A Simple Food Frequency Questionnaire for Japanese Diet–Part I. Development of the Questionnaire, and Reproducibility and Validity for Food Groups

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We developed a simple food frequency questionnaire (FFQ) based on one-day dietary records (DRs) among 1001 subjects in Nagoya, Japan. A total of 97 foods and dishes were selected through a two-step procedure; first by ranking food items according to the contribution to the population intake of nutrient variables, and second by stepwise multiple regression analyses of individual food items as the independent variables and of total nutrient intake as the dependent variables. For simplicity, questions on portion sizes were not included except for a few selected food items, which resulted in short time (about 20 minutes) to complete the questionnaire. This FFQ was validated for food groups by referring to four 4-day DRs among 88 men and women in central Japan, from 1996 to 1997. The energy-, sex- and age-adjusted test-retest correlation coefficients between the two FFQs administered at an one year interval ranged from 0.34 to 0.78. The de-attenuated, energy-, sex- and age-adjusted correlation coefficients between the second FFQ and the DRs were larger than 0.40 for most food groups, indicating the usefulness of this simple FFQ with its sufficient validity in epidemiological surveys.
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Food frequency questionnaires (FFQs) have been the most common method to assess food or nutrient intakes in epidemiological studies [1]. They are easy for respondents to complete as a self-administered form, and can be used at much lower cost. Moreover, FFQs can cover a longer period of time than such other methods as 24-hour recalls or short-period dietary records (DRs). In recent years, some FFQs to assess food or nutrient intakes have been proposed also in Japan [2-4]. Earlier Japanese FFQs, however, required a long list of food items, complicated questions about portion sizes, and/or a rather expensive color picture booklet of food samples. Detailed questionnaires might be required in Japan, in particular, to evaluate accurate food/nutrient intakes, because contemporary Japanese diet included a large variety of foods or dishes; traditional Japanese, Western and Chinese. Nevertheless, the complex questionnaires would be expensive to apply and also be a greater burden on subjects, which certainly discount the merits of food frequency method. Recently, some attempts have been made to develop much simpler questionnaires [5]. We, therefore, also tried to develop a simple and self-administered FFQ that would be able to assess individual diet with reasonable validity. This questionnaire was primarily developed for a case-control study of diet and bladder cancer in Japan.

Most studies on the reproducibility and validity of FFQs have been analyzed on the basis of nutrient intakes [6-12]. The reproducibility and validity for food groups [13-17] are, however, also important, since findings clarified by food group might be more directly useful to formulate dietary recommendations than those clarified by each nutrient. Such analyses may possibly detect shortcomings in FFQs, thus suggesting specific areas that should be improved at subsequent revisions of a questionnaire [1].

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We therefore conducted a validation study for both food groups and nutrients. In this communication, we will describe some processes in developing our FFQ, and its reproducibility and validity for food groups in particular. The reproducibility and validity for nutrients will be discussed in an accompanying paper [18].

MATERIALS AND METHODS

Development of the Simple Food Frequency Questionnaire

The self-administered FFQ contains questions on the average frequency of consumptions during preceding one year. These questions have 9 possible responses for most foods or dishes: less than once per month, once per month, 2-3 times per month, once per week, 2-4 times per week, 5-6 times per week, once per day, 2-3 times per day, and over 3 times per day. For simplicity, no question on usual portion size was primarily included, but for rice, alcoholic beverages and coffee, detailed questions on intake frequency and portion sizes were included.

Foods or dishes in our questionnaire were selected using a data-based approach, which used one-day DRs obtained from the participants in multiphasic health examination conducted at a worksite in Nagoya, Japan, from June 1990 to March 1993. A total of 1001 participants aged 50 years or more (679 men and 322 women, mean age±SD: 58.2±2.7 years for men and 58.9±2.1 years for women) were those used for this analysis. The subjects were instructed to fill in the dietary form for one-day DRs. They were asked to describe all foods and beverages in detail, which were consumed during one day without any special event. Dietitians directly checked the food records together with subjects during the health examination. Portion sizes were estimated by the dietitians from the records with a supplementary interview. For common dishes, dietitians defined their standard recipes and portion sizes in advance by reference to cooking books. If a participant in the health examination took a dish which is compatible with the standard recipe, it was recorded as one mixed dish using a special code. Serving size of the dish was recorded as a percentage of the standard portion size.

To select food items which should be included in the questionnaire, we applied a two-step procedure. Nutrient variables we considered were as follows; total energy, protein, fat, carbohydrate (excluding crude fiber), calcium, iron, potassium, vitamin A, retinol, carotene, vitamin D, vitamin C, saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), cholesterol, vitamin E, dietary fiber, magnesium, zinc, isoleucine, leucine, tryptophan and valine. The four amino acids were included because of their potential activities as promoters for bladder cancer [19].

First, the percent contribution to the total population intake of energy and nutrients was calculated for each food or dish, and all food items were ranked in descending order of their contribution [2,3,20]. We then selected the foods and dishes, based on their percent contribution to the consumption of the 24 nutrient variables, in order to cover 90% of the total population intake for each nutrient variable.

