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Validity and reproducibility of the FFQ (FFQW82) for dietary assessment in female adolescents

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Abstract

Objective: To assess the validity and reproducibility of a self-administered FFQ with eighty-two food items (FFQW82) for assessing the habitual diet in female adolescents.

Design: The validity of the FFQW82 for assessment of nutrient intake was evaluated by comparison with a 7 d weighed food record (7d-FRRI) reported as 'gold standard'. Reproducibility of the FFQW82 was assessed at an interval of 1 month (test–retest method). The first survey (FFQW82 and 7d-FRRI) was conducted in April 2007 and the second FFQW82 survey was conducted in May 2007. Daily consumption of energy from eleven food groups and nine nutrients were calculated from both instruments for breakfast, lunch, dinner and the whole day. Crude and energy-adjusted Pearson correlation coefficients were calculated using log-transformed data.

Setting: Middle school, Tokyo, Japan.

Subjects: Female adolescents aged 12–13 years.

Results: Sixty-three female adolescents completed both surveys. The relative difference between the energy intake calculated by the FFQW82 and the 7d-FRRI for the whole day, breakfast, lunch and dinner was 8%, 10%, 15% and 10%, respectively. As for validity, the correlation coefficient of total energy intake for the whole day was 0·31. The result for breakfast was relatively higher (0·59) compared with that for lunch (0·40) and dinner (0·32). For macronutrients, the energy-adjusted correlation coefficient ranged from 0·28 (carbohydrates) to 0·53 (protein). Reproducibility of total energy intake was 0·62 and ranged from 0·46 (fat) to 0·69 (carbohydrate) for macronutrients.

Conclusions: These results suggest that the FFQW82 has proved to have some potential with regard to reproducibility among our study population.

Keywords
FFQ
Validity
Reproducibility
Female adolescents
Nutrition assessment

In recent years, youth obesity[1,2] and lifestyle-related diseases[3–5] have increased significantly, as have problems related to a distorted body image[6]. The accurate assessment of nutritional intake is important in epidemiological studies. Although under-reporting of energy intake in young people has been shown[7], the FFQ is feasible for this purpose[8], considering the circumstances of young people that prohibit them from weighing foods, such as school attendance, as well as their ability to meticulously record food intake.

Thus far, various FFQ have been assessed to determine their validity for use in young people in Western countries[9–16]. To our knowledge, however, no study has determined the effectiveness of an FFQ in acquiring information on the diets of young people in Japan. Previously, we developed an FFQ with sixty-five food items (FFQW65) to be used in nutritional education for the prevention of diabetes[17]. This instrument assessed energy intake separately for breakfast, lunch and dinner in addition to intake for the entire day and was useful for nutritional education in adults. We reported on the assessment of the effect of nutritional education in a randomized controlled trial for a high-risk group of persons with diabetes using the FFQW65[17]. In the last decade, however, dietary habits and the variety of foods eaten by the Japanese have changed. To address the diversity of the current diet, we have newly developed an FFQ with eighty-two food items (FFQW82). The validity and reproducibility of the FFQW82 in adults was evaluated elsewhere[18]. To adapt the FFQW82 for use in adolescents, it must be evaluated using young subjects. Our earlier work[19] in adults looked at eating patterns for each meal among persons with diabetes, and the

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assessment led to success in nutrition education to correct excess eating at night and to increase dietary intake at breakfast. The younger generation in Japan tends to eat little for breakfast, and correcting that eating pattern is an objective of our nutrition education. Thus, it is important to ascertain the breakfast habits of this age group. The FFQW82 may be a useful instrument for this purpose. Thus the aim of the present study was to evaluate the relative validity and reproducibility of the FFQW82 for measuring dietary intake in female adolescents.

