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Validation of Self-Administered Dietary Assessment Questionnaires Developed for Japanese Subjects : Systematic Review

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ABSTRACT

Several self-administered dietary assessment questionnaires have recently been developed, validated, and used in nutritional epidemiological and clinical studies in Japan. This article describes recent evidence on development and validation of them. After extensive search of published articles both in English and Japanese languages, we identified 25 articles on 13 questionnaires of which validation studies have existed. Number of foods/menus assessed varied from 31 to 169 according to questionnaires. Eleven questionnaires were food frequency type, either with fixed portion size or semiquantitative, and two diet history types. All the 13 questionnaires were validated against intakes assessed with dietary record or 24-hour recall, and only two with biomarkers. Number of subjects used in the studies was between 23 and 350. All the studies used adult subjects. In the studies with dietary record or recall, the correlation coefficient for energy intake was between 0.22 and 0.65 (median = 0.44). Median correlation coefficient for nutrients was between 0.21 and 0.61. In the studies with biomarkers, serum marine-origin n-3 polyunsaturated fatty acids and carotenes, and urinary potassium seemed useful biomarkers. In conclusion, recent progress of this field in Japan is remarkable. But more research is needed for validation studies with biomarkers, and the development and validation of questionnaires for children and elderly subjects. (*J Community Nutrition* 5(2) : 83~92, 2003)

KEY WORDS : self-administered dietary assessment · validity · Japanese · review.

Introduction

Reliable information on diets, i.e., nutrient and food intakes, is one of the key factors in human nutritional studies. However dietary assessment is theoretically very difficult and the suitable methods vary according to characteristics of subjects, purpose of study, and feasibility of assessment.

In most of studies on human nutrition, conventional assessment methods such as dietary record or dietary recall are difficult to use because of the substantially heavy burden for subjects. This is particularly a severe problem in epidemiologic studies. Large day-to-day, i.e., intra-individual, variation of intake decreases the reliability of the results when habitual dietary intake is of interest (Nelson 1989). Because of this problem, it is inappropriate to use dietary data of a short period such as one-day in studies dealing with chronic diseases. In order to overcome these problems, dietary assessment questionnaires, either self-administered or interviewer-administered have become popular and broadly used in Western populations (Willett, Lenart 1998). But dietary assessment questionnaires do not assess dietary habits directly. Therefore basic studies to examine quality, i.e., validity and reproduci-ility, of the questionnaires are needed before they are used in studies.

Moreover, a questionnaire should be developed considering characteristics of subjects and purpose of the studies. The former is essential in Japan because dietary habits and foods available are considerably different from those in Western countries. Questionnaires used for Japanese subjects should be developed from basic stage of development, i.e., from the beginning rather than slight modification of ready-made questionnaire developed for Western subjects.

Recently, not a few dietary assessment questionnaires have been developed and started to use in Japan. But to our knowledge, no review article has yet existed. We therefore

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reviewed, in this article, current evidence on development and validation of dietary assessment questionnaires in Japan based on published articles either in English or Japanese.

Subjects and Methods

1. Literature search

We searched possibly related articles using Medline database, namely PubMed, with the following search strategy : ("validity" OR "validation") AND ("food" OR "diet" OR "dietary" OR "intake") AND "questionnaire" AND ("Japan" OR "Japanese"). We limited the search for articles published between 1990 and May 2003. We selected possibly related articles reading the abstracts of the 43 articles screened out. We also checked abstracts of all the articles published between 1990 and May 2003 in the following 4 journals written in Japanese language : Jpn J Public Health (Nippon Koshu Eisei Zasshi), Jpn J Hygiene, Jpn J Nutr (Eiyogaku Zasshi), and J Jpn J Soc Nutr Food Sci (Nippon Eiyo-shokuryogakkaishi). We also checked the reference lists of the screened 43 articles. Articles without English abstract were excluded from the present analyses. In some questionnaires, nutrient calculation algorism was developed using the data of the reference intakes obtained from the validation study, and the results, i.e., calculated nutrient intakes, were compared with the reference intakes. Results are theoretically better than the real validity when this type of development was used. The validation studies for this type of questionnaire were therefore excluded from the present analysis. Finally, 25 validation studies on 13 questionnaires have been included in the present analysis (Table 1).

2. Analyses

First, we identified self-administered dietary assessment questionnaires developed in Japan with validation studies and summarized the structures. Then we summarized study designs of validation studies. Because validation studies are roughly divided into two methods, i.e., with dietary intakes obtained from dietary record or recall methods and with biomarkers as gold standard. The results of the validation studies were summarized in separate tables in the present review.

Results

Table 1 shows summary of structure of 13 questionnaires with validation studies. Eight questionnaires were semiquantitative food frequency type, and 3 were food frequency type with fixed portion sizes with some variations. Two questionnaires were diet history type. Within these two questionnaires, one included several questions about detailed dietary behaviors. Number of foods/menus assessed varied according to questionnaires, i.e., from 31 to 169. Reference period was divided into two, i.e., one year or one month, with one exception without any specific reference period.

