A Simple Food Frequency Questionnaire for Japanese Diet-Part II. Reproducibility and Validity for Nutrient Intakes.

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A self-administered 97-item simple food frequency questionnaire (FFQ), without portion size questions for most items, was completed twice at an one-year interval by 88 men and women in central Japan to evaluate its reproducibility. This FFQ was further validated by referring to four 4-day weighed dietary records (DRs) which were performed at 3-month intervals. Mean energy and 18 nutrient intakes measured by the first and the second FFQs were quite similar to those measured by the DRs. In our reproducibility study, Pearson and intraclass correlation coefficients, adjusted for energy intake, sex and age, ranged from 0.48 to 0.82 (median =0.67). In the validation study, adjusted and de-attenuated correlation coefficients between the second FFQ and the DRs ranged from 0.42 for iron to 0.83 for calcium (median=0.61). The proportion of subjects classified by the FFQ into the same or adjacent quintiles defined by the DRs was between 65.9% and 83.0% (median=69.9%). These findings essentially suggested that our FFQ is well reproducible and sufficiently valid, and therefore, reasonably useful for nutritional epidemiological studies for Japanese diets, particularly for those of Tokai Area. *J Epidemiol*, 1999 ; 9 : 227-234.

reproducibility, validity, nutrient, food frequency questionnaire, Japan

Food frequency questionnaires (FFQs) have been commonly used in nutritional epidemiology to assess individual intakes of food and nutrients. They can easily cover a larger period than dietary records (DRs) or recalls at much lower cost even in large populations[1].

However, since FFQs would be less valid than detailed DRs, then energy and nutrient intakes, when estimated by a certain FFQ, should usually be validated[1-6]. Only a few validation study for FFQs, however, have been conducted in Japan[7-9]. Recently, we have developed a self-administered, 97-item simple food frequency questionnaire (FFQ), without portion size questions for most items, for epidemiological survey in the middle-aged and the older[10]. In the present study, we aimed to assess reproducibility and validity of this FFQ in terms of nutrients.

MATERIALS AND METHODS

Study Design and Subjects

The design of this validation study has been described in the preceding paper[10]. In short, 119 subjects aged 41 to 88 years, were recruited from the family members of students/graduates of the dietitian course. They completed our self-administered FFQ twice at an one-year interval in order to evaluate the reproducibility (the first and the second FFQ are denoted hereafter as FFQ1 and FFQ2). Along with this reproducibility study, the FFQ was validated by referring to four 4-day weighed dietary records (DRs) which were performed at 3-month intervals. Of the 119 subjects, 88 (73.9%, 46 men and 42 women) completed the two FFQs and the four 4-day DRs, and were included in the analysis.

The FFQ was designed to assess diets during preceding one year, and to rank individuals according to their nutrient intakes.

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The FFQ listed 97 items of foods and dishes, with 9 possible responses to be selected according to subjects' intake frequency[10].

Portion sizes were not asked except for rice, alcoholic beverages and coffee in order to simplify the FFQ, and standard portion sizes were assumed for other food items when calculating energy and nutrient intakes.

STATISTICAL METHODS

The dietary records were coded according to the Japanese food composition table[11,12]. When nutrient contents in some foods were not listed in the table, they were determined as follows. For magnesium and zinc, we referred to the Table of Trace Element Contents in Japanese foodstuffs[13]. Dietary fiber was estimated according to the method by Watanabe et al[14]. Saturated fatty acids, monounsaturated and polyunsaturated fatty acids, cholesterol and vitamin E were calculated in proportion to total fat of similar foods which compositions for these nutrients were available in the Japanese food composition table[11,12]. Moreover, energy and nutrients of common processed foodstuffs were drawn from the Composition Table for Processed Foodstuffs[15].

