RESEARCH COMMUNICATION

Reproducibility of a Semi-quantitative Food Frequency Questionnaire in Chaoshan Area, China

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Abstract

Objective: To examine reproducibility of assessed intake of foods and nutrients according to a semi-quantitative food frequency questionnaire (SQFFQ) in adult doctors and nurses residing in Chaoshan area of China. Subjects: The SQFFQ was administered first in October to December of 2004 to 120 adult doctors and nurses living in Chaoshan area of China and was then re-administered to 102 three months later between January and March of 2005 (SQFFQ 1 and SQFFQ 2). Methods: Reproducibility was evaluated in terms of consumption of 10 food groups and energy and 34 macro- and micro-nutrients based on the SQFFQ from the 102 doctors and nurses. Results: For intake of foods, Pearson's correlation coefficients (CCs) with log-transformation and energy adjustment (minimum – median - maximum) range from 0.43 (eggs) – 0.84 - 0.90 (teas). Spearman's rank CCs with energy adjustment ranged from 0.77 (cereals) – 0.84 - 0.94 (milks). Kappa statistics with energy adjustment ranged from 0.53 (vegetables) - 0.63 - 0.82 (teas). For consumption of nutrients, Pearson's correlation coefficients (CCs) with log-transformation and energy adjustment (minimum – median - maximum) range from 0.83 (docosahexaenoic acid and oryzanin) - 0.88 - 0.90 (linolenic acid, vitamin A, folic acid, vitamin E, calcium, sodium, selenium and magnesium). Spearman's rank CCs with energy adjustment ranged from 0.81 (oryzanin and vitamin C) – 0.86 – 0.90 (sodium). Kappa statistics with energy adjustment ranged from 0.49 (protein) - 0.60 - 0.77 (sodium). Conclusion: Substantially high reproducibility was observed; it is possible to use the tailored, relatively simple, but comprehensive, self-administered SQFFQ to facilitate assessment of the association between lifestyle and health/disease in large-scale epidemiological studies.

Key Words: Intake of foods and nutriments – semi-quantitative food frequency questionnaire – reproducibility - Chaoshan area - China - adults

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Introduction

Food frequency questionnaires (FFQ) are often used to assess habitual dietary intake (both past and present) in epidemiological studies on diet and chronic diseases (Briefel et al., 1992; Kushi, 1994). When using the FFQ, the results generally represent usual intakes over an extended period and are easier to collect and process. Additional uses of the FFQ include its ability to classify individuals by rank, identify groups at extremes of intake, and to monitor trends in dietary patterns (Zulkifli & Yu, 1992). The FFQ needs to have a guaranteed reproducibility (also termed as repeatability) as well as validity, in order to make the appropriate interpretation of dietary data, which are central to the assessment of dietary habits (Hankin & Wilkens, 1994).

Chaoshan area of Guangdong in South China is at a very high risk for some gastrointestinal cancers such as esophageal and cardiac cancer (Li, 2002), which may be related to some particular causes in this area. Thus it is essential for us to study the risk and protective factors of the cancers to establish a basis for cancer prevention in the area. So, we recently developed a SQFFQ to be used for an incoming large-scale case-referent study in Chaoshan, China (Song et al., 2005). The aim was to assess the intake of foods and nutrients considered to be important in cancer etiology. The validity of a dietary questionnaire is related to its ability to discriminate between subjects with true exposure differences. The SQFFQ developed by us for use in Chaoshan area, and was based on three-day dietary records and involves analysis by contribution and multiple regression analyses, has been recently validated (Ke et al., 2005). On

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the other hand, reproducibility measures the consistency of questionnaire (exposure) measurements made at different points in time with the same subjects. The objective of the present study was to report upon the reproducibility about intake of foods and nutrients of this 125–item SQFFQ by comparing results of two SQFFQs at a three-mouth interval among doctors and nurses lived in the area.

Subjects and Methods

Subjects and SQFFQ

We earlier designed an evidence-based SQFFQ according to multiple regression and contribution analyses, and validated the SQFFQ versus 3 day weighed diet records (WDRs) as described elsewhere (Song et al., 2005; Ke et al., 2005).