Concerning types of validation studies, only two questionnaires have been validated using biomarkers such as nutrients in serum/plasma and 24-hour excreted urine. The rest were validated only using dietary record or recall methods as gold standard. The number of days for dietary record or recall methods varied from 3-to 28-days. Dietary record was more frequently used than dietary recall. Number of subjects used in validation studies varied from 23 to 350. In the studies with dietary record or recall as gold standard, 3 studies assessed a questionnaire before the measurement of gold standard, and the rest, 11 studies, assessed after the measurement of gold standard. All the studies used adult subjects including university/college students. Some studies included elderly subjects, such as aged 70 years and over, as a part of the subjects. But no questionnaire was developed or validated for elderly subjects. Most validation studies used healthy volunteers with two exceptions that used mildly hypercholesterolemic subjects.

Table 2 shows the summary results of validation studies on correlation coefficients between intakes assessed with a questionnaire and with dietary record or dietary recall method as gold standard. In most of the studies energy-adjusted intakes for nutrient intakes were used for analysis with two exceptions. When Pearson correlation coefficient was used, residual model was applied for energy-adjustment in most studies. The correlation coefficient for energy intakes varied from 0.22 to 0.65 (median = 0.44). The median correlation coefficients for nutrients varied from 0.21 to 0.61. Among nutrients examined, saturated fatty acid (SFA), calcium, and phosphorus showed a relatively high level of correlation, i.e., 0.61, 0.57, and 0.52 respectively as median values of the studies. In contrast, niacin and polyunsaturated fatty acids (PUFA) showed a lower level of correlation, i.e., 0.21 and 0.28, respectively. The level of correlation was also relatively low in sodium, i.e., 0.33. The level of correlation varied among studies in potassium and cholesterol, i.e., the range was −0.10 −

Table 1. Dietary assessment questionnares developed and validated in Japan

ID Type	Charateristics of questionnaire: Quantification of foods/menus	Charateristics of questionnaire: Unit of major questions	Charateristics of questionnaire: Number of foods/menus assessed	Design of validation: Reference period	Design of validation: Gold standard	Design of validation: Order of survey°	Subjects: Sex	Subjects: n	Subjects: Age-range	Subjects: Characteristics, health status	Author and year of publication
1. FFQ	Semi	Menu	122	56 – 63 days	56 – 63 day DR	After	M + W	67	19 – 26	College student	Date, 1996
2. DHQ	Semi	Food	31	1 year	Twelve 1-day DR	After	M + W	31	35+		Takatsuka, 1997
3. DHQ	Semi	Food	147	1 month	3-day DR	Before	W	47	38 – 69	Mild hypercholesterolemia	Sasaki, 1998a
					Urinary biomarkers	Before	M + W	223		University freshmen students	Sasaki, 1998b
					Change in serum cholesterol	After	M + W	63	22 – 59	Mild hypercholesterolemia	Sasaki, 1999
					Serum biomarkers	At the same time	M + W	86	24 – 67		Sasaki, 2000
4. FFQ	Semi	Food	24	1 month	7-day DR	Before	M + W	72	50 – 76		Katagiri, 1998
5. FFQ	Semi	Food	169	1 year	3-day DR and 4-day 24-hour recalls	After	M + W	117	35+	Cohort subjects	Shimizu, 1999
6. FFQ	Fixed	Food	97	1 year	Four 4-day DR	After	M + W	88	41 - 88		Egami, 1999
7. FFQ	Semi	Food, each meal	65	1 month	7-day DR	After	M	71	43 – 60		Yamaoka, 2000
8. FFQ	Semi	Food	102	1 month	Four 7-day DR	Before	W	79	32 – 66	Dietitians	Tokudome, 2001
9. FFQ	Semi	Food	39	1 – 2 months	7-day DR	After	M + W	66	19 – 60		Takahashi, 2001
10. FFQ	Fixed	Food	40	1 year	Four 7-day DR	After	M	23	20 – 27		Lee, 2002
11. FFQ	Semi	Food	40	1 year	Four 3-day DR	After	M + W	113	45 – 77		Ogawa, 2003
12. FFQ	Semi	Food	147	1 year	Four 7-day DR, serum/plasma biomarkers, urinary biomarkers	After	M + W	215	45 – 64	Cohort subjects	Yamamoto, 2001; Tsugane, 2003; Kobayashi, 2003a; Kobayashi, 2003b; Karita, 2003; Iso, 2003; Sasaki, 2003a; Sasaki, 2003b
					Four 7-day DR	After	M + W	350	45 – 74	Cohort subjects	Ishihara, 2003
13. FFQ	Fixed	Food	44	1 year	Four 7-day DR	After	M + W	201	45 – 64	Cohort subjects	Tsubono, 2003

°After/before/at the same time : FFQ or DHQ was measured after/before/at the same time the meausement of gold standard
Abbreviations : FFQ : food frequency questionnaire, DHQ : dietary history questionnaire, DR : dietary record, M : men, W : women

Table 2. Summary of validation studies on correlation coefficients between intaks assessed with a questionnaire and with dietary record or recall methods as gold standard