When the subjects could not weigh foods in dishes (for example, when eaten out), they were instructed to describe the foods in detail, and we estimated portion sizes from the description. Even foods in a dish could not be identified, the participants recorded name of the dish and an approximate serving size. In this case, foods and their portions in the dish were estimated based on the common dish database developed by dietitians at the Nagoya City Personnel Health Management Center (unpublished).

In the present study, vitamin D and four amino acids (isoleucine, leucine, tryptophan and valine) were not included, since detailed food composition tables for these nutrients were not available in Japan.

Means and standard deviations were computed for energy and nutrient intakes from both the FFQs and the DRs. We used Pearson and intraclass correlations in order to assess the reproducibility for nutrients.

In analyzing data from a validation study, it is important to adjust nutrient intakes for such covariates as sex and age that are ultimately controlled in epidemiological analyses. The reason is that the between-person variation due to the covariates in dietary intake tends to increase observed correlations between FFQs and DRs[1]. Therefore, the correlation coefficients adjust-

Table 1. Mean daily intakes of energy and nutrients based on four 4-day dietary records (DRs) and the FFQ at the beginning (FFQ1) and the end (FFQ2) of validation study.

Nutrient	DRs (n=88)		FFQ1 (n=86)[a]			FFQ2 (n=88)		
	Mean	SD	Mean	SD	% of DRs	Mean	SD	% of DRs
Energy (kcal)	1864	367	1988	541	107	1990	571	107
Protein (g)	69.8	14.9	70.8	21.1	101	69.9	22.1	100
Fat (g)	52.4	13.9	53.3	19.8	102	53.1	19.7	101
Carbohydrate (g)	255.0	53.2	274.5	85.5	108	275.7	84.5	108
Calcium (mg)	456	139	529	258	116	521	283	114
Iron (mg)	9.5	2.2	9.6	3.2	102	9.7	3.3	103
Potassium (mg)	2329	583	2588	938	111	2549	993	109
Vitamin A (IU)	2604	1404	2683	1429	103	2666	1371	102
Retinol (μ g)	330	299	403	273	122	406	286	123
Carotene (μ g)	2658	1477	2361	1584	89	2311	1408	87
Vitamin C (mg)	87	35	123	88	142	118	77	137
SFA (g)[b]	14.0	4.1	14.9	6.4	107	14.7	6.3	105
MUFA (g)[b]	19.3	5.6	19.2	7.5	100	19.1	7.4	99
PUFA (g)[b]	13.4	3.6	13.3	4.7	99	13.5	4.6	101
Cholesterol (mg)	350	119	346	163	99	336	159	96
Vitamin E (mg)	8.0	2.0	8.1	2.9	102	8.2	3.0	103
Dietary fiber (g)	13.2	3.6	12.3	5.0	94	12.7	5.2	97
Magnesium (mg)	218	51	266	81	122	265	87	121
Zinc (μ g)	7741	1990	9114	2822	118	8828	2743	114

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.

b) SFA: saturated fatty acids, MUFA: monounsaturated fatty acids, PUFA: polyunsaturated fatty acids.

ed for energy intake, sex and age were also calculated. These covariates were adjusted by using the residuals from regression models[16]. All energy and nutrient intakes were natural-log transformed before analysis to improve their normality.

We used Pearson correlations for validating the FFQ by referring to the four 4-day DRs. Both crude and adjusted (adjusted for energy intake, sex and age by using regression models[16]) coefficients were computed. These coefficients were also presented by sex. Within-person variations in daily intake might attenuate correlations between the two methods. We, therefore, used the within- and between-person components of variation in the DR intake, treating one-day record as a random unit of observation to "de-attenuate" the correlations[17]. One-way analysis of variance was adopted to separate the between- and within-person variance components. The 95% confidence intervals of the de-attenuated coefficients were obtained by the method of Rosner and Willett[17]. 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.

To evaluate misclassification in detail, subjects were separately categorized into quintiles by energy-, sex- and age-adjusted nutrient intakes based on the DRs and by the second FFQ as well. The proportion of subjects, who were classified into the same quintile, within one quintile, and into the extreme quintiles, was used, when assessing the degree of misclassification.

