Original Article

Reproducibility and validity of a Chinese food frequency questionnaire used in Taiwan

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A 64-item Chinese food frequency questionnaire (FFQ) combined with open questions on types of staples and cooking oil most frequently consumed was designed for a prospective study in Taiwan to appraise participants' usual intake. We examined its reproducibility and validity. The form was administered three times at three-month intervals by face-to-face interview to 83 senior college students majoring in nutrition, in order to recall their usual dietary intake over the past six months. They also completed five-day (includes both weekends) diet records (DR) after each interview. Averaged intake levels of most nutrients assessed by the three FFQs were slightly higher than those of 15-day DR. Intraclass correlation coefficients for nutrient intakes assessed by three FFQs three months apart ranged from 0.37 for saturated fat to 0.82 for alcohol (average: 0.52). Averaged Pearson correlation coefficients between the unadjusted and energy-adjusted nutrient intakes measured by DR and by the third FFQ (which asked about diet during the six months encompassing the diet records) were 0.40 and 0.35, respectively, not including vitamins A and C. These correlations were higher (average: 0.47) after adjusting for the daily variation of the diet records. On average, 50% subjects were correctly classified into the same tertiles by both methods; 11% of the subjects were misclassified to extreme categories. These data indicate that this FFQ for Chinese-speaking people in Taiwan is reproducible and provides a useful measure of intake for many nutrients over a six-month period.

Key Words: Chinese Food-frequency questionnaire, Taiwan, diet record, reproducibility, validity, ratio of within- to between-person variation

Introduction

Studies of the relationships between food and health require a method capable of estimating current or past usual intake to permit reasonable ranking of the individuals[1,2] Food-frequency questionnaires (FFQs) are designed to appraise averaged long-term diet rather than to provide a precise estimate of short-term intake and are often used in epidemiologic studies to relate nutrient intakes with disease outcomes.[3-6]

Current or short-term dietary measurement methods may provide estimates of intake that are quantitatively more precise than those from FFQs. Though there is no gold standard in the assessment of individual dietary intake, recording food intake for several days and multiple 24-hour recalls of intake were two methods commonly used by researchers to estimate the short-term or current food intake of individuals in validity and reliability study of FFQ.[7-14] In studying the association between dietary intake and diseases of Taiwanese Chinese, researchers are handicapped by lack of a proper questionnaire. Though a few FFQs used in China have been developed and validated,[7,8,11,12] a Chinese version of FFQ for Taiwanese is necessary to consider, inter alia, the impact of food accessibility and economic factors on dietary pattern. We developed a FFQ based on those foods predictive of nutrient intakes in Taiwan.[15,16] The purpose of the present study is to examine the reproducibility and validity of this FFQ using the average of multiple diet records (DR) as gold standard.

Materials and Methods

The food frequency questionnaire

A 64-item frequency and amount (FAQ) type FFQ[1] was developed for the Cardiovascular two-township study and others in Taiwan area, in which participants answered how often and how much they usually consume an item of food or drink. Major contributor foods and predictors for fat, protein, carbohydrate, vitamin A, vitamin C, and calcium were considered for inclusion in this interviewer administered FFQ. Food items were arranged into sections of the major food groups; milk and soy drinks, soybean and wheat protein products, meats, sea foods, vegetables, and fruits. Similar foods were listed close to each other to prevent

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redundant recollection.

The frequency response section included 10 categories ranging from 'over 6 times per year', '1 to 3 times per month', 'once per week', '2 to 4 times per week', '5 to 6 times per week', 'once per day', '2 times per day', '3 times per day', '4 to 5 times per day' to 'over 6 times per day'. Ten categories of portion size information were also included. However the options were varied by habitual serving size. For example, vegetables are commonly served to a whole family but for one individual, therefore, fractional portion sizes are required across a narrower range (ranging from less than one fifth to 2.5 units). For food items that have a standard serving size, e.g., milk, fruits, and eggs, those options were bigger (ranging from a quarter to 3.4 units). Specific three-dimensional food models were used to help the subjects estimate their usual portion size. For staple foods, an open format was made available to fill in up to four staples most commonly consumed at breakfast, lunch, and dinner, since cooked rice made up 90% of the staples consumed in Taiwan and there is large number of other staple foods available for the remaining 10%. Most people consumed customarily 2-3 kinds of major staple foods. In addition, information on cooking method, cooking oil, and frequency of fried foods were collected to aid the estimation of total fat and fatty acid consumption. Vitamin supplementation and alcohol consumption also were included.