The SQFFQ was administered first in October to December of 2004 to 120 adult doctors and nurses living in Chaoshan area of China and was then re-administered to 102 three months later between January and March of 2005 ($SQFFQ_1$ and $SQFFQ_2$). The respondents were asked how often and how much they had eaten on average over the past year at both sessions. Fifteen percent of the study subjects who were interviewed initially refused to participate in the resurvey.

Accordingly, the results are shown as mean age ± standard deviation (minimum-maximum) of 37±9 (25-55) for the 39 males and 35±7 (23-55) for the 63 females, respectively. The values for height (cm), weight (kg) and body mass index (BMI) (kg/m^3) were 171±5.0 (156-180), 67±6.7 (49-78) and 22.9±2.1 (16.4-27.6) for the males, and 159±4.0 (152-167), 52±5.0 (42-65) and 20.5±2.0 (17.2-25.0) for the females, respectively.

Foods and Nutrients Selected

We chose ten foods/food groups and beverages including cereals, noodles, legumes, vegetables, meat, marine lives, eggs, fruits, milks, and teas.

In addition, energy and thirty-seven macro- and micro-nutrients were selected, including protein, fat, carbohydrate, total dietary fiber (TDF), minerals (potassium, calcium, magnesium, phosphorous, sodium, iron, zinc, selenium, manganese, and copper) and vitamins (carotene, retinol, vitamin A, E and C, folic acid, oryzanin, riboflavin and niacin).

Fat was divided into fatty acids, saturated fatty acids (SFAs), mono-unsaturated fatty acids (MUFAs) (including oleic acid), poly-unsaturated fatty acids (PUFAs), n-6 PUFAs, n-3 PUFAs and cholesterol. n-6 PUFAs were separated into linoleic acid (18: 2n-6) and arachidonic acid (20: 4n-6), and n-3 PUFAs into linolenic acid (18: 3n-3), eicosapentaenoic acid (EPA, 20: 5n-3) and docosahexaenoic acid (DHA, 22: 6n-3).

Intake of Foods and Nutrients

The SQFFQ of concern is composed of 125 food items with eight categories of food frequency (ever or seldom, 1-3 times/month, 1-2 times/week, 3-4 times/week, 5-6 times/week, once/day, twice/day, and more than twice/day), and five categories of portion size. Participants were presented with two dimensional food pictures of actual size on a computer by one interviewer through both SQFFQs in order minimize interviewer bias. Medium was defined as the portion sizes shown, small as about one-half or 3/4 the medium portion size and large as about one-and-a-half or two times the medium portion size.

We ascertained average daily intake of foods and nutrients by multiplying the food intake (in grams) or serving size and the nutrient content per 100 grams of food as listed in the China Food Composition (Yang et al., 2002), and Standard Tables of Food Composition in Japan, 5th revised ed. (Resource Council, Science and Technology Agency, Japan, 2000).

Statistical Analysis

Firstly, we compared daily consumption of 10 foods and beverages, and energy and 34 macro- and micro-nutrients according to the $SQFFQ_1$ and $SQFFQ_2$. The differences of means were examined by paired t-test.

Secondly, we calculated Pearson's crude correlation coefficients (CCs), Log-transformed CCs, energy-adjusted CCs and energy-adjusted CCs with log-transformation, and Spearman's rank CCs between intakes of selected foods/nutrients with the two SQFFQs. Third, after categorizing daily intakes of foods/nutrients measured in the two SQFFQs into three groups, we computed percentages of exact agreement and complete disagreement, and kappa statistics.

Results

Intake of Foods

Table 1 shows comparisons between daily intake of food groups according to the $SQFFQ_1$ and $SQFFQ_2$. There were no statistical differences in daily consumption of foods between the two questionnaires, except for legumes, meats and teas.