Author	Date	Takatsuka	Sasaki	Katagiri	Shimizu		Egami		Yamaoka	Tokudome	Takahashi	Lee	Ogawa		Tsugane		Ishihara		Tsubono		All studies		
Published year	1996	1997	1998	1998	1999		1999		2000	2001	2001	2003	2003		2003		2003		2003				
Questionnaire ID	1	2	3	4	5		6		7	8	9	10	11		12		12		13				
Sex	M+W	M+W	W	M+W	M	W	M	W	M	W	M+W	M	M	W	M	W	M	W	M	W			
Method of analysis																							
Log-transformation[a]	…	…	X	X	X		X		X	X	…	X	…		…		…		…				
Adjustment[b]	X	X	X	…	X		X		X	X	…	X	X		X		X		X		n	Median	Range
Deattenuation[c]	…	…	X	…	…		…		…	X	…	…	X		…		…		…				
Type of correlation	P,S	P	P	P	P		P		P	P,S	P	P	S		S		S		S				
Energy (kcal)	0.65	…	0.48	0.55	0.38	0.25	0.25	0.39	0.64	0.48	0.47	0.23	0.55	0.36	0.55	0.44	0.34	0.22	0.52	0.38	17	0.44	0.22−0.65
Carbohydrate (g)	0.58	0.34	0.48	0.57	0.51	0.29	0.52	0.24	0.56	0.57	0.49	0.45	0.57	0.43	0.56	0.37	0.59	0.39	0.51	0.33	18	0.51	0.29−0.59
Protein (g)	…	0.57	0.48	0.42	0.45	0.37	0.19	0.30	0.16	0.53	0.42	0.44	0.25	0.49	0.43	0.40	0.30	0.31	0.28	0.34	17	0.40	0.16−0.57
Fat (g)	…	−0.03	0.55	0.35	0.43	0.51	0.62	0.30	0.65	0.49	0.39	0.19	0.37	0.50	0.52	0.46	0.57	0.40	0.30	0.41	17	0.46	−0.03−0.65
SFA (g)	…	0.51	0.75	…	…	…	0.76	0.37	…	0.62	0.27	…	…	…	0.61	0.60	0.62	0.51	0.42	0.50	10	0.61	0.42−0.76
MUFA (g)	…	0.12	0.50	…	…	…	0.61	0.28	…	0.44	0.24	…	…	…	0.50	0.44	0.55	0.37	0.23	0.39	10	0.44	0.12−0.61
PUFA (g)	…	−0.15	0.37	…	…	…	0.39	0.42	…	0.28	0.24	…	…	…	0.27	0.24	0.44	0.33	0.06	0.22	10	0.28	−0.15−0.44
Cholsterol (mg)	…	0.52	0.49	…	0.36	0.31	0.53	0.21	−0.19	0.59	0.52	…	…	…	0.33	0.35	0.47	0.47	0.36	0.30	13	0.36	−0.19−0.59
Vitamin A (IU)	0.21	0.22	0.38	0.45	0.42	0.27	0.46	0.52	0.36	0.35	0.06	0.19	…	…	…	…	…	…	…	…	10	0.36	0.19−0.46
Retinol (μg)	0.53	0.21	…	…	…	…	0.63	0.48	…	…	0.18	…	0.38	0.30	0.22	0.43	0.35	0.47	0.36	0.34	11	0.36	0.21−0.63
Carotene (μg)	0.25	0.45	…	…	0.36	0.48	0.36	0.51	…	0.33	…	…	0.56	0.45	0.36	0.33	0.47	0.49	…	…	12	0.41	0.25 0.56
Thiamin (mg)	…	…	0.46	0.37	…	…	…	…	0.42	…	0.40	…	0.33	0.31	0.40	0.41	0.28	0.32	0.36	0.22	11	0.36	0.22−0.46
Riboflavin (mg)	…	…	0.58	0.36	…	…	…	…	0.37	…	0.42	…	0.43	0.54	0.34	0.45	0.55	0.55	0.43	0.39	11	0.43	0.34−0.58
Niacin (mg)	…	…	0.19	…	…	…	…	…	−0.07	…	0.24	…	0.33	0.47	0.35	0.15	0.33	0.22	0.14	0.11	10	0.21	−0.07−0.47
Vitamin C (mg)	0.38	0.44	0.45	0.36	0.21	0.21	0.45	0.40	0.52	0.42	0.48	0.35	0.58	0.43	0.42	0.22	0.46	0.44	0.38	0.29	18	0.42	0.21−0.58
Calcium (mg)	0.74	0.69	0.49	0.41	0.51	0.59	0.61	0.73	0.55	0.64	0.41	0.52	0.57	0.67	0.43	0.47	0.65	0.64	0.56	0.37	18	0.57	0.37−0.74
Phosphorus (mg)	…	…	0.59	…	…	…	…	…	0.26	0.58	0.45	…	0.52	0.69	0.37	0.42	0.49	0.54	0.56	0.44	11	0.52	0.26−0.69
Iron (mg)	…	…	0.40	0.15	…	…	0.22	0.57	0.14	0.55	−0.01	0.31	0.35	0.47	0.49	0.33	0.54	0.51	0.31	0.30	14	0.34	0.14−0.55
Sodium (mg)	0.26	0.33	0.32	0.16	0.18	0.10	…	…	0.34	…	0.43	…	0.37	0.33	0.41	0.48	0.42	0.45	0.33	0.49	15	0.33	0.10−0.49
Potassium (mg)	0.50	…	0.68	…	…	…	0.55	0.52	−0.10	0.61	0.23	0.63	0.45	0.45	0.39	0.31	0.49	0.49	0.38	0.37	14	0.47	−0.10−0.68
All nutrients[d]																							
n	8	13	17	10	9		14		14	14	18	8	14		18		18		17			282	
Median	0.44	0.34	0.48	0.37	0.42	0.31	0.53	0.41	0.35	0.54	0.40	0.40	0.41	0.46	0.41	0.41	0.48	0.46	0.36	0.34		0.42	
Macronutrients																							
n	1	6	6	3	3		6		3	6	6	3	3		6		6		6			94	
Mean	0.58	0.23	0.49	0.42	0.45	0.37	0.57	0.30	0.56	0.51	0.33	0.44	0.37	0.49	0.51	0.42	0.56	0.38	0.29	0.37		0.43	
Micronutrients																							
n	7	7	11	7	7		7		11	8	12	5	11		12		12		11			188	
Mean	0.38	0.44	0.46	0.36	0.36	0.29	0.50	0.52	0.34	0.57	0.41	0.35	0.43	0.45	0.38	0.38	0.47	0.48	0.36	0.34		0.41	

