

Original Article

Meal distribution, relative validity and reproducibility of a meal-based food frequency questionnaire in Taiwan

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Food frequency questionnaire is an important assessment tool for public health nutrition research. We describe the development history and conducted the validity and reproducibility studies for a meal-based Chinese food frequency questionnaire (Chinese FFQ) by five meal sequences. A total of 51 subjects were recruited to collect dietary information twice (6 months apart) with one 24-hr recall, 7-day food records and the Chinese FFQ. Combining data from both time sets, Chinese FFQ showed strong correlations of macro and micronutrients with 7-day records (n=60, r=0.29-0.50, p<0.05), but not with 24-hr recalls (n=60, r=0.01-0.23, p>0.05). The reproducibility of this Chinese FFQ (n=22) was consistently high for most nutrients, with Spearman correction coefficients between 0.42 for vitamin A to 0.79 for vitamin B₁₂. From a larger sample of 231 subjects who completed the Chinese FFQ and one 24-hr recall, we found the energy distributions of breakfast, lunch, dinner, afternoon and evening snacks combined from Chinese FFQ were 20%, 37%, 37% and 6%, and from 24-hour recalls were 19%, 36%, 44% and 1%, respectively. These results showed acceptable reproducibility and relative validity of this meal-based Chinese FFQ.

Key Words: meal distribution, relative validity, reproducibility, meal-based food frequency questionnaire, Taiwan

INTRODUCTION

Nutritional epidemiology is a rapidly growing science and relies largely on dietary assessment methods for the estimation of the "exposure" variables that may be related to disease risk. Much inspiration comes from the direct relevance of this type of research to crucial health problems of modern societies, such as cancers,¹ cardiovascular diseases,² osteoporosis,³ cataracts,⁴ diabetes⁵ and congenital malformations.⁶ All of these diseases/conditions have been the objects of research in nutritional epidemiology globally, and some of the findings have already been applied in ways that may improve public health. However, the major difficulty of nutritional epidemiology lies in the extremely complex nature of diet.⁷ Because short-term recall and diet record methods are generally expensive and inappropriate for assessment of individual usual past diet, investigators have sought alternative methods for measuring long-term dietary intakes. After Burke⁸ developed a detailed dietary history interview that attempted to assess an individual's usual diet, in the 1950's and 60's researchers in Europe, such as Heady⁹ and the USA, such as Hankin¹⁰ have been independently converging toward food frequency methods.

For many years, the development of an appropriate food frequency questionnaire (FFQ) as a long-term dietary assessment tool to facilitate diet-disease association studies, has been conducted in various populations including North America,¹¹ South America,¹² Europe¹³ and China.¹⁴ The

development process is extremely complex and highly technically oriented. Baghurst in a workshop of the second Berlin meeting on nutritional epidemiology reported that there is need of a period of over 10 years, for the development of data collection techniques and attendant computer analysis programs for diet history methods.¹⁵ In Taiwan, we have been utilizing the meal-based FFQ idea in an attempt to assess the usual dietary consumption for studying individuals for various case-control and family studies since 1998.¹⁶⁻¹⁸ In this study, we first describe the development history of the meal-based Chinese FFQ used in Taiwan. Second, we documented the relative validity and reproducibility study of the Chinese FFQ.

MATERIALS AND METHODS

Development of three versions of Chinese FFQ

Since 1998, we have developed early drafts of the first version of the Chinese food frequency questionnaire

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Manuscript received 8 January 2007. Initial review completed 4 February 2007. Revision accepted 24 May 2007.

(Chinese FFQv1), particular attention being paid to deciding food grouping, frequency, and portion size. We selected food items based on observations of meal patterns in urban Chinese (mainly Taipei, Taiwan) and also referenced the popular items of mixed dishes from National Health and Nutrition Examination Survey in Taiwan (personal communication). This Chinese FFQv1 was developed by a meal sequence consisting of breakfast (foods eaten before eleven o'clock in the morning); lunch (between eleven in the morning and two in the afternoon); afternoon snacks (between two and five in the afternoon); dinner (between five to nine o'clock in the afternoon); and evening snacks (after nine in the evening). Five categories of frequency were: less than once per month; 1-3 times per month; 1-3 times per week; 4-6 times per week; and more than once per day. Three portion sizes of small, medium and large were listed in the Chinese FFQv1 and subjects selected one of the three choices.

The second version of this questionnaire (Chinese FFQv2) intends to assess usual dietary intakes over 6 months and consists of eight categories of frequency: never (less than once per month); once per month; 2-3 times per month; once per week; 2-3 times per week; 4-6

times per week; once per day and more than once per day. Three portion sizes of small, medium and large were listed in the Chinese FFQv2 and study subjects selected one of the three choices. This version of questionnaire has reduced and regrouped the food items from 482 items in the first version, to 216 items, without changing the energy distributions from protein, fat and carbohydrate with comparison to group means by 24-hr recalls. The meal distributions for energy, protein, fat and carbohydrate calculated from 348 subjects by Chinese FFQv1, 231 subjects by Chinese FFQv2 and energy distribution from 40 subjects by 24-hour recalls are illustrated in Figure 1. The macronutrient distributions among five meals are comparable between the two versions, and the energy distribution is similar to results from 24-hour recalls. In 2002, we have developed the third version of the Chinese FFQ for assessing dietary patterns for pregnant women, further shortening the questionnaire by eliminating food items that more than 50% of subjects had never eaten in the second version of the Chinese FFQ. Table 1 shows the development and reduction of food items in five meal orders in the three versions of this Chinese food frequency questionnaire.