Second, forward stepwise multiple regression analyses were conducted to identify food items, which would be important to predict individual nutrient intake, from the items selected in the first step [6,21]. Foods or dishes were selected by the regression analysis, which treated, for each nutrient, individual food items as the independent variables and total nutrient intake as the dependent variable. Consumption in gram was included as the independent variables for individual foods, while a percentage of the standard portion size was used for mixed dishes compatible with the above-mentioned standard recipes. We applied the approach to ensure identifying foods and dishes which would be most important in discriminating individuals' nutrient intake. This means to identify food items which would be most important for ranking individuals. Food items in the model, which explained 80% of the between-person variability, were considered eligible to our questionnaire. Before and after the regression analyses, nutritionally and conceptually similar foods and dishes were eventually combined.

Since specific questions on usual portion sizes for foods/dishes were not included in our FFQ except for several items, standard portion sizes were assumed to estimate food group or nutrient intakes [7]. The standard portion sizes were determined using the one-day DRs mentioned above. Nutrient intake was calculated using the following formula for each food item: (reported consumption frequency) × (portion size in gram) × (nutrient content per 100 gram) × (seasonality factor, if any)/100. Nutrient intake was then summed up over all food items in order to obtain the intake per day. When several foods or dishes were collapsed into one, nutrient content values of the relevant items were averaged using the consumption of the items observed in the one-day DRs as weight. To compute intakes for food groups, dishes were decomposed into material foods. The FFQ (in Japanese) and the table to estimate food group or nutrient intakes are available from the corresponding author.

VALIDATION STUDY

Study Design and Subjects For the validation study, 119 subjects, aged 41 to 88 years, were recruited from the family of students/graduates of the dietitian course in Nagoya Bunri College and other universities. All the students or graduates recruited one family member (a parent or a grandparent on most occasions), except one student who did two family members.

The validation study was scheduled as illustrated in Figure 1. The study started in June 1996, when the first FFQ (FFQ1) was distributed to the subjects. Four 4-day weighed DRs

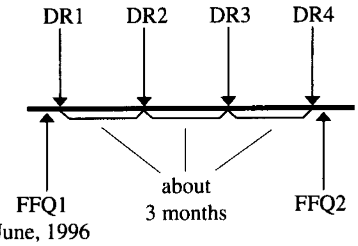

Figure 1. Schedule of the validation study.

(DR1, DR2, DR3 and DR4) were then conducted at intervals of three months, and the subjects were asked to fill in the second FFQ (FFQ2) after the final DRs. Response to FFQ1 was compared with that to FFQ2 to assess the reproducibility, and the questionnaire was validated by referring to the 16-day (four 4-day) DRs as the standard.

The dietary recording was carried out by each subject with assistance of responsible students/graduates, following the specific standardized procedure. Foods and beverages (excluding water and Japanese tea) consumed were weighed and recorded on the dietary form specifically designed for this validation study. When foods or beverages could not be weighed (for example, when eaten out), the subjects were instructed to describe the foods/beverages in detail, and the portion sizes were estimated from the description. The food records were initially coded by the students/graduates, but all of the records were thoroughly reviewed independently by two other dietitians. A dietitian telephoned responsible students/graduates to resolve ambiguities. Days with special events such as New Year's holidays were excluded from the dietary recording period.

Statistical Analysis The food records were coded according to the Japanese food composition table [22,23]. Foods were categorized to 18 food groups, and vegetables were further divided into green-yellow vegetables and others. The food composition table, supplemented by another source [24], was used to compute energy intake of the subjects.

We used Pearson and intraclass correlation coefficients between the two FFQs (FFQ1 and FFQ2) in order to assess the reproducibility for food groups. The correlations, adjusted for energy intake, sex and age, were also calculated. This adjustment was performed by computing residuals from regression models [25]. All values were $\log_e$ transformed in advance to improve their normality.

The questionnaire was validated by referring to the 16-day DRs. Pearson correlation coefficients between the FFQ and the DRs adjusted for energy intake, sex and age were computed as well as crude ones. The crude, and energy- and age-adjusted coefficients were also presented by sex.

Within-person day-to-day variations in individual intake for many food groups could be quite large and also attenuate correlations between the FFQ and the DRs. We, therefore, statistically adjusted the Pearson correlation coefficients between the two methods for this attenuation. If one day values were treated as random units of observation, as was done in the analyses for nutrients [18], population distributions of the consumption levels for food categories could not be easily approximated to normality. This is because the one day values from DRs can be considered a mixture of two different types of distribution, that is, a binomial distribution and a right-skewed (approximately log-normal) one for non-zero values [17]. Only after averaging the amounts of intake for food groups over 8 days, the population distributions could reasonably be approximated to normality by natural logarithmic transformation. Two 4-day DRs, the first and the second or the third and the final ones, were thus treated as an unit of observation when analyzing food groups. The natural logarithms of these 8-day averages were adjusted for total energy intake, sex and age by using regression models [25]. We assessed the within-person and between-person components of variance in 8-day food group intakes obtained from the DRs by one-way analysis of variance, and corrected (de-attenuated) the Pearson correlation coefficients of consumptions by food group between those based on the FFQs and those based on the DRs to take within-person variability into consideration [26]. The 95% confidence intervals of the de-attenuated coefficients were computed using the formula proposed by Rosner and Willett [26]. This de-attenuation was not made for the correlation coefficients by sex since the small sample size precluded us from estimating the sex-specific, de-attenuated coefficients with reasonable precision.

