Evaluating the diet quality of elderly Japanese people using the Healthy Eating Index-2020

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ABSTRACT

Background and Objectives: Globally, efforts are underway to evaluate foods and meals by their nutritional value. In Japan, however, there is no comprehensive system for evaluating overall diet quality. The aim of this study is to use the Healthy Earing Index (HEI)-2020, which is based on the American Dietary Guidelines, to evaluate the diet quality of independent elderly Japanese people to consider appropriate methods for evaluating the Japanese diet. **Methods and Study Design:** The subjects were 71 individuals aged 60 years or older who participated in a health examination. HEI-2020 was used to evaluate diet quality, with 13 components scored based on intake per energy unit. Associations of HEI-2020 scores with nutrient intake, food group intake, and dietary reference intakes (DRIs) for Japanese were analysed using statistical methods. **Results:** The median HEI-2020 score was 52/100 points. Among the components, the median score was the maximum for Saturated Fats and Added Sugars, but zero for Whole Grains and Refined Grains. The high-score group had significantly lower intake of saturated fatty acids and higher intake of dietary fiber, vitamin K, potassium, and magnesium. In comparison to DRIs, the high-score group had a significantly higher "% meeting the reference value" for several nutrients, including dietary fiber, magnesium, and potassium. **Conclusions:** This study shows that the HEI-2020 can identify nutrients such as dietary fiber and minerals that are lacking in the Japanese population. However, for more effective assessment, there is a need to adjust the reference values to match the intake of Japanese people.

Key Words: non-communicable diseases, diet quality, dietary evaluation, dietary reference intakes, nutrient profiling system

INTRODUCTION

The number of deaths due to non-communicable diseases such as cardiovascular diseases and cancer is increasing worldwide, and now accounts for nearly three-quarters of all deaths globally.[1-3] Suboptimal diets are a preventable risk factor for these diseases, particularly excessive intake of sodium and insufficient intake of whole grains.[2] Globally, initiatives are being implemented to evaluate food and beverages based on their nutritional quality to promote selection of healthier foods for public health dietary goals.[4-7] This approach is referred to as a nutrient profiling system, in which favorable or unfavorable nutrients are defined and diets and foods are classified and scored based on their content.[8] In Japan, a nutrient profiling system for processed foods and dishes has been developed,[9,10] but there is no government endorsed system to evaluate the overall diet quality among the Japanese. Modern Japanese meals are based on the principle of "one soup and three dishes," consisting of rice as the staple food, combined with a variety of side dishes such as fish, meat, vegetables, and legumes.[11] In Japan, the Japanese food guide spinning top has been in use since 2005,[12] and a previous study reported that its adherence was related to lower mortality among middle-aged Japanese. However, the adequate amount of salt and fat intakes were not shown in this dish-based guide.[13] Therefore, there is a need to evaluate the overall diet based on this variety of foods and nutrition in Japan.

The Healthy Eating Index (HEI)-2020 developed using the Dietary Guidelines for Americans is already used for evaluation of overall diet quality.[14-16] This assessment method evaluates the overall diet based on foods and nutrients, and results have already been published for people in various countries, allowing for international comparisons.[17-19] This index has also been shown to be associated with a reduced risk of non-communicable diseases,[20] and thus, using HEI-2020 to evaluate the diet of Japanese people may be useful to promote healthy eating. However, the Japanese diet is characterized by a lower meat intake and a higher intake of fish and sugar-free beverages compared to the American diet.[21,22] In addition, Japan has a lower obesity rate than the United States, and given the differences in food culture and public health issues between the United States and Japan, the utility of HEI-2020 needs to be examined for Japanese diets.[2,22,23] Thus, in this study, HEI-2020 was used to evaluate the diet quality of independent elderly people who do not require care. Such people are likely to consume a healthy diet, and thus, the purpose of the study was to examine use of HEI-2020 scores for evaluating Japanese diets and the associations of these scores with dietary reference intakes (DRIs) for Japanese people.

MATERIALS AND METHODS

Research participants

The subjects were 81 males and females aged 60 and over living independently in Kanazawa City, Ishikawa Prefecture, and its suburbs who participated in a municipal health examination in May 2019. Of these people, 71 (22 males, 49 females) were included in the analysis, after excluding 4 without physical measurements and 6 who did not complete a 2-day dietary survey.

This study was approved by the Ethics Committee of the Graduate School of Human Life Science, Osaka City University (Approval No.: 15-02, April 15, 2015; Approval No.: 16-05, May 11, 2016; Approval No.: 2024-54, October 16, 2024). All participants provided written informed consent prior to their inclusion in the study.

Health examination and dietary survey

The health examination included a medical examination by a doctor and measurements of height and weight. For the dietary survey, a weighing record method was used. Subjects were given a survey form (including instructions on how to fill it out) in advance to record their dietary intake for two days, regardless of whether these were weekdays or holidays, and consecutive or non-consecutive. To improve the accuracy of the records, interviews were conducted on the day of the health examination to check for omissions or misunderstandings, using standard food models and standard pictorial tools from the National Health and Nutrition Survey.[24]

The dietary survey data obtained were aggregated using the nutritional calculation software "Shokuji Shirabe" (National Institute of Health and Nutrition).[25] This software includes foods listed in the Standard Tables of Food Composition in Japan (seventh revised version) and also includes seasonings and processed foods not listed in these tables.[25] By entering cooking codes, the software can also account for changes in nutrient content due to cooking, allowing for more accurate determination of nutrient intake. The habitual intake distribution of energy and nutrients for each subject was estimated using the "Program for Estimating Habitual Intake Distribution from Dietary Surveys ver.1.2" (National Institute of Public Health), approximating a normal distribution using the best power method, and estimating the mean and distribution (25th, 50th, 75th percentiles).26 The average of the 2-day survey data was used as the intake for each food group for each subject. Use of dietary supplements was also recorded and adjusted for in the analyses.