[a]Values were log-transformed before analysis
[b]Values were adjusted for energy by residual method except for energy intake
[c]Values were deattenuated considering within-subject variation
[d]Except energy intake
Abbreviations : P : Pearson's product moment correlation coefficient, S : Spearman's rank correlation coefficient, … : Not reported, SFA : Saturated fatty acids,
SFA : saturated fatty acids, MUFA : onounsaturated fatty acids, PUFA : polyunsaturated fatty acids

Table 3. Summary of validation studies on percent differences between intaks assessed with a questionnaire and with dietary record or recall methods as gold standard

Author	Date	Takatsuka	Sasaki	Katagiri	Shimizu	Egami	Yamaoka	Tokudome	Takahashi	Lee	Ogawa		Tsugane		Ishihara		Tsubono		All studies		
Published year	1996	1997	1998	1998	1999	1999	2000	2001	2001	2002	2003		2003		2003		2003		n	Median	Range
Questionnaire ID	1	2	3	4	5	6	7	8	9	10	11		12		12		13				
Energy (kcal)	−8	…	1	−10	4	7	−8	−3	6	−39	−16	−27	0	11	−4	5	−15	−25	17	−6	−39–11
Carbohydrate (g)	−3	19	3	−13	0	8	−13	−5	3	−32	−6	−22	−4	7	−8	0	−2	−18	18	−4	−32–19
Protein (g)	…	28	1	−26	3	1	−8	1	3	−45	−32	−31	−4	11	−13	0	−30	−31	17	−6	−45–28
Fat (g)	…	23	−1	3	7	0	−8	2	9	−39	−37	−36	12	22	10	22	−41	−40	17	1	−41–23
SFA (g)	…	15	2	…	…	6	…	6	11	…	…	…	11	18	22	31	−20	−17	11	9	−20–31
MUFA (g)	…	15	7	…	…	−1	…	2	9	…	…	…	19	32	28	42	−46	−45	11	11	−46–42
PUFA (g)	…	24	7	…	…	−1	…	−2	13	…	…	…	−9	6	−11	2	−58	−58	11	−2	−58–24
Cholsterol (mg)	…	19	19	…	14	−1	−5	−5	5	…	…	…	−20	−11	−18	6	−33	−29	13	−5	−33–19
Vitamin A (IU)	−15	67	1	−16	14	3	66	17	4	−53	…	…	…	…	…	…	…	…	10	3	−53–67
Retinol (μg)	−12	8	…	…	…	22	…	…	12	…	17	8	49	63	53	71	76	86	12	49	−12–86
Carotene (μg)	−18	80	…	…	40	−11	…	5	…	…	−57	−39	16	29	7	26	…	…	11	7	−57–80
Thiamin (mg)	…	…	17	−19	…	…	−7	…	10	…	−30	−26	−4	10	−10	5	−30	−32	12	−10	−32–17
Riboflavin (mg)	…	…	15	−6	…	…	17	…	−1	…	−25	−22	15	25	2	14	−12	−6	12	2	−25–25
Niacin (mg)	…	…	6	…	…	…	25	…	5	…	−39	−34	−4	8	−16	0	−37	−40	11	−10	−40–25
Vitamin C (mg)	7	148	13	9	−19	41	−17	17	11	−44	−22	−17	29	40	13	30	−33	−28	18	9	−44–148
Calcium (mg)	10	34	25	−26	9	16	−7	13	5	−42	−29	−23	10	17	−3	3	−11	−5	18	3	−42–34
Phosphorus (mg)	…	…	9	…	…	…	−16	5	5	…	−31	−28	1	13	−7	6	−17	−18	12	−7	−31–13
Iron (mg)	…	…	16	−36	…	1	−6	0	−11	−50	−35	−33	−5	7	−18	−6	−35	−36	15	−12	−50–16
Sodium (mg)	2	24	2	−21	−20	…	−7	…	−3	…	−59	−56	9	17	1	8	−53	−56	15	−3	−59–24
Potassium (mg)	4	…	2	…	…	11	−17	2	3	−40	−36	−30	3	13	−8	4	−30	−28	15	−3	−40–13
All nutrients[a]																					
n	8	13	17	10	9	14	14	14	18	8	14	14	18	18	18	18	17	17		259	
Median	−1	24	7	−18	7	2	−7	2	5	−43	−32	−29	6	15	−5	6	−30	−29		1	
Range	−18–10	8–148	−1–25	−36–9	−20–40	−11–41	−17–66	−5–17	−11–13	−53–−32	−59–−17	−56–8	−20–49	−11–63	−18–53	−6–71	−58–76	−58–86		−59–148	
Macronutrients																					
n	1	6	6	3	3	6	3	6	6	3	3	3	6	6	6	6	6	6		85	
Median	−3	23	3	−13	3	1	−8	2	9	−39	−32	−31	4	15	1	12	−36	−36		1	
Range	−3	15–28	−1–7	−26–3	0–7	−1–8	−13–−8	−5–6	3–13	−45–−32	−37–−6	−36–−22	−9–19	6–32	−13–28	0–42	−58–−2	−58–−17		−58–42	
Micronutrients																					
n	7	7	11	7	6	8	11	8	12	5	11	11	12	12	12	12	11	11		174	
Median	2	24	13	−19	12	7	−7	5	5	−44	−31	−28	6	15	−5	6	−30	−28		1	
Range	−18–10	8–148	1–25	−36–9	−20–40	−11–41	−17–66	−5–17	−11–12	−53–−40	−59–17	−56–8	−20–49	−11–63	−18–53	−6–71	−53–76	−56–86		−59–148	