RESULTS

Development of the Simple Food Frequency Questionnaire

A total of 647 food and 168 dishes were listed from the one-day DRs. Of them, the number of food items which required to cover over 90% of the total population intake for each nutrient variable was as follows; energy 186, protein 208, fat 142, carbohydrate 119, calcium 159, iron 210, potassium 200, vitamin A 59, retinol 27, carotene 37, vitamin D 36, vitamin C 66, SFA 110, MUFA 107, PUFA 109, cholesterol 76, vitamin E 147, dietary fiber 94, magnesium 122, zinc 104, isoleucine 149, leucine 144, tryptophan 149 and valine 147. Then, we needed 357 food items to cover 90% of the total intake for energy and the nutrients.

By collapsing several similar food items into one, 281 food items were listed and included in the stepwise multiple regression analyses. The multiple regression models, accounting for R^2 of 80%, identified 209 foods or dishes to predict 80% of the between-person variability for all the 24 nutrients considered. We further combined some similar foods and dishes, and finally decided to adopt 108 items.

Ten foods or dishes that were consumed by fewer than 1% of the subjects in the one-day DRs were eliminated from the questionnaire. Although "liver" was consumed only by 9 (0.9%) subjects, we did not exclude it, since it provided as much as 23% of the total population intake of retinol. Five additional food items were also excluded, because they were considered to have extremely large seasonal variations (such as rice cake consumed primarily during New Year's holidays in Japan) or they could not be listed in the same manner as other food items (such as cooking oil). Alternatively, we included a question on intake frequency of tempura (deep-fried foods) or other fried foods in order to estimate a part of cooking oil consumption. Finally, we supplemented three alcohol beverages to assess ethanol intake, which is often required in epidemiological investigations. The 97 foods or dishes which were included in the final questionnaire were summarized in Appendix.

Reproducibility and Validity for Food Groups

Of the 119 subjects, 88 (73.9%, 46 men and 42 women) completed two FFQs and four 4-day DRs. Their mean age±standard deviation (SD) was 52.5±4.5 and 49.8±8.6 years for men and women, respectively. The mean body mass index (mean±SD, kg/m^2) was 22.5±2.7 in men and 22.5±2.4 in women. Time required to complete FFQ1 and FFQ2 (mean±SD) was 23±12 and 17±7 minutes, respectively. In the two subjects, consumption frequency was missing or less than once a month for more than two third of the listed food items in FFQ1. They were, therefore, excluded from the relevant analyses.

Mean daily consumptions for 20 food groups measured by the four 4-day DRs and by FFQs 1 and 2 are presented in Table 1. Compared with the mean daily amounts of food groups estimated from the DRs, rice, milk and dairy products, fruits, and alcoholic beverages were overestimated (>20%) on the FFQs, while underestimated (>20%) were breads, potatoes and starches, sugars and sweeteners, confectioneries, fishes and shellfishes, and seaweeds.

Table 2 shows the Pearson and intraclass correlation coefficients between FFQ1 and FFQ2. The crude Pearson correlation coefficients for food groups between the two FFQs ranged from 0.28 for eggs to 0.78 for alcoholic beverages (median=0.55). Adjustment for energy intake, sex and age provided no notable improvement of the reproducibility. The adjusted Pearson correlation coefficients ranged from 0.34 for eggs to 0.78 for breads. The intraclass correlations demonstrated almost the same values as the corresponding Pearson correlations.

Table 1. Mean daily consumption of food groups (g/day) based on four 4-day dietary records (DRs) and the first/second food frequency questionnaires (FFQ1/FFQ2).

Food group	DRs (n=88)		FFQ1 (n=86)[a]			FFQ2 (n=88)		
	Mean	SD	Mean	SD	% of DRs	Mean	SD	% of DRs
Rice	369	140	503	235	137	492	237	133
Breads	36	33	20	20	55	23	23	62
Noodles	86	52	84	63	100	90	72	105
Potatoes and starches	42	18	23	17	55	20	13	48
Sugars and sweeteners	8.4	4.5	4.0	2.1	47	3.9	2.0	47
Confectioneries	33	28	16	16	48	20	17	59
Fats and oils	11.1	4.9	11.8	5.5	106	12.2	6.6	110
Nuts and seeds	1.9	2.2	2.0	2.2	103	2.1	2.4	110
Pulses	64	37	61	34	99	64	41	100
Fishes and shellfishes	80	37	62	37	77	60	34	75
Meats	61	27	60	41	99	55	35	91
Eggs	42	18	45	29	108	44	28	105
Milk and dairy products	103	87	186	173	176	172	167	167
Vegetables	221	88	215	130	97	204	122	92
Green-yellow vegetables	79	46	91	86	115	84	68	106
Other vegetables	141	53	123	61	88	120	65	85
Fruits	88	68	147	127	164	143	115	162
Mushrooms	10.0	7.4	10.4	6.9	105	10.6	8.3	107
Seaweeds	7.1	5.6	2.5	1.9	35	2.9	3.1	40
Alcoholic beverages	137	205	209	274	158	187	251	137

a) Two subjects were excluded, because their consumption frequency was missing or less than once a month for more than 2/3 of the food items in FFQ1.

Table 2. Pearson (r) and intraclass (r_i) correlation coefficients for food groups between the two food frequency questionnaires (n=86)[a].