Methods

Subjects and study design

Subjects were 121 female adolescents aged 12–13 years who attended a private junior high school in Tokyo. The FFQW82 was validated by comparing data from that instrument with data obtained by an alternative dietary assessment method, a 7 d weighed food record reported intake (7d-FRRI). Of the 121 subjects, sixty-three completed the 7d-FRRI for at least six of the seven days (52·1 % of study subjects). Because many of the students usually bought their lunch while at school, a recall method was used for weekday lunch while the full procedure for the 7d-FRRI was used for all other meals, snacks, etc. An electronic scale was loaned to each subject to quantify the food portions consumed. Subjects and parents were instructed on how to use household measures and carry out procedures related to the 7d-FRRI. All students were requested to photograph their meals so that the accuracy of their records could be checked by dietitians. Dietitians attempted to reconstruct missing or ambiguous information after examining the completed 7d-FRRI. The first survey using the FFQW82 (FFQ1) was performed in April 2007. Shortly thereafter, the 7d-FRRI was conducted. Then 1 month later, a second survey using the FFQW82 (FFQ2) was conducted in May 2007 to determine the reproducibility of the FFQW82 (Fig. 1). All responses were reviewed after completion of the survey for possible errors or missed questions.

Reproducibility of the FFQW82 was evaluated using data on sixty of the sixty-three students (49·6 % of study subjects) who were administered both the FFQ1 and FFQ2. Three of the sixty-three students did not fully complete the FFQ2 for various reasons.

The study was approved by the Ethics Committee of Showa Women's University. The purpose of the study and the procedures involved were explained to all study subjects who then provided informed consent.

FFQW82

The FFQW82 is a self-administered questionnaire on recall of intake frequency and portion size over a period of 1 month from a list of foods with pictures. The FFQW82 can be completed in about 30 min. From responses to the FFQW82, energy and nutrient intake for breakfast, lunch and dinner as well as for the whole day can be estimated. The portion size is described as 'small', 'medium' or 'large'. The standard amount for 'medium' was determined by consulting a past survey (September 2006, for students of the former grade) and was shown by size on the food list. 'Small' is defined as half the amount of 'medium', whereas 'large' is defined as 1·5 times the amount of 'medium'. Intake frequency is indicated by six categories: (0 = 'absolutely do not eat'; 1 = 'eat once or twice per month'; 2 = 'eat once or twice per week'; 3 = 'eat 3 to 4 times per week'; 4 = 'eat 5 to 6 times per week'; and 5 = 'always eat at breakfast (or lunch or dinner)'). Some of the listed foods comprised more than type of food. For example, the category 'fat' included foods with various ingredients, such as 'stir-fried vegetables', 'deep-fried food', 'stew', 'fried rice', etc. Because some snacks, such as rice balls, can be considered part of a meal, it was not always possible to specify what was a snack or a meal. In these cases, we treated some snacks as meals. The estimated intake of energy and several nutrients for a whole day was calculated by simply summing up the estimated intake for each meal. Subjects were instructed to recall and then record what they ate and drank, including between-meal snacks or a food eaten multiple times per day. The Microsoft® Excel 2007 program (Microsoft Inc., Redmond,

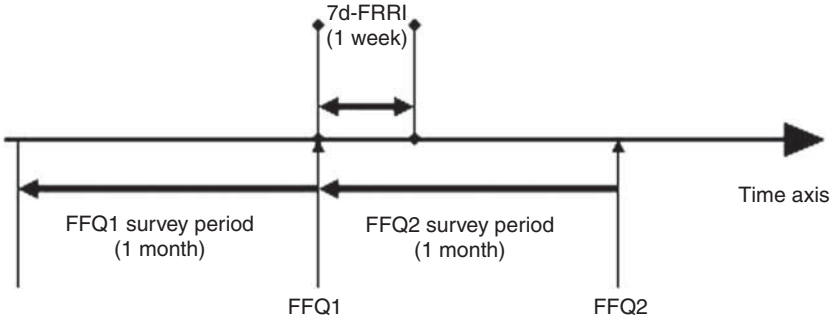

Fig. 1 Process of assessment using FFQW82 and 7d-FRRI in Japanese female adolescents (*n* 63) aged 12–13 years (FFQW82, FFQ with eighty-two food items; 7d-FRRI, 7 d weighed food record reported intake; FFQ1, first administration of FFQW82; FFQ2, second administration of FFQW82)

WA, USA) was used to obtain the nutrient compositions for items on the FFQW82[18].