Chinese FFQ Version1

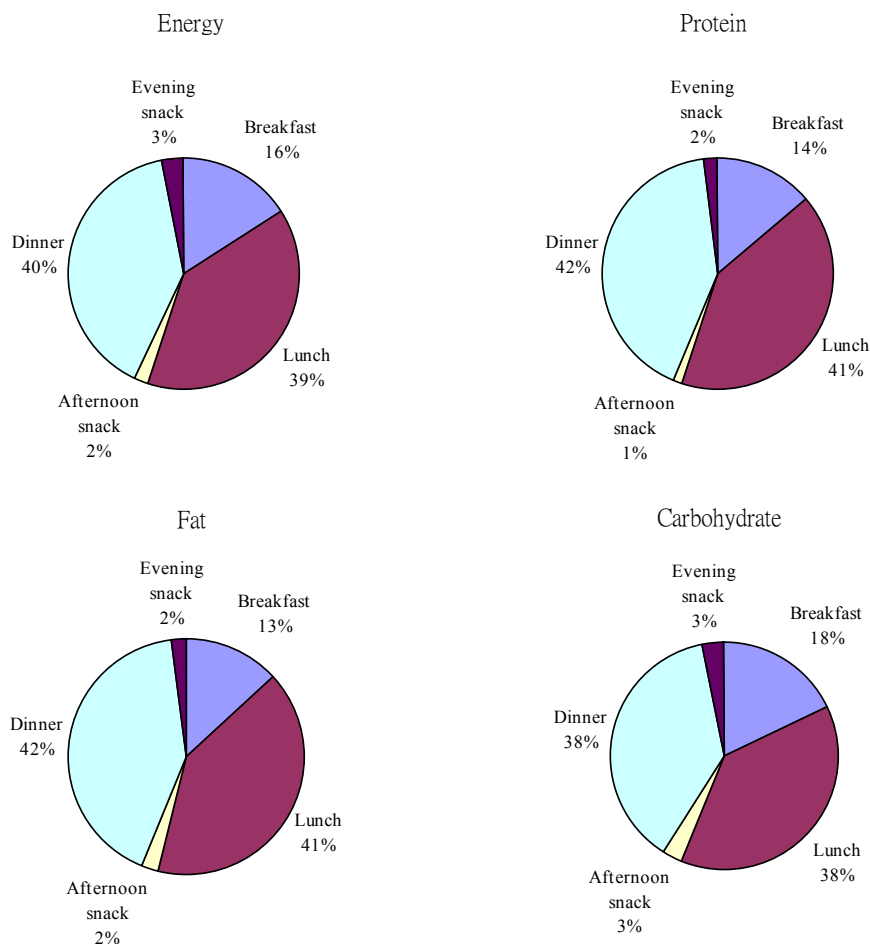


Figure 1. Meal distributions of macronutrients for Chinese FFQ Version 1, Chinese FFQ Version 2, and 24-hr recalls