See Table 2 for reference number and method of analysis
[a]Values were log-transformed before analysis
Abbreviations : SFA : saturated fatty acids, MUFA : monounsaturated fatty acids, PUFA : polyunsaturated fatty acids, … : not reported

Table 4. Summary of validation studies with biomarkers as gold standard : correlation coefficients between calculated intake and corresponding biomarker

Authors, years	Sasaki, 2000; Sasaki 1998		Kobayashi, 2003; Kobayashi, 2003; Kobayashi, 2003; Iso, 2003; Karita, 2003; Yamamoto, 2001; Sasaki, 2003; Sasaki, 2003	
Questionnaire ID	3		12	
Sex	Men	Women	Men	Women
Method of analysis				
Log-transformation[a]	X		…	
Adjustment[b]	X		X	
Type of correlation	Pearson		Spearman	
Serum/plasma concentration				
Fatty acid[c]	(n = 42)	(n = 44)	(n = 88)	
Palmitic acid	−0.16	−0.01	−0.44	…
Oleic acid	−0.13	−0.03	−0.05	…
Linoleic acid	0.15	0.39	0.18	…
Alpha-linoleic acid	−0.22	0.36	−0.09	…
Eicosapentaenoic acid	0.64	0.65	0.44	…
Docosahexaenoic acid	0.44	0.59	0.32	…
Marine origin n-3 PUFA	0.51	0.69	…	…
SFA	−0.20	0.00	−0.09	…
MUFA	−0.04	−0.05	0.04	…
PUFA	0.30	0.37	0.19	…
Vitamin			(n = 102)	(n = 113)
Alpha-carotene	0.56	0.42	0.21	0.08
Beta-carotene	0.34	0.49	0.34	0.30
Total carotene	0.40	0.47	0.18	0.33
Lycopene	…	…	0.26	0.10
Alpha-tocopherol	−0.23	0.09	…	…
Vitamin C	…	…	−0.20	−0.14
Folate	…	…	0.26 (n = 87)	…
Vitamin B_6	…	…	0.23 (n = 87)	…
Vitamin B_{12}	…	…	0.06 (n = 87)	…
Mineral			(n = 85)	(n = 95)
Selenium (in serum)	…	…	0.16	−0.02
Selenium (in erythrocyte)	…	…	0.15	0.13
Other nutrient			(n = 202)	
Daidzein	…	…	0.26	
Genistein	…	…	0.22	
24-hour urinary excretion[d]				
Mineral	(n = 154)	(n = 69)	(n = 32)	(n = 57)
Sodium	0.14	0.23	0.35	0.25
Potassium	0.34	0.40	0.48	0.18
Daidzein	…	…	0.40 (n = 202)	
Genistein	…	…	0.30 (n = 202)	

[a]Values were log-transformed before analysis
[b]Values were adjusted for energy by residual or density method
[c]In phospholipid fraction in serum
[d]Adjustment for creatinine
Abbreviations : SFA : saturated fatty acids, MUFA : monounsaturated fatty acids, PUFA : polyunsaturated fatty acids

Table 5. Summary of validation study for examining validity to assess change in intakes : correlation coefficients between calculated intake and corresponding biomarker

Author, year	Sasaki, 1999
Questionnaire ID	3
Biomarker = change in serum cholesterol (n = 63)	
SFA (%E)	0.25
PUFA (%E)	0.06
Cholesterol (%E)	0.22
Keys score (score)	0.33

Abbreviations : SFA : saturated fatty acids, MUFA : monounsaturated fatty acids, PUFA : polyunsaturated fatty acids, %E : percentage of energy intake

0.68 and −0.19 − 0.59 respectively.

Table 3 shows the percent differences between intakes assessed with a questionnaire and with dietary record or recall method as gold standard. The results varied by studies, i.e., 4 questionnaires substantially underestimated their intakes by more than nearly 20% or more as median, and one overestimated the intakes by more than 20% as median. Relatively cross estimate for macronutrients was shown in 4 questionnaires, i.e., the range was less than ± 10%. Relatively narrow range of percent difference, i.e., less than 30%, for micronutrients was observed in 4 questionnaires. Only two questionnaires developed by Sasaki et al. and Tokudome et al. were included in both. Among nutrients examined, vitamin C, carotene, and vitamin A showed considerably different results between studies, i.e., the difference between the minimum and the maximum values was more than 100%.

