J Community Nutrition 6(1) : 35~41, 2004

□ Original Article □

Development and Validation of Computerized Semiquantitative Food Frequency Questionnaire for Koreans with High-Risk of Hypercholesterolemia

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ABSTRACT

Cardiovascular disease has the highest mortality rate in South Korea. Previous studies have reported that serum cholesterol level relates to intake of dietary fat and cholesterol. Therefore, in this study we developed a semiquantitative food frequency questionnaire (FFQ) for Koreans with a high-risk of hypercholesterolemia and to validate the FFQ. Semiquantitative FFQ, which includes 160 food items, reflects intakes of energy, fat, saturated fatty acid (SFA), monounsaturated fatty acid (MUFA), polyunsaturated fatty acid (PUFA) and cholesterol. We chose food items from the previous study of our research group (Suh 1999) which reported a nutritional status of Korean adults with normocholesterolemia, borderline and hypercholesterolemia. To validate the FFQ, we compared the results of the FFQ with those of a 3-day food record using a paired t-test. In addition, we calculated Pearson's and Spearmen's correlation coefficients. Intakes assessed by the FFQ and a 3-day food record were classified into quartile and the degree of agreement was obtained. Fifty-five participants responded for the validation study by completing both the FFQ and a 3-day food record. Pearson's correlation coefficients between estimated intakes by respective methods for energy, fat, SFA, MUFA, PUFA and cholesterol were 0.32, 0.41, 0.37, 0.41, 0.37 and 0.21, respectively. Spearman's correlation coefficients of energy, fat, SFA, MUFA, PUFA, cholesterol were 0.31, 0.44, 0.39, 0.46, 0.46, and 0.37, respectively. Nutrient densities in 1000kcal were compared. Pearson's correlation coefficient of cholesterol density increased and other values were similar with original values. The average degree of agreement was 67% that intakes of energy, fat, SFA, MUFA, PUFA and cholesterol assessed by the FFQ and 3-day food records were classified within the same and the adjacent quartile. On the average, 8% were misclassified into the extreme opposite quartile. The average of weighted kappa was 0.46. In conclusion, the FFQ developed in this study is considered to be a reliable tool to assess nutrient intakes for Koreans with a risk of hypercholesterolemia because the FFQ reflects the intakes of energy, fat, SFA, MUFA, PUFA, and cholesterol. (*J Community Nutrition* 6(1) : 35~41, 2004)

KEY WORDS : food frequency questionnaire · hypercholesterolemia · fat · saturated fatty acid · monounsaturated fatty acid · polyunsaturated fatty acid · cholesterol

Introduction

Cardiovascular disease (CVD) has the highest mortality rate in South Korea (Korean National Statistical Office 1998). According to the Framingham study, serum cholesterol level is known as a risk factor of CVD (Kannel et al. 1976). It is known that chronic diseases like CVD are related with usual dietary intakes. Food frequency questionnaire (FFQ) is known as the most reliable tool to assess usual intakes and to identify associations between dietary intakes and diseases (Feskanich et al. 1993). Therefore, ranking of nutrient intake is more important than the absolute amount consumed because it reflects the relationship between the dietary factors and disease prevalence. FFQ method has been used in epidemiological and clinical studies because it is less expensive than other dietary assessment methods and it requires less labor of interviewers and data analysis (Willet 1998).

Validity of FFQ depends on the food lists and portion sizes.

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Willet (1998) has suggested that the food lists of FFQ should develop the list assessing comprehensive intake because some questions about diet, which are not consider as being important at the beginning, may became important at the end of a study. According to portion size provided, FFQ classifies into three kinds. Simple FFQ does not provide portion sizes, semi-quantitative FFQ specifies a portion size, and quantitative FFQ asks open-end question about usual portion size. To improve accuracy of portion size assessment, interviewers usually use food models, pictures, measuring cups, and spoons (Block et al. 1986 ; McDonald et al. 1991). In this study, we used the computerized FFQ which provided actual sized photos as portion sizes, which could prevent over or underestimating portion sizes. During the survey, we brought laptop computers and showed photos on the computer screen. Open-end questions for portions and frequency made almost quantitative estimation of nutrient intakes. To validate a FFQ, food records have been used as a standard because the errors of food records do not relate to those of FFQ. Errors from FFQ occur from fixed food lists, lack of memory, perception of portion sizes, and interpretation of questions. Food records can minimize the errors from FFQ because the records are open-ended questions, independent memory, and filling out direct portion sizes (Willet 1998).