Food group	Crude		Adjusted for energy, sex and age	
	r	r_i	r	r_i
Rice	0.62	0.62	0.60	0.61
Breads	0.73	0.73	0.78	0.78
Noodles	0.60	0.59	0.59	0.58
Potatoes and starches	0.48	0.48	0.38	0.38
Sugars and sweeteners	0.38	0.38	0.44	0.44
Confectioneries	0.45	0.44	0.42	0.42
Fats and oils	0.67	0.66	0.74	0.73
Nuts and seeds	0.55	0.55	0.53	0.53
Pulses	0.70	0.70	0.66	0.66
Fishes and shellfishes	0.48	0.47	0.44	0.43
Meats	0.54	0.54	0.62	0.62
Eggs	0.28	0.28	0.34	0.34
Milk and dairy products	0.73	0.73	0.71	0.71
Vegetables	0.56	0.56	0.53	0.54
Green-yellow vegetables	0.53	0.53	0.49	0.49
Other vegetables	0.46	0.46	0.44	0.44
Fruits	0.77	0.77	0.77	0.77
Mushrooms	0.55	0.55	0.54	0.54
Seaweeds	0.54	0.54	0.49	0.49
Alcoholic beverages	0.78	0.77	0.70	0.70
Median	0.55	0.55	0.54	0.54

a) Two subjects were excluded, because their consumption frequency was missing or less than once a month for more than 2/3 of the food items in FFQ1. All values were $\log_e$ transformed to improve normality.

The Pearson correlation coefficients between daily consumption of food groups based on the FFQs and the four 4-day DRs are summarized in Table 3. The correlations between FFQ2 and the DRs were stronger than those between FFQ1 and the food records. When adjusting for energy intake, sex and age, the correlations were slightly improved only for those between the second FFQ and the DRs. The de-attenuated, energy, sex and age-adjusted coefficients between FFQ1 and the DRs ranged from 0.19 for sugars and sweeteners or vegetables other than green-yellow ones to 0.71 for milk and dairy products or fruits (median=0.45), while those between FFQ2 and the DRs ranged from 0.16 for potatoes and starches to 0.83 for milk and dairy products (median=0.56).

Table 4 presents the sex-specific Pearson correlation coefficients between daily consumption of food groups based on the FFQs and the four 4-day DRs. In males, the energy and age-adjusted (but not de-attenuated) coefficients between FFQ2 and the DRs ranged from 0.09 for potatoes and starches or seaweeds to 0.75 for milk and dairy products (median=0.43). In females, they ranged from 0.09 for potatoes and starches to 0.69 for milk and dairy products (median=0.45). The coefficient for breads was higher in males than in females, while those for vegetables and meats were lower in males.

DISCUSSION

Development of the Simple Food Frequency Questionnaire

In developing the food list as simple as possible in our FFQ, we used a two-step procedure to select food items. The foods and dishes, which were initially selected based on their percent contribution to the population intake of energy or nutrients, could be further reduced in number by about 25% by using the stepwise regression analyses. As many as 97 food items, however, had to be included in the final FFQ, though much more limited food lists have been developed for FFQs in Western countries [6,7,27]. This might be primarily due to a large variety of modern Japanese diets. In particular, the sources of energy, protein, iron and potassium were widely distributed over many foods and dishes in the present analyses.

To add specific questions on portion sizes will double the number of questions in the FFQ, and impose greater burden on subjects. Among Western populations, individual estimation of portion sizes has not necessarily improved the validity of FFQs to substantial degree [15,28]. This might indicate that portion sizes themselves are of minor significance compared with frequencies or that the individual portion sizes could not be estimated correctly. In fact, a simple FFQ with no portion size question, which was developed by Pietinen et al. [7], could estimate energy-adjusted nutrient intake with reasonable validity.

These were the reasons why we did not include questions on portion sizes in our FFQ for most of the food items; resulting in shortening the time required to complete the questionnaire as well as the FFQ itself.

Reproducibility and Validity for Food Groups

The correlations between FFQ2 and the DRs were stronger than those between FFQ1 and the food records. This should be conceptually appropriate, because the FFQ refers to the diet during preceding one year and the DRs was carried out between FFQ1 and FFQ2.

In our validation study for food groups, the correlation coefficients between intakes estimated by the FFQs and the DRs were adjusted for energy intake. It has been extensively discussed that nutrient intakes should be adjusted for energy in epidemiological analyses. Intakes of most nutrients tend to be positively associated with total caloric intake. Specific nutrients may be associated with disease simply due to their correlation with energy intake. If only crude values are used, therefore, it may be unclear whether an association of a given nutrient intake with a disease is attributable to the nutrient *per se*. These arguments seem to be true also for food group intakes since most of them are positively related to total amount of food consumption, which is well represented by total energy intake. Thus, food group intakes adjusted for caloric intake

Table 3. Pearson correlation coefficients (r) between daily consumption of food groups based on food frequency questionnaires (FFQs) and four 4-day dietary records (DRs)[a].

