RESEARCH COMMUNICATION

Relative Validity of a Semi-quantitative Food Frequency Questionnaire Versus 3 day Weighed Diet Records in Middle-aged Inhabitants in Chaoshan Area, China

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Abstract

Objective: The purpose of the study was to validate a semi-quantitative food frequency questionnaire1 (SQFFQ) against 3 day weighted diet records (WDRs) for middle-aged inhabitants in the Chaoshan area, China. Subjects: 100 middle-age healthy residents. Methods: Validity was examined via descriptive statistics and Pearson's correlations. Results: Pearson's correlation coefficients (CCs) with energy-adjustment quantified by the SQFFQ and 3 day WDRs (minimum-median-maximum) ranged from 0.31(Vegetables)-0.35-0.53 (Cereals) for the selected foods, and 0.12 (retinol)-0.41-0.58 (phosphorous) for the selected nutrients. Favorably high agreement for intakes of foods/nutrients was achieved along with low disagreement. Conclusion: A moderate level of relative validity was observed; this food frequency questionnaire is reliable and valid for dietary assessment with middle-aged inhabitants in the Chaoshan area, China.

Key Words: food frequency questionnaire-validity-Chaoshan areas - China-middle-aged inhabitants

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Introduction

Dietary factors are likely to be related to the occurrence of several types of chronic disease (Willett, 1998). For large-scale epidemiological studies on chronic diseases, food frequency questionnaires (FFQ) are often the method of choice to obtain dietary exposure data (Willett, 2001). The two main reasons for this choice are the aim of measuring habitual long-term dietary intake and the fact that the method is relatively inexpensive since highly trained interviewers are not required (Subar et al., 2001; Hill et al., 2001). The semi-quantitative FFQ (SQFFQ) included questions on habitual portion size has been questioned whether this improves the validity of the method. The relative validity of food group intake estimated by a SQFFQ is reported less often than that of nutrient intake. Knowledge about this aspect is however important since it indicates more directly those questions or items in the questionnaire that should be considered for improvement, and since many epidemiological studies report relative risks for different levels of food group intake rather than nutrient intake.

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 energy, macronutrients, dietary fibre, retinol, vitamins C and E, carotene, fat and fatty acids, and food groups considered to be important in cancer etiology. Since the Chaoshan SQFFQ was newly developed, it needed to be validated before use. In the present paper, we conducted a validity investigation of nutrients as well as foods based on the SQFFQ vs. those according to 3 day weighed diet records (abbreviated WDRs hereafter) as the gold standard in the same target subjects.

Subjects and Methods

The Development of the Chaoshan SQFFQ

In December 2002 to August 2003, we developed a data-based SQFFQ according to cumulative contribution and multiple regression analysis as described elsewhere (Song et al., 2005). The questionnaire inquired about habitual dietary intake during the previous a year for 125 foods/

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recipes (Table 1), portion size and food frequency in seven categories.

The Development of the Chaoshan SQFFQ

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Validity Investigation

In November 2003, we initially recruited 150 middle-age healthy residents in Chaoshan area for the participation in the validity investigation, and first surveyed the SQFFQ and consecutive 3 day WDRs approximately one week later, but only 100 members (76 male and 24 female) completed the SQFFQ and a 3 day WDRs survey. The results are showed as mean age ± standard deviation of 41.8±6 for the 76 males and 40.9±5.9 for the 24 females. The values for height, weight and body mass index (BMI) were 166.8±5.9, 58.1kg±6.4 and 22.1±2.4, respectively.

Foods and Nutrients Selected

We chose 4 food groups, which include cereals, vegetables, meats and marine lives, and 20 nutrients, which include energy, protein, fat, carbohydrate, total dietary fiber (TDF; including soluble DF and insoluble DF), cholesterol, vitamins (including carotene, retinol, folic acid, and vitamins C and E) and minerals (including calcium, phosphorous, potassium, sodium, magnesium, iron, zinc, selenium and copper).

Fat was divided into saturated fatty acid (SFA), mono-unsaturated fatty acid (MUFA), poly--unsaturated fatty acid (PUFA), n-3 PUFA, n-6 PUFA and cholesterol.

