Food Diversity and Validity of Semiquantitative Food Frequency Questionnaire

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We hypothesized that validity of semiquantitative food frequency questionnaire would be affected by food diversity (variety of foods consumed), because greater food diversity may be related to greater within-individual variation of nutrient intake, which can attenuate the correlation coefficient measuring validity of the questionnaire. We obtained 12 one-day diet records over one year and responses to a semiquantitative food frequency questionnaire from 37 subjects. The food diversity score for each subject was determined by the total number of different foods consumed during the 12 days for the diet records, and the subjects were divided into two groups according to the score. The within-individual variances were similar in those with higher and lower food diversity scores. We never observed a significantly lower correlation coefficient for any nutrient in those with higher food diversity scores. The observed and corrected correlations for most of the micronutrients were higher in those with higher food diversity scores, and the differences were statistically significant for crude fiber, vitamin C, iron, and potassium. The validity of the semiquantitative food frequency questionnaire did not appear to be lowered greatly by greater food diversity. *J Epidemiol*, 1998 ; 8 : 297-301.

semiquantitative food frequency questionnaire, diet record, within-individual variation, between-individual variation, validity

Numerous studies have been devoted to the methods of measuring an individuals' usual dietary intake¹⁻⁴. Currently, semiquantitative food frequency questionnaires (FFQs) are commonly used to obtain estimates of individuals' dietary intake and to relate diet to the development of various diseases. There is no gold standard for directly assessing the validity of dietary assessment methods. However, the validity of the semiquantitative FFQs is often determined by comparing data derived from them with those obtained from diet records (DRs) or 24-hour recalls⁵. Because of day-to-day variation in an individual's food intake, memory lapses, misinterpretation, and restriction by a fixed list of foods, it is difficult to assess a usual diet accurately using a semiquantitative FFQ.

One of the characteristics of diet among the Japanese in the present day may be food diversity.

We hypothesized that a more varied diet should be related to a low validity of semiquantitative FFQ. It is possible that a

more varied diet is related to a large within-individual variation in nutrient intake.

The ratio of the within-individual to between-individual variance is used as an index of bias and power loss in etiological studies of disease⁶. A large ratio reduces the strength of any association. A large within-individual variation can distort the correlation coefficient.

Our hypothesis implies that food diversity makes it difficult to develop a semiquantitative FFQ with high validity to assess the diet among the Japanese. To examine our hypothesis, we analyzed data from 12 one-day DRs over one year and responses to a semiquantitative FFQ.

MATERIALS AND METHODS

A total of 50 healthy volunteers who were 35 years or over and living in or in the vicinity of Takayama City, Gifu were

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enrolled in the present study in May, 1994. They were asked to complete a self-administered one-day DR once a month over the course of one year.

We requested that foods were weighted or, when impossible, measured roughly using a standard unit or portion size.

The date for the DR was randomly selected every month.

We announced the date to each subject just before the day out of concern that he or she would intentionally change the diet for DR, knowing the date beforehand.

At the completion of the twelfth one-day DR, we administered a semiquantitative FFQ which is a modification of the original Diet History Questionnaire developed by Hankin et al.⁷. The questionnaire inquired about the usual frequency and portion size of 169 foods or dishes in the previous year. The detail of this questionnaire were described elsewhere⁸.

Out of 50 original subjects, 37 age 35 to 66 completed 12 one-day DRs. The DRs were interpreted and coded by a dietician, and nutrient intakes were computed using the national food composition tables in Japan⁹.

The food diversity score was computed as the total number of different foods consumed during the 12 days for DRs. The number of foods, whatever the calories, were counted. If the same food item was recorded repeatedly during the 12 days, it was counted as one.

The subjects were divided into two groups according to food diversity score (from 113 to 152 and from 153 to 209).

For each group, we calculated the within-individual and between-individual variances and the ratio of the within-individual to between-individual variances for nutrient intakes estimated from the 12 one-day DRs using the variance model¹⁰. It was assumed that true mean is constant during the study period for each individual and the variation within each individual represents random variation about his or her true mean. We computed the Pearson correlation coefficients comparing nutrient intakes from the semiquantitative FFQ with those from the 12 one-day DRs for each group stratified by food diversity score, and then compared them between the two groups.

We corrected the correlation coefficients using the ratios of the within-individual to between-individual variances to see whether the estimated true correlations still differed between the two groups.