	FFQ1 vs. four 4-day DRs (n=86)[b]					FFQ2 vs. four 4-day DRs (n=88)				
	Crude	Adjusted for energy, sex and age				Crude	Adjusted for energy, sex and age			
	r	r	σ_w^2/σ_b^2[c]	r*[d]	95% CI[e]	r	r	σ_w^2/σ_b^2	r*	95% CI
Rice	0.70	0.62	0.28	0.66	(0.50 – 0.78)	0.76	0.63	0.30	0.67	(0.51 – 0.79)
Breads	0.63	0.60	0.32	0.65	(0.48 – 0.77)	0.60	0.60	0.32	0.64	(0.47 – 0.77)
Noodles	0.23	0.25	1.08	0.31	(0.04 – 0.53)	0.37	0.34	1.06	0.42	(0.17 – 0.63)
Potatoes and starches	0.19	0.16	3.64	0.27	(-0.11 – 0.59)	0.10	0.10	3.57	0.16	(-0.19 – 0.48)
Sugars and sweeteners	0.16	0.16	1.00	0.19	(-0.07 – 0.43)	0.13	0.18	0.99	0.22	(-0.03 – 0.45)
Confectioneries	0.43	0.37	0.79	0.44	(0.20 – 0.63)	0.38	0.34	0.78	0.40	(0.16 – 0.60)
Fats and oils	0.28	0.39	0.72	0.46	(0.22 – 0.64)	0.48	0.53	0.71	0.62	(0.41 – 0.77)
Nuts and seeds	0.50	0.45	2.82	0.70	(0.21 – 0.91)	0.33	0.37	2.74	0.57	(0.17 – 0.81)
Pulses	0.44	0.52	1.71	0.70	(0.37 – 0.88)	0.52	0.59	1.54	0.79	(0.45 – 0.93)
Fishes and shellfishes	0.22	0.27	0.78	0.31	(0.07 – 0.52)	0.32	0.27	0.78	0.32	(0.07 – 0.53)
Meats	0.46	0.51	0.47	0.56	(0.36 – 0.72)	0.44	0.51	0.48	0.57	(0.37 – 0.72)
Eggs	0.30	0.38	0.80	0.45	(0.21 – 0.64)	0.39	0.47	0.82	0.56	(0.33 – 0.73)
Milk and dairy products	0.68	0.65	0.37	0.71	(0.55 – 0.82)	0.76	0.76	0.39	0.83	(0.69 – 0.91)
Vegetables	0.23	0.30	0.40	0.33	(0.11 – 0.53)	0.34	0.46	0.41	0.50	(0.30 – 0.66)
Green-yellow vegetables	0.36	0.38	0.62	0.43	(0.20 – 0.62)	0.46	0.50	0.62	0.58	(0.37 – 0.73)
Other vegetables	0.10	0.16	0.77	0.19	(-0.06 – 0.42)	0.21	0.30	0.77	0.36	(0.12 – 0.56)
Fruits	0.60	0.61	0.72	0.71	(0.50 – 0.84)	0.63	0.68	0.75	0.80	(0.60 – 0.90)
Mushrooms	0.43	0.42	1.46	0.55	(0.26 – 0.75)	0.38	0.35	1.46	0.46	(0.17 – 0.67)
Seaweeds	0.23	0.21	2.90	0.33	(-0.03 – 0.62)	0.12	0.15	2.94	0.24	(-0.10 – 0.53)
Alcoholic beverages	0.74	0.62	0.40	0.68	(0.51 – 0.80)	0.71	0.57	0.39	0.63	(0.45 – 0.76)
Median	0.39	0.39		0.45		0.39	0.46		0.56	

a) Two 4-day dietary records, the first and second ones or the third and final ones, were treated as an unit of observation in the analysis for food groups. All values were $\log_e$ transformed to improve normality.

b) Two subjects were excluded, because their consumption frequency was missing or less than once a month for more than 2/3 of the food items in FFQ1.

c) Ratio of the within-person to the between-person variance components of food group intake from the two 2×4-day dietary records.

d) r*: de-attenuated correlation coefficient.

e) CI: confidence interval.

would be useful in epidemiological investigations and therefore also in validation studies for FFQs. Dietary advice often begins with determining one's optimal energy intake and is followed by considering the best composition of his/her diet. Thus, calorie-adjusted food group intakes might be relevant also from a practical point of view.

We also adjusted the coefficients for sex and age. This is because these variables are almost always controlled in epidemiological analyses [1]. Between-person variation in dietary intake due to sex and age would increase the observed correlations between diet and disease in epidemiological studies, but this increased correlations are removed in the analyses adjusting for sex and age. It will be necessary, therefore, to present the coefficients adjusted for these covariates to validate a FFQ for nutritional epidemiology. We also presented sex-specific correlations since epidemiological data are often analyzed by sex.

We averaged food group intakes over 8 days, and treated their natural logarithms parametrically, that is, regarded them as normally distributed variables. Most of the food group intakes could reasonably be approximated to normality after these transformations, but some deviations from normal distribution were still observed for breads, confectioneries, nuts and seeds, and alcoholic beverages. We therefore computed Spearman's rank correlation coefficients between daily intakes based on the FFQs and the four 4-day DRs for the four food groups, and got figures similar to the crude Pearson correlation coefficients shown in Table 3. The methodological limitation, however, should be kept in mind when interpreting the adjusted or de-attenuated coefficients for these food groups.

The correlation coefficients for reproducibility and validity for food groups were not so high as those observed in previous studies [13-17]. The correlation between the FFQs and the DRs was found to be considerably weak in such food groups as potatoes and starches, sugars and sweeteners, and seaweeds. This might be ascribable to the small number of food items

Table 4. Pearson correlation coefficients (r) between daily consumption of food groups based on food frequency questionnaires (FFQs) and four 4-day dietary records (DRs) by sex[a].