Diet quality evaluation using Healthy Eating Index-2020

The diet of the subjects was evaluated using HEI-2020, which was developed based on the Dietary Guidelines for Americans.[14-16] The HEI-2020 evaluates 13 food and nutrient components, with each receiving a maximum of 5 or 10 points. Intakes between the minimum and maximum standards are scored proportionately. The total HEI-2020 score is the sum of the adequacy components and moderation components. There are nine adequacy components (foods that promote good health): Total Fruits (maximum 5 points), Whole Fruits (5), Total Vegetables (5), Greens and Beans (5), Whole Grains (10), Dairy (10), Total Protein Foods (5), Seafood and Plant Proteins (5), and Fatty Acids (ratio of unsaturated to saturated fatty acids, 10); and four moderation components (foods to limit for good health): Refined Grains (10), Sodium (10), Added Sugars (10), and Saturated Fats (10). Since there is no database for added sugars in Japan, an original database was created based on the method proposed by Fujiwara et al.[27]

The HEI-2020 scoring system is based on a cup or ounce equivalents of foods, but there is no definition of these equivalents for foods in Japan. Therefore, based on the Food Patterns Equivalents Database (FPED) and previous studies, 1 cup was defined as 236.59 g and 1 ounce as 28.35 g.[28,29] Nutrient and food group intakes for each component were 2-day averages. Except for Fatty Acids, each component score was calculated using the amount per 1000 kcal of energy and the % energy (for Added Sugars and Saturated Fats).

Evaluation using DRIs

To examine the association between HEI-2020 scores and nutrient insufficiency, estimated habitual nutrient intakes were compared with reference values for each age group and gender in the DRIs.[30] The nutrients for analysis were in accordance with previous studies,[29,31] and since the dietary survey was conducted in 2019, the 2015 edition of the DRIs was used, with the estimated average requirement (EAR) or tentative dietary goal for preventing lifestyle-related diseases (DG) as the reference values. The Adequate Intake (AI) was used for nutrients without EAR. For nutrients for which EAR or AI was established, the percentage of subjects whose intake exceeded these thresholds was calculated; for nutrients with a DG, the percentage of subjects with nutrient intake as a percentage of energy intake within the DG range was calculated as the "% meeting the reference value". For dietary fiber and potassium, the percentage of subjects with intake above the DG was evaluated, while for salt equivalent, the percentage with intake below the DG was determined. No subjects had nutrient intakes above the tolerable upper intake level (UL), so this was not taken into account in the study.

Data analysis

Statistical analysis was performed using SPSS Statistics 27 (IBM Japan, Tokyo). Subjects were first grouped by sex based on their HEI-2020 scores. Those with HEI-2020 scores above the median for each sex were classified as the high group, and those below the median as the low group. Differences in nutrient intakes and intakes by food groups between the high and low HEI-2020 score groups were evaluated by Mann-Whitney U test. The % meeting the reference value of nutrients based on the DRIs in the two groups was compared by chi-square test. A two-tailed $p < 0.05$ was considered to indicate a significant difference.

RESULTS

HEI-2020 evaluation

The HEI-2020 component scores and total scores by sex are shown in Table 1. The median total score for the total group was 52 points, with 39 subjects in the high group and 32 in the low group. The median score was 52 points for males, with 13 in the high group and 9 in the low group; and 53 points for females, with 26 in the high group and 23 in the low group. The overall median scores for Seafood and Plant Proteins, Added Sugars, and Saturated Fats were the highest, while those for Whole Grains and Refined Grains were the lowest.

Basic characteristics of the subjects

Age, height, weight, and body mass index (BMI) of each group by sex are shown in Table 1. The high group was significantly older for the total group and among females. There were no significant differences in height, weight, or BMI between the high and low groups. In all groups, the median BMI was within the target BMI range (21.5-24.9 kg/m^2) established by the DRIs.[32]

Association between HEI-2020 scores and nutrient intake

The distribution of habitual nutrient intake for each group by sex is shown in Table 2. The high group had significantly lower intake of saturated fatty acids and significantly higher intake of total dietary fiber, vitamin K, potassium and magnesium. There were no significant differences in intake of other nutrients between the two groups. Among males, the high group had significantly lower intake of total fat, saturated fatty acids, and salt equivalent, compared to the low group. Among females, the high group had significantly higher intake of total dietary fiber, vitamin K, vitamin C, potassium, and magnesium, compared to the low group.

Associations of HEI-2020 scores with intake by food groups

Intake by food groups for each group by sex is shown in Table 3. The high group had significantly higher intake of legumes, green and yellow vegetables, fresh fruits, and fresh seafood, and significantly lower intake of meat, and oils and fats. Among males, the high group had significantly higher intake of green and yellow vegetables, and significantly lower intake of meat and seasonings. Among females, the high group had significantly higher intake of legumes and fresh fruits.

Associations of HEI-2020 scores with % meeting the reference value of DRIs

Comparison of HEI-2020 scores with DRIs for each group by sex is shown in Figure 1. In the high group, the % meeting the reference value was significantly higher for saturated fatty acids, total dietary fiber, salt equivalent, potassium, vitamin B-1, magnesium, vitamin E, and vitamin K, and tended to be higher for all nutrients. The % meeting the reference value in the high group was significantly higher for saturated fatty acids, salt equivalent, vitamin K, and potassium among males; and for protein, saturated fatty acids, carbohydrates, total dietary fiber, potassium, vitamin B-1, vitamin B-2, vitamin C, magnesium, vitamin D, vitamin E, and vitamin K among females.