Pearson's CCs with log-transformation and energy adjustment (minimum-median-maximum) ranged from 0.43

Table 1. Comparison of Daily Intakes of Selected Food groups According to the SQFFQ1 and $SQFFQ_2$

Food	$SQFFQ_1$ $x \pm s.d.$	SQFFQ2 $x \pm s.d.$	P
Cereals (g)	275.9±137.0	285.2±125.2	0.284
Noodles	181.7±144.6	185.7±139.4	0.568
Vegetables	534.3±330.7	503.1±284.0	0.100
Legumes	65.9±67.7	58.3±55.2	0.036
Meats	351.6±208.5	315.3±162.4	0.005
Marine Lives	225.8±153.8	227.7±146.9	0.816
Eggs	44.5±28.0	46.2±29.7	0.381
Fruits	418.5±305.0	414.4±262.9	0.847
Milks	59.4±88.5	64.5±83.6	0.295
Teas	33.8±69.6	30.9±67.7	0.041

Table 2. Pearson's and Spearman's Rank Correlation Coefficients between Daily Intakes of Selected Food Groups Based on SQFFQ1 and SQFFQ2

Food	Pearson's CCs				Spearman's CCs	
	Crude	Energy-adjusted	Log-transformed	Log-transformed and energy-adjusted	Crude	Energy-adjusted
Cereals	0.78	0.84	0.86	0.87	0.77	0.77
Noodles	0.87	0.91	0.83	0.85	0.86	0.84
Vegetables	0.82	0.84	0.74	0.77	0.77	0.79
Legumes	0.85	0.89	0.96	0.96	0.84	0.85
Meats	0.79	0.79	0.81	0.83	0.82	0.84
Marine Lives	0.85	0.84	0.86	0.86	0.85	0.86
Eggs	0.77	0.83	0.38	0.43	0.81	0.79
Fruits	0.73	0.76	0.60	0.67	0.75	0.82
Milks	0.84	0.76	0.57	0.60	0.93	0.94
Teas	0.98	0.99	0.90	0.90	0.89	0.91
Median	0.83	0.84	0.82	0.84	0.83	0.84

(eggs) – 0.84 - 0.90 (teas) (Table 2). Spearman's CCs with energy adjustment ranged from 0.77 (cereals) – 0.84 - 0.94 (milks). Consistent amelioration was not exerted on Pearson's CCs by log-transformation with/without energy-adjustment. Spearman's rank CCs were not improved by energy-adjustment, either. All correlation coefficients are significant ($p<0.05$).

Agreement with energy adjustment ranged from 67% (vegetables) - 75% - 88% (teas) and disagreement ranged from 1% (noodles, marine lives and milks) - 2% - 4% (eggs) (Table 3). Kappa statistics with energy adjustment ranged from 0.53 (vegetables) - 0.63 - 0.82 (teas). All Kappa values exceeded 0.5 and were statistically significant ($P<0.05$).

Intake of Nutrients

Table 4 lists comparisons between daily intake of energy and macro- and micro-nutrients based on $SQFFQ_1$ and $SQFFQ_2$. In general, the values of $SQFFQ_1$ were almost equal to or larger than those of $SQFFQ_2$. There were no statistical differences in daily consumption of nutrients between the two, except for fat, fatty acid, SFAs, MUFAs, oleic acid, PUFAs, arachidonic acid, linolenic acid, selenium, copper and magnesium.

Table 3. Agreement, Disagreement and Kappa Statistics According to Tertile Classification of Daily Intakes of Selected Food Groups Based on $SQFFQ_1$ and $SQFFQ_2$

Food	Crude (%)			Energy-adjusted (%)		
	Agreement	Disagreement	Kappa	Agreement	Disagreement	Kappa
Cereals	78	2	0.68	75	2	0.62
Noodles	71	1	0.56	72	1	0.57
Vegetables	72	4	0.57	67	2	0.53
Legumes	76	2	0.65	76	2	0.65
Meats	74	3	0.60	74	3	0.60
Marine Lives	80	1	0.71	79	1	0.69
Eggs	83	4	0.75	75	4	0.62
Fruits	74	7	0.60	75	3	0.63
Milks	85	1	0.78	85	1	0.78
Teas	85	3	0.78	88	2	0.82
Median	77	3	0.67	75	2	0.63

Pearson's CCs with log-transformation and energy

Table 4. Comparison of Daily Intake of Selected Nutrients According to $SQFFQ_1$ and $SQFFQ_2$