RESULTS

Table 1 presents the mean daily intakes of energy and nutrients estimated from the DRs and the two FFQs. The intakes of energy and most nutrients estimated from FFQ1 and FFQ2 were similar to those measured by the DRs (89-142% of the DRs for FFQ1, and 87-137% for FFQ2). Intakes of retinol, vitamin C and magnesium, however, were overestimated by more than 20%.

Crude Pearson correlation coefficients between FFQ1 and FFQ2 ranged from 0.41 for cholesterol to 0.76 for calcium (Table 2). The correlation coefficients, adjusted for energy

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

Nutrient	Crude		Adjusted for energy intake, sex and age	
	r	r_i	r	r_i
Energy	0.58	0.58		
Protein	0.52	0.52	0.65	0.65
Fat	0.58	0.58	0.74	0.74
Carbohydrate	0.58	0.58	0.53	0.54
Calcium	0.76	0.76	0.82	0.82
Iron	0.62	0.62	0.69	0.69
Potassium	0.66	0.66	0.71	0.71
Vitamin A	0.56	0.56	0.59	0.60
Retinol	0.56	0.56	0.61	0.61
Carotene	0.53	0.53	0.48	0.48
Vitamin C	0.66	0.66	0.68	0.69
SFA[b]	0.63	0.63	0.79	0.79
MUFA[b]	0.57	0.57	0.69	0.70
PUFA[b]	0.61	0.61	0.66	0.66
Cholesterol	0.41	0.41	0.51	0.51
Vitamin E	0.58	0.58	0.62	0.62
Dietary fiber	0.67	0.67	0.73	0.73
Magnesium	0.68	0.67	0.69	0.68
Zinc	0.49	0.49	0.52	0.52
Median	0.58	0.58	0.67	0.67

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 energy and nutrient intakes were $\log_e$ transformed to improve normality.

b) SFA:saturated fatty acids, MUFA: monounsaturated fatty acids, PUFA: polyunsaturated fatty acids.

intake, sex and age, ranged between 0.48 (carotene) and 0.82 (calcium). Intraclass correlation coefficients showed almost the same values as the Pearson correlation coefficients.

Table 3 summarizes Pearson correlation coefficients between daily energy and nutrient intakes estimated from the FFQs and those measured by the DRs. For FFQ1, crude Pearson correlation coefficients ranged from 0.14 for protein to 0.52 for carbohydrate and calcium (median=0.32). Adjusted and de-attenuated correlation coefficients ranged from 0.29 for protein to 0.70 for calcium (median=0.53). For FFQ2, crude Pearson correlation coefficients ranged from 0.20 for iron to 0.56 for calcium (median=0.39). Adjusted and de-attenuated Pearson correlation coefficients ranged from 0.42 for iron to 0.83 for calcium (median=0.61).

Table 4 shows Pearson correlation coefficients between daily intakes of energy and nutrients based on the FFQs and the DRs by sex. For FFQ2, crude Pearson correlation coefficients in males ranged from -0.04 for iron to 0.52 for calcium (median=0.33), and so did those adjusted for energy and age from 0.12 for iron to 0.73 for saturated fatty acids (median=0.51). Corresponding crude correlation coefficients in females ranged from 0.31 for cholesterol to 0.63 for calcium (median=0.41), while so did the adjusted ones from 0.35 for cholesterol to 0.78 for calcium (medeian=0.51).

Table 5 summarizes the proportions of subjects classified into quintiles of the adjusted nutrient intakes, which were estimated from FFQ2 and from the DRs. For 18 nutrients, the proportion of subjects who were classified into the same or adjacent quintiles ranged from 65.9% for iron, vitamin A and zinc, to 83.0 % for calcium (median=69.9%). Only a small proportion of subjects, 3.4% at most, were misclassified into the extreme quintiles.