DISCUSSION

In this study, the dietary quality of independent elderly individuals in Japan was evaluated using HEI-2020, and associations of HEI-2020 scores with nutrient intake, food group intake, and DRIs were examined. According to the 2023 National Health and Nutrition Survey, Japan, adults aged 60 years and older have a balanced diet with sufficient vegetable intake, compared to younger age groups. Therefore, we considered it is important to further evaluate their diet thoroughly.[33] The study validated HEI-2020 for dietary quality evaluation for elderly Japanese people. Associations with DRIs showed that persons with high HEI-2020 scores had significantly higher % meeting the reference value of saturated fatty acids, total dietary fiber, salt equivalent, potassium, vitamin B-1, magnesium, vitamin E, and vitamin K compared to those with low HEI-2020 scores. Excessive intake of salt equivalents and insufficient dietary fiber intake are associated with incidence of noncommunicable diseases or mortality; in addition, potassium and magnesium supplementation are associated with improved risk of developing metabolic syndrome.[34-38] In this study, these nutrient intakes were identified even among relatively healthy elderly subjects. Therefore, the HEI-2020, which evaluates diet quality based on the American diet, may be useful for objective evaluation of diet quality, at least among elderly Japanese individuals.

Our results also suggest that it is possible to identify diet quality by comparing HEI-2020 scores with nutrient intakes and intakes by food group. Intake of vegetables and fruits is a concern as a risk factor for non-communicable diseases among Japanese people,[39,40] and in the current study, there were significant differences in intake of legumes, green and yellow vegetables, fresh fruits, fresh seafood, meat, and oils and fats between subjects with high and low HEI-2020 scores. Since legumes, green and yellow vegetables, fresh fruits, and fresh seafood are components of HEI-2020, and HEI-2020 also includes components related to

Fatty Acids and Saturated Fats, it was inferred that these intakes were reflected in the scores. These foods are rich in saturated fatty acids, dietary fiber, vitamins, and minerals,[25] and thus, differences in food intake led to significant differences in nutrient intake.

We also found a need to review reference values and add components in using HEI-2020 scores for Japanese people. The median HEI-2020 total scores in this study were slightly higher than the average scores from a previous study using 4-d non-consecutive dietary records, in Japanese adults aged 30–76 years.[23] Additionally, the interquartile range of HEI-2020 scores in this study was smaller than when assessing the American diet, and therefore less variability.[41,42] As shown in Table 1, the highest scoring components of Added Sugars and Saturated Fats, and the higher scores compared to the American scores, indicate that the Japanese diet is lower in sugar and saturated fatty acids compared to the American diet.[33,41,43,44] The lowest scoring components were Whole Grains and Refined Grains, with most subjects scoring zero points. These results reflect the diets of Japanese people, who consume low amounts of whole grains and refined rice as their staple food. The median saturated fatty acids intake per energy in Japan is approximately 8%, and the DG is set at 7% or less. In HEI-2020, the Saturated Fats component is given a maximum score for less than 8% saturated fatty acids per energy intake. Therefore, it was necessary to adjust the standard value for Saturated Fats given the intake of Japanese people. Likewise, since insufficient intake of whole grains is a major risk factor for non-communicable diseases,[2] it was also necessary to adjust the reference values. Regarding salt equivalent, which is a priority issue for Japanese people,[33.39,40] it was not possible to identify differences in intake, but such differences may be identifiable by increasing the total percentage Sodium scores. Improvements to these components would result in more appropriate scores for the Japanese diet.

We did not find an association of HEI-2020 scores with intake or DRIs of vitamin D and calcium, which are nutrients of concern for deficiency among Japanese people. Moreover, among males, those with lower HEI-2020 scores had higher intakes of protein and vitamin C. This may partly be due to the fact that the Seafood and Plant Proteins component, a source of vitamin D and calcium for Japanese people,[33] given a maximum score at the median for all groups, and that among male, the intake of meat and fruits tended to be higher in the lower group compared to the higher group. Thus, it may be important to adjust the Seafood and Plant Proteins criteria of the HEI-2020 and modify the distribution of scores for protein foods and fruits to improve the dietary quality evaluation such that it better reflects public nutrition in Japan.

There are several limitations in this study. First, the number of subjects is limited, the proportion of females was high, and the participants were recruited from a single region. These factors may have introduced bias into the overall results and limited the generalizability of the findings. In addition, although habitual intake was adjusted for within-person variability using the Best-Power method, seasonal variation was not considered because all dietary data were collected in May. Furthermore, although physical activity data were collected, they were not incorporated into the evaluation of nutrient intake, which represents another limitation of this study. Since the participants were independent elderly Japanese individuals, the findings cannot be generalized to the entire Japanese population, but may at least be applicable to this subgroup. However, all dietary surveys were carefully conducted by licensed dietitians, ensuring highly reliable dietary records. Moreover, this study is the first to evaluate the dietary quality of independent elderly Japanese individuals with relatively healthy diets using the HEI-2020. The results indicate that a diet with high HEI-2020 scores suggests that traditional Japanese diet, which include rice, legumes, green and yellow vegetables, fruits, and seafood while limiting meat and fats, are beneficial. In the future, by adding a system that calculates HEI-2020 alongside nutritional calculations of diets, there is potential to easily evaluate dietary quality. Future research will be needed to examine whether these findings can also be extended to younger generations. In addition, studies with larger, more demographically and geographically diverse populations will be important to confirm and extend our findings.

Conclusion

The HEI-2020, which is based on the American diet, can be useful for the objective assessment of diet quality, at least among elderly Japanese individuals. However, there is a need to change certain reference values and add items that take into account the dietary habits and nutrient deficiencies of Japanese people.

CONFLICT OF INTEREST AND FUNDING DISCLOSURE

HA declares that she is employed by NISSIN FOODS HOLDINGS CO., LTD. and has no competing interests. The other authors declare that they have no competing interests.