	FFQ1 vs. four 4-day DRs (n=86)				FFQ2 vs. four 4-day DRs (n=88)			
	Males (n=44)[b]		Females (n=42)		Males (n=46)		Females (n=42)	
	Crude	Adjusted for energy and age	Crude	Adjusted for energy and age	Crude	Adjusted for energy and age	Crude	Adjusted for energy and age
	r	r	r	r	r	r	r	r
Rice	0.72	0.71	0.61	0.51	0.67	0.54	0.74	0.65
Breads	0.70	0.69	0.50	0.41	0.71	0.71	0.35	0.35
Noodles	0.25	0.31	0.16	0.20	0.51	0.59	0.12	0.11
Potatoes and starches	0.26	0.27	0.07	0.03	0.04	0.09	0.15	0.09
Sugars and sweeteners	0.09	0.13	0.34	0.22	0.06	0.13	0.30	0.27
Confectioneries	0.51	0.47	0.25	0.27	0.33	0.34	0.39	0.37
Fats and oils	0.29	0.38	0.34	0.37	0.34	0.49	0.57	0.57
Nuts and seeds	0.37	0.35	0.63	0.60	0.42	0.47	0.24	0.22
Pulses	0.36	0.44	0.66	0.65	0.45	0.54	0.66	0.66
Fishes and shellfishes	0.33	0.31	0.25	0.21	0.22	0.16	0.33	0.33
Meats	0.18	0.18	0.64	0.63	0.13	0.36	0.59	0.61
Eggs	0.55	0.58	0.10	0.14	0.46	0.49	0.41	0.42
Milk and dairy products	0.61	0.61	0.76	0.73	0.76	0.75	0.68	0.69
Vegetables	0.11	0.09	0.40	0.52	0.23	0.31	0.43	0.52
Green-yellow vegetables	0.22	0.20	0.51	0.59	0.36	0.39	0.53	0.57
Other vegetables	-0.02	-0.06	0.30	0.41	0.04	0.12	0.33	0.42
Fruits	0.61	0.60	0.56	0.56	0.65	0.67	0.57	0.66
Mushrooms	0.42	0.40	0.47	0.50	0.31	0.28	0.48	0.48
Seaweeds	0.21	0.15	0.29	0.27	0.09	0.09	0.20	0.18
Alcoholic beverages	0.72	0.71	0.46	0.46	0.59	0.55	0.54	0.62
Median	0.34	0.37	0.43	0.44	0.35	0.43	0.42	0.45

a) Two 4-day dietary records, the first and second ones or the third and final ones, were treated as an unit of observation in the analysis for food groups. All values were $\log_e$ transformed to improve normality.

b) Two subjects were excluded, because their consumption frequency was missing or less than once a month for more than 2/3 of the food items in FFQ1.

included in the questionnaire for these food groups. Only small proportion of these food groups was seemingly covered by our FFQ, as indicated by the low mean intake (less than 50% of the DRs) based on the FFQ. In general, intakes of food groups had to be considered when selecting food items which should be included in FFQs, as so were that of nutrient variables in order to increase the validity at food group level.

Some foods were collapsed into one question, in particular, for potatoes and starches, fishes, and seaweeds. For example, we asked how often "potatoes (white potato, taro and sweet potato)" were eaten during preceding one year. These "combined" questions might be difficult to answer [1] and might result in lower reproducibility and validity.

Consumption of rice or milk and dairy products were overestimated by more than 30% (Table 1), though estimates derived from the FFQ showed excellent correlations with intakes based on the DRs for these food groups. Contrary to our expectation, it was not easy to standardize portion sizes of rice and milk. Four serving sizes for rice (small, medium and large rice bowls ("chawan"), and a China bowl ("donburi")) were listed in our FFQ. These serving sizes corresponded well to the actual distribution of portions appeared in the DRs. Nevertheless, the participants did not necessarily select appropriate portion sizes in the FFQ; the responses showed an overconcentration into medium rice bowls and small ones in males and females, respectively. Intelligible description of portions including pictures would be required to estimate rice consumption more precisely. Rice in some mixed dishes may be more difficult to be quantified with FFQs than rice itself and therefore might also be overestimated.

The standard portion size for milk had been determined to be 200 gram. In fact, milk was most frequently consumed by 200 gram in the validation study, reflecting the Japanese size of bottled milk. Milk was, however, often drunk also by less than 200 gram perhaps in a glass or cup, while only rarely consumed by more than 200 gram. The resulting overestimation in intake may be ascribable to limitations of FFQs without questions on portion sizes. Other dairy products had more various portions and it would not be easy to determine "standard" serving sizes.

The validity of our FFQ for vegetables and meats was poorer in males than in females. This may be because these foods are frequently included in mixed dishes. Men are not so likely to cook their own meals in Japan, and it would be difficult for those who do not cook to tell how often vegetables and meats are used in mixed dishes. Pure dish-based FFQs [2] would be required to improve the validity for these groups of foods in males.

Another issue in our FFQ is that the standard recipes for mixed dishes were defined by dietitians, and therefore might be different from those for dishes eaten by the target populations. Dish databases based on actual dietary records or recalls should be prepared to improve validity of the FFQ.