7d-FRRI

With the 7d-FRRI, actual intake was calculated based on weight of foods consumed. Specifically, the average intake for a whole day and for each meal was calculated separately. Food intake in the morning was included under the category of breakfast, that in the afternoon was considered as lunch, and that at night was under the category of dinner. These categories matched those in the FFQW82. All reports were reviewed by dietitians. After examining the completed 7d-FRRI, dietitians contacted the subjects to obtain missing or ambiguous information.

Statistical methods

Summary statistics were calculated. The data were logarithmically transformed to achieve normal distributions. In the case of no intake (0 value), we added 1 as a small value.

To assess the true validity of an FFQ would require measuring with high accuracy the usual self-selected diet of individuals corresponding to the duration of the FFQ. However, that is not feasible. Therefore, we assessed relative validity by comparing the FFQ with a 7d-FRRI as an alternative dietary assessment method; we assumed the latter as the 'gold standard.' The Pearson correlation coefficient between the reported intake from the 7d-FRRI and the estimated intake from the FFQ2 was calculated for each food group, for the whole day and for each meal, as well as for each of the nine nutrients shown in Table 2. We used the average of seven days for the 7d-FRRI as the reported intake when we calculated Pearson and Spearman correlation coefficients.

Reproducibility (test–retest reliability) was evaluated by the correlation between the estimated intake from results of the FFQ1 and the FFQ2. Crude and energy-adjusted Pearson correlation coefficients[9] were calculated.

Because categories of intake, such as meals, snacks, food groups, etc., included no intake (0 values) and logarithmic transformations did not necessarily achieve normal distributions, the Spearman correlation coefficient was also calculated for both validity and reproducibility. In addition, due to the skewness of the nutrient data, we added a sensitivity analysis for transformation. Namely, the nutrient values were transformed to approximate normality using a Box–Cox transformation; thereafter, the Pearson correlation coefficient was calculated. The SAS for Windows statistical software package version 9·13 (SAS Institute, Cary, NC, USA) was used for the analysis.

Results

Table 1 shows basic statistics for estimated energy intake and actual energy intake by food group for a whole day and for each meal in sixty-three subjects. The median of the difference between estimated energy intake and actual energy intake was largest for lunch (457 kJ) and was 769 kJ for the whole day. Among food groups, the difference was particularly large for meat (−183 kJ) at dinner, but, for the whole day, the difference for sweets/snacks (381 kJ) was largest. As shown in Table 2, with regard to nutrients, the crude differences were greater for K (314 mg) and Ca (130 mg).

Results for validity of the FFQW82 by food group for a whole day and for meals are shown in Table 3. For daily total energy intake, the Pearson correlation coefficient was 0·31 and ranged from 0·18 (grains, fish) to 0·80 (eggs); the Spearman correlation coefficient ranged from 0·12 (grains) to 0·74 (milk). Table 4 shows results for validity with regard to nutrients. The energy-adjusted Pearson correlation coefficients for macronutrients ranged from 0·28 (carbohydrate) to 0·53 (protein). The Spearman correlation coefficients ranged from 0·19 (salt) to 0·55 (Ca).

With regard to reproducibility, the Pearson correlation coefficient for total energy intake was 0·62 (energy) and for the food groups ranged from 0·11 (fat) to 0·83 (milk; Table 3). Spearman correlation coefficients ranged from 0·13 (fat) to 0·86 (milk; Table 3). As for the Box–Cox transformation, the results did not differ greatly from those of log transformation and varied from 0·26 (Fe) to 0·52 (Ca; results not shown).

Discussion

The FFQW82 has the advantage of assessing dietary intake at meals, which makes it possible to devise nutrition education to encourage young people to have adequate intake at breakfast. This is one of the important points for development of the FFQW82. Although not high, the Pearson correlation for total energy was about the same as in other studies (see Table 5) and did not differ greatly from the Spearman correlation.