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Table 1. HEI-2020 score per day and basic characteristics of subjects

	Total			Males			Females		
	Total (n=71)	High (n=39)	Low (n=32)	Total (n=22)	High (n=13)	Low (n=9)	Total (n=49)	High (n=26)	Low (n=23)
Total (Maximum 100)	52.0 (56.0-47.0)	56.0 (54.0-59.0)	46.0 (43.0-49.0)	52.0 (45.0-55.0)	54.0 (52-58.0)	45.0 (40.5-46.5)	53.0 (48.0-56.0)	56.0 (54.0-59.0)	48.0 (43.0-50.0)
Total Fruits (5)	2.0 (1.0-2.0)	2.0 (1.0-3.0)	2.0 (1.0-2.0)	1.0 (1.0-2.0)	1.0 (1.0-2.0)	2.0 (1.0-2.0)	2.0 (1.0-3.0)	2.5 (2.0-3.0)	1.0 (1.0-2.0)
Whole Fruits (5)	3.0 (2.0-4.0)	4.0 (2.0-5.0)	3.0 (1.3-3.0)	2.0 (2.0-3.0)	2.0 (2.0-2.5)	3.0 (1.5-3.5)	3.0 (2.0-5.0)	4.0 (3.0-5.0)	2.0 (0.0-3.0)
Total Vegetables (5)	3.0 (2.0-4.0)	3.0 (2.0-4.0)	2.0 (2.0-3.0)	2.0 (1.8-3.0)	3.0 (2.0-3.5)	2.0 (1.0-2.0)	3.0 (2.0-4.0)	3.0 (2.8-4.0)	2.0 (2.0-3.0)
Greens and Beans (5)	5.0 (4.0-5.0)	5.0 (5.0-5.0)	5.0 (3.0-5.0)	4.5 (3.0-5.0)	5.0 (3.0-5.0)	4.0 (2.0-5.0)	5.0 (4.5-5.0)	5.0 (5.0-5.0)	5.0 (3.0-5.0)
Whole Grains (10)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)
Dairy (10)	2.0 (1.0-5.0)	3.0 (2.0-5.0)	2.0 (1.0-4.0)	2.0 (1.0-3.3)	2.0 (1.0-4.5)	2.0 (1.0-2.5)	2.0 (1.0-5.0)	3.0 (2.0-5.0)	2.0 (1.0-5.0)
Total Protein Foods (5)	4.0 (3.0-5.0)	5.0 (4.0-5.0)	3.0 (2.3-5.0)	3.5 (3.0-5.0)	5.0 (3.0-5.0)	3.0 (1.5-3.5)	5.0 (3.0-5.0)	5.0 (4.0-5.0)	4.0 (3.0-5.0)
Seafood and Plant Proteins (5)	5.0 (5.0-5.0)	5.0 (5.0-5.0)	5.0 (5.0-5.0)	5.0 (5.0-5.0)	5.0 (5.0-5.0)	5.0 (5.0-5.0)	5.0 (5.0-5.0)	5.0 (5.0-5.0)	5.0 (5.0-5.0)
Fatty Acids (10)	6.0 (4.0-8.0)	7.0 (4.0-10.0)	5.0 (3.0-7.0)	7.0 (4.0-8.5)	8.0 (4.0-10.0)	8.0 (3.5-7.0)	5.0 (4.0-7.5)	6.5 (4.0-9.3)	4.0 (2.0-6.0)
Refined Grains (10)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)
Sodium (10)	2.0 (0.0-5.0)	3.0 (0.0-6.0)	0.0 (0.0-3.0)	3.0 (0.0-6.0)	5.0 (3.0-10.0)	0.0 (0.0-1.5)	2.0 (0.0-5.0)	2.0 (0.0-6.0)	1.0 (0.0-3.0)
Added Sugars (10)	10.0 (9.0-10.0)	10.0 (9.0-10.0)	10.0 (8.0-10.0)	10.0 (9.0-10.0)	10.0 (9.0-10.0)	10.0 (7.5-10.0)	10.0 (9.0-10.0)	10.0 (9.8-10.0)	10.0 (8.0-10.0)
Saturated Fats (10)	10.0 (9.0-10.0)	10.0 (10.0-10.0)	9.5 (7.3-10.0)	10.0 (10.0-10.0)	10.0 (10.0-10.0)	10.0 (8.7-10.0)	10.0 (8.0-10.0)	10.0 (9.0-10.0)	9.0 (7.0-10.0)
Basic characteristics									
Age (years old)	76.0 (72.0-79.0)	77.0 (75.0-80.0)	74.5 (70.3-78.0)	76.5 (73.0-79.8)	77.0 (75.5-80.5)	76.0 (72.5-80.5)	76.0 (72.0-78.0)	77.0 (73.5-80.8)	74.0 (70.0-77.0)
Height (cm)	154.4 (150.0-161.1)	154.9 (149.1-161.6)	154.2 (151.2-160.9)	164.6 (161.1-169.8)	163.2 (159.5-170.2)	167.0 (161.5-169.5)	151.8 (149.0-154.7)	150.4 (148.6-155.4)	151.9 (150.0-154.5)
Weight (kg)	52.5 (46.5-62.0)	53.5 (46.5-61.0)	52.0 (48.5-63.4)	62.5 (58.0-72.9)	61.0 (57.5-67.8)	66.0 (54.8-74.5)	50.5 (45.5-56.0)	47.8 (45.3-54.0)	51.0 (45.5-56.5)
Body mass index (kg/m^2)	22.1 (20.3-24.7)	22.0 (20.1-24.7)	22.2 (20.5-24.6)	24.5 (21.2-25.7)	22.6 (20.8-26.0)	24.7 (20.3-25.8)	21.5 (20.2-23.9)	21.5 (19.8-23.9)	21.6 (20.3-24.1)

The high group was defined as above the median of each gender HEI-2020 score (52 for males and 53 for females) and the low group was defined as below the median. Values represent the median for each HEI component and total score for each group, as well as the basic characteristics of the subjects, with the interquartile ranges shown in parentheses.