For the WDR, food weight was quantified before cooking

Table 1. List of Foods/Recipes Included in the Semi-Quantitative Food Frequency Questionnaire of Shaoshan Areas, China

Cereals	Melons and nightshade	66. Pig stomach*	98. Fish-pellet[d]
1. Rice	34. Balsam pear	67. Banger	Mushrooms
2. Rice conjee	35. White gourd	68. Ham*	99. Mushroom (dried)
3. Thin rice noodle	36. Tomato	Poultry	100. Straw mushroom*
4. Fried sticks	37. Cucumber*	69. Chicken	101. Fungus
5. Noodle	38. Pimiento	70. Geese	102. Laver
6. Rice noodle**	Cauliflower	71. Duck**	103. Agaric
7. Instant noodles	39 cauliflower*	72. Chook wing	Nuts
8. Corn**	Roots	73. Chook claw	104. Pignut
9. Steamed bread**	40. Radish	Milk	105. Sunflower seed
10. Dumpling*	41. Bamboo shoot	74. Milk*	Cakes
11. Changfen*[a]	42. Carrot	75. Milk powder	106. Bread
Legumes	43. Potato	Eggs	107. Biscuit*
12. Soybean milk*	44. Pachyrhizus**	76. Egg	108. Cake*
13. Tofu	45. Ginger*	77. Duck egg	Condiments
14. Soybean	46. Garlic**	78. Salted duck egg**	109. Salt
15. Dried tofu	Fruits	Pickles	110. Monosodium glutamate
16. Mung bean	47. Apple	79. Dried turnip**	111. Soy sauce
17. Black soy**	48. Banana	80. Salted mustard	112. Vinegar**
Fresh legumes	49. Pear	81. Pickled vegetables	113. White sugar
18. Green bean	50. Lichee	82. Pickled chinese cabbage	114. Fermented fish sauce
19. Kidney bean*	51. Orange	Marine life	Oils
20. Bean sprout	52. Mandarin orange	83. Yellow croaker**	115. Peanut oil*
Vegetables	53. Peach	84. Grass card	116. Mixed oil
21. Chinese cabbage	54. Mango	85. Marine fish	117. Lard
22. Cabbage mustard	55. Grape*	86. Hair tail	Beverages
23. Water shield	56. Guava*	87. Sleeve-fish	118. Distilled spirit
24. Cole	57. Longan*	88. Salted fish**	119. Beer
25. Spinach	Meats	89. Red fish	120. Iron kwan-yin tea**
26. Water spinach	58. Pork	90. Carp	121. Baiye tea
27. Greengrocery	59. Pork chops	91. Crucian	122. Phoenix tea
28. Cabbage	60. Beef	92. Eel	123. Oolong tea
29. Celery**	61. Pig bone	93. Shrimp	124. Longjing tea
30. Caraway*	62. Beef-pellet[b]	94. Crab	125. Red tea
31. Watercress	63. Pettitoes	95. Dried small shrimps	
32. Leek*	64. Filet*[c]	96. Seashell	
33. Shallot	65. Chitterlings	97. Dried sleeve-fish**	

*Included only in the urban version. **Included only in the rural version.
a -Rice flour, vegetable and egg or meat. b -Mixture of beef and potato flour.
c -Mixture of meat and flour. d -Mixture of fish and rice flour.

if it was prepared at home, otherwise after cooking. We compute the mean daily intake of selected foods and compute nutrients by multiplying the food intake (in grams) or serving size and the nutrient content per gram of food as listed in the China Food Composition (Yang et al., 2002) and Standard Tables of Food Composition in Japan (Resources Council, Science and Technology Agency, Japan, 2000).

With the SQFFQ, considering food frequency in seven categories (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), we similarly estimated average daily intake of selected foods and estimated nutrients by multiplying the food intake (in grams) or serving size according to the values in the literature.

Analysis for Validity

Validity Analysis for the SQFFQ was performed using the same procedure as adopted by Tokudome and his colleagues (Tokudome, 2001). First, we calibrated mean daily intakes of 4 food groups and 20 nutrients according to the SQFFQ against those based on the 3 day WDRs. Average (±s.d.) was based on the mean of individual's 3 day WDRs. The differences of means were examined by t-test.

Second, 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 based on the SQFFQ and the 3 day WDRs (Liu et al., 1978; Beaton et al., 1983).

Third, after categorizing daily intakes of foods/nutrients measured by the SQFFQ and the 3 day WDRs into three, we computed percentages of exact agreement and complete disagreement, and Kappa statistics (Fleiss et al., 2003).

