

ORIGINAL

Validity of dietary diversity assessed using short-form questionnaire among older Japanese community dwellers

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Abstract : The validity of dietary variety score (DVS) using a short-form questionnaire has not been investigated using dietary diversity based on a quantitative distribution of consumed foods in older Japanese. We examined the association between DVS and objective dietary diversity using a Quantitative Index for Dietary Diversity (QUANTIDD) based on the quantitative distribution of foods consumed by older Japanese community dwellers. The subjects were 65 older Japanese community dwellers aged 60–79 years. We used two kinds of scores for assessment of dietary diversity. At first, dietary diversity was determined using DVS calculated from answers to a questionnaire about frequencies of intake of 10 food groups. Second, dietary intake was assessed using a 3-day dietary record with photographs, and dietary diversity was determined using QUANTIDD. The relationships between DVS and QUANTIDD were assessed using partial correlation coefficients controlling for confounders. The correlation coefficient between DVS and QUANTIDD was moderate ($r = 0.212-0.458$). After controlling for confounders, those correlation coefficient between DVS and QUANTIDD remained moderate. The findings suggest that there was a moderate relationship between DVS and QUANTIDD, and DVS using a short-form questionnaire may be useful for assessing dietary diversity in older Japanese community dwellers. *J. Med. Invest.* 69 : 31-37, February, 2022

Keywords : dietary diversity, dietary variety, older Japanese community dwellers

INTRODUCTION

Populations worldwide are aging rapidly (1, 2). In Japan, older people aged 65 years or older account for 27.7% of the total population and the percentage of older people is expected to increase to 38.4% by 2026 (3). It has been suggested that environmental factors including dietary intake play an important role in the longevity of Japanese. Recently, it has been reported that comprehensive diets that reflect foods combinations are associated with good health status in older populations (4-7).

Several assessment scales including Healthy Eating Index (8), Mediterranean Diet Scale (9), Japanese Diet Index (10), and Quantitative Index for Dietary Diversity (QUANTIDD) (11) have been used for evaluating a comprehensive diet. However, it is difficult to continue to evaluate those scores in a survey targeting older people because data on dietary intake from a dietary recording method and a food intake frequency survey are required to calculate these scores. On the other hand, dietary variety score (DVS) developed by Kumagai *et al.* is a score obtained from a short-form questionnaire about frequencies of intake per week of 10 food items, and it is easy to use as an assessment tool for dietary diversity in an older population (12).

There has been no validation study on the correlation between DVS score and QUANTIDD score based on dietary record, except for a report on the relationship between DVS and food groups / nutrient intake in 181 older people (13). Thus, we investigated the relationship between dietary diversity using DVS

and objective dietary diversity using QUANTIDD based on the quantitative distribution of consumed foods in older Japanese community dwellers.

MATERIALS AND METHODS

Study subjects

An overview of the subjects analyzed in the present study is shown in Table 1. The study participants included 65 voluntary community-dwelling subjects aged 60–79 years. Of the 65 participants in this study, we excluded subjects who lacked data for any dietary intake using a 3-day dietary record ($n = 6$) and potential cofounders including a medical history of diabetes, hypertension or dyslipidemia, smoking habit, drinking habit, and current physical activity ($n = 3$). The remaining 59 subjects (4 men and 55 women) were used for analysis (Table 1). We obtained written informed consent for study participation from each participant. The study protocol was approved by the institutional review board of Tokushima University Hospital (ethical approval number : 2556).

Dietary assessment

Dietary intake was assessed using three-consecutive-day (two weekdays and 1 weekend day) dietary weight records. The raw food materials were weighed separately on a scale (2 kg digital home scale UH-3303 ; A&D Company, Limited, Tokyo,

Abbreviations used :

BMI, body mass index ; DVS, dietary variety score ; EAR, Estimated Average Requirement ; MMSE, Mini-Mental State Examination ; QUANTIDD, Quantitative Index for Dietary Diversity ; SD, standard deviation