Characteristics of the FFQW82

Several dietary instruments have been used to collect information on food intake to estimate the distribution of average intake of nutrients and foods in a population and to monitor such intake over time. Tooze *et al.*[20] aimed to increase the precision of the predicted usual intake and of the estimated diet–health outcome relationships by combining two or more instruments. Our purpose is, as described above, to interpret correlations between the FFQW82 and 7d-FRRI, although we recognize that these instruments have limitations. It is important that an FFQ should be concise and easy to answer when assessing food intake[21], especially in young people whose knowledge of food and cooking is generally limited. The FFQW82 was designed to present eighty-two food items according to food group and separately question intake frequency and portion size of each food at meals. The kind and quantity

Table 1 Basic statistics on estimated energy (kJ) from FFQW82 and actual energy (kJ) from 7d-FRRI by food group (whole day, breakfast, lunch and dinner) in Japanese female adolescents (*n* 63) aged 12–13 years

		Estimated energy				Actual energy				Difference		
Meal/Food group	*n*	Median	P25	P75	% with no intake	Median	P25	P75	% with no intake	Median	P25	P75
Whole day												
Grains	63	3170	2640	3814	0	2986	2746	3417	0	194	−387	641
Fish	63	238	165	481	0	256	152	377	3	48	−105	176
Meat	63	533	326	847	0	836	674	1084	2	−306	−493	16
Eggs	63	142	41	319	5	215	120	299	5	−22	−97	49
Cheese	63	30	0	90	25	41	0	88	38	0	−24	29
Beans	63	154	80	274	0	96	46	132	8	61	−14	158
Vegetables	63	226	131	335	0	176	128	266	0	27	−51	114
Milk	63	300	83	628	6	179	62	403	17	82	−23	266
Fruits	63	130	54	287	3	74	30	172	10	29	−24	120
Sweets/snacks	63	664	279	1130	0	100	0	373	27	381	151	870
Fat	63	614	394	830	0	684	476	859	2	26	−216	170
Total	63	6809	5631	9442	0	6313	5330	7234	0	769	−355	2320
Breakfast												
Grains	63	839	495	946	0	697	500	893	0	62	−199	290
Fish	63	9	0	69	35	0	0	16	62	1	0	41
Meat	63	35	9	83	22	38	0	120	37	0	−34	12
Eggs	51	41	10	82	22	72	0	119	29	0	−62	11
Cheese	54	15	0	60	46	0	0	41	63	0	0	15
Beans	63	12	0	56	41	0	0	16	63	0	0	28
Vegetables	63	25	4	51	19	13	0	39	25	3	0	19
Milk	63	209	23	345	14	158	2	282	24	0	−42	88
Fruits	60	20	0	88	30	20	0	84	45	0	−20	22
Sweets/snacks	63	106	21	333	21	0	0	88	63	32	0	162
Fat	63	55	15	136	17	64	0	133	29	0	−38	43
Total	63	1602	1250	2320	0	1458	1090	1860	0	187	−218	833
Lunch												
Grains	63	1223	972	1527	0	1150	909	1321	0	16	−173	449
Fish	49	64	28	125	0	33	10	63	16	23	−16	90
Meat	61	229	121	370	0	322	236	428	0	−53	−237	90
Eggs	48	95	41	190	0	110	63	152	0	10	−45	74
Cheese	29	15	15	60	0	20	0	48	15	5	−21	19
Beans	39	27	14	75	0	6	0	23	25	17	6	64
Vegetables	62	56	30	92	0	38	23	61	5	13	−2	55
Milk	23	46	11	102	0	0	0	7	24	22	11	102
Fruits	46	43	17	87	0	19	0	62	26	22	−3	49
Sweets/snacks	62	232	128	499	0	37	0	167	46	158	62	346
Fat	61	260	133	465	0	219	117	330	13	95	−38	258
Total	63	2385	1924	3305	0	2071	1652	2476	0	457	26	991
Dinner												
Grains	63	1191	1063	1419	0	1127	998	1373	0	31	−255	257
Fish	63	170	108	319	0	189	126	327	6	−12	−152	82
Meat	63	237	147	486	2	456	321	611	2	−183	−353	0
Eggs	56	20	20	82	0	76	29	97	2	−9	−60	16
Cheese	60	15	0	15	40	0	0	20	68	0	0	15
Beans	63	85	40	174	3	61	21	105	13	36	−21	105
Vegetables	63	131	78	188	0	130	77	180	0	−4	−59	57
Milk	63	43	0	213	25	0	0	40	59	26	0	148
Fruits	62	61	22	87	11	12	0	51	40	26	0	82
Sweets/snacks	63	142	60	333	6	0	0	57	65	98	33	326
Fat	63	220	107	376	0	329	241	474	2	−85	−232	50
Total	63	2990	2234	3827	0	2719	2299	3239	0	198	−353	683