Participants

We assessed the validity of the FFQ among 83 senior college students (58 males, 25 females) majoring in nutrition who were attending a Public Health Nutrition course at the Fu-Jen University (n=35) and Therapeutic Nutrition at the Shin-Chien College (n=47) in Taipei during the autumn semester of 1991. The students were asked to complete three FFQs and 15 DRs in a period of 6 months (September 1991 to February 1992). Each time, they were asked to fill out an FFQ about their eating habits during the past half year (summer vacation was omitted). The students filled out the FFQ in class, while a researcher (M-S. Lee) instruct them according to a standardized manual used in actual fieldwork, to mimic a face-to-face interview. Food models were shown at the same time to aid the students in their estimation of habitual portion size. No probing was used. They were also taught how to complete five-day DRs with the aid of a booklet during a 20-minute group session, in which the students were given time to ask questions. The subjects were asked to complete the five-day DRs during the week after in-class interview for both weekend days and three weekdays most representative of their normal intake.

Data analysis

Two dBase programs were developed to convert FFQs and DRs to nutrient data. The food-composition data base used to calculate nutrient values is based primarily on Taiwan Food Composition Data Base[17-19] and other published sources.[20-22] Means and standard deviations were calculated on total nutrient intakes from FFQ and DRs. Most nutrients' distributions were skewed to the right; therefore, all nutrients were log (natural) transformed before statistical analysis. Because all nutrients were correlated with energy intake, energy-adjusted nutrients were derived by the residual method.[23] We selected two statistics to measure reproducibility and validity: the intraclass correlation coefficient (ICC),[24] which measures agreement rather than linear trend and accounts for the variance between and within subjects; and the Pearson correlation coefficients, which measure the linear relationship between two methods. The ratio of within- and between-person variations was used to de-attenuate Pearson correlation coefficients[25] because the within-person variation in RDs intake can attenuate corre-lation between two methods.[9] The degree of mis-classification was also used to evaluate validity of FFQ further. The purpose of this study was to quantify mea-surement error rather than to test hypotheses; therefore, *p* values are not presented.

Results

Daily nutrient intakes

We list the means for average daily intakes of selected nutrients from three five-day DRs, 15 DRs, and from the first and third FFQs for the 63 subjects who had completed the third FFQ and more than 10 days of DRs (Table 1). The third FFQ estimates of total energy intake and the macronutrients (protein, fat and carbohydrates) were within ± 15% of the estimates produced from the mean of the DRs. The percentages of energy from the macronutrients from both FFQ and DR (data not shown) were comparable to the results of National Survey of the same age group by 24-hour recall (protein: 15%, fat: 32.2%, carbohydrate: 51.7%).[26] For most nutrients, intake was generally higher when estimated by questionnaire than by DRs (within 9 to 40%). Total intakes of vitamin B_{12} and vitamin C were overestimated (near 60%) by FFQ, with or without inclusion of supplements.

Test–retest reproducibility of the FFQ

We computed ICC for unadjusted and energy-adjusted mean daily nutrient intakes between three sets of five-day DRs and between three FFQs (Table 2). All information collected was used in these calculations, regardless of whether all three FFQs had been completed in order to obtain the largest possible power. The comparison between unadjusted mean nutrient intakes from three sets of five-day DRs indicated a moderate degree of reproducibility that ranged from ICC=0.15 for alcohol to r=0.54 for monounsaturated fat. The ICCs for the unadjusted nutrients from three FFQ spaced three months apart averaged 0.52 and ranged from 0.37 for saturated fat to 0.82 for alcohol. Adjusting for total energy intake decreased averaged ICCs to 0.33 for DRs and 0.47 for FFQs.

Ratios of within- to between-person variation

The ratios of within- to between-person variation calculated from the average daily intake estimated from each set of five-day DRs are shown in Table 2, with a higher ratio indicating a higher intra-individual variance component. The ratios were slightly greater than one for total energy and for the energy-yielding nutrients (energy: 1.02, protein: 1.35, fat: 1.04, carbohydrates: 1.19). However, the ratios for vitamins and minerals were bigger.