Table 2. Association between HEI-2020 scores and nutrient intake per day[†]

	Total (n=71)		Males (n=22)		Females (n=49)	
	Median (interquartile range)	*p* (High vs Low)	Median (interquartile range)	*p* (High vs Low)	Median (interquartile range)	*p* (High vs Low)
Energy (kcal/day)		0.936		0.262		0.749
Total	1,744 (1,450-1,982)		1,800 (1,679-1,957)		1,674 (1,395-1,921)	
High	1,752 (1,468-1,937)		1,852 (1,727-2,235)		1,688 (1,382-1,918)	
Low	1,729 (1,449-2,054)		2,014 (1,710-2,375)		1,706 (1,322-1,936)	
Protein (g/day)		0.288		0.896		0.149
Total	64.8 (56.5-78.8)		65.8 (59.2-82.0)		64.2 (52.9-75.4)	
High	67.7 (55.8-80.7)		66.5 (58.6-80.9)		69.0 (53.3-80.2)	
Low	61.1 (56.7-71.4)		64.0 (58.7-88.6)		59.7 (52.1-67.4)	
Total fat (g/day)		0.196		0.011*		0.548
Total	51.2 (39.0-60.4)		51.5 (40.9-59.8)		48.4 (38.4-60.8)	
High	48.2 (39.0-55.5)		49.7 (38.7-53.4)		47.6 (38.8-57.9)	
Low	54.0 (39.0-66.3)		58.1 (42.1-72.0)		53.9 (38.2-65.0)	
Saturated fatty acids (g/day)		0.008**		0.025*		0.100
Total	14.04 (11.33-18.53)		13.97 (12.27-17.85)		14.45 (11.07-18.65)	
High	12.68 (11.20-14.96)		13.25 (11.22-14.18)		12.31 (11.02-16.62)	
Low	16.14 (12.77-19.46)		17.63 (13.38-19.90)		16.06 (10.95-19.25)	
Carbohydrates (g/day)		0.343		0.471		0.118
Total	235.4 (205.0-280.4)		258.5 (215.1-306.4)		221.1 (194.0-273.0)	
High	241.8 (209.0-282.3)		243.6 (208.9-287.5)		232.7 (208.5-282.7)	
Low	221.9 (194.3-274.1)		268.5 (219.5-352.3)		215.7 (176.6-253.4)	
Added sugars (g/day)[‡]		0.133		0.324		0.253
Total	21.4 (16.0-33.6)		21.8 (15.9-32.0)		21.4 (16.1-33.8)	
High	20.9 (16.0-28.9)		19.8 (13.7-29.4)		20.9 (16.8-28.5)	
Low	26.1 (16.0-45.3)		22.6 (16.5-63.0)		27.5 (16.0-41.5)	
Total dietary fiber (g/day)		0.003**		0.110		0.011*
Total	14.5 (11.4-16.7)		14.0 (11.3-16.0)		14.7 (11.5-17.6)	
High	16.0 (13.1-18.7)		15.1 (12.4-17.2)		16.6 (13.0-18.9)	
Low	12.5 (10.9-15.4)		12.3 (11.1-14.0)		13.3 (10.5-15.8)	
Vitamin A (μgRAE/day)		0.386		0.744		0.336
Total	430 (320-620)		380 (290-580)		440 (320-700)	
High	440 (320-660)		380 (330-560)		460 (310-780)	
Low	420 (290-560)		380 (250-600)		430 (320-510)	

[†]The high group was defined as above the median of each gender HEI-2020 score (52 for males and 53 for females) and the low group was defined as below the median. Values represent the median intake of nutrients for each group, with the interquartile ranges shown in parentheses.

[‡]Average of 2 day

p values were calculated using the Mann-Whitney U test

*$p < 0.05$, **$p < 0.01$

Table 2. Association between HEI-2020 scores and nutrient intake per day† (cont.)

	Total (n=71)		Males (n=22)		Females (n=49)	
	Median (interquartile range)	*p* (High vs Low)	Median (interquartile range)	*p* (High vs Low)	Median (interquartile range)	*p* (High vs Low)
Vitamin D (µg/day)		0.514		0.393		0.167
Total	7.6 (3.5-13.6)		7.5 (3.0-13.6)		7.7 (3.6-13.7)	
High	8.0 (3.8-14.3)		7.0 (2.8-11.5)		8.8 (4.1-14.8)	
Low	6.7 (2.7-13.4)		7.6 (4.0-15.0)		5.5 (2.7-12.2)	
Vitamin E (mg/day)		0.089		0.647		0.096
Total	6.8 (5.0-8.6)		6.7 (4.3-8.2)		6.8 (5.1-8.9)	
High	7.2 (5.8-8.7)		7.0 (5.3-8.2)		7.4 (5.7-9.2)	
Low	5.9 (4.1-8.2)		5.4 (3.7-8.4)		5.9 (4.6-8.3)	
Vitamin K (µg/day)		0.009**		0.110		0.045*
Total	190 (110-310)		160 (100-270)		200 (120-310)	
High	210 (160-320)		210 (130-310)		210 (170-370)	
Low	150 (92-250)		110 (69-210)		170 (110-270)	
Vitamin B-1 (mg/day)		0.282		0.324		0.062
Total	0.85 (0.67-1.09)		0.88 (0.69-1.19)		0.83 (0.66-1.05)	
High	0.91 (0.72-1.07)		0.87 (0.62-1.04)		0.93 (0.72-1.08)	
Low	0.78 (0.65-1.10)		0.88 (0.75-1.39)		0.76 (0.60-0.89)	
Vitamin B-2 (mg/day)		0.686		0.096		0.114
Total	1.29 (0.95-1.65)		1.38 (0.98-1.68)		1.24 (0.92-1.65)	
High	1.32 (0.96-1.62)		1.30 (0.86-1.58)		1.37 (1.03-1.71)	
Low	1.18 (0.93-1.85)		1.65 (1.08-2.56)		1.10 (0.80-1.55)	
Vitamin C (mg/day)		0.548		0.082		0.037*
Total	100 (68-150)		88 (71-140)		110 (63-150)	
High	110 (73-150)		80 (69-100)		130 (85-160)	
Low	100 (57-140)		140 (75-230)		97 (48-130)	
Equivalent salt content (g/day)		0.087		0.001**		0.873
Total	8.4 (6.5-10.6)		9.5 (6.8-11.2)		8.2 (6.4-10.1)	
High	7.6 (6.1-10.0)		6.8 (5.9-9.5)		8.1 (6.0-10.5)	
Low	9.4 (6.9-10.9)		11.1 (10.7-12.1)		8.2 (6.7-10.2)	
Potassium (mg/day)		0.007**		0.431		0.008**
Total	2,500 (1,900-3,000)		2,400 (2,000-2,900)		2,500 (1,900-3,200)	
High	2,800 (2,100-3,300)		2,500 (2,000-3,200)		2,800 (2,300-3,400)	
Low	2,200 (1,800-2,700)		2,300 (2,000-2,700)		2,100 (1,700-2,600)	
Calcium (mg/day)		0.159		0.896		0.161
Total	530 (380-680)		530 (350-620)		550 (380-700)	
High	590 (430-680)		530 (350-680)		610 (430-730)	
Low	490 (360-610)		520 (340-590)		450 (360-660)	
Magnesium (mg/day)		0.013*		0.845		0.009**
Total	260 (200-300)		260 (210-300)		260 (200-310)	