It is known that energy intake confounds the intake of other nutrients because higher intake of energy correlates with higher intake of other nutrients (Willet 1998). Willett has proposed that the adjustment for total energy intake may increase the precision of specific nutrient measurements. The common methods to adjust energy intake are calculating nutrient density and analyzing by multiple regression. In this study, we calculated nutrient density according to Liu et al's (1994) suggestion.

In the United States, several FFQ have developed and have been used to estimate fat and cholesterol intake for CVD patients (Curtis et al. 1992 ; Feunekes et al. 1993). In Korea, Kim and Yang (1998) developed FFQ for patients with diabetes and Paik et al. (1995) did so for patients with chronic diseases. However, they showed low correlation coefficient with fat intake assessed by 24hr recalls. Therefore, development of FFQ for hypercholesterolemia patients was requested.

We conducted this study to develop and validate a semi-quantitative food frequency questionnaire (FFQ) which reflects dietary intakes of energy, fat, SFA, MUFA, PUFA and cholesterol. According to previous reports about dietary factors relating to serum cholesterol level, total fat, fatty acids, and cholesterol, intake affects the level of serum cholesterol (Chenoweth et al. 1981 ; Kris-Etherton et al. 1988). Therefore, we decided that FFQ should be developed to assess the intakes of energy, fat, SFA, MUFA, PUFA and cholesterol. Dietary fiber also is known to modulate the serum cholesterol level. However, the Korean food composition database did not include dietary fiber but crude fiber so we could not assess the intake of dietary fiber, Since the National Cholesterol Education Program (National Cholesterol Education Program Expert Panel 1988) suggests that serum cholesterol can be changed by diet therapy in 3 months, our reference period was 3 months. We developed a comparison computerized semiquantitative FFQ that provides actual sized pictures as portion sizes and validated it by comparing with a 3-day food record.

Subjects and Methods

1. Subjects

The participants were recruited from the Center for Health Promotion, a general hospital in Seoul, South Korea in October, 1999. When they visited the Center, they did not have any previously diagnosed disease. One hundred nine participants were interviewed by the FFQ and among them, 55 participants (29 female and 26 male) completed a 3-day food record. To validate the FFQ, the data from 55 participants was used. Mean age and education level of 55 participants did not differ with those of 109 participants (Table 1).

2. Development of food frequency questionnaire

In order to develop the FFQ which reflects intakes of energy, fat, SFA, MUFA, PUFA, and cholesterol, we selected the food items from the previous study of our research group (Suh 1999), which assessed nutritional status of 177 Korean adults

Table 1. General characteristics of subjects participating in the food frequency questionnaire

Characteristics	FFQ (range)[1]	FFQ & food record (range)[2]
Number	109	55
Age (year)	45.1 ± 12.6[3] (20.9 – 70.3)	47.4 ± 13.0[3] (20.9 – 70.3)
Education (year)	10.0 ± 5.0 (0 – 16)	9.5 ± 5.3 (0 – 16)

[1] Subjects who participated in the food frequency questionnaire
[2] Subjects who participated in the food frequency questionnaire and a 3-day food record
[3] Values are mean ± SD

with normocholesterolemia (serum cholesterol < 200mg/dl), borderline (200mg/dl ≤ serum cholesterol < 240mg/dl), and hypercholesterolemia (240mg/dl ≤ serum cholesterol). A more extensive description of the study methods and results can be found in Suh's thesis (1999). We chose 60 food items which contribute to the intake of energy, 50 items which contribute to the intake of SFA, MUFA, PUFA, respectively and 31 items that contribute to the intake of cholesterol from the previous study (Suh 1999). Although 12 food items and 2 mixed dishes showed low contribution on energy intake, they were included to the FFQ because of high popularity among Koreans. Eight seasonal food items and supplements were also added in the FFQ. The FFQ has 61 questions for foods and food groups (Table 2), and each question has 1 to 10 subquestions about the mixed dishes. We used the recipes from Bark et al's (1994) and Suh's (1999) researches. The types of oil used for cooking and seasoning were asked at the beginning and the oils in recipes were automatically changed by the selection of oil types. The reference period of the FFQ was 3 months. We referred the dietary history questionnaire which were used for the Coronary Artery Risk Development in Young Adults Study (McDonals et al. 1991).