Table 4 shows the summary results of validation studies in which biomarkers were used as gold standard. Eicosapentaenoic and docosahexaenoic acids, alpha- and beta-carotene showed in general a reasonably high level of correlation in both questionnaires. Folate and vitamin B_6 in serum also showed meaningful correlation in one questionnaire. In the analysis with 24-hour urinary excretions, potassium showed a reasonably high level of correlation in both questionnaires. The correlations observed in daidzein and genistein in one questionnaire was of interest. The correlation for sodium was relatively high in men in one questionnaire, but not so in the other. The correlation in women was moderate in both questionnaires.

Table 5 shows summary results for examining validity to assess change in intake. Only one questionnaire was examined using change in serum cholesterol as biomarker. The calculated Keys score showed a reasonable level of correlation, 0.33, with the change in serum cholesterol.

Discussion

Although the level of research activities on human nutrition in Japan is much behind those in Western countries, development and use of dietary assessment questionnaires have rapidly increased during these 8 years.

The correlation coefficients reported in the validation studies included in the present study were generally lower than those reported by studies in Western countries (Willett Lenart 1998). Although we can not know real reasons, it may partly attribute to the dietary pattern of Japanese subjects and their recognition of foods and menus. For example, a Japanese meal usually consists of main staple, main dish, side dishes and miso (fermented soybean paste) soup. Main and side dishes contain several, at least three or four, food items. In each dish, meat and vegetables are usually mixed. Their portion size varies according to dishes. Therefore, Japanese do not have a clear concept for "standard portion size". This may make answers to questions about portion size difficult. This problem may severely affect to underreporting among subjects who do not know cooking and ingredients in dishes, and overreporting among subjects who know them very much, because the former may omit several food items included in mixed dishes and the latter may count foods with small portions in mixed dishes. But no report has yet existed for this topic in Japanese populations.

Number of foods/menus assessed in a questionnaire should carefully be considered when developing a dietary assessment questionnaire. A questionnaire with a large number of foods/menus can expect higher validity than that with a fewer number of foods/menus. On the other hand, the opposite is expected for feasibility. When the correlation coefficients listed in Table 2 were divided into two groups, i.e., 7 questionnaires with 97 foods/menus or more and with 65 or less, the mean correlation coefficient was 0.44 (n = 11) and 0.36 (n = 9) (the difference was statistically significant, $p < 0.01$) respectively. But interpretation of this result is not so easy because the comparisons between questionnaires and results of validation studies are difficult because both structures of questionnaires and characteristics of subjects were different from each other.

For correlation coefficients observed in the studies with dietary record or recall methods as gold standard, relatively high level of correlation was observed in SFA (median r =

0.61), calcium (median r = 0.57), and phosphorus (median r = 0.52). In contrast, it was relatively low in niacin (median r = 0.22), PUFA (median r = 0.28). It varied between questionnaires in potassium (range of r = −0.10 − 0.68) and cholesterol (range of r = −0.19 − 0.59). The low validity in PUFA may attribute partly to cooking oil. In contrast, milk, which is relatively easy to assess, is one of the major contributors of SFA as wells as calcium in the Japanese population (Tokudome et al. 1999). High validity of milk intake may partly contribute to the high validity in SFA as well as calcium. Validity in sodium was not so high (median = 0.33). The difficulty of assessment of sodium intake by questionnaire has long been discussed (Shepherd et al. 1985). Several dietary assessment questionnaires developed in Western countries did therefore not include sodium in the targeted nutrients. Among these 13 questionnaires, 3 questionnaires did not report validity for sodium. Expected correlation is slightly lower and higher than a true correlation when a questionnaire is assessed before and after the measurement by dietary record or recall, respectively (Willett, Lenart 1998). Majority of validation studies included in the present analysis used assessment of questionnaire after the completion of measurement of gold standard. This may be considered to evaluate validity of a questionnaire although many other confounders do exist.

Biomarkers were used only in two questionnaires. In both questionnaires, reasonable validity was observed for marine-origin n-3 PUFA, and carotenes. In studies with 24-hour urinary excretion as biomarker, potassium showed a relatively reasonable validity except for women in one questionnaire. But more careful validation seems necessary for sodium. In one questionnaire, several nutrients were examined. Among them, folate ad vitamin B6 showed a relatively high level of correlation. The validation for daidzein and genistein was of great interest because their intake was extremely high in Japanese compared to Western populations (Greendale et al. 2002), and several health effects are postulated in these nutrients (Setchell 1998).

Only one questionnaire developed by Sasaki et al. was validated of its ability to assess change in nutrient intakes. Change in serum cholesterol was used as a biomarker for this purpose. This type of validity, which is called "responsiveness", is essential when a questionnaire is used for evaluating change in dietary habits. This is particularly important in questionnaires used in dietary intervention studies.

In most of epidemiologic studies to examine relative risk of exposures to outcome measures, ranking ability is more important than ability to estimate true, i.e., absolute, intake levels. In these studies, questionnaires with high level of correlation coefficients of targeted nutrients shown in Table 2 are more useful regardless of the results on percent difference shown in Table 3. In contrast, in health educations absolute values of intakes, rather than the ranking, are used, ability to estimate absolute intake at an individual level is needed. In this case, high level of ability both in correlations shown in Table 2 and percent differences shown in Table 3 is required. Further research is needed to develop this type of questionnaire for Japanese subjects.

