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Development of a Semi-quantitative Food Frequency Questionnaire Based on Dietary Data from the Korea National Health and Nutrition Examination Survey

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Objective : This study was carried out to develop a semi-quantitative food frequency questionnaire (SQFFQ) for estimating average dietary intake to determine the risk factor for lifestyle-related diseases in a conjoint cohort study.

Design : We developed an SQFFQ for genomic epidemiological studies based on the data in the '98 Korea Health and Nutrition Examination Survey. A subset of data on informative food items was collected using the 24-hr recall method with 2,714 adults aged 40 or older living in middle-sized cities or in rural areas in Korea. The cumulative percent contribution and cumulative multiple regression coefficients of 17 nutrients (energy, fat, carbohydrate, protein, fiber, iron, potassium, sodium, calcium, phosphorus, vitamin A, retinol, β-carotene, vitamin B_1, vitamin B_2, niacin and vitamin C) of each food were computed.

Results : Two hundred and forty-nine foods, which were selected based on their 0.9 cumulative percent contribution, and 254 foods, which were selected based on their 0.9 cumulative multiple regression coefficients, respectively, were grouped into 97 food groups according to their nutrient contents. Several popular Korean foods, which were missing from the list due to the seasonality of the survey, were included. The portion sizes were derived from the same data set. The SQFFQ covered 84.8 percent of the intake of 17 nutrients in the one day diet record data of our 326 cohort study subjects.

Conclusions : The final list included 103 food items. The foods list in the SQFFQ described herein accounted for 84.8 percent of the average intake of 17 nutrients. Therefore, the list could be used for the assessment of the baseline dietary intakes of the conjoint cohort studies.

Key words : SQFFQ, cohort, 24-hr recall, cumulative % contribution, cumulative multiple regression coefficients

INTRODUCTION

Dietary habits are one of the most important environmental effectors on the development of lifestyle-related adult onset common chronic diseases such as hypertension, diabetes and osteoporosis. Therefore, the estimation of dietary intake is one of the crucial factors in epidemiological studies concerning chronic diseases.

The food frequency questionnaire (FFQ) is a tool for the estimation of food and nutrient consumption and has been used widely in investigating the relationship between diet and chronic diseases[1,2]. One of the advantages of this method is that the average long-term dietary intake of an individual can be easily obtained by making a single measurement. It is important, however, that the foods on the list be carefully selected in order to gather information most relevant to the objectives of studies where the FFQ is to be utilized. Moreover, the significance of nutrient intake can be assessed based on the absolute values of consumption or on the rank order of consumption within the study group in question. Therefore, foods for an FFQ can be selected on the basis of each food's contribution either to total dietary intake of a subject group or to the between-person difference in dietary patterns[3]. Willett has suggested three characteristics of a food informative of dietary patterns[4]. First, the food is consumed reasonably often by an appreciable number of individuals. Second, it has a substantial content of the nutrients of interest. Third, it has a discriminating power with respect to personal preference, consumption frequency or nutrient contents. To choose informative foods, Block et al.[5] have suggested an approach based on existing dietary data

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(data-based approach), that is, to rank the food items by percent nutrient contribution to total nutrient intake. To identify foods that can explain interpersonal differences, a regression approach has also been suggested[1,6,7].

We developed an SQFFQ for prospective cohort studies that were implemented in 2001. The objectives of the cohort studies were to estimate the incidence and prevalence of specified diseases and to collect and analyze variables of lifestyle and individual genomic variability such as single nucleotide polymorphisms (SNP) that might have causal effects on the development of chronic diseases.

In Korea, several prospective cohort studies of chronic disease are ongoing. However, there have been few attempts to investigate the relationship between chronic diseases and diet. Some food frequency questionnaires were developed using the 24-hr recall data of a small group and validated[8,9,10,11] while others were developed with food items which were reported as frequently consumed in other studies[12,13]. A well-designed FFQ should be developed to assess the general diet as a risk factor for the cohort of genomic epidemiological studies. A rational approach to designing such a questionnaire was to build it on the basis of available data on the dietary intake of the Korean people, data which had been previously obtained from participating household members in the "'98 Korea Health and Nutrition Examination Survey (KHANES)" using the 24-hr recall method. The food items were selected based on both the cumulative percent contribution and cumulative multiple regression coefficients. This SQFFQ has been used in ongoing community-based cohort studies. A study for validity and reproducibility of the FFQ is ongoing.