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Table 1. Subject characteristics

| | Total participants (n = 59) | |
|--|-----------------------------|-----------|
| Age (years) † | 67.6 | ± 4.7 |
| Age groups ‡ | | |
| 60–69 years | 41 | (69.5) |
| 70–79 years | 18 | (30.5) |
| Men ‡ | 4 | (6.8) |
| Body mass index (kg/m ²) † | 24.0 | ± 3.9 |
| Body weight groups ‡ | | |
| Underweight | 6 | (10.2) |
| Normal | 33 | (55.9) |
| Overweight | 20 | (33.9) |
| Current physical activity (+) † | 36 | (61.0) |
| Mini-Mental State Examination score † | 28.1 | ± 1.9 |
| Education ‡ | | |
| ≤9 years | 4 | (6.8) |
| 9–12 years | 28 | (47.5) |
| >12 years | 27 | (45.8) |
| Annual household income ‡ | | |
| <1.49 million yen | 29 | (49.2) |
| 1.50–4.49 million yen | 19 | (32.2) |
| >4.50 million yen | 11 | (18.6) |
| Smoking habit ‡ | | |
| Current | 0 | (0.0) |
| Former/never | 59 | (100.0) |
| Drinking habit ‡ | | |
| Current | 17 | (28.8) |
| Former/never | 42 | (71.2) |
| Medical history ‡ | | |
| Hypertension (+) | 18 | (30.5) |
| Dyslipidemia (+) | 13 | (22.0) |
| Diabetes (+) | 3 | (5.1) |
| Heart disease (+) | 1 | (1.7) |

† Mean ± SD ; ‡ Number (%)

|| Abbreviations : SD, standard deviation

Japan) before being cooked or portion size was estimated. We asked the subjects to photograph their plates before and after eating their food by using a disposable camera (27 shots; Fuji Film, Tokyo, Japan), digital camera or a mobile phone's camera function. Dietitians used these photos to complete missing data and telephoned the subjects to resolve any discrepancies or obtain further information when necessary. The average intakes of 18 food groups (cereals, potatoes and starches, deep yellow vegetables, other vegetables, mushrooms, seaweed, beans, fish and shellfish, meat, eggs, milk and dairy products, fruits, confectionaries, beverages, sugar and sweeteners, nuts and seeds, fat and oil, and seasonings and spices) and nutrition intakes were calculated according to the Standard Tables of Food Composition in Japan 2015.

Dietary diversity assessment

We used two kinds of scores to assessment for dietary diversity in this study.

Dietary diversity was determined using the QUANTIDD score developed by Katanoda *et al.* (11). The QUANTIDD score

is calculated by the proportion of foods that contribute to total energy or the amount of foods and the number of food groups using the following formula :

$QUANTIDD = (1 - \text{summation operation } \text{prop}[j]^2) / (1 - 1/n)$, where $\text{prop}(j)$ is the proportion of food group(s) j that contributes to total energy or nutrient intake, n is the number of food groups, and $j = 1, 2, \dots, n$. The possible score ranges from 0 to 1. A higher score reflects equal distributions of food groups, and a lower score reflects an unbalanced diet.

We used the QUANTIDD score in this study by following two calculation patterns : the QUANTIDD score based on the amounts of 17 food groups excluding beverages (4) as the first calculation pattern and the QUANTIDD score based on the amounts of 13 food groups excluding confectionaries, beverages, sugar and sweeteners, fat and oil, and seasonings and spices as the second calculation pattern (6).

We assessed DVS using a short-form questionnaire proposed by Kumagai *et al.* for assessment of dietary diversity (12). DVS is a scale for dietary diversity with possible scores ranging from 0 to 10 points. The questionnaire includes simple questions regarding the frequencies of the following 10 food items consumed per week (how many times each item consumed per week) in order to assess dietary diversity : fish and shellfish, meats, eggs, dairy products, legumes, deep yellow vegetables, potatoes, and oil and fats. The frequencies of intake of the 10 food items were classified into the following four categories : 'almost every day' (7 times/week), 'once every two days' (3-4 times/week), 'once or twice a week' (1-2 times/week) and 'almost never' (0 times/week) (Supplemental Table 1).