Nutrient	$SQFFQ_1$ $x \pm s.d.$	$SQFFQ_2$ $x \pm s.d.$	P
Energy (kcal)	3213.6±1195.0	3127.6±991.3	0.158
Protein (g)	147.1±65.5	142.5±54.5	0.124
Fat (g)	111.6±50.7	103.9±42.7	0.009
Carbohydrate (g)	434.5±162.5	435.3±138.3	0.928
Total dietary fiber (g)	31.7±18.8	31.9±16.8	0.809
Fatty acid (g)	104.2±50.4	96.4±40.6	0.007
SFAs (g)	32.9±16.7	30.1±13.1	0.004
MUFAs (g)	45.9±22.5	42.4±18.2	0.006
18:1 (mg)	40.5±19.7	37.1±15.5	0.004
PUFAs (g)	21.1±9.4	19.9±8.0	0.033
18:2n-6 (mg)	19.7±9.5	18.7±8.3	0.064
20:4n-6 (mg)	0.2±0.1	0.2±0.1	0.010
18:3n-3 (mg)	3.0±1.7	2.8±1.5	0.007
20:5n-3 (mg)	0.1±0.1	0.1±0.1	0.472
22:6n-3 (mg)	0.1±0.1	0.1±0.1	0.438
Cholesterol (mg)	563.4±317.5	538.5±279.2	0.097
Carotene (μg)	7903.1±5453.0	7532.0±5317.7	0.121
Retinol (μg)	216.2±122.2	214.0±113.1	0.717
Vitamin A (μg RE)	1526.8±964.0	1462.8±932.0	0.114
Folic acid (mg)	784.0±473.8	748.9±461.5	0.055
Oryzanin (mg)	1.7±0.8	1.6±0.6	0.059
Riboflavin (mg)	2.1±1.0	2.1±0.9	0.339
Niacin (mg)	46.0±22.7	46.0±21.6	0.970
Vitamin C (mg)	226.2±124.1	219.7±115.2	0.414
Vitamin E (mg)	32.0±15.8	31.5±14.1	0.471
Calcium (mg)	972.3±506.9	939.5±455.6	0.114
Phosphorous (mg)	1811.0±763.5	1770.2±640.3	0.247
Potassium (mg)	4139.9±2106.6	4028.9±1917.6	0.152
Sodium (mg)	5227.8±2906.5	5058.1±2887.2	0.119
Magnesium (mg)	586.3±275.0	572.4±237.2	0.221
Iron (mg)	56.9±35.2	58.2±30.6	0.512
Zinc (mg)	24.0±10.4	23.3±8.6	0.144
Selenium (μg)	156.5±74.7	149.8±67.6	0.037
Copper (mg)	4.2±2.2	4.0±1.9	0.038
Magnesium (mg)	19.1±21.9	18.0±20.4	0.045

adjustment ranged from 0.83 (docosahexaenoic acid and oryzanin) - 0.88 - 0.90 (linolenic acid, vitamin A, folic acid, vitamin E, calcium, sodium, selenium and magnesium) (Table 5). Spearman's rank CCs with energy adjustment ranged from 0.81 (oryzanin and vitamin C) – 0.86 – 0.90 (sodium). Consistent amelioration was not observed for Pearson's CCs by log-transformation with/without energy-adjustment. Spearman's Rank CCs were not improved by energy-adjustment, either. All correlation coefficients are significant (p<0.05).

Agreement with energy adjustment ranged from 66% (protein) - 74% - 84% (sodium) and disagreement ranged from 0% (retinol, iron and sodium) - 2% - 5% (fatty acid) (Table 6). Kappa statistics with energy adjustment ranged from 0.49 (protein) - 0.60 - 0.77 (sodium). All Kappa values were statistically significant (P<0.05).