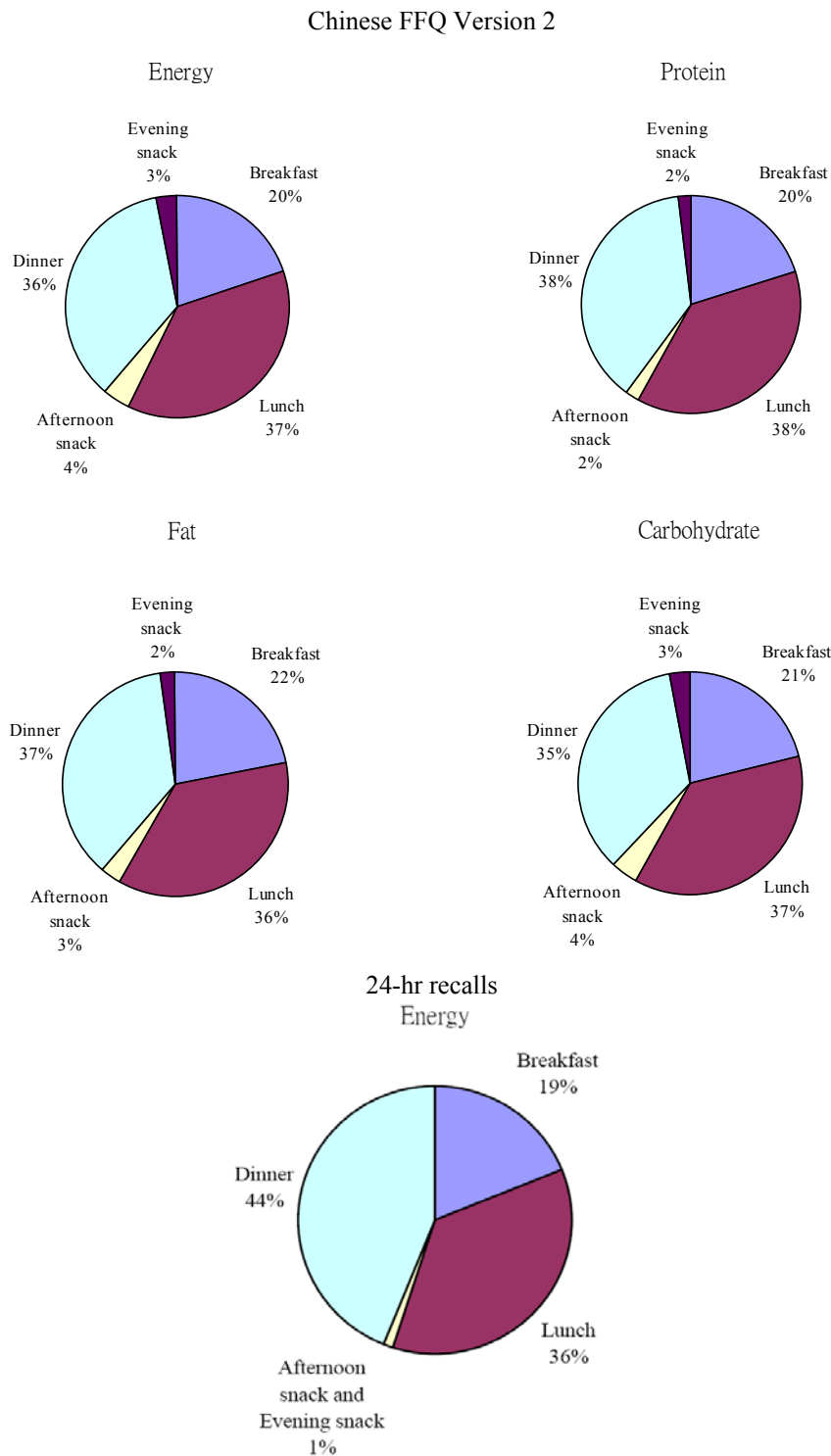


Figure 1. Meal distributions of macronutrients for Chinese FFQ Version 1, Chinese FFQ Version 2, and 24-hr recalls

Table 1. Reduction of food items by different versions of Chinese FFQ

	Version1	Version2	Version3
Breakfast	105	36	28
Lunch	135	64	54
Afternoon snack	40	27	16
Dinner	134	64	54
Evening snack	68	25	19
Others	0	1	1
Total	482	217	172

Validity and reproducibility of second version of Chinese FFQ

From Jan. 2001 to May 2002, we recruited 51 subjects (10 men and 41 women) from age 20 to 62, with a mean age of 29 years, to collect dietary information by the first set of one 24-hr recall, the 7-day food records and the Chinese FFQv2. We collected the second set of these three methods from Aug. 2001 to June 2002. The participants were mostly university students and staff. A total of 39 subjects (8 men and 31 women) completed all three methods in the first set, and 22 subjects (2 men and 20 women) completed the second set, both with an average age of 29. The main drop out reason was the lack of

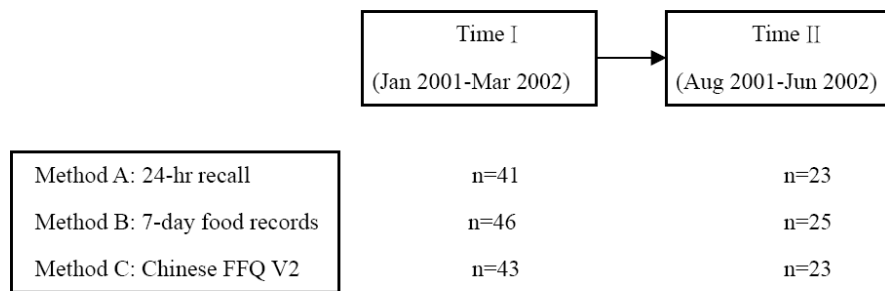


Figure 2. Design and subject number of validity and reproducibility study of the Chinese food frequency questionnaire

willingness to conduct the 7-day food records. Figure 2 shows the study design and numbers of subjects who completed each method in the two sequences for the validity and reproducibility of the Chinese FFQv2. The time range between the two sets was from 5 to 18 months, with an average of 7.5 months.

We collected one day 24-hour recall and Chinese FFQ by face-to-face interviews, the 7-day food records by self-administrated method after an instruction on household measures description. All food recall and records were processed by standardized procedures and coding manuals for home recipes and commercial products were developed and utilized to convert common portions to actual grams. Since 1998, we have developed an integrated database management system, not only to manage food composition table for more than 200 nutrients. This system also contains the recall and record calculation system considering dates, number of days and meal separations. In addition, the Chinese Food Frequency Editing System contains the management of food list, frequency and portion size selections to facilitate processing the various versions of Chinese FFQ.¹⁹ The nutrients included in the analyses consisted of energy, protein, fat, carbohydrate, vitamin A, vitamin E, vitamin B₁, vitamin B₂, Niacin, vitamin B₆, vitamin B₁₂, vitamin C, calcium, phosphorus, iron, cholesterol and dietary fiber.

Statistical analyses

Demographic characteristics including age, sex and educational levels of completed participants were compared from the first and second time periods and found not to be significantly different. Since the study sample was small, we combined dietary information from men and women and calculated mean and standard deviations for subgroup analyses. One outlier consumed more than 10,000 kcal from the first Chinese FFQv2 and was both included and eliminated from the data for analyses, both results were compared and documented. The paired *t*-test for testing repeated measures, Students' *t*-test for group comparisons, and one-way analysis of variance (ANOVA) were used for comparing results from three dietary methods and two time periods. Both nonparametric Spearman coefficients from ranked data and Pearson coefficients were calculated for normally distributed dietary data or natural log transformed data.