We used the total DVS in this study by following two calculating patterns. As the first calculation pattern, the total DVS score was calculated as the sum of all 10 food items according to 'almost every day' as 1 point and 'once every two days', 'once or twice a week' and 'almost never' as 0 points (DVS1). As the second calculating pattern, the total DVS score was calculated as the sum of all 10 food items according to 'almost every day' as 1 point, 'once every two days' as 0.5 points, 'once or twice a week' as 0.25 points and 'almost never' as 0 points (DVS2).

Other measurements

The height of each subject was measured to the nearest 0.1 cm with each subject standing without shoes, and body weight was measured to the nearest 0.1 kg with each subject wearing lightweight clothing. Body mass index (BMI) was calculated as weight (kg)/height (m)². Cognitive function was assessed by the Mini-Mental State Examination (MMSE). In a face-to-face interview, the MMSE was conducted by graduate students who had received intensive training. The MMSE is a widely used scale for screening of dementia in the elderly, with possible scores ranging from 0 to 30 points. Data regarding level of education, annual household income, current and previous histories of diseases, current physical activity, drinking habit and smoking habit were collected using a self-administered questionnaire.

Statistical analysis

Continuous variables were expressed as means ± standard deviation (SD), and categorical variables were expressed as numbers and proportions (%).

To assess the differences in dietary characteristics according to the DVS1 score, we used a generalized linear model after controlling for gender and age and estimated adjusted means and 95% confidence interval. At this time, subjects were divided into two groups according to the cut-off value of DVS1 score for malnutrition (≤ 3 or ≥ 4) based on a previous study (12).

Furthermore, the relationship between each DVS score and QUANTIDD score was investigated by Pearson's correlation

coefficient test and Spearman's rank correlation coefficient test to assess validity of DVS for estimation of dietary diversity (crude model). That relationship was also investigated by a partial correlation coefficient test after controlling for the following variables. The adjusted variables were 1) Model 1, sex (binary ; men or women) and age (continuous, years) ; 2) Model 2, sex and age-adjusted model + smoking habit (binary ; current or former/never), drinking habit (binary ; current or former/never), physical activity (binary ; yes or no), education level (categorical ; ≤9 years, 9-12 years or > 12 years), annual household income (≤1.49 million yen, 1.5-4.49 million yen or ≥4.5 million yen), medical history (binary ; yes or no) of hypertension, hyperlipidemia, diabetes and heart disease, BMI (continuous, kg/m²) and energy intake (continuous, kcal/day).

All statistical tests were based on two-sided probabilities and

were performed using SPSS version 18.0J for Windows (SPSS Inc., Japan, Tokyo Japan). All *p* values <0.05 were considered statistically significant.

RESULTS

Characteristics of participants

Table 1 shows the characteristics of the subjects. The mean age of the subjects was 67.6 ± 4.7 years and mean BMI was 24.0 ± 3.9 kg/m². The proportion of subjects with an education term of more than 9 years was 93.3% and the mean MMSE score were 28.1 ± 1.9. There were no current smokers.

The distribution of dietary diversity scores is shown in Figure 1 and Figure 2. Figure 1 show the distributions of QUANTIDD17

Supplemental table 1. Distribution of DVS answers according to each food group†

| Food groups | almost never | once or twice a week | once every two days | almost every day |
|-------------------------|--------------|----------------------|---------------------|------------------|
| Fish and shellfish | 0 (0.0) | 12 (20.3) | 21 (35.6) | 26 (44.1) |
| Meats | 1 (1.7) | 14 (23.7) | 25 (42.4) | 19 (32.2) |
| Eggs | 1 (1.7) | 16 (27.1) | 23 (39.0) | 19 (32.2) |
| Milk and dairy products | 14 (23.7) | 7 (11.9) | 8 (13.6) | 30 (50.8) |
| Soy and soy products | 1 (1.7) | 9 (15.3) | 19 (32.2) | 30 (50.8) |
| Deep yellow vegetables | 0 (0.0) | 4 (6.8) | 8 (13.6) | 47 (79.7) |
| Seaweed | 2 (3.4) | 28 (47.5) | 18 (30.5) | 11 (18.6) |
| Potatoes | 4 (6.8) | 26 (44.1) | 20 (33.9) | 9 (15.3) |
| Fruits | 1 (1.7) | 15 (25.4) | 14 (23.7) | 29 (49.2) |
| Fats and oil | 1 (1.7) | 11 (18.6) | 20 (33.9) | 27 (45.8) |