Discussion

We have developed and evaluated the performance of an SQFFQ for Chaoshan area, China, in terms of its validity (Ke et al., 2005) and reproducibility. In other reproducibility studies, the correlation coefficients have generally varied from 0.5 to 0.7 for food and nutrient intakes (Bueno de Mesquita et al., 1992; Date et al., 2005; Goulet et al., 2004; Willett, 1998; Zhang et al., 2005) and the results of the present study are higher than these findings. The potential reason is that the respondents in our studies were mainly educated doctors and nurses. When measuring the reproducibility of an SQFFQ, one must compare at least two independent measurements of the same situation for the same person (Willett, 1998). If the period between the two measurements is too short, the respondent might

Table 5. Pearson's and Spearman's Rank Correlation Coefficients between Daily Intakes of Selected Nutrients Based on $SQFFQ_1$ and $SQFFQ_2$

nutrient	Pearson's CCs				Spearman's CCs	
	Crude	Energy-adjusted	Log-transformed	Log-transformed and energy-adjusted	Crude	Energy-adjusted
Energy	0.86		0.86		0.85	
Protein	0.89	0.88	0.90	0.88	0.88	0.86
Fat	0.82	0.83	0.86	0.86	0.82	0.84
Carbohydrate	0.85	0.88	0.84	0.85	0.82	0.84
Total dietary fiber	0.88	0.89	0.88	0.89	0.85	0.86
Fatty acid	0.83	0.83	0.86	0.86	0.80	0.83
SFAs	0.81	0.82	0.86	0.86	0.81	0.83
MUFAs	0.82	0.83	0.86	0.86	0.80	0.83
18:1	0.81	0.82	0.85	0.85	0.79	0.82
PUFAs	0.82	0.83	0.86	0.86	0.80	0.82
18:2n-6	0.83	0.85	0.85	0.86	0.79	0.82
20:4n-6	0.80	0.81	0.85	0.86	0.80	0.84
18:3n-3	0.93	0.93	0.90	0.90	0.81	0.83
20:5n-3	0.79	0.80	0.80	0.84	0.79	0.83
22:6n-3	0.78	0.77	0.81	0.83	0.79	0.83
Cholesterol	0.88	0.86	0.90	0.89	0.89	0.87
Carotene	0.90	0.93	0.86	0.89	0.82	0.86
Retinol	0.87	0.89	0.83	0.86	0.83	0.83
Vitamin A	0.91	0.94	0.88	0.90	0.84	0.86
Folic acid	0.92	0.93	0.90	0.90	0.88	0.87
Oryzanin	0.78	0.81	0.80	0.83	0.78	0.81
Riboflavin	0.88	0.87	0.90	0.89	0.86	0.85
Niacin	0.77	0.83	0.84	0.86	0.85	0.86
Vitamin C	0.78	0.81	0.81	0.84	0.80	0.81
Vitamin E	0.90	0.89	0.91	0.90	0.89	0.88
Calcium	0.91	0.91	0.91	0.90	0.87	0.87
Phosphorous	0.89	0.88	0.89	0.88	0.86	0.86
Potassium	0.93	0.92	0.91	0.89	0.87	0.86
Sodium	0.93	0.92	0.89	0.90	0.87	0.90
Magnesium	0.91	0.90	0.90	0.89	0.88	0.87
Iron	0.84	0.86	0.89	0.89	0.88	0.87
Zinc	0.88	0.86	0.89	0.87	0.88	0.86
Selenium	0.90	0.90	0.91	0.90	0.89	0.86
Copper	0.90	0.90	0.89	0.88	0.87	0.86
Magnesium	0.97	0.97	0.90	0.90	0.85	0.87
Median	0.88	0.88	0.88	0.88	0.85	0.86

Table 6. Agreement, Disagreement and Kappa Statistics According to Tertile Classification of Daily Intakes of Selected Nutrients based on $SQFFQ_1$ and $SQFFQ_2$