RESULTS

To compare results from two sets of collected data, Table 2 shows the daily intakes of selective nutrients by three

dietary assessment methods at two time periods from 22 subjects by paired *t*-test. The Chinese FFQv2 shows similar daily intakes for every nutrient from two time points. However, the 24-hour recall and 7-day food records methods demonstrated decreased nutrient intakes, including energy, protein, fat, carbohydrate, vitamin A, vitamin E, vitamin B₁, vitamin B₂, niacin, vitamin B₆, vitamin B₁₂, vitamin C, calcium, phosphorus, iron, cholesterol and dietary fiber at the second time consistently, but only energy, protein, carbohydrate, vitamin E, niacin, vitamin C, calcium, iron and dietary fiber from 24-hour recalls reached significant levels ($p < 0.05$). However the percents of energy from protein, fat and carbohydrate are similar between the two time sets for all three methods (24-hour recall and 7-day record: 15%, 30%, 55%, Chinese FFQv2: 16%, 33%, 51%) indicating the percentage of major energy contributors are fairly consistent between the two time sets. Table 3 shows the comparisons of these three methods combined the first and second sets ($n=61$). The Chinese FFQv2 demonstrated significantly higher intakes of energy, protein, protein (%), fat, fat (%), carbohydrate, vitamin A, vitamin B₂, vitamin C, calcium, phosphorus, cholesterol and dietary fiber, and lower carbohydrate (%) compared to 24-hour recalls ($p < 0.05$). In comparison with 7-day food records, the Chinese FFQv2 showed significantly higher intakes of energy, protein, protein (%), fat, carbohydrate, vitamin A, vitamin B₁, vitamin B₂, vitamin C, calcium, phosphorus, cholesterol and dietary fiber, and lower carbohydrate (%) ($p < 0.05$). Even though vitamin B₁₂ consumption was lower and iron intake was higher from the Chinese FFQv2 than the two other methods, the level did not reach significance.

Correlation coefficients (*r*) indicating the relative validity for the Chinese FFQv2 of selective nutrient intakes compared to 24-hour recalls and 7-day dietary records, are illustrated in Table 4. Dietary consumption by 7-day records showed high correlations with results from the Chinese FFQv2. Except for percents of energy from protein, fat, carbohydrate and vitamin A, all other nutrients, including energy source nutrients: protein ($r=0.45$), fat ($r=0.43$) and carbohydrate ($r=0.52$), fat soluble vitamins including vitamin E ($r=0.36$), water soluble vitamins including vitamin B₁, B₂, B₆, B₁₂, C and niacin ($r=0.26-0.49$), minerals including calcium, phosphorus and iron ($r=0.40-0.45$), cholesterol ($r=0.36$) and dietary fiber ($r=0.38$) had significant correlations between these two methods. However, in comparison to 7-day food records, the relative validity of the CFFQv2 versus 24-hour recalls was lower. Only carbohydrate ($r=0.35$), vitamin B₁

Table 2. Daily intakes of selective nutrients by three dietary assessment methods at two time periods

	24-hr recall		7-day food records				Chinese FFQ V2	
	Time I (n=22)	Time II (n=22)	Time I (n=22)	Time II (n=22)	Time I (n=22)	Time II (n=22)		
Energy (Kcal)	2046.7 ± 646.1*	1633.4 ± 607.6	1758.2 ± 358.3	1738.1 ± 344.0	2455.5 ± 881.7	2573.5 ± 1301.2		
Protein (g)	74.4 ± 27.1*	59.9 ± 23.6	64.7 ± 13.0	62.8 ± 14.1	99.7 ± 39.4	105.0 ± 57.7		
Protein (%)	14.5 ± 2.6	14.9 ± 3.5	14.8 ± 1.3	14.4 ± 1.3	16.2 ± 2.6	16.1 ± 2.0		
Fat (g)	66.6 ± 26.7	56.5 ± 23.9	62.8 ± 17.6	59.8 ± 13.5	93.1 ± 39.4	96.2 ± 54.6		
Fat (%)	29.2 ± 7.3	31.0 ± 7.5	32.0 ± 4.8	30.9 ± 2.7	33.6 ± 6.3	33.0 ± 5.2		
Carbohydrate (g)	293.3 ± 98.8*	227.0 ± 92.7	238.1 ± 49.2	238.9 ± 45.8	301.9 ± 108.8	319.3 ± 152.4		
Carbohydrate (%)	57.6 ± 7.6	55.5 ± 7.4	54.2 ± 4.5	55.1 ± 2.9	50.0 ± 8.0	50.6 ± 6.4		
Vit A (RE)	1521.4 ± 1182.9	904.5 ± 1304.6	1510.5 ± 1086.5	1397.8 ± 667.1	3300.5 ± 1980.3	4235.0 ± 3075.0		
Vit E (α -TE (mg))	9.2 ± 5.6*	5.9 ± 2.4	7.0 ± 2.7	5.9 ± 2.0	10.2 ± 4.7	10.8 ± 6.5		
Vit B ₁ (mg)	1.1 ± 0.7	1.1 ± 1.0	1.0 ± 0.3	1.0 ± 0.4	1.1 ± 0.4	1.2 ± 0.6		
Vit B ₂ (mg)	1.3 ± 0.6	1.1 ± 0.6	1.1 ± 0.3	1.1 ± 0.3	1.5 ± 0.7	1.5 ± 0.8		
Niacin (mg)	12.9 ± 5.3**	9.4 ± 3.6	10.9 ± 2.3	10.8 ± 2.9	18.0 ± 9.2	18.4 ± 10.8		
Vit B ₆ (mg)	1.3 ± 0.8	1.1 ± 0.5	1.0 ± 0.3	1.1 ± 0.4	1.8 ± 1.4	1.8 ± 1.5		
Vit B ₁₂ (μ g)	10.1 ± 25.1	3.6 ± 4.4	5.7 ± 5.3	4.1 ± 2.8	3.9 ± 2.5	4.5 ± 3.5		
Vit C (mg)	140.6 ± 122.0*	87.0 ± 45.6	129.6 ± 79.4	111.7 ± 46.6	196.8 ± 90.5	183.8 ± 88.7		
Ca (mg)	489.5 ± 248.6*	350.6 ± 179.1	372.3 ± 108.5	371.9 ± 149.2	560.6 ± 267.9	593.9 ± 323.3		
P (mg)	991.8 ± 350.4	809.2 ± 385.4	843.7 ± 154.7	848.0 ± 191.4	1256.4 ± 486.5	1321.4 ± 691.4		
Fe (mg)	14.3 ± 9.0*	9.6 ± 4.7	12.9 ± 7.8	12.8 ± 5.3	14.8 ± 6.4	15.8 ± 8.8		
Cholesterol (mg)	356.4 ± 241.5	285.4 ± 158.4	328.9 ± 123.7	298.3 ± 103.2	494.7 ± 258.1	459.6 ± 259.3		
Dietary fiber (g)	16.1 ± 7.5**	10.6 ± 5.2	14.5 ± 5.2	13.2 ± 3.5	20.2 ± 7.6	20.4 ± 10.2		