For instance, the ratios for all water-soluble vitamins, calcium and iron were greater than two. With the exception of vitamins B_2, C and niacin; vitamins and minerals without supplement tended to have higher ratios than those from diet only. These ratios allowed us to calculate the de-attenuated correlation coefficients between RDs and FFQs.

Validity of the FFQ

We used three techniques to assess the validity of the FFQ (Tables 3-5). First, we compared unadjusted and energy-adjusted nutrient intakes estimated from the first and the third FFQ with the 15-day average from DRs (Table 3). Correlations between the first FFQ and the averaged DRs were slightly lower than those between the third FFQ and the DRs. The third FFQ provided reasonably good correlations for energy-adjusted consumption of alcohol (0.65) and vitamin B_2 (0.57), niacin (0.57), iron (0.57) with supplements, and caffeine (0.57)

Table 1. Mean (standard deviation) absolute daily nutrient intakes estimated by three sets of five-day diet records (DRs) and from questionnaires completed by 63 college students in Taiwan

	1st 5 DRs		2nd 5 DRs		3rd 5 DRs		15 DRs		Questionnaire 1		Questionnaire 3	
	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)
Energy (kcal)	2215	(582)	2154	(583)	2064	(525)	2147	(456)	2359	(622)	2248	(563)
With alcohol	2232	(595)	2155	(583)	2078	(540)	2158	(465)	2381	(646)	2274	(596)
Protein (g)	73.9	(19.7)	71.5	(18.0)	66.6	(17.6)	70.9	(14.5)	87.0	(29.1)	81.8	(26.0)
Total fat (g)	86.8	(23.9)	82.4	(24.5)	79.1	(21.4)	83.0	(18.8)	77.8	(31.5)	74.6	(30.8)
Saturated fat (g)	29.1	(8.6)	27.1	(8.5)	25.9	(7.6)	27.5	(6.6)	26.4	(11.0)	25.6	(9.8)
Polyunsaturated fat (g)	25.7	(8.3)	25.4	(8.9)	24.3	(7.1)	25.2	(5.9)	24.1	(11.2)	23.4	(12.6)
Monounsaturated fat (g)	30.5	(9.1)	28.6	(9.5)	27.4	(8.7)	29.0	(7.6)	26.2	(11.6)	24.5	(10.5)
Cholesterol (mg)	361	(145)	335	(127)	333	(111)	344	(104)	413	(157)	385	(244)
Carbohydrates (g)	285	(85.9)	282	(89.8)	273	(81.1)	280	(68.5)	329	(85.9)	314	(93.5)
With alcohol	286	(86.5)	282	(89.8)	273	(81.8)	280	(69.0)	330	(86.3)	315	(95.0)
Dietary fiber (g)	15.7	(7.0)	15.2	(6.0)	14.4	(4.7)	15.0	(4.5)	22.7	(8.9)	20.8	(10.0)
*Vitamin A (RE)**	766	(358)	800	(522)	784	(490)	785	(358)	1122	(780)	1217	(1154)
Without supplements	725	(320)	712	(336)	760	(448)	729	(268)	914	(506)	905	(570)
Vitamin B_1 (mg)	1.41	(1.40)	1.29	(0.95)	1.30	(2.04)	1.33	(1.07)	1.97	(1.32)	2.22	(3.44)
Without supplements	1.22	(1.04)	10.7	(0.40)	1.03	(0.64)	1.10	(0.48)	1.51	(0.80)	1.23	(0.54)
Vitamin B_2 (mg)	1.55	(0.99)	1.58	(1.08)	1.58	(2.00)	1.57	(0.93)	2.08	(1.29)	2.62	(3.33)
Without supplements	1.35	(0.43)	1.33	(0.47)	1.30	(0.47)	1.33	(0.34)	1.62	(0.62)	1.59	(0.58)
Vitamin B_6 (μg)	586	(262)	517	(198)	533	(201)	546	(159)	671	(300)	600	(281)
Without supplements	586	(262)	517	(198)	533	(201)	546	(159)	670	(300)	599	(281)
Vitamin B_{12} (μg)	6.30	(7.62)	5.25	(4.81)	5.36	(5.89)	5.68	(4.51)	14.8	(17.7)	13.9	(19.0)
Without supplements	6.16	(7.64)	5.01	(4.66)	5.18	(5.86)	5.50	(4.25)	14.3	(17.6)	13.3	(18.8)
Niacin (mg)	15.8	(7.8)	15.7	(9.8)	14.8	(13.7)	15.5	(7.6)	24.7	(12.6)	25.5	(24.7)
Without supplements	14.3	(4.3)	13.6	(4.6)	12.7	(4.1)	13.6	(3.5)	20.5	(8.6)	17.6	(7.7)
Folate (μg)	118	(54.8)	117	(62.8)	112	(66.4)	116	(54.3)	161	(91.2)	154	(87.7)
Without supplements	112	(42.0)	109	(31.3)	102	(34.9)	108	(26.7)	146	(53.4)	139	(56.6)
Vitamin C (mg)	117	(98.8)	109	(77.9)	102	(103)	109	(63.8)	293	(209)	277	(273)
Without supplements	98.3	(62.2)	95.8	(55.6)	88.5	(39.0)	94.4	(40.5)	242	(143)	206	(136)
Vitamin E (mg)	10.2	(4.2)	10.3	(6.9)	9.83	(6.6)	10.1	(4.8)	19.1	(54.6)	16.1	(28.3)
Without supplements	9.48	(3.13)	9.38	(3.88)	8.85	(3.29)	9.22	(2.59)	8.88	(3.95)	8.63	(4.70)
Calcium (mg)	505	(163)	497	(210)	478	(169)	494	(132)	601	(240)	634	(251)
Without supplements	503	(163)	490	(211)	476	(171)	490	(132)	579	(230)	622	(246)
Iron (mg)	10.9	(3.5)	10.7	(5.6)	10.0	(4.1)	10.6	(3.9)	14.8	(8.7)	13.8	(8.6)
Without supplements	10.5	(3.0)	9.81	(2.98)	9.67	(3.14)	10.0	(2.2)	12.2	(5.5)	11.9	(5.2)
Alcohol (g)	2.07	(5.49)	0.17	(0.80)	1.52	(5.86)	1.24	(2.88)	2.71	(10.8)	2.99	(11.4)
Caffeine (mg)	29.9	(52.7)	25.8	(41.6)	22.4	(41.4)	25.4	(35.4)	49.6	(122)	33.1	(38.5)