Nutrient	Crude (%)			Energy-adjusted (%)		
	Agreement	Disagreement	Kappa	Agreement	Disagreement	Kappa
Energy	71	2	0.56			
Protein	70	1	0.54	66	1	0.49
Fat	75	2	0.62	75	2	0.62
Carbohydrate	67	2	0.50	68	1	0.52
Total dietary fiber	75	2	0.62	76	2	0.65
Fatty acid	74	3	0.60	77	5	0.66
SFAs	77	3	0.66	75	2	0.62
MUFAs	75	2	0.62	77	3	0.66
18:1	73	4	0.59	74	3	0.60
PUFAs (g)	66	3	0.49	68	1	0.52
18:2n-6	68	3	0.52	71	2	0.56
20:4n-6	74	5	0.60	74	1	0.60
18:3n-3	62	3	0.43	68	1	0.52
20:5n-3	80	2	0.71	75	2	0.62
22:6n-3	79	5	0.69	75	1	0.63
Cholesterol	80	4	0.62	72	3	0.57
Carotene	64	3	0.46	72	1	0.57
Retinol	75	1	0.63	75	0	0.62
Vitamin A	67	2	0.50	72	2	0.56
Folic acid	81	1	0.72	75	1	0.63
Oryzanin	71	4	0.56	69	2	0.53
Riboflavin	79	3	0.69	74	1	0.60
Niacin	76	2	0.65	74	1	0.60
Vitamin C	73	2	0.59	76	4	0.65
Vitamin E	83	1	0.75	75	2	0.62
Calcium	75	4	0.62	76	2	0.65
Phosphorous	75	1	0.63	72	1	0.57
Potassium	76	2	0.65	71	2	0.56
Sodium	81	1	0.72	84	0	0.77
Magnesium	78	2	0.68	72	1	0.57
Iron	75	1	0.63	76	0	0.65
Zinc	76	2	0.65	75	2	0.62
Selenium	76	0	0.65	71	2	0.56
Copper	74	1	0.60	74	1	0.60
Magnesium	75	3	0.63	75	2	0.62
Median	75	2	0.62	74	2	0.60

remember what he or she reported in the first interview at re-interview. Therefore, the two measurements will not be independent, and reproducibility will be overestimated. However, if this period is too long, the dietary intake of the respondent might change and reproducibility will be underestimated. For example, in a study conducted over intervals of 2.5 years, 2.0 years, and 4-5 months in Iowa, the correlations for repeated administrations were greatest over the shortest interval of 5 months (Willett et al., 1988). As mentioned in a previous study, in order to avoid the influences of memory and physical conditions on recalled dietary habits, a three-month interval may be appropriate for reproducibility assessment (Imaeda et al., 2002). The reproducibility studies conducted by Willett et al.(1985), with SQFFQs administered 1 year part, resulted in Pearson's correlations with ranges of 0.52 – 0.71, which is slightly lower than our result. The kappa values and percent agreement found in the present study are similar to those of Hankin et al. (1990), Lazarus et al. (1995), kim et al. (2003) and Pietinen (1988). These comparative studies were conducted in elderly, who have more stable patterns of food purchase, meal preparation, and eating habits, although they were expected to show poorer reproducibility due to failing memory or cognition. From the results of this reproducibility study and the previous validation, it is highly unlikely that the SQFFQ has important food or nutrient omissions (Willett, 1998). Furthermore, there is little chance that the SQFFQ fails to represent an accurate measure of the usual food and nutrient intake (Goldbohm et al., 1995).

There are several approaches for assessing reproducibility, including Pearson's CCs, Spearman's CCs, percentages of agreement/disagreement and kappa statistics. Each procedure has its own strengths and weaknesses. For continuous variables, Pearson's CCs are often adopted; however, for other type variables, Spearman's CCs may be more appropriate. For discrete variable, agreement and disagreement analyses include errors by chance, while kappa statistics shore up such weaknesses, and consistently improve the values. For ameliorating values of CCs, log-transformation may not be particularly useful although it reduces the width of the distribution and actually transforms a skewed into a normal distribution. Further, energy adjustment does not appear to powerful for amending the figures of CCs.

In conclusion, the results of this study verify that it is possible to use tailored, relatively simple, but comprehensive, self-administered food frequency questionnaires to study nutrient consumption in large-scale epidemiological studies, and that reasonably high SQFFQ response rates can be expected. This is a very important finding which demonstrates that dietary data can be collected from the adults lived in this area for epidemiological studies and processed at low-cost with acceptable validity (Ke et al., 2005) and reproducibility. The hope is that high-fidelity data can be secured to facilitate assessment of the association between lifestyle and health/disease.

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