† Number (%)

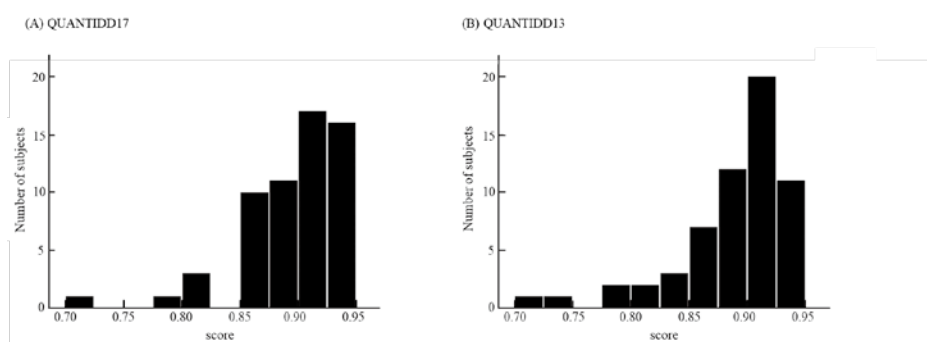


Figure 1. Distribution of QUANTIDD scores. Distributions of QUANTIDD17 scores (A) and QUANTIDD13 scores (B) are shown. The mean QUANTIDD17 score was 0.89 ± 0.043 points and the mean QUANTIDD13 score was 0.89 ± 0.048 points.

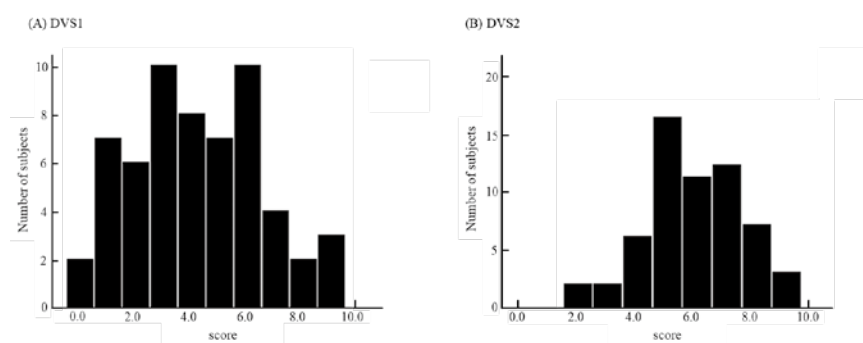


Figure 2. Distribution of DVS scores. Distributions of DVS1 scores (A) and DVS2 scores (B) are shown. The mean DVS1 score was 4.2 ± 2.3 points and the mean DVS2 score was 6.3 ± 1.7 points.

scores (A) and QUANTIDD13 scores (B). The mean QUANTIDD17 score was 0.89 ± 0.043 points and the mean QUANTIDD13 score was 0.89 ± 0.048 points. The mean QUANTIDD scores were similar. Figure 2 show the distribution of each DVS1 scores (A) and DVS2 scores (B). The mean DVS1 score was 4.2 ± 2.3 points and the mean DVS2 score was 6.3 ± 1.7 points.

Differences in dietary diversity, intake of food groups and nutrient intake according to DVS1 score

Table 2 shows dietary diversity scores, amounts of food intake and amounts of nutritional intake according to the DVS1

score. There was no significant difference, though the higher DVS1 groups (DVS1 score ≥ 4) had higher scores for both QUANTIDD17 and QUANTIDD13 than those in the lower DVS1 groups (DVS1 score ≤ 3). Regarding food intake of groups, subjects in the higher DVS1 groups consumed significantly less cereals and consumed significantly more milk and dairy products than did subjects in the lower DVS1 groups. Furthermore, subjects in the higher DVS1 groups consumed significantly more saturated fatty acids contained in milk and dairy products than did subjects in the lower DVS1 groups.