* RE, retinol equivalent

and moderate correlations for energy-adjusted consumption of vitamin B_1 (0.50) and vitamin E (0.43) with supplements. The averaged correlation coefficients between the third FFQ and mean DRs were 0.40 for unadjusted and 0.35 for energy-adjusted nutrient intakes. The correlations between nutrient intake from FFQ and those from DRs correcting for the effects of within-person variation are listed in Table 3 (columns labelled "De-attenuate"). The de-attenuated correlation coefficients between the third FFQ and DRs ranged from 0.15 for vitamin A to 1.0 for alcohol. All the de-attenuated correlations were appreciably higher than the Pearson correlations with an average of 0.47, not including vitamins A and C. Tertile categorization of selective nutrient distributions was used to evaluate the agreement in the cross-classification of subjects between the third FFQ and averaged 15-day DRs (Table 4). On average, 50% of subjects were classified in the same category by DRs and

Table 2. Intraclass correlation coefficients (ICC) and ratios* of coefficients of variation for three sets of five-day diet records and three food frequency questionnaires (FFQ) completed by 83 college students in Taiwan†

	Diet records, sets 1-3				FFQ 1-3	
	Unadjusted		Adjusted		Unadjusted	Adjusted
	ICC	Ratio	ICC	Ratio	ICC	ICC
Energy (kcal)	.49	1.02			.58	
With alcohol	.50	1.00			.60	
Protein (g)	.43	1.35	.38	1.64	.51	.43
Total fat (g)	.49	1.04	.46	1.19	.38	.29
Saturated fat (g)	.49	1.06	.43	1.34	.37	.29
Polyunsaturated fat (g)	.32	2.09	.24	3.21	.39	.36
Monounsaturated fat (g)	.54	.85	.53	.90	.41	.32
Cholesterol (mg)	.38	1.64	.51	.95	.40	.37
Carbohydrates (g)	.46	1.19	.43	1.32	.58	.50
With alcohol	.45	1.23	.41	1.42	.58	.50
Dietary fiber (g)	.33	2.05	.34	1.89	.61	.57
Vitamin A (RE) ‡	.39	1.56	.35	1.82	.50	.45
Without supplements	.35	1.87	.33	2.00	.48	.43
Vitamin B_1 (mg)	.32	2.17	.28	2.59	.46	.43
Without supplements	.19	4.24	.10	9.37	.47	.42
Vitamin B_2 (mg)	.26	2.78	.23	3.34	.43	.37
Without supplements	.34	1.93	.29	2.49	.48	.39
Vitamin B_6 (μg)	.28	2.63	.19	4.34	.51	.46
Without supplements	.27	2.68	.18	4.44	.51	.46
Vitamin B_{12} (μg)	.30	2.29	.28	2.52	.54	.54
Without supplements	.27	2.74	.25	2.96	.53	.54
Niacin (mg)	.36	1.74	.33	2.02	.57	.49
Without supplements	.50	1.02	.51	.97	.59	.51
Folate (μg)	.41	1.43	.39	1.57	.50	.46
Without supplements	.28	2.55	.22	3.63	.49	.45
Vitamin C (mg)	.31	2.20	.31	2.19	.53	.49
Without supplements	.38	1.63	.39	1.59	.55	.51
Vitamin E (mg)	.44	1.29	.42	1.39	.49	.48
Without supplements	.35	1.90	.32	2.17	.41	.40
Calcium (mg)	.32	2.12	.32	2.14	.56	.50
Without supplements	.30	2.34	.29	2.40	.57	.52
Iron (mg)	.43	1.31	.41	1.46	.59	.59
Without supplements	.28	2.59	.21	3.67	.56	.54
Alcohol (g)	.15	5.47	.14	6.26	.82	.80
Caffeine (mg)	.41	1.15	.41	1.44	.63	.59
Average	.36		.33		.52	.47