High	280 (220-320)		260 (210-300)		290 (220-330)	
Low	220 (190-280)		260 (200-290)		220 (190-270)	
Iron (mg/day)		0.155		1.000		0.133
Total	7.4 (5.9-9.1)		7.6 (5.9-9.3)		7.4 (5.9-9.1)	
High	7.8 (6.4-9.5)		8.1 (5.9-8.7)		7.8 (6.6-9.7)	
Low	7.2 (5.7-8.2)		7.3 (6.1-9.3)		7.2 (5.3-8.2)	

†The high group was defined as above the median of each gender HEI-2020 score (52 for males and 53 for females) and the low group was defined as below the median. Values represent the median intake of nutrients for each group, with the interquartile ranges shown in parentheses.
‡Average of 2 day
p values were calculated using the Mann-Whitney U test
*$p < 0.05$, **$p < 0.01$

Table 3. Associations of HEI-2020 scores with intake by food groups per day†

	Total (n=71)		Males (n=22)		Females (n=49)	
	Median (interquartile range)	*p* (High vs Low)	Median (interquartile range)	*p* (High vs Low)	Median (interquartile range)	*p* (High vs Low)
Rice (g/day)		0.053		0.512		0.052
Total	220.0 (160.0-300.0)		281.3 (200.0-379.0)		207.5 (141.3-275.3)	
High	225.0 (190.0-340.0)		320.0 (200.0-381.0)		222.5 (181.1-300.0)	
Low	206.3 (123.6-283.1)		270.0 (172.5-350.0)		175.0 (110.0-225.0)	
Other grains (g/day)		0.083		0.647		0.073
Total	110.0 (60.0-185.0)		97.7 (54.4-228.5)		117.0 (61.0-180.1)	
High	90.0 (45.0-165.0)		85.3 (31.8-275.0)		99.5 (47.5-155.6)	
Low	137.4 (78.8-210.1)		133.0 (69.0-222.1)		139.7 (82.5-203.0)	
Potatoes (g/day)		0.724		0.695		0.904
Total	27.0 (4.5-69.0)		51.5 (9.4-87.7)		25.8 (3.9-63.3)	
High	27.5 (7.5-65.9)		25.1 (8.8-96.3)		27.9 (6.1-62.9)	
Low	26.4 (3.6-79.6)		56.6 (6.8-88.0)		25.1 (3.3-66.8)	
Sugar and sweeteners (g/day)		0.607		0.556		0.351
Total	5.6 (1.5-10.1)		4.7 (1.3-10.7)		6.2 (1.4-9.7)	
High	3.8 (1.0-10.4)		3.8 (1.8-11.2)		3.7 (1.0-10.1)	
Low	6.5 (2.3-9.2)		5.6 (0.8-9.2)		6.8 (3.0-9.4)	
Legumes (g/day)		0.007**		0.471		0.007**
Total	50.0 (18.8-75.0)		50.0 (13.8-71.7)		45.0 (25.0-96.3)	
High	60.0 (35.0-90.0)		60.0 (21.5-72.2)		61.5 (33.8-116.0)	
Low	28.4 (8.5-50.0)		27.5 (12.5-70.6)		29.2 (5.0-50.0)	
Nuts and seeds (g/day)		0.649		0.512		0.279
Total	0.8 (0.0-4.0)		1.6 (0.0-5.0)		0.6 (0.0-3.5)	
High	0.8 (0.0-6.0)		1.5 (0.0-7.3)		0.0 (0.0-2.6)	
Low	1.5 (0.0-3.0)		1.8 (0.0-2.8)		1.5 (0.0-4.0)	
Green and yellow vegetables (g/day)		0.021*		0.036*		0.214
Total	123.5 (73.7-192.0)		102.2 (45.6-198.4)		124.7 (82.0-181.6)	
High	140.0 (83.8-239.4)		159.7 (74.2-239.7)		139.3 (83.8-204.9)	
Low	95.8 (47.6-152.9)		54.5 (38.1-121.5)		98.4 (71.6-168.6)	
Other vegetables (g/day)		0.132		0.948		0.078
Total	123.7 (68.1-172.8)		99.8 (58.4-163.9)		125.8 (80.7-185.7)	
High	130.0 (79.4-205.0)		113.2 (57.8-164.3)		135.3 (88.0-220.6)	
Low	115.0 (59.7-149.1)		86.4 (46.1-161.7)		123.7 (60.2-149.4)	

†The high group was defined as above the median of each gender HEI-2020 score (52 for males and 53 for females) and the low group was defined as below the median.
Values represent the median of the intake by food group for each group averaged over 2-days, with the interquartile ranges shown in parentheses.
p values were calculated using the Mann-Whitney U test.
*p < 0.05, **p < 0.01,

Table 3. Association between HEI-2020 scores and nutrient intake per day† (cont.)