** $p < 0.01$; * $p < 0.05$

Table 3. Comparisons of selective daily nutrient intakes by three dietary assessment methods

	24-hr recall (n=61)	7-day food records (n=61)	Chinese FFQ V2 (n=61)
Energy (Kcal) **	1930.2 ± 688.1 ^a	1784.6 ± 416.7 ^a	2861.5 ± 1739.1 ^b
Protein (g) **	69.8 ± 26.9 ^a	65.0 ± 15.8 ^a	115.94 ± 68.5 ^b
Protein (%)**	14.6 ± 2.8 ^a	14.6 ± 1.4 ^a	16.23 ± 2.3 ^b
Fat (g) **	65.2 ± 27.3 ^a	63.2 ± 18.0 ^a	107.45 ± 67.4 ^b
Fat (%)*	30.5 ± 7.5 ^a	31.7 ± 4.0 ^{ab}	33.47 ± 5.8 ^b
Carbohydrate (g)**	271.8 ± 107.0 ^a	242.2 ± 58.0 ^a	355.28 ± 288.7 ^b
Carbohydrate (%)**	56.3 ± 8.0 ^a	54.4 ± 4.5 ^a	50.11 ± 7.2 ^b
Vit A (RE) **	1365.0 ± 1396.6 ^a	1385.7 ± 845.3 ^a	3958.04 ± 2746.6 ^b
Vit E (α-TE (mg)) **	8.1 ± 4.8 ^a	6.9 ± 2.6 ^a	12.23 ± 8.7 ^b
Vit B ₁ (mg) *	1.2 ± 0.9 ^{ab}	1.0 ± 0.4 ^a	1.13 ± 0.8 ^b
Vit B ₂ (mg) **	1.2 ± 0.6 ^a	1.2 ± 0.3 ^a	1.68 ± 1.1 ^b
Niacin (mg) **	11.7 ± 5.0 ^a	11.0 ± 3.0 ^a	20.27 ± 12.2 ^b
Vit B ₆ (mg) **	1.2 ± 0.6 ^a	1.1 ± 0.3 ^a	1.92 ± 1.5 ^b
Vit B ₁₂ (μg)	6.5 ± 15.7 ^a	5.2 ± 6.2 ^a	4.81 ± 4.4 ^a
Vit C (mg) *	146.3 ± 175.7 ^a	127.6 ± 90.0 ^a	211.48 ± 114.2 ^b
Ca (mg) **	427.6 ± 243.1 ^a	371.2 ± 126.6 ^a	640.15 ± 405.4 ^b
P (mg) **	937.6 ± 388.5 ^a	855.2 ± 190.8 ^a	1439.61 ± 858.3 ^b
Fe (mg)	14.6 ± 13.3 ^a	13.3 ± 7.0 ^a	18.10 ± 13.0 ^a
Cholesterol (mg) **	327.1 ± 222.6 ^a	314.7 ± 130.7 ^a	521.19 ± 354.4 ^b
Dietary fiber (g) **	14.9 ± 8.1 ^a	14.3 ± 5.7 ^a	23.59 ± 15.8 ^b

** $p < 0.01$; * $p < 0.05$: all groups are significantly different by one-way ANOVA.; ¹ Sharing the same letter means no significant different ($p > 0.05$).