* The within-person/ between-person ratio is calculated using ANOVA to separate the between- and within-person variance components.
† All data are $\log_e$ transformed. ‡ RE, retinol equivalent

the third FFQ; 11% of the subjects were misclassified to an extreme category. We also used the technique of "actual values for surrogate categories".[27] With this approach, subjects were first grouped into categories such as tertiles on the basis of the surrogate method (i.e., the third FFQ). Then the "true value" for these same subjects based on the more-detailed method (i.e., DR) was assigned to the categories defined by the surrogate to the method. The mean daily DRs values of selective nutrients were ordered from the lowest values of first tertile highest values of the third tertile (Table 5). The variation of the mean daily DRs in FFQ tertile is somewhat elevated by adjustment for energy, even though adjustment for energy decreased the correlation coefficient, which has been shown in Table 3.

Discussion

Food selection of a defined population is strongly affected

Table 3. Pearson correlation coefficients (r) between food frequency questionnaires and the average of 15 diet records* calculated for unadjusted and energy-adjusted nutrients†

	Questionnaire 1			Questionnaire 3		
	Unadjusted r	Adjusted r	De-attenuated‡ r	Unadjusted r	Adjusted r	De-attenuated r
Energy (kcal)	.44		.52	.44		.52
With alcohol	.46		.54	.46		.54
Protein (g)	.44	.39	.50	.40	.38	.48
Total fat (g)	.38	.32	.39	.33	.25	.30
Saturated fat (g)	.56	.53	.65	.40	.34	.42
Polyunsaturated fat (g)	.21	.23	.34	.25	.18	.27
Monounsaturated fat (g)	.44	.34	.39	.38	.33	.38
Cholesterol (mg)	.44	.33	.39	.40	.35	.41
Carbohydrates (g)	.37	.30	.37	.39	.33	.41
With alcohol	.38	.31	.39	.41	.33	.41
Dietary fiber (g)	.14	.16	.21	.20	.14	.18
Vitamin A (RE) §	.29	.26	.33	.15	.11	.15
Without supplements	.12	.11	.15	.11	.11	.15
Vitamin B_1 (mg)	.34	.29	.41	.51	.50	.70
Without supplements	.29	.21	.45	.26	.16	.34
Vitamin B_2 (mg)	.43	.35	.53	.57	.57	.86
Without supplements	.36	.25	.35	.24	.16	.22
Vitamin B_6 (μg)	.32	.21	.34	.22	.16	.26
Without supplements	.32	.21	.34	.22	.17	.26
Vitamin B_{12} (μg)	.22	.16	.20	.42	.41	.30
Without supplements	.19	.14	.20	.41	.42	.61
Niacin (mg)	.45	.34	.45	.55	.57	.76
Without supplements	.38	.25	.29	.38	.35	.41
Folate (μg)	.46	.49	.62	.39	.34	.43
Without supplements	.29	.32	.49	.26	.19	.29
Vitamin C (mg)	.13	.15	.20	.19	.22	.30
Without supplements	.05	.07	.09	.07	.08	.10
Vitamin E (mg)	.28	.28	.35	.41	.43	.53
Without supplements	.26	.29	.39	.26	.23	.31
Calcium (mg)	.39	.39	.53	.38	.34	.46
Without supplements	.34	.33	.46	.35	.31	.43
Iron (mg)	.57	.52	.65	.60	.57	.71
Without supplements	.38	.31	.48	.49	.48	.74
Alcohol (g)	.44	.36	.59	.72	.65	1.0
Caffeine (mg)	.31	.30	.36	.55	.56	.67
Average	.34	.29	.40	.36	.32	.44
Average without vitamins A and C	.36	.31	.42	.40	.35	.47