The above-mentioned weakness of our FFQ, which was suggested by the validation study, should be taken into account when developing subsequent questionnaires. Nevertheless, the de-attenuated, energy-, sex- and age-adjusted correlation coefficients between FFQ2 and the four 4-day DRs were larger than 0.40 for most food groups; indicating usefulness of our simple FFQ when ranking respondents according to food group consumption in epidemiological surveys among the middle-aged and the elderly.

In summary, we developed a simple FFQ based on one-day DRs. A total of 97 foods and dishes were selected through a two-step procedure; first by ranking food items according to the contribution to the population intake of energy and nutrients, and second by stepwise multiple regression analyses of individual food items as the independent variables and of total nutrient intake as the dependent variable. For simplicity, questions on portion sizes were not included except for a few selected food items; resulting in short time to complete the questionnaire. The FFQ was validated for food groups by referring to four 4-day DRs. The correlation coefficients between the FFQ and the DRs were larger than 0.40 for most food groups; indicating the usefulness of our FFQ with its sufficient validity in epidemiological studies among the middle-aged and the elderly in Japan.

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REFERENCES

Willett W. Nutritional Epidemiology. Oxford University Press, New York, 1990.

1. Willett W. Nutritional Epidemiology. Oxford University Pree, New York, 1990.
2. Date C, Yamaguchi M, Tanaka H. Development of a food frequency questionnaire in Japan. J Epidemiol, 1996; 6(suppl.): S131-S136.
3. Tsubono Y, Takamori S, Kobayashi M, et al. A data-based approach for designing a semiquantitative food frequency questionnaire for a population-based prospective study in Japan. J Epidemiol, 1996; 6: 45-53.
4. Shimizu H. A basic report on Takayama study. Department of Public Health, Gifu University School of Medicine, Gifu, Japan, 1996.
5. Takatsuka N, Kurisu Y, Nagata C, et al. Validation of simplified diet history questionnaire. J Epidemiol, 1997; 7: 33-41.
6. Willett WC, Sampson L, Stampfer MJ, et al. Reproducibility and validity of a semiquantitative food frequency questionnaire. Am J Epidemiol, 1985; 122: 51-65.
7. Pietinen P, Hartman AM, Haapa E, et al. Reproducibility and validity of dietary assessment instruments: II. a qualitative food frequency questionnaire. Am J Epidemiol, 1988; 128: 667-676.
8. Tjønneland A, Overvad K, Haraldsdōttir J, et al. Validation of a semiquantitative food frequency questionnaire developed in Denmark. Int J Epidemiol, 1991; 20: 906-912.
9. Rimm EB, Giovannucci EL, Stampfer MJ, et al. Reproducibility and validity of an expanded self-administered semiquantitative food frequency questionnaire among male health professionals. Am J Epidemiol, 1992; 135: 1114-1126.
10. Block G, Thompson FE, Hartman AM, Larkin FA, Guire KE. Comparison of two dietary questionnaires validated against multiple dietary records collected during a 1-year period. J Am Diet Assoc, 1992; 92: 686-693.
11. Callmer E, Riboli E, Saracci R, Åkesson B, Lindgärde F. Dietary assessment methods evaluated in the Malmö food study. J Intern Med, 1993; 233: 53-57.
12. Jain M, Howe GR, Rohan T. Dietary assessment in epidemiology: comparison of a food frequency and a diet history questionnaire with a 7-day food record. Am J Epidemiol, 1996; 143: 953-960.

13. Pietinen P, Hartman AM, Haapa E, et al. Reproducibility and validity of dietary assessment instruments: I. a self-administered food use questionnaire with a portion size picture booklet. Am J Epidemiol, 1988; 128: 655-666.
14. Hankin JH, Wilkens LR, Kolonel LN, Yoshizawa CN. Validation of a quantitative diet history method in Hawaii. Am J Epidemiol, 1991; 133: 616-628.
15. Tjønneland A, Haraldsdóttir J, Overvad K, et al. Influence of individually estimated portion size data on the validity of a semiquantitative food frequency questionnaire. Int J Epidemiol, 1992; 21: 770-777.
16. Männistö S, Virtanen M, Mikkonen T, Pietinen P. Reproducibility and validity of a food frequency questionnaire in a case-control study on breast cancer. J Clin Epidemiol, 1996; 49: 401-409.
17. Kaaks R, Slimani N, Riboli E. Pilot phase studies on the accuracy of dietary intake measurements in the EPIC project: overall evaluation of results. Int J Epidemiol, 1997; 26(suppl. 1): S26-S36.
18. Egami I, Wakai K, Kato K, et al. A simple food frequency questionnaire for Japanese diet: Part II. reproducibility and validity for nutrient intakes. J Epidemiol, 1999; 9: 227-234.
19. Nishio Y, Kakizoe T, Ohtani M, et al. L-isoleucine and L-leucine: tumor promoters of bladder cancer in rats. Science, 1986; 231: 843-845.
20. Block G, Hartman AM, Dresser CM, et al. A data-based approach to diet questionnaire design and testing. Am J Epidemiol, 1986; 124: 453-469.
21. Byers T, Marshall J, Fiedler R, Zielezny M, Graham S. Assessing nutrient intake with an abbreviated dietary interview. Am J Epidemiol, 1985; 122: 41-50.
22. Committee on Resources, Science Bureau of Japan. Standard tables of food composition in Japan, 4th ed. Printing Office, Ministry of Finance, Tokyo, 1983.
23. Committee on Resources, Science Bureau of Japan. Standard tables of food composition in Japan, 5th ed. (for new foods). Printing Office, Ministry of Finance, Tokyo, 1997.
24. Kagawa Y. Composition table for processed foodstuffs. Kagawa Nutrition University Publishers, Tokyo, 1995.
25. Willett W, Stampfer MJ. Total energy intake: implications for epidemiologic analyses. Am J Epidemiol, 1986; 124: 17-27.
26. Rosner B, Willett WC. Interval estimates for correlation coefficients corrected for within-person variation: implications for study design and hypothesis testing. Am J Epidemiol, 1988; 127: 377-386.
27. Decarli A, Franceschi S, Ferraroni M, et al. Validation of a food-frequency questionnaire to assess dietary intakes in cancer studies in Italy: results for specific nutrients. Ann Epidemiol, 1996; 6: 110-118.
28. Hernandez-Avila M, Master C, Hunter DJ, et al. Influence of additional portion size data on the validity of a semiquantitative food frequency questionnaire (abstract). Am J Epidemiol, 1988; 128: 891.