	Total (n=71)		Males (n=22)		Females (n=49)	
	Median (interquartile range)	*p* (High vs Low)	Median (interquartile range)	*p* (High vs Low)	Median (interquartile range)	*p* (High vs Low)
Pickles (g/day)		0.628		0.096		0.582
Total	4.0 (0.0-15.0)		3.1 (0.0-14.0)		4.0 (0.0-15.4)	
High	3.0 (0.0-15.0)		0.0 (0.0-10.0)		4.0 (0.0-19.2)	
Low	5.0 (0.0-16.4)		10.0 (1.1-28.8)		3.5 (0.0-10.0)	
Fresh fruits (g/day)		0.008**		0.357		<0.001**
Total	113.8 (60.0-157.5)		97.3 (48.8-126.1)		119.0 (61.9-181.3)	
High	126.5 (66.0-190.0)		66.0 (47.5-114.4)		175.3 (106.6-199.6)	
Low	92.5 (20.9-125.0)		125.0 (45.0-135.2)		72.5 (0.0-120.0)	
Jam (g/day)		0.549		0.647		0.742
Total	0.0 (0.0-0.0)		0.0 (0.0-0.0)		0.0 (0.0-0.0)	
High	0.0 (0.0-0.0)		0.0 (0.0-1.8)		0.0 (0.0-1.8)	
Low	0.0 (0.0-0.0)		0.0 (0.0-0.0)		0.0 (0.0-0.0)	
Fruit juice and fruit beverages (g/day)		0.447		0.794		0.182
Total	0.0 (0.0-0.0)		0.0 (0.0-0.0)		0.0 (0.0-0.0)	
High	0.0 (0.0-0.0)		0.0 (0.0-0.0)		0.0 (0.0-0.0)	
Low	0.0 (0.0-0.0)		0.0 (0.0-7.5)		0.0 (0.0-0.0)	
Mushrooms (g/day)		0.493		0.695		0.282
Total	4.5 (0.0-20.5)		2.0 (0.0-15.4)		5.0 (0.0-24.5)	
High	5.0 (0.0-25.0)		2.0 (0.0-12.8)		12.0 (0.0-27.4)	
Low	1.0 (0.0-17.3)		2.0 (0.0-19.7)		0.5 (0.0-18.0)	
Seaweeds (g/day)		0.799		0.601		0.388
Total	10.1 (0.8-29.0)		9.3 (0.0-27.2)		14.0 (2.0-30.3)	
High	10.1 (0.8-31.5)		9.5 (0.0-20.8)		14.3 (2.4-42.5)	
Low	9.8 (1.8-25.6)		9.0 (2.3-44.5)		10.5 (1.5-21.0)	
Fresh seafood (g/day)		0.034*		0.051		0.249
Total	42.5 (17.5-77.2)		44.3 (16.2-78.2)		37.5 (17.5-77.6)	
High	61.3 (25.0-85.3)		65.0 (35.8-110.6)		56.1 (22.7-81.3)	
Low	35.3 (1.3-72.3)		36.7 (0.0-58.0)		33.8 (5.0-72.8)	
Processed seafood (g/day)		0.428		0.393		0.725
Total	25.0 (7.5-35.0)		23.8 (11.3-35.6)		25.0 (6.1-37.5)	
High	24.5 (5.0-35.0)		21.5 (5.4-34.0)		24.8 (4.5-36.3)	
Low	25.0 (12.0-46.3)		25.0 (13.8-85.4)		25.0 (8.0-45.0)	
Meat (g/day)		0.036*		0.017*		0.253
Total	55.0 (32.7-72.5)		58.6 (39.6-84.4)		52.5 (30.0-68.8)	
High	50.0 (30.0-64.8)		50.0 (30.0-60.6)		48.8 (21.9-65.0)	
Low	58.9 (45.3-83.0)		70.6 (55.9-131.9)		55.0 (43.0-80.0)	

†The high group was defined as above the median of each gender HEI-2020 score (52 for males and 53 for females) and the low group was defined as below the median.
Values represent the median of the intake by food group for each group averaged over 2-days, with the interquartile ranges shown in parentheses.

p values were calculated using the Mann-Whitney U test.
*p < 0.05, **p < 0.01,

Table 3. Association between HEI-2020 scores and nutrient intake per day† (cont.)