* All data are $\log_e$ transformed. † The energy-adjusted correlations between dietary methods use the residuals from regressing each nutrient on the total calories as measured by the food frequency questionnaire or diet records. ‡ The de-attenuated correlation coefficient is calculated using the ratio of the within- to between-person variance (Table 2) measured by the three five-day averages for the diet records. The formula for this corrected correlation is calculated as: $\rho_c = \rho_o\sqrt{1+ratio/n}$ where ρ_o is the observed correlation between the energy-adjusted nutrients (except for energy itself) from the questionnaire and diet records, and *n* is the weighted number of replicate measurements for unbalanced design. In this case, *n*=2.54. § RE, retinol equivalent

Table 4. Cross-classification (tertile) of nutrient distribution assessed by the average of three five-day diet records and the third food frequency questionnaire completed by 83 college students in Taiwan

	Exact agreement (%)	Misclassified to extreme tertile (%)
Calories	52	4
Protein	52	10
Saturated fat	45	14
Cholesterol	51	14
Vitamin E	51	12
Iron	49	13
Alcohol	54	14
Caffeine	54	6

Table 5. Use of actual values for surrogate categories to compare the third food frequency questionnaire (FFQ) with the average of 15-day diet records

Mean daily diet record values in FFQ tertile				
FFQ tertile	Protein (g)	Total fat (g)	Cholesterol (mg)	Iron* (mg)
Crude intake				
1	64	80	285	8.5
2	73	83	339	10.0
3	79	88	384	11.9
Energy-adjusted				
1	59	81	281	8.8
2	72	86	296	11.1
3	88	90	423	12.0

by its accessibility to foods and economic status.[28] Therefore, even though several FFQs for Chinese living in China have been developed and validated;[7,8,11,12] undoubtedly, Taiwanese studies need validated FFQ of its own. This paper evaluated the reproducibility and validity of a Chinese version of food frequency questionnaire designed for Taiwanese against the DRs as well as the variation in nutrient intakes.

Daily nutrient intakes

In the current study, the mean daily energy and macronutrient intakes, in terms of percentages of total energy, estimated by FFQ and DR, of 63 college students were comparable to the intake of the same age group of the National Survey by 24-hour recall.[26] It indicated that the coverage of this FFQ was not far away from sufficient, at least for those food items which are energy-yielding. In agreement with literature,[1,29] compared with DRs, our FFQ slightly overestimated consumption for most nutrients. This might be a reflection of the length of food list and a systematic error of FFQ. The longer the list, the greater degree of overestimation is more evident.[29]

However, by the present FFQ, the intakes of vitamin B_{12} and vitamin C were overestimated by nearly 60%, whether or not supplements were included in calculation. For vitamin C, it may be because there is a tremendous variety of fruits and vegetables available in Taiwan, a subtropical country. Vitamin C predictors may be affected by seasonality.[16] In order to avoid possible seasonal and weekday variation, we collected dietary information three times at three-month intervals and DRs had to cover weekdays and weekends. The operational manual asked subjects to recall their usual consumption of fruits and vegetables only when they were available; the time frame (the past six months but not the past year) might confuse respondents and cause overestimation. Animal foods are the only dietary source of vitamin B_{12}, especially organ meats. In our version of FFQ, the frequency response section of organ meats has the same as for the other food items, “over 6 times per year” to “over 6 times per day”. Because organ meats were not commonly consumed,[26] for those who actually ate far less than “over 6 times per year” we may overestimate their vitamin B_{12} (and vitamin A) intake. The above explanations also applied to the small correlation coefficients of vitamins A and C of FFQ against DR.