Table 4. Correlation coefficients (r) between nutrients estimated by three dietary assessment methods

	24-hr recall and Chinese FFQ V2						7-day food records and Chinese FFQ V2					
	Time I (n=39)		Time II (n=22)		Total (n=61)		Time I (n=39)		Time II (n=22)		Total (n=61)	
	Pearson	Spearman	Pearson	Spearman	Pearson	Spearman	Pearson	Spearman	Pearson	Spearman	Pearson	Spearman
Energy (Kcal)	0.23	0.33*	0.13	0.13	0.23	0.25	0.61**	0.58**	0.37	0.34	0.56**	0.53**
Protein (g)	0.11	0.20	0.03	-0.05	0.11	0.13	0.44**	0.47	0.28	0.34	0.40**	0.45**
Protein (%)	0.10	0.19	0.30	0.10	0.17	0.15	0.07	0.01	-0.02	-0.10	0.05	-0.04
Fat (g)	-0.02	0.14	0.05	0.07	0.33	0.14	0.44**	0.46**	0.21	0.31	0.40**	0.43**
Fat (%)	0.16	0.13	0.14	0.09	0.15	0.11	0.22	0.15	-0.01	0.06	0.17	0.16
Carbohydrate (g)	0.37*	0.37*	0.23	0.27	0.35**	0.35**	0.72**	0.54**	0.46*	0.43*	0.67**	0.52**
Carbohydrate (%)	0.18	0.12	0.01	-0.04	0.13	0.08	0.26	0.27	-0.20	-0.16	0.17	0.14
Vit A (RE)	-0.003	0.06	0.10	0.06	-0.01	0.11	0.14	0.25	0.17	0.11	0.15	0.18
Vit E (α -TE (mg))	0.02	0.07	-0.13	-0.13	0.04	0.04	0.28	0.47**	0.09	0.15	0.26	0.36**
Vit B ₁ (mg)	0.31	0.42**	0.11	0.22	0.24	0.33**	0.31	0.35*	0.18	0.20	0.24	0.31*
Vit B ₂ (mg)	0.44**	0.26	0.05	0.04	0.35**	0.19	0.58**	0.56**	0.17	0.27	0.46**	0.43**
Niacin (mg)	0.18	0.19	0.13	0.08	0.20	0.19	0.40*	0.37*	0.41	0.26	0.41**	0.35**
Vit B ₆ (mg)	0.14	0.19	0.22	0.13	0.17	0.90	0.56**	0.53**	0.77**	0.44*	0.64**	0.49**
Vit B ₁₂ (μ g)	0.02	0.17	0.01	-0.09	0.03	0.09	0.04	0.42**	0.03	0.12	0.04	0.30*
Vit C (mg)	0.47**	0.26	0.06	0.15	0.44**	0.24	0.41**	0.19	0.47*	0.39	0.43**	0.26*
Ca (mg)	0.34*	0.21	0.34	0.53*	0.35**	0.28*	0.30	0.31	0.32	0.56**	0.30*	0.40**
P (mg)	0.16	0.17	0.09	0.09	0.16	0.15	0.46**	0.49**	0.32	0.45*	0.41**	0.45**
Fe (mg)	-0.07	0.05	0.22	0.43*	0.01	0.17	0.37*	0.43**	0.26	0.37	0.36**	0.40**
Cholesterol (mg)	0.02	-0.02	0.08	-0.08	0.05	-0.01	0.53**	0.42**	0.24	0.30	0.47**	0.36**
Dietary fiber (g)	0.30	0.39*	0.12	0.23	0.31*	0.33**	0.35*	0.44**	0.28	0.30	0.36**	0.38**

** $p < 0.01$; * $p < 0.05$

Table 5. Correlation coefficients (r) between nutrients estimated by repeated Chinese FFQ V2

	Time I and Time II (n=22)	
	Pearson	Spearman
Energy (Kcal)	0.71**	0.66**
Protein (g)	0.69**	0.70**
Protein (%)	0.69**	0.66**
Fat (g)	0.71**	0.76**
Fat (%)	0.78**	0.73**
Carbohydrate (g)	0.65**	0.52*
Carbohydrate (%)	0.75**	0.64**
Vit A (RE)	0.29	0.42*
Vit E (α -TE (mg))	0.75**	0.74**
Vit B ₁ (mg)	0.76**	0.77**
Vit B ₂ (mg)	0.80**	0.75**
Niacin (mg)	0.69**	0.67**
Vit B ₆ (mg)	0.90**	0.48*
Vit B ₁₂ (μ g)	0.87**	0.79**
Vit C (mg)	0.59**	0.64**
Ca (mg)	0.60**	0.56**
P (mg)	0.73**	0.70**
Fe (mg)	0.61**	0.58**
Cholesterol (mg)	0.83**	0.80**
Dietary fiber (g)	0.60**	0.56**

** $p < 0.01$; * $p < 0.05$

($r=0.33$), calcium (0.28) and dietary fiber ($r=0.33$) had significant correlations between the Chinese FFQv2 and 24-hour recalls ($p < 0.05$). When one outlier consumed more than 10,000 kcal from the first Chinese FFQv2 and was eliminated from the final analyses, the Chinese FFQv2 still showed strong correlations of macro- and micronutrients, with 7-day records ($n=60$, $r=0.29-0.50$, $p < 0.05$), but not with 24-hr recalls ($n=60$, $r=0.01-0.23$, $p > 0.05$) (data not shown).

Table 5 shows the correlation coefficients representing the reproducibility of the Chinese FFQv2 from 22 subjects who completed the Chinese FFQv2 in the two time periods. Pearson correlation coefficients and Spearman correlation coefficients of all the selective nutrients between two administrations of the Chinese FFQv2 were significant, except Pearson correlation coefficient of vitamin A ($r=0.29$, $p > 0.05$). Generally speaking, the reproducibility of this Chinese FFQv2 was consistently high for most nutrients, with Spearman correction coefficients between 0.42 for vitamin A to 0.79 for vitamin B₁₂. The macronutrients and micronutrients had a similar magnitude of correlations.