One of the shortcomings in nutritional research in Japan is a lack of reliable food composition tables in several nutrients Several missing values exist especially in micro- and trace nutrients. It has made the nutrient calculation by the developed questionnaires difficult or impossible. Some groups have developed food composition tables of nutrients for their research interest such as fatty acids (Sasaki et al. 1999) and carotenes (Takahashi et al. 2001). They included the tables into the nutrient calculation algorism of questionnaires developed by their own. This is considerably important because targeted nutrients in recent nutritional epidemiologic studies and dietary education shifted from conventional macronutrients to micro- and trace-nutrients.

Most of the validation studies used middle-aged subjects. Epidemiologic studies and dietary education is also interesting and necessary for children and elderly subjects. To our knowledge, neither development nor validation study has been published either for children nor elderly subjects. Development and validation of specific population may be one of the future research topics in this field.

Although beyond the scope of this review, feedback system with high quality seems to be important in order to obtain high feasibility. This is, without doubt, important when a questionnaire is used for health education.

Summary and Conclusion

Few self-administered dietary assessment questionnaires have been developed and validated in Japan during these 8 years. These questionnaires are now widely used in several nutritional epidemiological and dietary intervention studies in Japan. We can expect several scientific communications in this field from Japan in near future. At the same time, more validation studies using biomarkers are needed because studies with dietary record or dietary recall method are imperfect. We also need to develop and validate new questionnaires for special purposes and populations such as studies for children and elderly subjects.

References

Date C, Yamaguchi M, Tanaka H (1996) : Development of a food frequency questionnaire in Japan. *J Epidemiol* 6 : S131-S136

Egami I, Wakai K, Kato K, Lin Y, Kawamura T, Tamakoshi A, Aoki R, Kojima M, Nakayama T, Wada M, Ohno Y (1999) : A simple food frequency questionnaire for Japanese diet-Part II, Reproducibility and validity for nutrient intakes. *J Epidemiol* 9 : 227-234

Greendale GA, Fitzgerald G, Huang MH, Sternfeld B, Gold E, Seeman T, Sherman S, Sowers M (2002) : Dietary soy isoflavones and bone mineral density : results from the study of women's health across the nation. *Am J Epidemiol* 155 : 746-754

Ishihara J, Sobue T, Yamamoto S, Yoshimi I, Sasaki S, Kobayashi M, Takahashi T, Iitoi Y, Akabane M, Tsugane S (2003) : Validity and reproducibility of a self-administered food frequency questionnaire in the JPHC Study Cohort II : Study design, participant profile and results in comparison with Cohort I. *J Epidemiol* 13 (1 suppl) : S134-S147

Iso H, Moriyama Y, Yoshino K, Ishihara J, Sasaki S, Tsugane S (2003) : Validity of the self-administered food frequency questionnaire used in the 5-year follow-up survey of the JPHC Study Cohort I to assess folate, vitamin B_6 and B_{12} intake : Comparison with dietary records and blood level. *J Epidemiol* 13 (1 suppl) : S98-S101

Itoh K, Masuda A, Uezono K, Kawasaki T (1992) : Assessment of dietary intake estimating using a simple questionnaire method. *J Jpn Soc Nutr Food Sci* 45 : 535-543 (in Japanese with English abstract)

Karita K, Sasaki S, Ishihara J, Tsugane S (2003) : Validity of a self-administered food frequency questionnaire used in the 5-year follow-up survey of the JPHC Study Cohort I to assess selenium intake : Comparison with dietary records and blood levels. *J Epidemiol* 13 (1 suppl) : S92-S97

Katagiri A, Hashimoto S, Ohashi Y, Shirogane K, Sakamoto N, Makimoto S (1998) : Reproducibility and validity of a semi-quantitative food frequency questionnaire. *Nippon Koshu Eisei Zasshi* 45 : 1127-1136 (in Japanese with English abstract)

Kobayashi M, Sasaki S, Kawabata T, Hasegawa K, Tsugane S (2003) : Validity of a self-administered food frequency questionnaire used in the 5-year follow-up survey of the JPHC Study Cohort I to assess fatty acid intake : Comparison with dietary records and serum phospholipid level. *J Epidemiol* 13 (1 suppl) : S64-S81

Kobayashi M, Sasaki S, Tsugane S (2003) : Validity of a self-administered food frequency questionnaire used in the 5-year follow-up survey of the JPHC Study Cohort I to assess carotenoids and vitamin C intake : Comparison with dietary records and blood level. *J Epidemiol* 13 (1 suppl) : S82-S91

Lee KY, Uchida K, Shirota T, Kono S (2002) : Validity of a self-administered food frequency questionnaire against 7-day dietary records in four seasons. *J Nutr Sci Vitaminol* 48 : 467-476

Nelson M, Black AE, Morris JA, Cole TJ (1989) : Between-and within-subject variation in nutrient intake from infancy to old age : estimating the number of days required to rank dietary intakes with desired precision. *Am J Clin Nutr* 50 : 155-167

Ogawa K, Tsubono Y, Nishino Y, Watanabe Y, Ohkubo T, Watanabe T, Nakatsuka H, Takahashi N, Kawamura M, Tsuji I, Hisamichi S (2003) : Validation of a food-frequency questionnaire for cohort studies in rural Japan. *Public Health Nutr* 6 : 147-158