Test–retest reproducibility of the FFQ

The ICCs among three FFQs three months apart ranged from 0.37 to 0.82 in the present study (Table 2). It appears that the test–retest reproducibility was comparable to the reproducibility of other FFQs already reported in the literature.[1,9,10,27] By contrast, the ICCs among DRs were smaller than FFQs’, which implied that the information obtained by FFQ has wider coverage (time frame) than DRs, which was the major reason to use FFQ to measure usual diet. This indicates that the FFQ, developed for Taiwanese is reproducible.

There is an argument whether the energy-adjusted or absolute nutrient should be taken into consideration in FFQ validation study and further epidemiolgic studies.[30-33] Theoretically, males tend to consume more energy than females, this will increase correlation with absolute intakes when the population is heterogeneous.[34] In the current study, we did not have enough sample size of female subjects to analyze by gender. The ICCs and Pearson correlation coefficients for two genders together did decrease after energy-adjustment, which demonstrated that energy-adjustment may be the better strategy for data analysis (i.e dietary composition). However, following the expert’s suggestions, we list the findings for both absolute and energy-adjusted nutrient intakes in the present paper.[30,32]

Ratios of within- to between-person variation

Because we have collected multiple DRs, we were able to calculate the variation in nutrient intakes. A large intra-individual variance in data for the independent variable under consideration will bias estimates of correlation coefficients and those of regression coefficients toward 0.[35] These fluctuations, which can be due to day-to-day or seasonal factors, result in measurement error in the diet records. Generally the daily energy intake of the most free-living populations is relatively constant. The small ratio of energy and macronutrients in the present analysis indicates this feature. The within-person variance for most micronutrients was much greater than that for macronutrients. For instance, most vitamins and the minerals calcium and iron, usually are abundant in specific foods, such as dairies, red meats and organ meats. However, these foods are infrequently consumed in Taiwan. The effects of this within-person variation, which may attenuate correlations between the FFQ and DRs, can be reduced by increasing the number of diet record measurements or corrected statistically by using the within-to between- variability ratio.[7]

Validity of the FFQ

In this paper, the third FFQ provided reasonably good correlations (average: 0.35, ranged from 0.2 to 0.65 without vitamins A and C) with 15-day DRs, for energy-adjusted consumption of most nutrients. Using the information of variation in nutrient intakes, we obtained de-attenuated correlation coefficients between the third FFQ and DRs, which were higher than the Pearson correlations (average: 0.47, ranged from near 0.3 to 1.0). These data suggested that this FFQ revealed an acceptable validity except vitamins A and C.[1,9,10,14,27,31]

Poor correlations between FFQ and DR were found for vitamins A and C. The possible explanations include seasonal variations and the use of six-month DRs. In this FFQ, two and three fruit groups were designated as providing estimates of vitamin A and C, respectively. However, the availability of most of these fruits depends on the season. Therefore, subjects' recall of their dietary intake over the past six months would cause under- or over-estimation for a FFQ developed for a one-year time frame. Another explanation would be the small number of very concentrated sources of some vitamins (e.g., vitamin A in livers) and their episodic consumption.

Suggestions from experts of appraising agreement between two methods is by cross-classification and the percentage of agreement.[27,30] Our results showed 50% subjects were assigned to the same tertiles and around 10% subjects were to the opposite tertiles, which were similar to a validation study of China.[11] The method of "actual values for surrogate categories" carries the actual quantitative differences in DRs that correspond to the relative categories defined by the FFQ. These values are a function of both the true variation in DR within the population and the measurement error associated with the FFQ.[27] With this approach, we showed that the relative order of nutrient intakes was as expected and which indirectly suggests that our FFQ was valid.