FFQW82, FFQ with eight-two food items; 7d-FRRI, 7 d food record reported intake; estimated energy, estimated energy based on FFQW82; actual energy, actual energy from 7d-FRRI; difference, estimated energy minus actual energy; P25, 25th percentile; P75, 75th percentile.

of foods consumed usually differ among meals. Therefore, the method of asking about each meal individually in the FFQW82 allows for ease of use by the subjects. With this design, the FFQW82 makes it possible to estimate the energy intake by meals individually as well as by food group. The FFQW82 has the unique characteristic that it can be used as a tool for assessing the effect of nutritional education for each meal type[18]. In addition, the full-colour photographs might enable the subject to easily remember the actual foods eaten from the food list while doing the survey, make the survey easier to complete and increase the subject's motivation.

7d-FRRI of female adolescents

The validity of an FFQ is usually evaluated with food records, which are considered to be the 'gold standard' in

Table 2 Basic statistics on estimated energy and actual energy for the whole day by nutrient in Japanese female adolescents (*n* 63) aged 12–13 years

	Estimated energy			Actual energy			Difference		
Nutrient	Median	P25	P75	Median	P25	P75	Median	P25	P75
Energy (kJ)	6842	5631	9442	6313	5330	7234	769	−355	2320
Protein (g)	58	47	86	56	46	67	5	−8	25
Fat (g)	49	37	77	51	41	63	4	−9	17
Carbohydrate (g)	239	199	288	194	175	223	47	7	75
Fe (mg)	6	5	8	5	4	6	0	−1	3
Ca (mg)	468	312	654	338	217	458	130	11	251
Mg (mg)	204	153	281	168	132	192	37	−5	102
K (mg)	2099	1462	2942	1679	1344	2109	314	−187	913
Dietary fibre (g)	11	8	15	9	7	11	2	0	6
Salt (g)	9	5	8	7	5	8	2	0	4

Estimated energy, estimated energy based on FFQW82; FFQW82, FFQ with eight-two food items; actual energy, actual energy from 7d-FRRI; 7d-FRRI, 7 d food record reported intake; difference, estimated energy minus actual energy; P25, 25th percentile; P75, 75th percentile.

Table 3 Validity and reproducibility of FFQW82 by food group in Japanese female adolescents (*n* 63) aged 12–13 years

	Validity*								Reproducibility†	
	Pearson				Spearman				Pearson	Spearman
Food group	Whole day	Breakfast	Lunch	Dinner	Whole day	Breakfast	Lunch	Dinner	Whole day	Whole day
Grains	0·18	0·32	0·40	0·14	0·12	0·20	0·25	0·05	0·54	0·63
Fish	0·18	0·47	0·14	0·25	0·28	0·27	0·15	0·16	0·63	0·64
Meat	0·59	0·72	0·36	0·55	0·20	0·51	0·18	0·12	0·54	0·46
Eggs	0·80	0·71	0·42	0·22	0·58	0·53	0·39	0·34	0·60	0·43
Cheese	0·71	0·69	−0·35	0·47	0·44	0·70	−0·24	0·57	0·69	0·53
Beans	0·52	0·59	0·38	0·45	0·37	0·49	0·28	0·31	0·56	0·52
Vegetables	0·46	0·79	0·47	0·41	0·32	0·50	0·34	0·18	0·77	0·66
Milk	0·76	0·81	0·36	0·57	0·74	0·76	0·18	0·62	0·83	0·86
Fruits	0·59	0·67	0·15	0·44	0·41	0·48	−0·03	0·52	0·49	0·34
Sweets/snacks	0·49	0·55	0·40	0·35	0·35	0·35	0·23	0·29	0·46	0·48
Fat	0·67	0·73	0·39	0·54	0·41	0·50	0·37	0·35	0·11	0·13
Total	0·31	0·59	0·40	0·32	0·28	0·49	0·37	0·25	0·62	0·58