DISCUSSION

Our FFQ was found to be sufficiently comparable with those

Table 3. Pearson correlation coefficients (r) between daily intakes of energy and nutrients based on food frequency questionnaires (FFQ1 and FFQ2) and those based on four 4-day dietary records (DRs)[a].

Nutrient	FFQ1 vs. DRs (n=86)[b]					FFQ2 vs. DRs (n=88)				
	Crude	Adjusted for energy intake, sex and age				Crude	Adjusted for energy intake, 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
Energy	0.41					0.47				
Protein	0.14	0.27	3.02	0.29	(0.08 – 0.50)	0.28	0.42	3.08	0.46	(0.27 – 0.64)
Fat	0.28	0.53	2.52	0.57	(0.38 – 0.71)	0.36	0.60	2.55	0.64	(0.47 – 0.76)
Carbohydrate	0.52	0.41	1.75	0.43	(0.22 – 0.60)	0.53	0.49	1.82	0.52	(0.33 – 0.67)
Calcium	0.52	0.66	1.81	0.70	(0.53 – 0.79)	0.56	0.78	1.87	0.83	(0.70 – 0.89)
Iron	0.21	0.41	2.52	0.44	(0.23 – 0.61)	0.20	0.39	2.56	0.42	(0.21 – 0.59)
Potassium	0.32	0.52	1.40	0.54	(0.36 – 0.68)	0.44	0.67	1.44	0.70	(0.56 – 0.80)
Vitamin A	0.37	0.50	4.43	0.56	(0.35 – 0.71)	0.41	0.47	4.53	0.54	(0.32 – 0.69)
Retinol	0.50	0.58	6.99	0.69	(0.47 – 0.83)	0.44	0.52	5.95	0.61	(0.39 – 0.76)
Carotene	0.35	0.42	4.47	0.48	(0.25 – 0.65)	0.38	0.40	4.51	0.45	(0.22 – 0.62)
Vitamin C	0.37	0.43	3.30	0.47	(0.26 – 0.64)	0.46	0.55	3.35	0.61	(0.42 – 0.74)
SFA[f]	0.43	0.62	2.83	0.67	(0.50 – 0.79)	0.43	0.67	2.86	0.73	(0.58 – 0.83)
MUFA[f]	0.29	0.50	2.88	0.55	(0.35 – 0.70)	0.39	0.61	2.86	0.66	(0.49 – 0.78)
PUFA[f]	0.22	0.43	3.96	0.48	(0.27 – 0.65)	0.34	0.45	4.03	0.51	(0.30 – 0.67)
Cholesterol	0.28	0.42	5.86	0.49	(0.26 – 0.67)	0.34	0.46	5.67	0.53	(0.31 – 0.70)
Vitamin E	0.26	0.47	4.11	0.52	(0.31 – 0.68)	0.32	0.54	4.20	0.61	(0.40 – 0.74)
Dietary fiber	0.39	0.53	1.93	0.56	(0.38 – 0.70)	0.40	0.60	1.95	0.63	(0.46 – 0.75)
Magnesium	0.27	0.47	1.97	0.49	(0.30 – 0.65)	0.36	0.60	1.99	0.63	(0.47 – 0.76)
Zinc	0.31	0.45	6.23	0.53	(0.31 – 0.71)	0.33	0.42	6.27	0.49	(0.27 – 0.68)
Median	0.32	0.47		0.53		0.39	0.53		0.61	

a) All energy and nutrient intakes 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 nutrient intake from the 16-day (4x4-day) dietary records.

d) r*: de-attenuated correlation coefficient.

e) CI: confidence interval.

f) SFA: saturated fatty acids, MUFA: monounsaturated fatty acids, PUFA: polyunsaturated fatty acids.

Table 4. Pearson correlation coefficients (r) between daily intakes of energy and nutrients based on food frequency questionnaires (FFQ1 and FFQ2) and four 4-day dietary records (DRs) by sex[a].