DISCUSSION

The food frequency method is one of the three currently usable dietary methods, the other two being 24-hour recall and food record, (both actual diet assessment methods for measuring short-term intakes).²⁰ In general, there are two major types of food frequency methods: first, the semi-quantitative questionnaire consisting of two major components, food group (food list) and food frequency. Second, the quantitative total diet questionnaire with three components includes food group, frequency, and portion size. These two types of FFQ have served their purposes similarly in practice, but with very different conceptual bases and process procedures. Moreover the overesti-

mated or underestimated daily values calculated from various FFQ were depending upon the numbers of food items (double counting of similar food items or omitting foods not in the list), frequency category and portion size assignment, therefore this method generally was not used to estimate average daily intakes of nutrients.

We have developed the first and second versions of the meal-based Chinese food frequency questionnaire with five meal sequences and three portion sizes, and have utilized them for assessing dietary patterns in Taiwan. Our data showed that by comparing the group means to 7-day records and 24-hour recalls, the Chinese FFQv2 showed a slightly higher percent of energy from protein (16.2% vs. 14.7% and 14.6%) and fat (33.5% vs. 31.8% and 30.7%) and a lower percent of energy from carbohydrate (50.0% vs. 54.2% and 56.0%). One of the possible reasons is that we did not include food items with starchy roots and tubers such as potatoes, sweet potatoes and taro products in the Chinese FFQv2. In 2002, we developed the third version of the Chinese FFQ for assessing dietary patterns for pregnant women, further shortening the questionnaire and eliminating the portion size choices, because pregnant women tend to increase meal quantities continuously along with the pregnancy. We also trained the interviewers to utilize the blank food items to document missing starchy root and tuberous food items in the Chinese FFQv3, if frequently eaten by the subjects.

Many researchers suggested that dietary studies should attempt to assess the whole diet, not one or a few nutrients. Total diet quantitative questionnaires such as Block²¹ and Hankin^{22,23} have developed in the USA, are good examples of this type of format, consisting of three major components: a long list of food groups; a frequency category; and a portion size category. There is a major difference between the "pure diet history method" and the "frequency method". The context of a diet history is always in terms of a given meal, but the frequency method usually loses the variation by meals.²⁴ It was our attempt to develop a method to retain the meal sequences that may play a role in increasing the precision of the Chinese FFQ method. Until the present, we have developed a format for breakfast, lunch, afternoon snacks, dinner, evening snacks, five time periods corresponding with each meal. These meal-based food frequency methods were developed and reported by O'Donnell in London,²⁴ Wheeler et al. in Australia,²⁵ and Fregapane and Asensio-Garcia in Spain.²⁶ Our questionnaire was based on five time sequences of meal habits, while the format was to ask separately about the frequency of consumption of each recipe in the meal. Our data in figure 1 also suggested that precise estimations for dietary patterns and meal distributions by meal-based FFQ warrant further improvements in addition to the acceptable reproducibility and relative validity of this Chinese FFQ.

The design and analysis of validation and precision studies of the quantitative total diet FFQ method depends upon the purpose of the ultimate study in which the FFQ will be used to associate nutrient intake with disease occurrence. Since studies of absolute validity of food frequency methods are limited, most studies have assessed only relative validity.^{23, 27-29} Block and coworkers reported the validity of two quantitative FFQ: one was her

Health and History Questionnaire (HHHQ); and the other was the University of Michigan (UM) FFQ; and both showed high correlations on most nutrients, but the UM FFQ produced overestimates for energy and all nutrients examined.²⁹ Bingham in UK have reported that in comparisons to weighted records and various biological markers, among 7-day estimated records, 24-hour recall and a food frequency questionnaire, FFQ did not yield better assessment than repeated food diaries.³⁰ Our data showed that in comparison to 7-day food records, the relative validity of the Chinese FFQv2 versus 24-hour recalls was lower. Only carbohydrate ($r=0.35$), vitamin B₁ ($r=0.33$), calcium ($r=0.28$) and dietary fiber ($r=0.33$) had significant correlations between the Chinese FFQv2 and 24-hour recalls ($p<0.05$). When one outlier consumed more than 10,000 kcal from the first Chinese FFQv2 and was eliminated from the final analyses, the Chinese FFQv2 still showed strong correlations of macro- and micronutrients with 7-day records ($n=60$, $r=0.29-0.50$, $p<0.05$), but not with 24-hr recalls ($n=60$, $r=0.01-0.23$, $p>0.05$). The large day-to-day variation by one day 24-hour recall would attenuate the correlations. Those correlations with good strength demonstrate this Chinese FFQv2 has strong relative validity compared to two other dietary assessment methods, especially 7-day food records.