FFQW82, FFQ with eight-two food items; FFQ2, second administration of FFQW82; 7d-FRRI, 7 d food record reported intake; FFQ1, first administration of FFQW82.
*Correlation of estimated energy from FFQ2 and actual energy from the 7d-FRRI.
†Correlation of the estimated energy from FFQ1 and FFQ2.

Table 4 Validity and reproducibility of FFQW82 by nutrient in Japanese female adolescents (*n* 63) aged 12–13 years

	Validity*			Reproducibility†	
Nutrient	Pearson	Energy adjusted	Spearman	Pearson	Spearman
Energy (kJ)	0·31	–	0·28	0·62	0·58
Protein (g)	0·35	0·53	0·33	0·62	0·56
Fat (g)	0·37	0·42	0·32	0·46	0·34
Carbohydrate (g)	0·29	0·28	0·25	0·69	0·70
Fe (mg)	0·31	0·31	0·29	0·63	0·57
Ca (mg)	0·52	0·49	0·55	0·76	0·70
Mg (mg)	0·37	0·42	0·36	0·70	0·63
K (mg)	0·37	0·53	0·40	0·73	0·65
Dietary fibre (g)	0·29	0·45	0·25	0·74	0·68
Salt (g)	0·35	0·38	0·19	0·66	0·62

FFQW82, FFQ with eight-two food items; FFQ2, second administration of FFQW82; 7d-FRRI, 7 d food record reported intake; FFQ1, first administration of FFQW82.
*Correlation of estimated energy from FFQ2 and actual energy from the 7d-FRRI.
†Correlation of estimated energy from FFQ1 and FFQ2.

nutritional epidemiology[8]. Because the FFQW82 asks about intake over a period of 1 month, in making comparisons of its usefulness, it is desirable to keep food records for the same period of time. However, in studies of young people, we should consider their limited knowledge, skills and motivation for a dietary study[22].

Table 5 General information and adjusted correlation coefficients of validation studies of youth/adolescent FFQ

Study	Our study	Rockett *et al.*[15]	Slater *et al.*[14]		Lietz *et al.*[13]	Yaroch *et al.*[11]	MacIntyre *et al.*[12]	Field *et al.*[10]		Rockett *et al.*[9]		
Publication year	2010	2007	2003		2002	2000	2000	1999		1997		
Survey year(s)	2007	1993–1994	1999		2000–2001	1992	1996–1998	1993–1994		1993–1994		
Country	Japan	USA	Brazil		UK	USA	South Africa	USA		USA		
Reference data for validation	7 d diary record	3 × 24 h dietary recalls	3 × 24 h dietary recalls		7 d weighed dietary record	3 × 24 h dietary recalls	7 d weighed dietary record	4 × 24 h dietary recalls over 1-year period		3 × 24 h dietary recalls		
FFQ type	Self-administered	Self-administered	Self-administered		Interview-based	Picture-sort	Interview-based	Semi-quantitative		Self-administered		
FFQ interval	1 month	1 year	Only once		Only once	2 weeks	6–12 weeks	1 year		1 year		
FFQ items	82	26	76		131	97	145	97		126		
Sample size	63	261	79		50	22	74	109		261		
Gender	All girls	Girls 53 %, boys 47 %	Girls 49·4 %, boys 50·6 %		Girls 64 %, boys 36 %	All girls	Women 80 %, men 20 %	Girls 52 %, boys 48 %		Girls 53 %, boys 47 %		
Age (years)	13–14	9–18	14–18		11–13	11–17*	15–65	4–7th grade†		9–18		
Correlation coefficient	Pearson	Pearson	Pearson		Spearman	Pearson	Spearman rank	Spearman		Pearson		
Nutrient	Total	Total	Female	Male	Total	Total	Total	4–5th grade	6–7th grade	9–13 years	14–18 years	Total
Energy (kcal)	0·31	0·34	0·86	0·82	0·33	0·63	0·31	0·26	0·47	0·21	0·49	0·35
Protein (g)	0·53	0·30	0·17	0·21	0·31	0·32	0·30	0·21	0·43	0·28	0·47	0·37
Fat (g)	0·42	0·41	−0·07	0·33	0·66	0·59	0·25	0·24	0·44	0·44	0·54	0·49
Carbohydrate (g)	0·28	0·33	0·12	0·43	0·50	0·65	0·31	0·22	0·47	0·42	0·39	0·40
K (mg)	0·53	0·32	–	–	0·60	–	–	–	–	0·41	0·48	0·44
Ca (mg)	0·53	0·54	0·50	0·46	0·47	–	0·24	0·35	0·55	0·52	0·57	0·55
Mg (mg)	0·37	0·45	–	–	–	–	–	–	–	0·51	0·54	0·52
Fe (mg)	0·31	0·51	0·10	0·11	–	–	0·20	0·04	0·35	0·47	0·59	0·53
Dietary fibre (g)	0·45	0·41	0·48	0·62	0·49‡	–	0·14	0·06	0·45	0·46	0·46	0·46
Na (mg)	–	0·05	–	–	0·26	–	–	–	–	0·13	0·32	0·21
Salt (g)	0·38	–	–	–	–	–	–	–	–	–	–	–