Table 2. Dietary diversity score, food intake and nutritional intake according to the DVS1 score^{†, ‡}

| | DVS1 score | | <i>P</i> |
|--|------------------------------|------------------------------|----------|
| | DVS1 score ≤ 3 (n = 25) | DVS1 score ≥ 4 (n = 34) | |
| <i>Dietary diversity score</i> | | | |
| QUANTIDD17 (score) | 0.883 (0.866 , 0.901) | 0.903 (0.889 , 0.918) | 0.086 |
| QUANTIDD13 (score) | 0.876 (0.857 , 0.896) | 0.896 (0.880 , 0.913) | 0.131 |
| DVS1 (score) | 2.0 (1.4 , 2.5) | 5.8 (5.4 , 6.3) | <0.001 |
| DVS2 (score) | 4.8 (4.4 , 5.2) | 7.4 (7.0 , 7.7) | <0.001 |
| <i>Food intake</i> | | | |
| Cereals (g/1000kcal/day) | 211.3 (189.2 , 233.5) | 180.9 (161.9 , 199.8) | 0.043 |
| Potatoes (g/1000kcal/day) | 18.0 (11.5 , 24.5) | 20.5 (15.0 , 26.1) | 0.566 |
| Sugar (g/1000kcal/day) | 5.8 (3.7 , 8.0) | 7.3 (5.5 , 9.1) | 0.306 |
| Legumes (g/1000kcal/day) | 47.9 (36.0 , 59.7) | 35.7 (25.6 , 45.8) | 0.128 |
| Seeds (g/1000kcal/day) | 1.4 (0.3 , 2.5) | 1.5 (0.6 , 2.5) | 0.836 |
| Deep yellow vegetables (g/1000kcal/day) | 98.5 (72.8 , 124.2) | 92.8 (70.9 , 114.8) | 0.742 |
| Other vegetables (g/1000kcal/day) | 111.6 (91.4 , 131.7) | 104.9 (87.6 , 122.1) | 0.618 |
| Fruits (g/1000kcal/day) | 64.3 (36.5 , 92.1) | 85.1 (61.4 , 108.9) | 0.265 |
| Mushrooms (g/1000kcal/day) | 5.4 (2.2 , 8.7) | 6.7 (3.9 , 9.4) | 0.559 |
| Seaweed (g/1000kcal/day) | 5.0 (1.8 , 8.3) | 3.8 (1.0 , 6.6) | 0.576 |
| Fish and shellfish (g/1000kcal/day) | 41.7 (31.6 , 51.9) | 43.1 (34.5 , 51.8) | 0.837 |
| Meats (g/1000kcal/day) | 36.8 (28.9 , 44.8) | 32.7 (25.9 , 39.5) | 0.434 |
| Eggs (g/1000kcal/day) | 23.4 (18.3 , 28.5) | 21.9 (17.6 , 26.3) | 0.669 |
| Milk and dairy products (g/1000kcal/day) | 58.0 (31.7 , 84.4) | 99.1 (76.5 , 121.6) | 0.023 |
| Fats and oil (g/1000kcal/day) | 5.3 (3.8 , 6.8) | 5.5 (4.2 , 6.8) | 0.807 |
| Sweets (g/1000kcal/day) | 12.9 (4.9 , 20.9) | 21.7 (14.9 , 28.5) | 0.102 |
| Beverages (g/1000kcal/day) | 335.9 (257.2 , 414.5) | 319.6 (252.4 , 386.8) | 0.756 |
| Seasoning (g/1000kcal/day) | 28.2 (24.3 , 32.2) | 25.9 (22.5 , 29.2) | 0.369 |
| <i>Nutritional intake</i> | | | |
| Total energy (kcal/day) | 2001.5 (1815.3 , 2187.7) | 2095.4 (1936.4 , 2254.5) | 0.451 |
| Protein (g/1000kcal/day) | 38.8 (36.4 , 41.1) | 39.1 (37.1 , 41.2) | 0.817 |
| Fat (g/1000kcal/day) | 32.2 (28.3 , 36.2) | 31.7 (28.3 , 35.1) | 0.840 |
| Saturated fatty acids (g/1000kcal/day) | 7.9 (7.0 , 8.8) | 9.2 (8.4 , 10.0) | 0.044 |
| Monounsaturated fatty acids (g/1000kcal/day) | 10.6 (9.4 , 11.7) | 10.7 (9.7 , 11.7) | 0.908 |
| Polyunsaturated fatty acids (g/1000kcal/day) | 11.1 (4.9 , 17.3) | 7.6 (2.4 , 12.9) | 0.398 |
| Sodium (mg/1000kcal/day) | 1942.9 (1777.5 , 2108.4) | 1859.1 (1717.8 , 2000.5) | 0.449 |
| Calcium (mg/1000kcal/day) | 288.8 (250.3 , 327.2) | 339.2 (306.4 , 372.1) | 0.053 |
| Magnesium (mg/1000kcal/day) | 167.7 (146.8 , 188.6) | 159.9 (142.1 , 177.8) | 0.579 |
| Iron (mg/1000kcal/day) | 4.7 (4.3 , 5.1) | 4.6 (4.2 , 4.9) | 0.587 |
| Zinc (mg/1000kcal/day) | 4.2 (3.9 , 4.5) | 4.5 (4.2 , 4.7) | 0.179 |
| VitaminA (μ g/1000kcal/day) | 332.5 (202.0 , 463.0) | 368.4 (256.9 , 479.9) | 0.681 |
| Vitamin C (mg/1000kcal/day) | 75.5 (63.5 , 87.6) | 65.5 (55.2 , 75.8) | 0.215 |
| Fiber (g/1000kcal/day) | 8.8 (7.8 , 9.8) | 8.8 (7.9 , 9.6) | 0.945 |
| Salt (g/1000kcal/day) | 4.9 (4.5 , 5.3) | 4.7 (4.3 , 5.0) | 0.470 |