Portion sizes were determined by the average food intake of the previous study (Suh 1999) or household units (e.g. one medium sized apple). The photos of portion sizes showed on the computer screen as the actual size. Portion size and frequency are open-ended questions.

Interviewers were all registered dietitians and they were trained on how to use the computerized FFQ program. Interviews took approximately 40min per person.

3. Dietary records

Completion of one method may influence response to the other. In order to minimize this effect, we collected FFQ first and did not evaluate the results until submitting a 3-day food record. Recording food intakes could be influenced by dietary habits, not by the FFQ.

After FFQ interview, how to keep food records were demonstrated toparticipants and were suggested to fill out for 3 days, two week-days and one weekend. They were asked to record all foods and beverages consumed in detail as much as possible. Also, participants were asked to describe their portion size in household units or dimensions. One week later, they submitted records to the interviewers. Interviewers reviewed re-

Table 2. The food lists needed in the food frequency questionnaire*

Categories	Grains and potatoes (n = 13)	Meats and eggs (n = 4)	Fishes and shellfishes (n = 12)	Vegetables (n = 19)	Others (n = 13)
Questions	Rice	Pork	Yellow croaker	Salad with mayonnaise sauce	Dietary supplements
	Bread	Beef	Hair tail	Kimchi	Alcohol
	Noodle	Chicken	Mackerel	Soybean paste stew	Tofu
	Rice cake stew	Egg	Pacific saury	Miso soup with vegetable	Soy bean and/or black bean
	Rice cake		Alaskan pollack	Laver	Milk and/or soy milk
	Cereal		Alaskan pollack, dried	Sea mustard	Yogurt
	Dumpling		Anchovy	Soybean sprout	Fruits
	Potato		Squid	Zucchini	Nuts
	Sweet potato		Clam	Egg plant	Chocolate
	Corn		Shrimp	Radish	Soft drink
	Starch vermicelli		Oyster	Spinach	Coffee
	Cookies		Fish paste	Cham chwi (wild plant)	Fruit juice
	Cake			Root of Chinese bellflower	Candies
				Mushroom	
				Cucumber	
				Braken	
				Water dropwort	
				Lettuce and/or perilla leaf	
				Fried vegetable with flour	

* : In the FFQ, types of oil typically used in cooking and seasoning were asked, and oils in the mixed dishes were changed by the selection of oil types

cords and asked additional questions when they were necessary.

4. Data analysis

For analysis of nutrient intakes using the FFQ or a 3-day food record, we developed two computer programs that use the same food composition database. The database was established from domestic data (The Korean Nutrition Society 2000). When domestic data was not available, USDA database was used (U. S. Department of Agriculture 1998). We compared the nutrient intakes estimated by the FFQ to them by a 3-day food record using paired t-test. In addition, we obtained Pearson's and Spearman's correlation coefficients. Also, we calculated nutrient density and obtained Pearson's and Spearman's correlation coefficients of nutrient density. Intakes assessed by the FFQ and a 3-day food record were classified into quartile and obtained the degree of agreement by weighted kappa.

5. Statistic analysis

SAS program (Cary, NC, USA) was used for analysis.

Table 3. Anthropometric measurements of the subjects participating in the food frequency questionnaire and a 3-day food record

	Total (n = 55)	Male (n = 26)	Female (n = 29)
Height (cm)	162.4 ± 9.3	169.3 ± 4.5	155.9 ± 7.8
Weight (kg)	62.1 ± 8.6	66.2 ± 7.1	58.2 ± 8.3
BMI (kg/m^2)	23.6 ± 3.2	23.1 ± 2.4	24.5 ± 3.7

Values are mean ± SD

Results

Fifty-five subjects participated the validation study for the FFQ and among them 26 were male and 29 were female. Table 3 presents the anthropometric measurements of 55 subjects. The average body mass index (BMI) of males was 23.1 ± 2.4 and that of females was 24.1 ± 3.7.

We compared dietary intakes of energy, fat, SFA, MUFA, PUFA and cholesterol by the FFQ to those by a 3-day food record. Table 4 shows mean dietary intakes assessed by the FFQ and a 3-day food record. Energy, fat, SFA, MUFA, PUFA intake calculated by the FFQ were significantly higher than those by a 3-day food record. Cholesterol intake estimated by the two methods did not differ. Pearson's correlation coefficients between nutrient intakes by the FFQ and by a 3-day food record were significant in energy (0.32), fat (0.41), SFA (0.37), MUFA (0.41) and PUFA (0.37), but Pearson's correlation coefficient of cholesterol (0.21) was not significant. Spearman's ranking correlation coefficients of energy (0.31), fat (0.44), SFA (0.39), MUFA (0.46), PUFA (0.46), and cholesterol (0.37) were significant.