*Subjects were all low-income, overweight African-Americans.
†Subjects were all low-income and 84 % were African-Americans.
‡Englyst fibre.

Considering the feasibility of conducting a dietary survey, we used the average intake for seven continuous days (1 week) instead of the average intake over seven randomly selected days over a period of 1 month as an approximation. However, nearly half of the subjects did not complete the required 7 d of record keeping, with most not continuing to weigh food for the requested time. This is the limitation of our survey. The 'fatigue factor' might affect the quality of what is reported after 3 to 4 d in a 7 d dietary record, as the subject tires of the task and becomes negligent regarding details. Although we examined daily distribution of energy intake as well as daily fat intake, we did not find evidence of decreased quality in the reporting after 3 to 4 d. The subjects who completed the survey did not differ from those who did as to age or instructions on use of the instrument. We felt that the data provided by the sixty-three remaining female subjects met our needs. Considering the lifestyle of adolescents, it is a potentially acceptable method to assess intake over a period of 1 week by weighed food records, including both a weekend and weekdays.

Validity and reliability

Rockett *et al.*[9] conducted a study of the validity of their instrument in 149 subjects (9–13 years old) who were similar in age to our subjects. In their study, the correlation coefficient between the 24 h recall method for 3 d and the FFQ (126 items) was 0·21 for energy while that in our study was 0·31. Also in comparison with their results, our study found similar energy-adjusted correlation coefficients for macronutrients. With the exception of results by Slater *et al.*[14], which showed higher correlations for energy (0·86 for females), the correlations were not very high (Table 5).

Divergence for sweets/snacks was shown in the present study, with an estimated intake of 664 kJ while the actual intake was 100 kJ for sweets/snacks, which were included in a list of confectioneries and beverages, and the median of the difference was 381 kJ. This appeared to strongly influence the correlation for energy at 0·31. On the other hand, reproducibility for energy was high at 0·62. Therefore, it was thought that there was an omission at the time of recording the weight of sweets/snacks, including confectioneries and beverages, when completing the 7d-FRRI. In the study by Watson *et al.*[23] participants who had not completed food records instead completed a 24 h recall of food intake. To use two or more instruments is a good way to improve the reference standard.

Marchioni *et al.*[24] studied the reproducibility of an FFQ consisting of seventy-six items with forty-six subjects aged 16–19 years. The correlation coefficient for energy was 0·53 for their study and 0·62 for our study. The energy-adjusted correlation coefficients were also very much higher in our study than in their study except for fat (ours = 0·11). This may be because under the category of 'fat' were foods such as seeds and oils, which are not easy to quantify on the FFQW82. Another reason is that half of the foods in the 'fat' group were mixtures of various constituents. Results might be improved if there was a direct question about the quantity of oils.