[†] Adjusted mean (95% confidence interval)

[‡] A sex and age-adjusted general linear model was used. Independent variables were dietary or nutritional intakes. The dependent variable was groups depending on DVS1 score.

Correlations between DVS score and QUANTIDD scores

Table 3 shows the correlation between each DVS score and QUANTIDD score. In the crude model using Pearson's correlation coefficient test, a statistically significant moderate correlation was observed between DVS1 and each QUANTIDD score : $r = 0.361$ ($p = 0.005$) in QUANTIDD17 and $r = 0.348$ ($p = 0.007$) in QUANTIDD13. A more statistically significant moderate correlation was observed between DVS2 and each QUANTIDD score : $r = 0.458$ ($p < 0.001$) in QUANTIDD17 and $r = 0.439$ ($p = 0.001$) in QUANTIDD13. In the crude model using Spearman's rank correlation coefficient test, a moderate correlation was observed between DVS1 and each QUANTIDD score : $r = 0.229$ ($p = 0.081$) in QUANTIDD17 and $r = 0.212$ ($p = 0.107$) in QUANTIDD13. A statistically significant moderate correlation was observed between DVS2 and each QUANTIDD score : $r = 0.297$ ($p = 0.022$) in QUANTIDD17 and $r = 0.267$ ($p = 0.041$) in QUANTIDD13.

After controlling for sex and age (Model 1), a moderate partial correlation was found between DVS1 and each QUANTIDD score : $r = 0.328$ ($p = 0.014$) in QUANTIDD17 and $r = 0.302$ ($p = 0.017$) in QUANTIDD13. A statistically significant moderate partial correlation was found between DVS2 and each QUANTIDD score : $r = 0.431$ ($p = 0.001$) in QUANTIDD17 and $r = 0.415$ ($p = 0.001$) in QUANTIDD13.

Those moderate correlations between DVS1 and QUANTIDD scores were similar after controlling for other confounding variables (Model 2) : $r = 0.332$ ($p = 0.024$) in QUANTIDD17 and $r = 0.334$ ($p = 0.023$) in QUANTIDD13. In addition, statistically significant moderate partial correlations were found between DVS2 and QUANTIDD scores : $r = 0.433$ ($p = 0.003$) in QUANTIDD17 and $r = 0.434$ ($p = 0.003$) in QUANTIDD13.

These results did not change substantially after excluding male participants (data not shown).