Nutrient densities in 1000kcal were obtained in order to adjust energy intake (Table 5). Cholesterol density by the FFQ was significantly lower than that by a 3-day food record. Nutrient densities of fat, SFA, MUFA, and PUFA did not

Table 4. Comparison of nutrient intake levels obtained by the food frequency questionnaire and by a 3-day food record

Nutrient	FFQ (n = 55)	Food record (n = 55)	Pearson's correlation coefficient	Spearman's correlation coefficient
Energy (kcal)	2476 ± 937*[1)]	1839 ± 4581	0.32†	0.31†
Fat (g)	51.6 ± 35.4*	38.8 ± 17.4	0.41†	0.44†
SFA (g)	13.81 ± 10.02*	10.34 ± 5.29	0.37†	0.39†
MUFA (g)	16.01 ± 11.93*	11.92 ± 6.21	0.41†	0.46†
PUFA (g)	14.29 ± 9.94*	9.00 ± 5.04	0.37†	0.46†
Cholesterol (mg)	250.0 ± 212.6	215.3 ± 129.6	0.21	0.37†

SFA : Saturated fatty acid, MUFA : Monounsaturated fatty acid, PUFA : Polyunsaturated fatty acid, [1)] Values are mean ± SD, * : Mean values are significantly different from those of a 3-day food record by paired t-test ($p < 0.05$), † : Estimated mean intakes by two methods are significantly correlated by Pearson's in quantity and Spearman's in ranking ($p < 0.05$)

Table 5. Comparison of nutrient density obtained by the food frequency questionnaire and a 3-day food record

Nutrient	FFQ (n = 55)	Food record (n = 55)	Pearson's correlation coefficient	Spearman's correlation coefficient
Fat (g/1000kcal)	19.2 ± 7.6[1)]	20.9 ± 7.6[1)]	0.41†	0.44†
SFA (g/1000kcal)	5.10 ± 2.35	5.57 ± 2.53	0.42†	0.39†
MUFA (g/1000kcal)	5.85 ± 2.66	6.41 ± 2.86	0.41†	0.45†
PUFA (g/1000kcal)	5.39 ± 2.34	4.79 ± 2.19	0.30†	0.48†
Cholesterol (mg/1000kcal)	90.0 ± 52.5*	117.8 ± 64.5	0.34†	0.35†

SFA : Saturated fatty acid, MUFA : Monounsaturated fatty acid, PUFA : Polyunsaturated fatty acid, [1)] Values are mean ± SD, * : Mean value is significantly different from that of a 3-day food record by paired t-test ($p < 0.05$), † : Estimated mean nutrient density by two methods are significantly correlated by Pearson's in quantity and Spearman's in ranking ($p < 0.05$)

Table 6. Percent of classifying participants into the same levels by the food frequency questionnaires with a 3-day food record based on joint classification by quartiles (%)

Food record quartile	Lowest			Highest		
FFQ quartile	Lowest	Lowest2	Highest	Highest	Highest2	Lowest
Energy	30.8	30.8	7.7	42.9	14.3	21.4
Fat	61.5	7.7	0	28.6	14.3	0
SFA	53.8	38.5	0	35.7	14.3	7.1
MUFA	61.5	23.1	0	35.7	28.6	7.1
PUFA	61.5	7.7	7.7	57.1	28.6	7.1
Cholesterol	46.2	23.1	15.4	28.6	28.6	21.4
Average	52.6	21.8	5.1	38.1	21.5	10.7

SFA : Saturated fatty acid, MUFA : Monounsaturated fatty acid, PUFA : Polyunsaturated fatty acid

Table 7. Percent of classifying subjects equally into same quartile by mean intake of nutrients from the food frequency questionnaire and those from a 3-day food record

Nutrient	Number of subjects (Total = 55)	% of total	Kappa*
Energy	17	30.9	0.36
Fat	22	40	0.46
SFA	20	36.4	0.45
MUFA	21	38.2	0.53
PUFA	21	38.2	0.50
Cholesterol	21	38.2	0.44
Average	20.3	37	0.46

* : Weighted kappa

show any difference between the two dietary assessment methods. Pearson's correlation coefficients of nutrient densities in fat, SFA, MUFA, PUFA, and cholesterol intake were statistically significant and ranged 0.30 − 0.42. Also, Spearman's correlation coefficients were statistically significant and ranged 0.35 − 0.48.