Advantages and limitations of the study

The present study has several advantages. First, to our knowledge, this is the first study to examine the validity between FFQ and 7d-FRRI in Japanese female adolescents. The advantage of the FFQW82 is that a habitual diet can be analysed by meal type (breakfast, lunch and dinner) and by food group. Second, specific problems related to dietary intake of young people, such as skipping breakfast or excessive intake of snacks at night, can be revealed and the goals of dietary improvement based on scientific evidence can be planned and practised. Especially, breakfast habits affect overall nutrient profiles[25,26] and to ascertain the breakfast habits of this age group is important. Additionally, assessment of the effect of nutritional education may also be possible. Third, the validity for breakfast was higher than for lunch or dinner, which ranged from 0·32 (grains) to 0·81 (milk). Assessing problems by meal type is important for giving dietary guidance not only in Japan, but also overseas. The FFQW82 is designed to ask for the frequency of intake and the amount of a typical portion of each food for breakfast, lunch and dinner separately.

The study has some limitations. First, the subjects were limited to female adolescents 12–13 years of age. Thus, we cannot discuss or draw conclusions on the dietary habits of male adolescents. As for the gender effect on the validity of the study, Rockett *et al.*[15] evaluated the validity of an FFQ in youths from 9 to 18 years old by gender. The results showed that the correlation coefficient for energy was 0·30 in males and 0·33 in females and for macronutrients ranged from 0·38 (protein) to 0·52 (fat) in males and from 0·35 (carbohydrate) to 0·49 (fat) in females. They indicated no gender difference in the validity of the FFQ with subjects in this age group. It appears that since the dietary needs at these ages are fulfilled primarily at home, the food content is almost the same but the amount of intake differs. Therefore, they suggested that no gender difference existed in the correlations. The FFQW82 might be used for male adolescents; however, there is the need for some additional work in the future if young males are to be served by this instrument. Second, data for only sixty-three of the 121 students were used in the final analysis. The remaining subjects either did not complete at least six of the seven days of the dietary record or missed recording several meals. As for possible factors that may be associated with use of the FFQW82 and 7d-FRRI between subjects who did and did not complete the 7d-FRRI, we examined differences among subjects who did not and who did complete the dietary record in terms of BMI, sports

activity, dietary behaviour, hours of sleep and hours of study at home, from information obtained previously through a self-administered questionnaire (results not shown here). However, there was no significant difference ($P > 0{\cdot}05$) between the two groups for BMI (19·1 *v.* 18·6 kg/m^2), sports activities and other responses. From these potential factors, we interpreted that the effects of bias might be not so large, although we cannot prove it. Because the aim of the study was to assess the correlations between FFQW82 and 7d-FRRI, this may not seriously bias the results. Third, the fact that the estimated correlations between the FFQ and 7d-FRRI were 'relatively high' does not generally mean that the FFQ is 'acceptable to use' when both have correlation errors. However, the 7d-FRRI is more objective and the correlation bias of self-report might be less with this instrument. Furthermore, the 7d-FRRI, which involved the use of photographs, was reviewed by dietitians. Thus, this may reduce bias. It might be possible that the subjects under-ate during the recording period. Although the actual intake was lower than the estimated intake, this does not necessarily indicate that these subjects under-ate for the entire week, with the exception of sweets/snacks. That is, both the median of the difference and the percentage of no intake in sweets/snacks were large and the chance of reporting under-eating was high. This should be interpreted carefully. Fourth, FFQ are generally recognized to involve substantial measurement error, both random and systematic. In the present study, because of limitation of the data, we cannot examine this point. As for the Spearman correlation coefficient, it can be used for ordinal or categorical data even when there is a spike at zero in the data and it may be helpful in interpretation of the association.

Conclusions

In the current study, the validity and reproducibility of the FFQW82 in female adolescents were evaluated. This instrument, originally developed for use in adults, has proved to have some potential with regard to reproducibility among our study population. However, the study only showed reliability for intake at breakfast, as reliability was somewhat lower for lunch and dinner in female adolescents. Further work is necessary to refine this instrument to make it more valid for lunch and dinner.

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