Table 3. Correlation between DVS score and QUANTIDD score†

| | DVS1 | <i>p</i> | DVS2 | <i>p</i> |
|-------------------|-------|----------|-------|----------|
| <i>QUANTIDD17</i> | | | | |
| Crude model ‡ | 0.361 | 0.005 | 0.458 | <0.001 |
| Crude model | 0.229 | 0.081 | 0.297 | 0.022 |
| Model 1§ | 0.328 | 0.014 | 0.431 | 0.001 |
| Model 2 ¶ | 0.332 | 0.024 | 0.433 | 0.003 |
| <i>QUANTIDD13</i> | | | | |
| Crude model ‡ | 0.348 | 0.007 | 0.439 | 0.001 |
| Crude model | 0.212 | 0.107 | 0.267 | 0.041 |
| Model 1§ | 0.302 | 0.017 | 0.415 | 0.001 |
| Model 2 ¶ | 0.334 | 0.023 | 0.434 | 0.003 |

† Correlation coefficients.

‡ The correlation between each DVS score and QUANTIDD score was estimated using Pearson's correlation coefficient test.

|| The correlation between each DVS score and QUANTIDD score was estimated using Spearman's rank correlation coefficient test.

§ Model 1 : adjusted for sex and age

¶ Model 2 : adjusted for sex, age, smoking habit, drinking habit, physical activity, education level, annual household income, medical history of hypertension, hyperlipidemia, diabetes and heart disease, BMI and energy intake

DISCUSSION

In this study, we investigated the relationship between dietary diversity using DVS and objective dietary diversity using QUANTIDD based on the quantitative distribution of foods consumed by older Japanese community dwellers. Although there was no significant difference in QUANTIDD scores between higher DVS1 groups (DVS1 score ≥ 4) and lower DVS1 groups (DVS1 score ≤ 3), statistically significant moderate correlations were found between DVS and QUANTIDD scores in the subjects.

In the present study, we showed that subjects in the higher DVS1 groups consumed less cereals and consumed more dairy products and saturated fatty acids than did subjects in the lower DVS1 groups. The results are consistent with the results of a study by Narita *et al.* (13). They showed in their cross-sectional study that the amounts of intake of dairy products, seaweed and potatoes were smaller and that the amount of intake of rice was larger in the low DVS group than in the high DVS group (13). The results of both our study and that previous study indicate that a higher dietary diversity score estimated by DVS might mean that the energy contribution from cereals that make up the main staple food is smaller and that the energy contribution from food groups that make up the main dish and/or side dishes is larger. In addition, we investigated whether there were differences in food groups and intake of nutrients between the higher DVS1 groups (DVS1 score ≥ 4) and lower DVS1 groups (DVS1 score ≤ 3). As a result, although there were no subjects with protein intake below the estimated average requirement (EAR), which is related to functional decline, frailty and difficulties with independent living (14), the proportion of subjects with calcium and/or zinc intake below the EAR was higher in lower DVS1 groups than in the higher DVS1 groups : proportion of subjects with calcium intake below the EAR, 36.0% in the lower DVS1 groups vs. 23.5% in the higher DVS1 groups ; proportion of subjects with zinc intake below the EAR, 16.0% in the lower DVS1 groups vs. 8.8% in the higher DVS1 groups. Regarding dietary fiber, the proportions of subjects whose dietary fiber intake was below the Tentative Dietary Goal for Preventing Life-style-related diseases were 72% in the lower DVS1 groups and 41.2% in the higher DVS1 groups, and the difference was significant. Kumagai *et al.* determined the cut-off value of DVS for malnutrition (3/4) in subjects (mean age : 71.5 ± 5.3 years, education duration > 7 years : 8.8%) in a survey conducted in rural areas of Akita Prefecture (12). On the other hand, the subjects in the present study were younger (mean age : 67.6 ± 4.7 years) and had a higher education level (education duration > 7 years : over 90%). In addition, the subjects in the present study lived in a rural area of Tokushima, which differs in lifestyle and food culture including dietary intake. Therefore, grouping the subjects in the present study with a cutoff value of 3/4 might not necessarily distinguish between malnutrition and non-malnutrition. However, classification based on the DVS1 cutoff value (3/4) might be useful as an indicator of future frailty even in healthy older people, according to both the results of our study and results of previous studies showing that a deficiency of serum and/or dietary micronutrients is an important factor causing frailty (15-17).