Results

Comparison of Daily Intakes of Selected Food Groups and Nutrients

Foods: Mean daily intakes of foods assessed according to the SQFFQ were similar to those based on the 3 day WDRs for cereals and vegetables but the values for average consumption of marine lives were smaller than with the WDR. The opposite was, however, the case for meats (Table 2).

Nutrients: In general, average intakes of nutrients according to the SQFFQ were similar to those based on the WDR. Mean intakes of protein, cholesterol, retinol, phosphorus, and sodium were smaller, whereas total dietary fiber, carotene, iron, and zinc were larger (Table 2).

Correlation Analysis of Daily Intakes of Selected Food Groups and Nutrients

Foods: Pearson's CCs with energy-adjustment between intakes of foods (minimum—median—maximum) assessed by the SQFFQ and the 3 day WDRs ranged from 0.31 (Vegetables)—0.35—0.53 (Cereals) (Table 3).

Nutrients: Pearson's CCs with energy-adjustment between intakes of Nutrients quantified by the SQFFQ and 3 day WDRs ranged from 0.12 (retinol)—0.41—0.58 (phosphorous) (Table 4).

Table 2. Comparison of Daily Intakes of Selected Foods and Nutrients According to the SQFFQ and the 3 day WDRs

Food groups and nutrients	SQFFQ χ±s.d.	WDR χ±s.d.	P
Cereals (g)	462.3±118.8	457.3±116.6	0.696
Vegetables (g)	109.2±60.9	120.8±64.8	0.137
Meats (g)	308.6±211.0	241.6±106.1	0.002
Marine lives (g)	154.4±120.5	184.6±84.7	0.011
Energy (kcal)	1883.5±413.2	1973.5±502.2	0.111
Protein (g)	64.8±21.4	77.4±23.4	0.000
Fat (g)	53.9±24.6	57.7±27.2	0.134
Carbohydrate (g)	346.6±78.7	341.6±81.1	0.601
Total dietary fiber (g)	6.1±2.3	5.5±1.4	0.029
Cholesterol (mg)	175.2±110.8	228.3±109.7	0.000
Carotene (μg)	2600.5±2703.9	1507.3±1114.2	0.000
Retinol (μg)	33.9±22.1	73.8±20.1	0.047
Folic acid (mg)	287.2±167.6	264.3±97.9	0.078
Vitamins C (mg)	87.4±61.0	82.8±42.1	0.49
Vitamins E (mg)	7.9±4.3	8.5±2.8	0.153
Calcium (mg)	264.0±146.5	268.9±106.7	0.753
Phosphorous (mg)	846.6±238.6	946.3±256.0	0.001
Potassium (mg)	1202.4±476.0	1277.2±333.1	0.146
Sodium (mg)	411.6±328.8	586.4±522.4	0.000
Magnesium (mg)	255.5±79.0	260.5±70.0	0.581
Iron (mg)	30.9±25.7	17.7±5.3	0.000
Zinc (mg)	14.2±6.7	12.8±3.7	0.029
Selenium (g)	69.8±53.2	68.5±29.6	0.834
Copper (mg)	1.8±0.5	1.9±0.8	0.083
SFA (g)	14.8±5.7	15.1±6.1	0.129
MUFA (g)	19.6±7.2	21.8±8.6	0.098
PUFA (g)	15.4±6.3	16.7±7.1	0.223
n-3 PUFA (g)	3.3±1.3	3.4±1.5	0.324
n-6 PUFA (g)	13.8±7.8	14.2±8.9	0.254

Agreement, disagreement and Kappa statistics according to tertile classification of daily intakes of selected food groups and nutrients

Foods: Percentages of exact agreement with energy adjustment ranged from 42 (meats)—44—51 (cereals). However, percentages of complete disagreement were 5 (cereals)—18—22 (meats). Kappa statistics ranged from 0.13 (meats)—0.17—0.27 (cereals) (Table 5).

Nutrients: Percentages of exact agreement with energy adjustment ranged from 39 (iron)—48—63 (sodium). Percentages of complete disagreement were 3 (Sodium)—10—19 (Iron). Kappa statistics ranged from 0.09 (iron)—0.22—0.45 (sodium) (Table 6).