Nutrient	FFQ1 vs. DRs (n=86)				FFQ2 vs. 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
Energy	0.25		0.39		0.21		0.38	
Protein	0.08	0.19	0.31	0.30	0.08	0.24	0.36	0.53
Fat	0.35	0.62	0.32	0.30	0.25	0.60	0.46	0.50
Carbohydrate	0.47	0.52	0.40	0.24	0.42	0.46	0.38	0.53
Calcium	0.46	0.61	0.65	0.73	0.52	0.71	0.63	0.78
Iron	0.11	0.22	0.42	0.57	-0.04	0.12	0.41	0.52
Potassium	0.33	0.55	0.39	0.52	0.31	0.57	0.54	0.73
Vitamin A	0.40	0.46	0.37	0.52	0.43	0.49	0.41	0.45
Retinol	0.55	0.63	0.44	0.48	0.48	0.56	0.34	0.36
Carotene	0.36	0.36	0.41	0.51	0.34	0.33	0.44	0.46
Vitamin C	0.40	0.45	0.34	0.40	0.46	0.55	0.45	0.53
SFA[c]	0.51	0.76	0.40	0.37	0.44	0.73	0.42	0.48
MUFA[c]	0.40	0.61	0.30	0.28	0.33	0.63	0.46	0.53
PUFA[c]	0.16	0.39	0.39	0.42	0.06	0.39	0.55	0.49
Cholesterol	0.46	0.53	0.18	0.21	0.41	0.50	0.31	0.35
Vitamin E	0.36	0.50	0.26	0.40	0.30	0.58	0.33	0.41
Dietary fiber	0.39	0.45	0.44	0.61	0.33	0.51	0.47	0.64
Magnesium	0.11	0.38	0.39	0.54	0.18	0.43	0.40	0.68
Zinc	0.28	0.49	0.41	0.40	0.18	0.36	0.35	0.45
Median	0.36	0.50	0.39	0.41	0.33	0.51	0.41	0.51

a) All energy and nutrient intakes 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) SFA: saturated fatty acids, MUFA: monounsaturated fatty acids, PUFA: polyunsaturated fatty acids.

previously reported in terms of reproducibility and validity[2-8, 18-21]. In this study, most of the mean nutrient intakes estimated from FFQ1 and FFQ2 were found to differ only by less than 10% from those measured by the DRs.

Vitamin C, however, was overestimated by about 40%. In Japan, we have four clearly different seasons, and different kinds of fruits are available in different seasons of the year[22]. This study might not catch up changeable vitamin C intake from seasonal fruits, possibly because the fruits might have not been taken in the four days selected from a 3 month period for the DR. Willett et al[2] obtained a good estimation of usual diet from four 7-day dietary records. Long-term records, however, may force participants to unwillingness, and a total of 7 to 14-day records seem to be enough to evaluate usual diets in validation studies[23, 24]. Consumption of fruits has also frequently been overestimated in other validation studies[3, 25, 26]. Health-conscious participants may overreport their consumption of fruits, since they may believe that fruits are good for health.

Our adjusted correlation coefficients calculated for reproducibility study ranged from 0.48 to 0.82 (median=0.67), which were quite compatible with those reported in previous studies[2, 5, 7, 21, 26, 27].This sufficiently good reproducibility suggests, in general, that our subjects had not largely changed their diets during extensive dietary recording.

Correlation coefficients calculated for validation studies have generally been reported to be 0.5-0.7 in previous studies[1, 2, 4, 5, 19-21, 28]. Overall, we could obtain similar correlation coefficients (median=0.61 for FFQ2) for 18 nutrients. As for macronutrients, our de-attenuated and adjusted Pearson correlation coefficients ranged from 0.46 to 0.64; being quite comparable with those observed in other studies[2, 4, 7, 19, 21, 28]. We obtained not so large correlation coefficients for macronutrients. This may be largely due to probable measurement errors, since macronutrients, protein in particular, have multiple sources[10, 29].