In the present study, we found statistically significant moderate correlations between DVS and QUANTIDD scores in the subjects. The association between DVS2 and each QUANTIDD score was stronger than that between DVS1 and each QUANTIDD score. This result suggests that DVS2 rather than DVS1 might be more meaningful as an objective and quantitative score for dietary diversity like the QUANTIDD score. DVS was developed as a convenient way to evaluate dietary diversity in older

people and was scored by counting 'almost every day' as 1 point and other points as 0 points, and a total score of ≤ 3 was often used to define low dietary diversity (malnutrition) (12). In this scoring method, some information may be lost by categorizing 'once every two days', 'once or twice a week', and 'almost never' into 0 points when calculating DVS1 score. When using DVS to divide people into multiple groups (e.g. malnutrition or non-malnutrition) as in previous studies (18-20), a conventional scoring method such as DVS1 ('almost every day' as 1 point and other points as 0 points) would be better. However, if an objective and quantitative score for dietary diversity such as the QUANTIDD score is considered to be more important, it might be better to use gradual scoring according to frequency such as DVS2.

The present study is first study to clarify the correlation between DVS and QUANTIDD score in healthy older Japanese. The DVS, which is calculated by the intake frequency of only about 10 food groups, can be easily used for nutritional research in an older population. However, it was unclear how much DVS correlates with a score for dietary diversity based on quantitative estimation because standard portion sizes for food groups are not taken into account in DVS. In this study, we were able to clarify the magnitude of the relationship between DVS and QUANTIDD score among healthy older Japanese community dwellers. However, our study has several limitations. First, the sample size in the present study was small ($n=59$). Second, almost all of the subjects were healthy older women (number and percentage of women : $n=55$, 93.2%). It has been reported that women tend to make healthy food choices and/or have healthy dietary behavior compared to those for men (21). Furthermore, women spend much more time for housework including cooking than that spent by men after marriage in Japan (22). Therefore, the correlation coefficient in this study might have been estimated to be higher than that in a study in which the male-female ratio of the subjects is not biased, because the validity of dietary records in women might be higher than that in men. Although our results can be applied to healthy older women, it might not be possible to generalize our results in elderly people with impaired physical functions such as those admitted to hospitals. Third, while DVS was evaluated by intake frequency in 7 days, QUANTIDD score, food group intake, and nutrient intake were evaluated by a 3-day weighing method. A previous study showed that the ratios of intra- to interindividual variance tended to be smaller for macronutrients and larger for minerals and vitamins (23). Since a larger number of subjects and survey days are required to consider the daily variance in the intake of micronutrients, the use a 3-day weighing method might not be sufficient for assessment of the intake of micronutrients. In addition, regarding food groups such as potatoes, vegetables, and fruits, it has been reported that the intake may vary depending on the season of the survey (24). Since the frequency or amount of intake of these food groups is used when calculating DVS score and QUANTIDD score, the estimated correlation between DVS and QUANTIDD might be higher if it is possible to carry out a long-term dietary survey considering the seasons. In the present study, although the proportion of underweight subjects was low (10.2%), the proportion of overweight subjects was high (33.9%). Overweight individuals are known to be likely to underreport dietary intake (25-27). In fact, when the correlation coefficient between DVS1 and QUANTIDD17 score was calculated by stratifying the subjects according to body type, a lower correlation was shown in overweight subjects than in non-overweight subjects : $r=0.233$ in overweight subjects, $r=0.450$ in non-overweight subjects. It is necessary to fully consider these points when interpreting our results.

In conclusion, our results indicate the possibility that there are moderate relationships between DVS and QUANTIDD, and

DVS using a short-form questionnaire may be useful for assessing dietary diversity in older Japanese community dwellers. Larger studies should be conducted in the future to examine the associations between DVS and QUANTIDD.

CONFLICT OF INTEREST

All authors state that they have no conflicts of interest.

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