Appendix. Foods and dishes included in the food frequency questionnaire.

Cereals	
1	rice
2	pilaf, Chinese fried rice
3	curry and rice, rice with hashed meat
4	bowl of rice topped with a chopsuey-like mixture, Japanese pilaf
5	bowl of rice topped with pork cutlets/chiken and egg/beef, etc.
6	sushi
7	rice ball
8	breads
9	Japanese noodles (udon, soba, somen and hiyamugi)
10	Chinese noodles in soup (lamian)
11	chow mein
12	spaghetti, macaroni
Eggs and dairy products	
13	egg, egg dishes
14	corn cream soup, white stew
15	milk
16	yogurt
17	cheeses
Pulses	
18	miso (soybean paste) soup
19	mapo tofu (bean curd mixed with Chinese meat and chili sauce)
20	boiled or chilled tofu (bean curd)
21	fried bean curd
22	nattou (fermented soybeans)
23	boiled soybeans
Meats	
24	liver
25	gyoza (jiaozi)
26	other minced meat dishes (hamburg steak, meatball, minced meat cutlet, etc.)
27	beefsteak, roast beef
28	other beef dishes (sukiyaki, vegetables fried with beef, potatoes and beef, etc.)
29	breaded pork cutlet, pork fillet steak, pork cutlet on a skewer
30	sautéed pork
31	other pork dishes (vegetables fried with pork, sweet-and-sour pork, etc.)
32	roast pork
33	ham, sausage, bacon
34	deep-fried chicken
35	other chicken dishes (roast chicken, chicken broiled with soy sauce, etc.)
Fishes and shellfishes	
36	canned tuna
37	salmon, trout
38	horse mackerel (including dried one)
39	Pacific saury, mackerel, sardine, yellowtail
40	fishes with red flesh (tuna, marlin/swordfish, bonito, etc.)
41	fishes with white flesh (cod, flatfish, etc.)
42	eel
43	small fishes eaten bones and all (dried sardine, smelt, dried young sardines, etc.)
44	cod roe, herring roe
45	cuttlefish, prawn/shrimp, fried prawn
46	oyster, fried oyster (in season)
47	other shellfishes (asari, shijimi, clam, scallop, etc.)
48	fish paste products (kamaboko, chikuwa, hanpen, etc.)

Continued

Potatoes		
	49	mashed potatoes
	50	croquette
	51	potatoes (white potato, taro, sweet potato)
Green-yellow vegetables		
	52	tomato juice, vegetable juice
	53	tomato
	54	carrot
	55	pumpkin
	56	spinach
	57	greens other than spinach (komatsuna, shungiku, leaves of Japanese raddish, etc.)
	58	green pepper
	59	broccoli
Light-colored vegetables		
	60	grated radish
	61	Japanese radish (excluding grated radish)
	62	burdock
	63	lotus root
	64	cabbage, lettuce, cucumber
	65	Chinese cabbage
	66	eggplant
	67	string beans
	68	pickles
mushrooms		
	69	mushrooms (shiitake, shimeji, enokitake, etc.)
Seaweeds		
	70	hijiki, wakame, kombu (excluding those in miso soup)
Fruits		
	71	citrus fruits (mandarin, orange, grapefruit, etc.)
	72	apple
	73	strawberry (in season)
	74	persimmon (in season)
	75	kiwi fruit
	76	banana
	77	other fruits
Confectioneries		
	78	rice cakes
	79	peanuts
	80	cracker, cookie
	81	cake, sponge cake, Japanese cakes
Miscellaneous		
	82	deep-fried foods, tempura
	83	butter for breads, etc.
	84	margarine for breads, etc.
	85	jam, honey for breads, etc.
	86	dressing
	87	mayonnaise
	88	soy sauce
	89	Worcester sauce
	90	sesame
Beverages		
	91	sake (rice wine)
	92	beer
	93	wine
	94	whiskey
	95	shochu (liquor distilled from sweet potatoes, rice, buckwheat, etc.)
	96	other alcoholic beverages
	97	coffee