Nutrient intakes were log-transformed for statistical analyses because the values were skewed to the right. The homogeneity of variances between the two groups was tested for statistical significance with Bartlett's test¹¹. The method recommended by Rosner and Willett¹² was used to compare the corrected correlations between the two groups stratified by food diversity score. All the statistical analyses were performed using SAS programs¹³.

RESULTS

The means of age and body mass index (BMI) were similar in the two groups stratified by food diversity score; the means (SD) for age and BMI were 52.0 (11.6) and 22.5 (2.8) in those with lower food diversity scores ($n = 20$), and 47.4 (11.8) and 21.2 (2.5) in those with higher food diversity scores ($n = 17$), respectively. The proportions of men were 40.0% in the former group and 52.9% in the latter group.

There was no significant difference in the within-individual variances between the two groups stratified by food diversity score for any nutrient studied (Table 1). The ratios of the within-individual variances in those with higher food diversity scores to those with lower food diversity scores varied from 0.77 for vitamin A to 1.24 for crude fiber. The ratios of the within-individual to between-individual variances tended to be greater for most of the nutrients in those with higher food diversity scores.

The observed Pearson correlation coefficients comparing the semiquantitative FFQ and the 12 one-day DRs tended to be higher in those with higher food diversity scores than the coefficients in those with lower food diversity scores, except for energy, fat, carbohydrate, retinol, and cholesterol (Table 2). The observed correlation coefficients for crude fiber, vitamins C and E, iron, and potassium were statistically significantly higher in those with higher food diversity scores. Similarly, the corrected correlation coefficients for crude fiber, potassium, and vitamin C were significantly higher in those with higher food diversity scores. The correction of correlation coefficients did not change the results substantially except for fat. The corrected correlation coefficient for fat was higher in those with higher food diversity scores, although it did not attain statistical significance.

Adjustment for total energy did not substantially alter the results for the relations of the food diversity score to the within-individual variance and the correlations comparing the two dietary assessment methods.

DISCUSSION

We expected low observed correlations between nutrient intakes estimated from the two methods in those with higher food diversity scores. However, we never observed a significantly lower correlation for any nutrient in them. The results were rather contrary to our hypothesis for some micronutrients.

Greater food diversity did not appear to be linked with a large within-individual variance. The estimated true correlations (corrected correlations) for some micronutrients were still strong in those with higher food diversity scores, further suggesting higher validity of the semiquantitative FFQ in those with greater food diversity.

Morgan et al.¹⁴ analyzed the variation in dietary intakes of

Table 1. Comparison of square roots of within-individual variances (Sw) and ratios of the within-individual to between-individual variances (Sw^2/Sb^2) for nutrient intakes^a estimated from 12 one-day diet records in the two groups stratified by the total number of foods consumed.

Nutrient	Total number of foods						Ratio ^b for Sw	Ratio ^c for Sw ² /Sb ²
	113-152			153-209				
	Mean	Sw	Sw ² /Sb ²	Mean	Sw	Sw ² /Sb ²		
Energy, kcal	2007	0.07	0.8	2230	0.08	3.1	1.12	3.82 *
Protain, g	75.7	0.10	1.2	85.9	0.10	2.6	1.08	2.19
Total fat, g	54.6	0.14	2.8	61.9	0.14	78.7	1.03	28.57 **
Cholesterol, mg	295	0.35	3.2	319	0.30	7.8	0.86	2.46 *
Carbohydrate, g	280	0.07	0.9	309	0.09	3.4	1.18	3.82 *
Crude fiber, g	4.0	0.10	1.3	4.8	0.13	1.5	1.24	1.11
Retinol, mg	302	0.42	6.0	316	0.36	6.5	0.86	1.09
Carotene, mg	2329	0.42	7.9	3042	0.32	2.4	0.77	0.30 **
Vitamin A, IU	2321	0.35	10.0	2800	0.27	2.9	0.77	0.29 **
Vitamin B1, mg	1.0	0.07	0.5	1.2	0.07	7.0	1.10	3.17
Vitamin B2, mg	1.4	0.06	0.9	1.7	0.08	2.0	1.25	2.32
Vitamin C, mg	112	0.22	2.1	140	0.22	2.0	0.84	0.79
Vitamin D, mg	330	0.71	5.3	278	0.58	4.8	0.81	0.91
Vitamin E, mg	7.4	0.14	3.6	8.6	0.14	3.0	1.02	0.82
Iron, mg	10.8	0.10	1.6	12.5	0.12	1.9	1.13	1.18
Phosphate, mg	1074	0.10	1.0	1235	0.10	1.3	1.06	1.41
Calcium, mg	579	0.14	0.7	683	0.15	1.0	1.08	1.40
Sodium, mg	4901	0.10	1.5	5384	0.12	2.7	1.15	1.79
Potassium, mg	2626	0.11	1.2	3320	0.99	1.8	0.84	0.83

