38.2	29.2	0.036
Low HDL cholesterol	9.5	2.5	0.002
High fasting glucose	21.9	26.7	0.211

Data are expressed as %.

AHA-HDS, American Heart Association-recommended healthy diet score.

High adherence to AHA-HD and risk reduction for metabolic syndrome

High adherence to the AHA-HD was associated with a low prevalence of metabolic syndrome compared with low adherence (logistic regression analysis) (Table 5). After adjustment for age (Model 1) and for age, total energy intake, smoking habit, and alcohol drinking (Model 2), high adherence to AHA-HD was significantly associated with low prevalence of metabolic syndrome. However, this association was attenuated in the fully adjusted model, when physically active status was added as an adjustment factor (Model 3).

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Table 5: High adherence to AHA-HD and risk reduction for the metabolic syndrome by multivariable-adjusted logistic regression analysis

Model	Odds ratio	95% CI	p
Crude	0.65	0.43 – 0.98	0.040
Model 1	0.61	0.40 – 0.93	0.020
Model 2	0.64	0.42 – 0.97	0.038
Model 3	0.67	0.44 – 1.04	0.075

Model 1: adjusted for age (years).
Model 2: adjusted for age (years), total energy intake (kcal/day), smoking (yes, no), alcohol drinking (low, moderate, high).
Model 3: adjusted for model 2 components plus physically active (yes, no).
CI, confidence interval.

Discussion

To the best of our knowledge, this is the first study to report on the prevalence of adherence to the AHA-HD overall as well as each component of the AHA-HD in male Japanese workers. There are few studies in Asian countries that report the status of ideal cardiovascular health metrics [19-25]. However, there is no report that evaluates the association between healthy dietary patterns and metabolic syndrome. One strength of the present study is that we especially focused on adherence to the AHA-HD, along with individual dietary components. Notably, no subject in our study had a full score for the AHA-HDS (maximum 8 points) and only 1.0% of subjects had a score of 7 points. One of the reasons for this finding was that ideal salt intake was not likely to meet the definition used in our study population. It is difficult to achieve the original AHA-HD criteria (sodium <2300 mg per day) in Japan, due to the high consumption of miso soup, salty fish, and Japanese pickles, all of which contain high levels of sodium and are commonly eaten foods in Japan [26]. It was reported that the average salt intake in Japanese men is 11.0 g per day [27]. Considering that, in this study, we corrected the upward cutoff of salt intake (<8 g per day) according to the report of the Dietary Reference Intake for Japanese 2015 [16]. Nevertheless, only 0.8% of subjects met this cutoff value. Many components of the AHA-HD resemble a traditional Japanese diet: high intakes of fish, vegetables, and legumes, and low intakes of processed meat and sugar-sweetened beverages. In other words, persons who adhere to the AHA-HD might consume a healthy Japanese diet. However, the Japanese diet contains high salt intakes that are not seen in the AHA-HD. Similarly, the prevalence of high fiber/carbohydrate ratio, which represents a high intake of whole grains, was low in our study population. Two reasons for this finding are that (1) white rice is preferred in Japan compared to brown rice or other whole grain foods, and (2) white bread is also generally eaten in Japan. Therefore, it is reasonable that low prevalence of whole grain intake was seen in our data.

Adherence to this optimal diet was low in persons with metabolic syndrome. Several studies reported the prevalence of metabolic syndrome among various working populations, and these populations are often considered to have unhealthy eating habits [28]. Our results suggest that a healthy diet should be encouraged, especially in a working population. In addition, we found that an achievement of eating behaviors of ≥4 components of the AHA-HD was associated with a lower risk for metabolic syndrome.

This study has some limitations. First, among the AHA-HD components, we modified some cutoffs or assessment tools from the original AHA-HD definitions. For example, the cutoff of salt intake was amended to correct upwards (<8 g per day), as described in the Methods section. The BDHQ used in this study is not designed to evaluate the total amount of whole grains, and therefore, whole grain intake was transformed to the ratio of dietary fiber to carbohydrate (≥0.1 in this study). This definition comes from a report from the Harvard School of Public Health [13]. The Harvard researchers evaluated 545 grain products to find the best way to identify a healthful whole grain food: food that met the 10:1 ratio that tends to match unprocessed wheat [13]. The assessment for fruits and vegetables was also modified from the original AHA-HD definition (≥4.5 servings per day) to the surrogate definition (≥400 g per day), because use of serving units for fruits and vegetables is not common in Japan. Second, the lack of a randomly selected sample could lead to selection bias. Additional investigations including subjects with a wider range of occupations are needed. Third, education level, family income of participants, job stress, and the presence of shift work might contribute to adherence to a healthy diet, but we did not have such information. Finally, as a cross-sectional study, the present results cannot prove a causal relationship between the AHA-HD adherence and the risk reduction for metabolic syndrome. In addition, the independent effect of high adherence to AHA-HD was attenuated by the fully adjusted model (by adding physical activity as a confounding factor). Although it is commonly said that both physical activity and healthy dietary habits may contribute to a lower risk for metabolic syndrome [29], it is controversial whether physical activity or a healthier diet is more closely related to risk reduction of metabolic syndrome.

Despite these limitations, the main strength of our study was that we collected detailed data on dietary intakes and we could apply all 8 components of the AHA-HD. In recent decades, Japan has been replacing the traditional Japanese diet with an American-style diet or with other less healthy eating habits. This study adds new information regarding the lack of ideal healthy dietary status in contemporary Japan, and in particular, male workers.

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In conclusion, the prevalence of metabolic syndrome was significantly lower in subjects with high adherence to AHA-HD (met ≥4 components) than in those with low adherence (21.8% vs. 30.1%, respectively). High adherence to the AHA-HD was significantly associated with a low prevalence of metabolic syndrome (OR, 0.64; 95%CI, 0.42-0.97; p=0.038) after adjustment for age, total energy intake, smoking habit, and alcohol drinking. Improvement of adherence to the AHA-HD may be an effective approach to promoting better health and reducing the risk for metabolic syndrome.

Declarations

a. Conflicts of interest: There is no conflict of interest to disclose.

b. Ethical Approval: This study was approved by the Institutional Review Board of Kio University.

c. Clinical trial registration: This was an observational study. Written informed consent was obtained from each participant.

Data availability statement

The datasets analyzed during the current study are available from the corresponding author upon reasonable request.

Authors' contributions

Masao Kanauchi conceived the study design, carried out data collection, analyzed the data, and drafted the paper. Kimiko Kanauchi helped with data collection and drafting the paper. All authors read and approved the final version of the paper.

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