Discussion

Comparison between the SQFFQ and the diet record was used to estimate validity for the newly developed SQFFQ in the present study, in which questionnaires were delivered prior to diet record to avoid education/learning effects. Regarding our subjects' characteristics, it should be noted

Table 3. Pearson's and Spearman's Rank Correlation Coefficients between Daily Intakes of Selected Foods Based on the 3 day WDRs and the SQRRQ

Food	Pearson's CCs				Spearman's CCs	
	Crude	Energy -adjusted	Log -transformed	Log-transformed and energy-adjusted	Crude	Energy-adjusted
Cereals	0.41**	0.53**	0.38**	0.49**	0.32**	0.51**
Vegetables	0.24*	0.31**	0.30**	0.30**	0.30**	0.31**
Meats	0.23*	0.33**	0.48**	0.53**	0.36**	0.31**
Marine lives	0.40**	0.36**	0.67**	0.69**	0.46**	0.57**
Median	0.32	0.35	0.43	0.51	0.34	0.41

**P<0.01,* P<0.05.

Table 4. Pearson's and Spearman's Rank Correlation Coefficients between Daily Intakes of Selected Nutrients Based on the SQFFQ and the 3 day WDRs

Nutrients	Pearson's CCs				Spearman's CCs	
	Crude	Energy -adjusted	Log -transformed	Log-transformed and energy-adjusted	Crude	Energy-adjusted
Energy	0.26**		0.29**		0.31**	
Protein	0.25*	0.24*	0.32**	0.33**	0.30**	0.40**
Fat	0.32**	0.34**	0.34**	0.32**	0.39**	0.35**
Carbohydrate	0.27**	0.41**	0.27**	0.40**	0.27**	0.42**
Total dietary fiber	0.19	0.18	0.17	0.20	0.17	0.19
Cholesterol	0.41**	0.51**	0.49**	0.56**	0.46**	0.56**
Carotene	0.17	0.30**	0.39**	0.44**	0.25**	0.34**
Retinol	0.16	0.12	0.44**	0.39**	0.48**	0.43**
Folic acid	0.28**	0.43**	0.45**	0.50**	0.37**	0.50**
Vitamins C	0.23**	0.37**	0.57**	0.60**	0.33**	0.44**
Vitamins E	0.45**	0.52**	0.54**	0.59**	0.49**	0.63**
Calcium	0.34**	0.49**	0.52**	0.63**	0.36**	0.57**
Phosphorous	0.33**	0.58**	0.38**	0.63**	0.33**	0.56**
Potassium	0.24**	0.50**	0.37**	0.57**	0.30**	0.54**
Sodium	0.52**	0.53**	0.65**	0.63**	0.70**	0.67**
Magnesium	0.28**	0.45**	0.32**	0.47**	0.28**	0.46**
Iron	0.29**	0.36**	0.31**	0.33**	0.29**	0.30**
Zinc	0.42**	0.34**	0.43**	0.40**	0.42**	0.52**
Selenium	0.32**	0.35**	0.30**	0.40**	0.29**	0.34**
Copper	0.41**	0.48**	0.38**	0.47**	0.32**	0.33**
SFA	0.51**	0.52**	0.63**	0.61**	0.68**	0.65**
MUFA	0.43**	0.50**	0.52**	0.57**	0.47**	0.61**
PUFA	0.38**	0.44**	0.48**	0.58**	0.39**	0.59**
n-3 PUFA	0.35**	0.37**	0.38**	0.35**	0.42**	0.38**
n-6 PUFA	0.25*	0.21*	0.29**	0.30**	0.27**	0.38**
Median	0.29	0.41	0.38	0.47	0.33	0.44

**P<0.01,* P<0.05.

Table 5. Agreement, Disagreement and Kappa Statistics According to Tertile Classification of Daily Intakes of Selected Food Groups Based on the SQFFQ and the 3 day WDRs

Food	Crude (%)			Energy-adjusted (%)		
	Agreement	Disagreement	Kappa	Agreement	Disagreement	Kappa
Cereals	50	14	0.25**	51	5	0.27**
Vegetables	47	11	0.21**	45	19	0.18*
Meats	39	11	0.09	42	22	0.13
Marine lives	46	10	0.19**	43	17	0.15*
Median	49	11	0.20	44	18	0.17

**P<0.01, * P<0.05.

that the validity study was conducted using ordinary residents, free from apparent disease/infirmity, from Nanao county of Chaoshan area. They did not have any special motivation to participate and were from somewhat lower educational and occupational levels (being mainly fishing population) than those of other population in the world.