	Total (n=71)		Males (n=22)		Females (n=49)	
	Median (interquartile range)	*p* (High vs Low)	Median (interquartile range)	*p* (High vs Low)	Median (interquartile range)	*p* (High vs Low)
Eggs (g/day)		0.698		0.051		0.241
Total	37.5 (18.2-58.5)		37.9 (15.5-62.8)		35.4 (19.1-55.1)	
High	27.6 (22.0-57.0)		24.2 (0.0-53.1)		36.5 (25.0-58.4)	
Low	47.4 (14.0-59.3)		58.5 (35.1-66.0)		25.0 (7.5-52.4)	
Dairy products (g/day)		0.186		0.601		0.351
Total	100.0 (35.0-246.0)		89.3 (26.9-200.0)		104.5 (38.5-268.8)	
High	118.0 (55.5-267.5)		100.0 (27.5-302.5)		134.0 (71.9-268.1)	
Low	66.3 (25.0-227.9)		85.0 (26.3-149.0)		57.5 (20.5-295.0)	
Oils and fats (g/day)		0.032*		0.060		0.214
Total	6.3 (3.0-11.7)		6.7 (2.9-12.9)		6.3 (3.1-11.6)	
High	4.5 (2.6-10.9)		4.3 (1.8-9.8)		5.5 (2.8-11.6)	
Low	8.2 (4.2-16.1)		7.8 (5.8-18.7)		8.5 (4.1-16.1)	
Confectionery (g/day)		0.385		0.744		0.323
Total	22.5 (0.0-50.0)		27.5 (0.0-75.3)		22.5 (0.8-41.5)	
High	20.0 (0.0-40.0)		20.0 (0.0-74.0)		17.5 (1.1-32.6)	
Low	38.5 (0.0-56.3)		50.0 (0.0-86.0)		37.5 (0.0-50.0)	
Alcoholic beverages (g/day)		0.526		0.262		0.593
Total	4.0 (0.0-95.8)		122.9 (0.6-269.8)		2.5 (0.0-19.3)	
High	6.0 (0.0-150.0)		176.1 (3.8-284.0)		2.5 (0.0-12.9)	
Low	2.3 (0.0-39.6)		0.8 (0.0-375.0)		3.5 (0.0-38.3)	
Other beverages (g/day)		0.627		0.845		0.446
Total	450.0 (308.0-630.0)		425.0 (267.8-626.3)		451.5 (314.0-654.8)	
High	451.5 (285.0-620.0)		540.0 (270.0-625.0)		435.8 (294.8-594.8)	
Low	432.5 (329.1-657.4)		400.0 (226.0-777.5)		500.0 (375.0-660.0)	
Seasonings (g/day)		0.106		0.030*		0.718
Total	65.8 (39.6-106.5)		65.8 (37.6-109.5)		65.8 (41.6-110.6)	
High	61.6 (31.5-98.0)		40.1 (27.7-84.5)		69.0 (34.0-108.5)	
Low	79.0 (50.6-169.8)		94.4 (69.6-195.3)		65.7 (43.-126.3)	
Low	58.9 (45.3-83.0)		70.6 (55.9-131.9)		55.0 (43.0-80.0)	

†The high group was defined as above the median of each gender HEI-2020 score (52 for males and 53 for females) and the low group was defined as below the median.
Values represent the median of the intake by food group for each group averaged over 2-days, with the interquartile ranges shown in parentheses.
p values were calculated using the Mann-Whitney U test.
*p < 0.05, **p < 0.01,

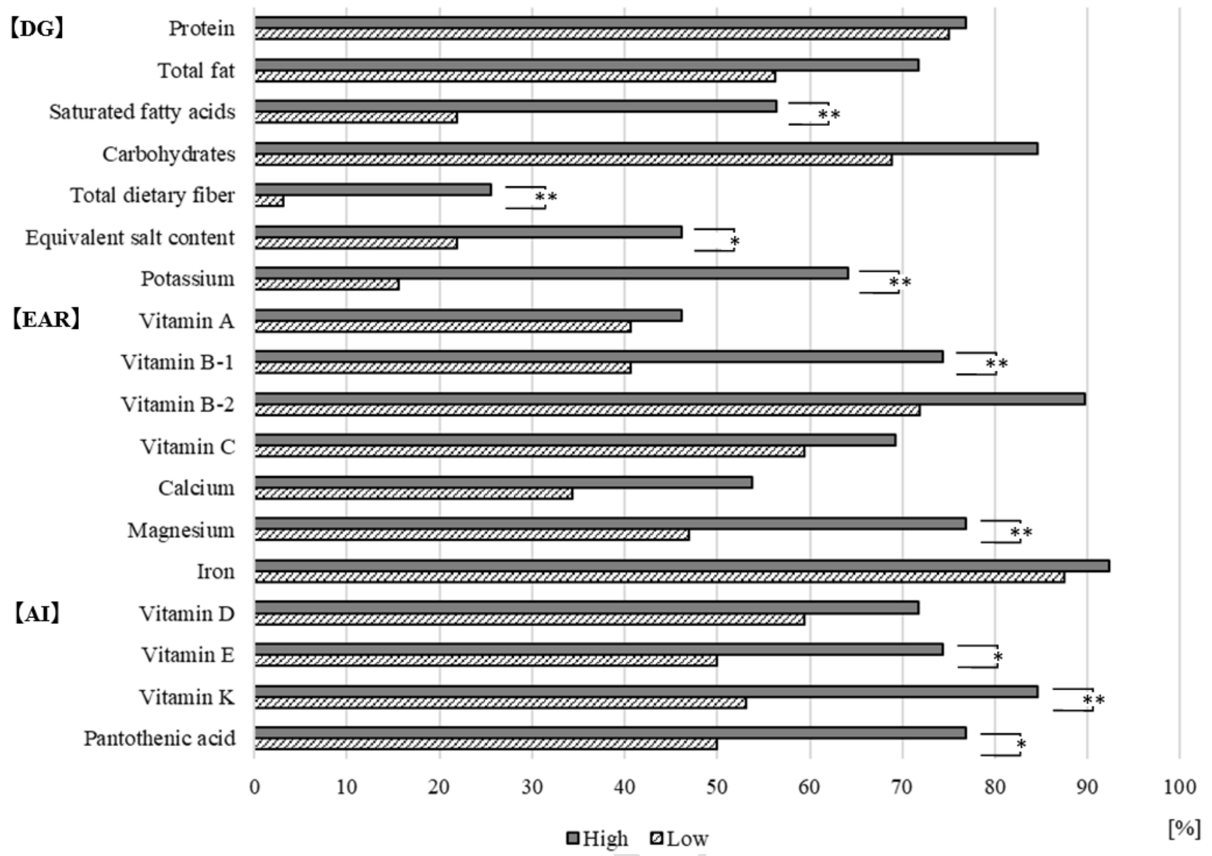

Figure 1. Proportion (%) Meeting the Reference Value of DRIs.
AI, adequate intake; DG, tentative dietary goal for preventing life-style related diseases; EAR, estimated average requirement.
The high group was defined as above the median of each gender HEI-2020 score (52 for males and 53 for females) and the low group was defined as below the median. Values represent the number of subjects in each group whose nutrient intake was within the DG range or above the EAR and AI, and in parentheses the percentage of the group. The p values were calculated using the x2 test. $*p < 0.05$, $**p < 0.01$