The reproducibility of the FFQ for assessing usual mean intakes depends on the time frame of the method as well as the time lag of the method.³¹ The reproducibility of this Chinese FFQv2 was consistently high for most nutrients, with Spearman correction coefficients between 0.42 for vitamin A to 0.79 for vitamin B₁₂, with an average time interval of 7.5 months. In the Netherlands, van Staveren³² found there was a good overall agreement between the two repeated questionnaires. However, for weekend days, precision was poorer, especially for saturated fat, carbohydrate, and linoleic acid, because of greater dietary variability during weekends. In a case-control study on breast cancer in a group of Caucasian and Japanese-Hawaiian women, a quantitative FFQ was repeated after 3 months. Amounts of food consumed were estimated using photographs for each food, shown in three serving sizes (small, medium and large). Mean intakes of selective nutrients for all subjects on the two occasions were not significantly different, as tested by the paired t-test.³² Willett and coworkers in 1985 investigated the validity and precision of the semi-quantitative FFQ on 173 female registered nurses designed to estimate food intake.³³ For the reproducibility study, there was a time lapse of one year; and for the validity study, it was during a one-year period. They compared nutrient intake scores derived from the FFQ with those estimated from one-week records. Portion sizes of 99 foods were specified using household measures. The results showed that mean daily nutrient intakes were similar from the two FFQ administrations.

Willett and colleagues have developed a semi-quantitative type of FFQ since the 1980's, an FFQ with only two components: a food list and a frequency section. The food items selected in the food list have three general characteristics: first, the food must be used often by an appreciable number of individuals; second, the food must have a substantial content of nutrients; and third, the use

of the food must vary from person-to-person in order to be discriminating.³³ The researchers and dietitians used several approaches to compile a food list, including identifying the foods that contain substantial amounts of the nutrients of interest, using stepwise regression to reduce the list by finding major nutrient contributors, and using open-ended data.³³ However, learning from experiences, they suggested the method of identifying food simply on the basis of their contribution to absolute intake might not lead to an optimal questionnaire. Foods such as mushrooms, eggplants, and turnips (such as daikon), although they are not abundant in known essential nutrients, are consumed in large amounts by some individuals. For the Chinese diet in Taiwan, Lee³⁴ and Pan³⁵ have published two articles documenting the major food contributors to macro- and micronutrients from the first National Nutrition Survey that collected household food inventory information from 1980-1981. Furthermore, a 64-item Chinese food frequency questionnaire combined with open questions on staple and cooking oil was tested the reproducibility and validity by Lee et al.³⁶

The adjustment and calibration factors relating the questionnaire format and content need to be developed to allow the investigator to use shorter or modified questionnaires while obtaining nutrient values nearer the correct absolute values.³⁷ Our developmental experiences with three versions of the Chinese FFQ in Taiwan mainly were from observations of meal patterns of urban populations. Pan and colleagues suggested considering additional questions about cooking methods and incorporation of fat-modified foods.³⁸ An example of shortening the FFQ was demonstrated by the Block questionnaire.¹¹ The study showed comparable results from long and reduced versions of the FFQ. The food items were reduced from 98 to 60, and required as short as 17 minutes to be administered by an interviewer. This reduced version of the questionnaire provided lower values of macronutrients, but most micronutrients were not underestimated. Our first version of the Chinese FFQ had 482 food items and took each interviewer approximately 1.5 to 2 hours to complete. The Chinese FFQv2 of 217 items took about one hour, and the current, third version of 172 items without portion selections took about 30 minutes by personal interviews. Through comparisons of meal distributions of macronutrients, we recognized that the Chinese FFQv2 overestimated fat and protein consumption, and underestimated carbohydrate intake, therefore more attention will be paid to this issue in the development of future versions. In addition, the reduction of food items of this Chinese FFQ relied on past experience and other adjustment factors including geographic variation, ethnic factors, purpose and hypothesis for the specific study, will be considered in the further development of the Chinese FFQ in Taiwan.

ACKNOWLEDGEMENTS

This project was funded by Taiwan National Science Council grant 89-2320-B-003-002. We thank the participating subjects, graduate students and interviewers for completing this project.

AUTHOR DISCLOSURES

Li-Ching Lyu, Chi-Fen Lin, Fang-Hsin Chang, Heng-Fei Chen, Chiao-Chen Lo and Hong-Fa Ho, no conflicts of interest.

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Original Article

Meal distribution, relative validity and reproducibility of a meal-based food frequency questionnaire in Taiwan

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臺灣分餐次之中式食物頻率問卷的餐次分佈、相對效度及信度研究

食物頻率問卷為公共衛生營養相關研究之重要的飲食評估工具。此研究描述分為五餐次之中式食物頻率問卷的發展歷程及信效度分析結果。總共有 51 位參加者，研究收集二次中式食物頻率問卷（相隔 6 個月）及一次 24 小時回憶及 7 天飲食紀錄。將兩次時間點合併分析結果發現，中式食物頻率問卷所得之巨量及微量營養素與 7 天飲食紀錄的相關性強($n=60$, $r=0.29-0.50$, $p<0.05$)，但與 24 小時回憶之相關性不顯著($n=60$, $r=0.01-0.23$, $p>0.05$)。而兩次中式食物頻率問卷之信度($n=22$)在大多數營養素皆佳，斯皮爾曼相關係數範圍由維生素 A 之 0.42 到維生素 B₁₂ 之 0.79。另外，較大樣本之 231 位參加者完成中式食物頻率問卷及一次 24 小時回憶，分析發現中式食物頻率問卷的早餐、午餐、晚餐、下午點心及宵夜相加的熱量分佈為 20%、37%、37%及 6%；而 24 小時回憶為 17%、36%、44%及 1%。研究報告此分餐次之中式食物頻率問卷具可接受之相對效度及信度。

關鍵字：餐次分佈、相對效度、信度、分餐次之中式食物頻率問卷、臺灣。