Intakes of participants classified into quartiles and the percents of classifying participants into the same levels by the FFQ and a 3-day food record were obtained (Table 6). Seventy-four percent of the participants in the lowest quartile by a 3-day food record were classified into the lowest and the second lowest quartile by the FFQ, but five percent were classified into the highest. Sixty percent of the participants in the highest quartile by a 3-day food record were classified into the highest and the second highest quartile by the FFQ, but eleven percent were classified into the lowest. Table 7 presents the percent of classifying subjects equally into the same quartile by the FFQ and a 3-day food record. The average of weighted kappa was 0.46.

Discussion

We developed the semiquantitative FFQ, which can reflect the intakes of energy, fat, SFA, MUFA, PUFA and cholesterol for Koreans with high-risk of hypercholesterolemia. In order to validate the FFQ, 55 adults participated and we estimated nutrient intakes by the FFQ and by a 3-day food record.

Willet et al. (1985) validated a semiquantatitive FFQ with four one-week food records for one year and reported that the use of four rather than a single one-week record clearly strengthened correlation with the FFQ. In our study, we collected one 3-day food record because the reference period was 3 months which was shorter than that of Willet's 1 year. We expect that nutrient intakes estimated by a 3-day food record might not differ with a one-week food record because we collected records from two weekdays and one weekend day.

The previous studies have reported that dietary intake assessed by FFQ show the tendency of overestimation than dietary intake by food record (Bingham et al. 1994) and this tendency also was observed in our study. Threfore, the rank of subjects is more reliable than the absolute level of nutrient intakes assessed by a FFQ.

Pearson's correlation coefficients of energy (0.32), fat (0.41), SFA (0.37), MUFA (0.41) and PUFA (0.37) between estimated intake by the FFQ and by a 3-day food record were comparable to the previous studies, but that of cholesterol 0.21 was low (Willett et al. 1985). Willett et al. (1985) compared nutrient intakes of FFQ with those of four one-week diet records and reported that Pearson's correlation coefficients of fat, SFA, PUFA, and cholesterol were 0.27, 0.31, 0.31, and 0.41, respectively. These results suggests that the FFQ developed by our research group need to add the food items which have high cholesterol contents and improve estimation of cholesterol intake.

Spearman's correlation coefficients, which represent correlation of ranking, were calculated. Spearman's correlation coefficients of energy (0.31), fat (0.44), SFA (0.39), MUFA

(0.46), PUFA (0.46), and cholesterol (0.37) in our study were close to Kemppainene et al's (1993) which reported that Spearman's correlation coefficients between their FFQ and a 3-day food record of SFA, MUFA, and PUFA were 0.55, 0.34, and 0.52, respectively. Our results of Spearman's correlation coefficients means that our FFQ reflects the rank of nutrient intakes very well.

To adjust energy intake, we calculated nutrient density of fat, SFA, MUFA, PUFA and cholesterol. Pearson's correlation coefficient of cholesterol density obtained statistical significance, which implied this FFQ might be reliable to assess cholesterol density. Pearson's and Spearman's correlation coefficients of other nutrient density were significant and similar to the values of nutrient intakes.

To evaluate the degree of agreement and misclassification associated with categorized intakes assessed by our FFQ, we examined the joint classification of nutrient intakes. Sixty-seven percent of the participants in the lowest or the highest quartile by a 3-day food record were correctly classified into the lowest and the second lowest quartile or the highest and the second highest quartile by the FFQ, but approximately eight percent were misclassified into the opposite quartile. These values are close to Willett's et al's (1985), which classified energy -adjusted intake of fat, SFA, PUFA, and cholesterol by quintile and 68 − 88% of participants were correctly classified and 3 − 9% were misclassified. Therefore, our FFQ can classify the subjects who have high or low intake of nutrients.

Summary and Conclusion

The FFQ developed in our study is considered to be a reliable tool to assess energy, fat, SFA, MUFA, PUFA, and cholesterol intake because the nutrient intakes assessed by the FFQ had good correlation with those assessed by a 3-day food record. Therefore it can be used for hypercholesterolemia patients and high-risk population. The FFQ developed in our study is an user-friendly computerized program and we expect it to be used for health promotion through the internet because it is capable of being self-administered.

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