Sasaki S, Ishihara J, Tsugane S (2003) : Validity of a self-administered food frequency questionnaire in the 5-year follow-up survey of the JPHC Study Cohort I to assess sodium and potassium intake : Comparison with dietary records and 24-hour urinary excretion level. *J Epidemiol* 13 (1 suppl) : S102-S105

Sasaki S, Ishikawa T, Yanagibori R, Amano K (1999) : Responsiveness to a self administered diet history questionnaire in a worksite dietary intervention trial for mildly hypercholesterolemic Japanese subjects : correlation between change in dietary habits and serum cholesterol. *J Cardiol* 33 : 327-338

Sasaki S, Kobayashi M, Tsugane S (1999) : Development of substituted fatty acid food composition table for the use in nutritional epidemiologic studies for Japanese populations : its methodological backgrounds and the evaluation. *J Epidemiol* 9 : 190-207

Sasaki S, Matsumura Y, Ishihara J, Tsugane S (2003) : Validity of a self-administered food frequency questionnaire used in the 5-year follow-up survey of the JPHC Study Cohort I to assess dietary fiber intake : Comparison with dietary records. *J Epidemiol* 13 (1 suppl) : S106-S114

Sasaki S, Ushio F, Amano K, Morihara M, Todoriki T, Uehara Y, Toyooka T (2000) : Serum biomarker-based validation of a self-administered diet history questionnaire for Japanese subjects. *J Nutr Sci Vitaminol* 46 : 285-296

Sasaki S, Yanagibori R, Amano K (1998a) : Self-administered diet history questionnaire developed for health education : a relative validation of the test-version by comparison with 3-day diet record in women. *J Epidemiol* 8 : 203-215

Sasaki S, Yanagibori R, Amano K (1998b) : Validity of a self-administered diet history questionnaire for assessment of sodium and potassium. Comparison with single 24-hour urinary excretion. *Jpn Circ J* 62 : 431-435

Setchell KD (1998) : Phytoestrogens : the biochemistry, physiology, and implications for human health of soy isoflavones. *Am J Clin Nutr* 68 : 1333S-1346S

Shepherd R, Farleigh CA, Land DG (1985) : Estimation of salt intake by questionnaire. *Appetite* 6 : 219-233

Shimizu H, Ohwaki A, Takatsuka N, Ido M, Kawakami N, Nagata C, Inaba S (1999) : Validity and reproducibility of a quantitative food frequency questionnaire for a cohort study in Japan. *Jpn J Clin Oncol* 29 : 38-44

Takahashi K, Yoshimura Y, Kaimoto T, Kunii D, Komatsu T, Yamamoto S (2001) : Validation of a food frequency questionnaire based on food groups for estimating individual nutrient intake. *Jpn J Nutr* 59 : 221-232 (in Japanese with English abstract)

Takahashi Y, Sasaki S, Tsugane S (2001) : Development and validation of specific carotene food composition tables for use in nutritional epidemiologic studies for Japanese populations. *J Epidemiol* 11 : 266-275

Takatsuka N, Kurisu Y, Nagata C, Owaki A, Kawakami N, Shimizu H (1997) : Validation of simplified diet history questionnaire. *J Epidemiol* 7 : 33-41

Tokudome S, Imaeda N, Tokudome Y, Fujiwara N, Nagaya T, Sato J, Kuriki K, Ikeda M, Maki S (2001) : Relative validity of a semi-quantitative food frequency questionnaire versus 28 day weighed diet records in Japanese female dietitians. *Eur J Clin Nutr* 55 : 735-742

Tokudome Y, Imaeda N, Ikeda M, Kitagawa I, Fujiwara N, Tokudome S (1999) : Foods contributing to absolute intake and variance in intake of fat, fatty acids and cholesterol in middle-aged Japanese. *J Epidemiol* 9 : 78-90

Tsubono Y, Kobayashi M, Sasaki S, Tsugane S (2003) : Validity and reproducibility of a self-administered food frequency questionnaire used in the baseline survey of the JPHC Study Cohort I. *J Epidemiol* 13 (1 suppl) : S125-S133

Tsugane S, Kobayashi M, Sasaki S (2003) : Validity of a self-administered food frequency questionnaire used in the 5-year follow-up survey of the JPHC Study Cohort I : Comparison with dietary records for main nutrients. *J Epidemiol* 13 (1 suppl) : S51-S56

Willett W, Lenart E (1998) : Reproducibility and validity of food-frequency questionnaire. In : Willett W. Nutritional epidemiology, 2nd edition. pp.101-147. Oxford University Press. Oxford

Yamamoto S, Sobue T, Sasaki S, Kobayashi M, Arai Y, Uehara M Adlercreutz H, Watanabe S, Takahashi T, Iitoi Y, Iwase Y, Akabane M, Tsugane S (2001) : Validity and reproducibility of a self-administered food-frequency questionnaire to assess isoflavone intake in a Japanese population in comparison with dietary records and blood and urine isoflavones. *J Nutr* 131 : 2741-2747

Yamaoka K, Tango T, Watanabe M, Yokotsuka M (2000) : Validity and reproducibility of a semi-quantitative food frequency questionnaire for nutritional education of patients of diabetes mellitus (FFQW65). *Nippon Koshu Eisei Zasshi* 47 : 230-244 (in Japanese with English abstract)