Table 6. Agreement, Disagreement and Kappa Statistics According to Tertile Classification of Daily Intakes of Selected Nutrients Based on the SQFFQ and the 3 day WDRs

Nutrients	Crude (%)			Energy-adjusted (%)		
	Agreement	Disagreement	Kappa	Agreement	Disagreement	Kappa
Energy	45	15	0.19**			
Protein	39	15	0.09	46	10	0.34**
Fat	49	7	0.24**	44	8	0.16*
Carbohydrate	44	18	0.16*	41	9	0.12
Total dietary fiber	37	19	0.06	42	12	0.13
Cholesterol	55	1	0.25**	61	9	0.42**
Carotene	46	16	0.19**	55	14	0.25**
Retinol	52	1	0.28**	48	10	0.22**
Folic acid	48	16	0.22**	52	14	0.28**
Vitamins C	42	12	0.13	48	12	0.22**
Vitamins E	41	11	0.12	57	5	0.36**
Calcium	38	16	0.07	55	11	0.33**
Phosphorous	44	18	0.16*	55	8	0.31**
Potassium	44	16	0.16*	46	10	0.19**
Sodium	56	4	0.34**	63	3	0.45**
Magnesium	46	18	0.19**	47	9	0.21**
Iron	45	17	0.18*	39	19	0.09
Zinc	49	15	0.24**	49	9	0.24**
Selenium	33	22	0.01	41	15	0.12
Copper	46	16	0.19**	45	15	0.18*
SFA	51	11	0.26**	42	13	0.13
MUFA	43	19	0.15	44	13	0.16*
PUFA	54	8	0.32**	52	15	0.28**
n-3 PUFA	46	11	0.18*	54	8	0.32**
n-6 PUFA	49	10	0.26**	47	7	0.19*
Median	45	15	0.19	48	10	0.22

**P<0.01,* P<0.05.

Therefore, the results of this study may underestimate validity of the SQFFQ. However, it can be more generalized. Compared to the diet records in this study, the food frequency questionnaire overestimated energy intake by 4.8%. Recent validation studies comparing food frequency questionnaires against diet records and recalls in U.S. women have reported biases in energy intake ranging from –3.4% (Subar et al., 2001) to +25% (Jones et al., 1997). The apparent differences among validation studies in the direction (over or under-estimation of nutrient means) and degree of bias may be explained partly by variations in the number and specificity of items on the questionnaire (Warneke et al., 2001).

Research suggests that diet records and multiple 24-hour recalls may underestimate energy and nutrient intakes in females by as much as 10–46% (Hill et al., 2001; Martin et al., 1996; Sawaya et al., 1996). This may be particularly true for obese subjects (Lichtmanv et al., 1992; Kretsch et al., 1999) and may explain the greater difference obtained between food frequency questionnaire and diet record estimates in the low-income postpartum women, 58% of whom were either overweight or obese (BMI≥25). It may be plausible that the estimates obtained from the food frequency questionnaire are closer to the true intakes of the participants than those suggested by the diet records and recalls.

The majority of studies validating food frequency questionnaires against diet records and recalls have reported correlation coefficients ranging between 0.4 and 0.7 for nutrients (Willett, 1998). Energy-adjusted Pearson's CCs obtained in the present study lie generally within this range. For certain nutrients (eg. protein), SQFFQ estimates in the present study were significantly different from those of diet records, even though estimates from the two methods were correlated significantly. It is plausible that although the food frequency questionnaire underestimated means for certain nutrients with the exception of carotene, iron and zinc, it did so in a consistent manner. The SQFFQ demonstrated strong correlations for energy, carbohydrate and fat, but it may be less robust for certain nutrients such as dietary fiber. It is essential to continually update food frequency questionnaires because of changing demographics and rapidly evolving food supplies.

Recent evidence suggests that food frequency questionnaires and other self-reported dietary measures, including diet records, may share certain person-specific biases or errors (Kipnis et al., 2001) such as misreporting of portion sizes. It is preferable that biases in the reference instrument are independent of those in food frequency questionnaires. One way to overcome this shared bias is to utilize biomarkers such as urinary nitrogen, serum nutrient levels or doubly labeled water (Kipnis et al., 2001; Livingstone et al., 2003). Although biomarkers may serve as useful reference instruments for food frequency validation, the cost involved and associated subject burden were outside the scope of this study.

In conclusion, a moderate level of relative validity was observed; this food frequency questionnaire may be used to identify areas of dietary concern in adult in order to better target nutrition interventions, and to examine relationships between dietary patterns and health outcomes.

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