^a log₁₀-transformed after being added to 1.^b Sw in those who had total number of foods ≥ 153 / Sw in those who had total number of foods ≤ 152 .^c Sw^2/Sb^2 in those who had total number of foods ≥ 153 / Sw^2/Sb^2 in those who had total number of foods ≤ 152 .* Significant at $p < 0.05$.** Significant at $p < 0.01$.

energy, fat, vitamin A and iron using 12 one-day diet records and observed that those with higher mean intakes had greater within-individual variances. This tendency was notable for vitamin A intake in their study. In our study, the mean intakes of these nutrients were higher in those with higher food diversity scores but the within-individual variance for vitamin A was somewhat lower in those with higher food diversity scores.

As the subjects in our study were not randomly sampled from the general population, the observed magnitudes of the within-individual and between-individual variances would not be representative of those in the general population. However, it is unlikely that the within-individual variation in nutrient intakes would be directly dependent on participation in the present study.

Thirteen subjects could not complete the 12 one-day DRs. They were younger than those who completed the DRs (the means (SD) of age were 39.5 (6.1) vs 49.9 (11.7) years), but the means of individual nutrient intakes estimated from the reported DRs were similar between those who completed the

DRs and those who did not.

The correlation coefficients comparing the semiquantitative FFQ and the 12 one-day DRs tended to be lower in men than in women. However, it is unlikely that higher correlation coefficients in the group with higher food diversity scores were due to the effect of sex, because the proportion of men was slightly higher in the group with higher food diversity scores.

The reason for higher correlations for some micronutrient in those with higher food diversity scores is not clear. Their carefulness or ability in responding to the semiquantitative FFQ should not be the principal reason. The contribution of one food to the intake of each nutrient tends to be greater in those with lower food diversity scores. It is possible that the foods which were truly consumed but not reported or not included in the semiquantitative FFQ would cause relatively greater bias, which lead to low correlations in those with lower food diversity scores.

The small number of subjects in our study may have precluded us detecting the difference in within-individual vari-

Table 2. Observed and corrected Pearson correlation coefficients between nutrients estimated from semiquantitative food frequency questionnaire and from 12 one-day diet records according to the total number of foods consumed^a.

Nutrient	Observed		Corrected	
	Total No. of foods		Total No. of foods	
	113-152	153-209	113-152	153-209
Energy, kcal	0.62	0.50	0.63	0.56
Protein, g	0.53	0.62	0.55	0.69
Total fat, g	0.44	0.22	0.49	0.62
Cholesterol, mg	0.56	0.33	0.62	0.42
Carbohydrate, g	0.59	0.41	0.61	0.46
Crude fiber, g	0.28	0.80 **	0.30	0.85 **
Retinol, mg	0.15	0.12	0.18	0.15
Carotene, mg	0.18	0.50	0.24	0.55
Vitamin A, IU	0.30	0.55	0.40	0.62
Vitamin B1, mg	0.27	0.45	0.30	0.56
Vitamin B2, mg	0.54	0.77	0.55	0.82
Vitamin C, mg	0.16	0.66 **	0.17	0.69 *
Vitamin E, mg	0.21	0.71 **	0.24	0.79
Iron, mg	0.29	0.78 **	0.31	0.86 **
Phosphate, mg	0.49	0.77	0.50	0.81
Calcium, mg	0.64	0.84	0.65	0.87
Sodium, mg	0.21	0.61	0.23	0.67
Potassium, mg	0.36	0.78 *	0.38	0.82 *

* Significant at $p < 0.05$.** Significant at $p < 0.01$.

ances or correlation coefficients between the two groups. For example, we need about 200 subjects to detect a difference in the observed correlation coefficients for fat between the two groups with 5% significance and 80% power. The observed correlation coefficients for energy, fat, and carbohydrate were lower in those with higher food diversity scores, although the differences were not statistically significant. Therefore, regarding these nutrients, we cannot deny the possibility that the validity of the semiquantitative FFQ is affected by greater food diversity.

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