A high correlation (r=0.83) was observed for calcium. In

Table 5. Joint classification of subjects by quintiles of energy-, sex- and age-adjusted nutrient intakes based on dietary records and the second food frequency questionnaire (n=88)[a].

Nutrient	Classified into the same quintile (%)	Classified within one quintile (%)	Classified into the extreme quintiles (%)
Protein	29.5	70.5	1.1
Fat	36.4	72.7	0.0
Carbohydrate	33.0	69.3	0.0
Calcium	52.3	83.0	0.0
Iron	27.3	65.9	3.4
Potassium	39.8	78.4	0.0
Vitamin A	33.0	65.9	1.1
Retinol	36.4	72.7	1.1
Carotene	27.3	67.0	2.3
Vitamin C	30.7	68.2	0.0
SFA[b]	40.9	79.5	0.0
MUFA[b]	37.5	73.9	0.0
PUFA[b]	27.3	69.3	0.0
Cholesterol	34.1	71.6	3.4
Vitamin E	31.8	68.2	2.3
Dietary fiber	35.2	71.6	0.0
Magnesium	38.6	69.3	0.0
Zinc	30.7	65.9	3.4
Median	33.6	69.9	0.0

a) All energy and nutrient intakes were $\log_e$ transformed to improve normality.
b) SFA: saturated fatty acids, MUFA: monounsaturated fatty acids, PUFA: polyunsaturated fatty acids.

Japan, main food sources of calcium are milk, pulses and fishes[29]. Milk intake could accurately be reported because there are many people who regularly drink milk in Japan[30]. In fact, high validity for milk and dairy products was observed in our study[10]. The correlations for iron, carotene and zinc, however, appeared to be weaker. We did not use portion sizes in this FFQ except for rice, alcoholic beverages and coffee. Then, it might have been difficult to estimate dietary intakes of nutrients rich in vegetables, meats and fishes. And liver and oyster, which contain much iron and zinc, might have not taken in the short period of DRs. Categorization into quintiles by iron and zinc might be more likely to suffer from misclassification, as compared with categorization by other nutrients, probably due to the lack of portion size information. Validity for protein and iron was poor in males. This limitation should be considered when analyzing data obtained by this FFQ by sex.

Our subjects were all volunteers, and willingly completed the protocols during one year. The proportion of subjects (73.9%), who successfully provided the two FFQs and four 4-day DRs, was quite similar to that in the published studies (73-77%)[2, 3, 28], which also compared dietary nutrient estimates between FFQs and DRs.

Our subjects were all assisted, when recording their diets, by their daughters or granddaughters who were well-educated for nutritional science as students. A previous study[31], in which grandmothers' diets were surveyed by well-educated granddaughters, claimed that such intimate human relationship itself would result in more detailed dietary recordings, and accordingly, in valid estimation of individual dietary intakes.

Volunteers may, in general, be more conscious of their own diets than general population; possibly resulting in overestimation of the validity coefficients. It is usually difficult to ask a large sample of general population to complete DRs. A few studies used, in fact, subjects randomly sampled from general population, but the proportion of those who successfully completed was quite small: 22% for twelve 24-hour dietary recalls[25] or 39% for two one-week DRs[21].

In our FFQ, which could be administered in about 20 minutes, portion size questions were not included for most items[10]. Absolute nutrient intake could not be estimated from a FFQ without portion size questions. However, relative nutrient composition of the diet, which is essentially and validly useful for nutritional epidemiological studies[1], could be grasped by our FFQ, as indicated by the good validity for energy-adjusted intakes.

In summary, our FFQ was concluded to be reasonably useful for nutritional epidemiological surveys of the middle-aged and the older, since its good reproducibility and sufficient validity were both proved in the present study.

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