Strengths and limitations of the study

We collected three 5-day DRs at three months intervals as the comparison method. This up-to-15 days DRs made our 'gold standard' a relatively stable estimate of usual diet and least correlated error to FFQ when compared to by using 24-hour recall as comparison method. It may imply that our study was with minimal correlated error and did not overestimate in both reproducibility and validity. The most difficult aspect of conducting a validation study like the present one was to find a group of subjects who was able to keep diet records and would be very cooperative for at least six months. Thus, feasibility was the major concern. The compromise was to use a convenient sample that may not represent the general population. The present study had two major study-design limitations. The first was the use of college students, who majored in nutrition, as the study subjects rather than a random sample from general population. The difference in the ages of these students was only two to three years. Thus, the results may not be generalized, without qualification, to other populations. In addition, because of their professional training, these students are more able to recognize foods and estimating portion size than are persons without this training. However, there was no indication that the results obtained using nutrition-major students as subjects would be any different to from those obtainable in the general population.

Second, the time frame in the present study was six months, rather than the conventional one-year time frame. Because of the seasonal variation in some foods, which are good sources of some vitamins, e.g., vitamins A and C, under- or over-estimation of dietary intake becomes a problem that needs to be solved. Modification of the nutrient data-generating program may help to correct this defect.

Because there are no typical serving size for most home-made dishes of Taiwanese family, we designed our FFQ as a FAQ type. However, to include the portion size options or not is still under debate.[1,6,29,33] Some research found there was no need to include options of portion size in FFQ, for it only introduced artificial error.[6,33] We may need to verify this argument in the future by using a fixed portion size, e.g. mode of the options of the portion size, have been chosen by respondents, instead of the present setting. Then a check of the reproducibility and validity of the revised FFQ would be desirable.

The applicability of this study, both inside Taiwan and abroad, requires reflection. The diets of Chinese living in various parts of Taiwan used to be rather homogeneous, with the exception of indigenous Taiwanese. The diet of the Taiwanese indigenes has some unique features, and a separate questionnaire should be designed for them. In recent decade, western style fast foods have rapidly moved into cities in Taiwan, which will gradually widen the differences in diets between the rural and urban populations. Regarding the applicability to Chinese living in other societies, the information obtained in this paper could be supplementary material for them, since overseas Chinese lifestyles are usually results of mixed cultures. Moreover, the information obtained from our study could be a reference for Chinese living in the cities of China, but farmers' diets in China are much simpler and vary from province to province. More work needs to be done to verify the food-composition database used and to collect more diet-related information, e.g., recipes. Moreover, considerations should be given to how to improve the FFQ, for example, whether to add more items, to change the response categories, or to make it semi-quantitative. Our ultimate goal is to develop a valid and reliable tool that can be applied in studying diet-health relationships in Chinese-speaking populations.

In summary, we compared individual nutrient intakes estimated by a 64-item FFQ with intakes calculated from three five-day DRs collected three months apart in a group of college students majoring in nutrition. After corrections were made for within-person variation, correlations for most nutrients were good or moderate, except those for vitamins A and C. This FFQ can be used with acceptable reproducibility and validity as an alternative tool in the study of relationships between diet and health.

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Original Article

Reproducibility and validity of a Chinese food frequency questionnaire used in Taiwan

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摘要

膳食頻率問卷因其簡易及涵蓋個人長期飲食訊息的特性，為營養流行病學研究常用工具。本研究目的在評估一份專為台灣地區一個前瞻性研究研擬之中文膳食頻率問卷問卷 (64項食物) 之信度及效度。83名輔仁大學及實踐管理學院營養系學生參與本研究。以飲食記錄法所得之結果當作真值，與膳食頻率問卷的結果比較，問卷回顧時間為半年。在半年內完成三次膳食資料蒐集，每次參與者均填答問卷及五天 (含週末) 之飲食記錄， 之間間隔三個月。

結果顯示，對大部分營養素而言，以膳食頻率問卷測得的平均值較十五天的平均值稍高。組內相關係數(信度) 的範圍從飽和脂肪酸之0.37到酒精的0.82 (平均相關係數：0.52)。

不計維生素A與C的狀況下，飲食記錄之平均值與第三次問卷之平均未調整及能量調整相關係數 (效度) 分別為0.40及0.35。 經調整三次五天之飲食記錄之變異之後， 平均相關係數升高到0.47。以兩種飲食測量法將受試分成人數相等的三組，平均50%的受試者被分到同一組內;10%受試被分到極端的兩組。本研究的結果指出，該問卷之信度與效度可被接受。