SUBJECTS AND METHODS

The data source

KHANES is a nation-wide survey of the health and nutritional status of Korean citizens that is performed every 3 years. The dietary data used for designing the SQFFQ presented in this paper were those obtained by the KHANES that was carried out during a two-month period from November through December of 1998. The samples in the survey were selected from 200 sample clusters based on the National Census of 1995. Thus, 13,523 households were recruited and the entire membership of selected households participated in the survey.

Dietary data were obtained from 11,525 subjects (age 1 year or older) in 4,395 households using the 24-hour recall method. Trained dietitians interviewed all of the participants in person using measuring cups and two-dimension food models. They also checked each household's tableware and ingredients of leftover foods. Nutrient intake was calculated based on the 5th ed. Food Composition Table[14] and database of processed and fast foods.

Development of the semi-quantitative food frequency questionnaire

Among the 11,525 subjects with dietary data, 2,714 (1,213 males and 1,501 females) individuals of age 40 or older who lived in a middle-sized cities or rural areas were selected to match the sites of cohort studies. The mean ages (mean ± S.D.) for males and females were 56.1 ± 11.2 and 58.3 ± 12.1, respectively. The total number of the reported food entities was 989, which could be grouped into 723 items based on their nutrient contents. The following 17 nutrient categories were selected; energy, fat, carbohydrate, protein, fiber, iron, potassium, sodium, calcium, phosphorus, vitamin A, retinol, β-carotene, vitamin B_1, vitamin B_2, niacin and vitamin C.

Food items contributing to total nutrient intake were obtained by cumulative percent contribution (cPC). The percent contribution of a nutrient by particular food i was estimated using the following equation,

$$\frac{\sum_{j=1}^{2,714} d_{ij} \sum_{k=0}^{S_{ij}} nutrient_{ijk}}{\sum_{j=1}^{2,714} \sum_{i=1}^{723} d_{ij} \sum_{k=0}^{S_{ij}} nutrient_{ijk}}$$

where i = food items, 1, 2,···723 ; j = persons, 1, 2,···2,714; k = servings of the food item to the particular person, 0, 1, 2,···, S_{ij} ; S_{ij} = the number of servings of the ith food consumed by the jth person ; d_{ij} = 1 if the jth person consumed the ith food, = 0 otherwise ; $nutrient_{ijk}$= the amount of the nutrient contained in serving k of food i to individual j[15].

The foods were listed up until the cPC reached 90%. Forward multiple regression analysis was then performed with total intake of a specific nutrient as the dependent variable and with the overall amount of nutrients from 269 foods as independent variables for each individual. Prior to calculating the regression coefficients, 454 foods with very low consumption frequency (below 20 counts) were defined as low contributing and were excluded. The foods were also added up until the cumulative multiple regression coefficients (cMRC; cumulative partial R^2) reached 0.9, except vitamin A, retinol and β-carotene.

The applicability to the cohort sites

A study of the validity and reproducibility of the FFQ using diet records and biochemical parameters is ongoing and the results will be presented in the near future. However, we calculated the coverage using one-day diet records of 163 subjects each from the Ansan and Ansung areas who were recruited for the cohort studies. The diet

records were collected during a two-month period from January through February of 2002. Nutrient intake was calculated based on the Food Composition Table in the Recommended Dietary Allowances for Koreans[16]. The percent coverage of 17 nutrients in the SQFFQ was computed as the proportion of nutrient intake of foods on the list of FFQ to the total nutrient intake of individuals in diet records.

RESULTS

Table 1 lists the average amount of nutrients consumed by the study subjects in KHANES. Average total energy intake was 1,855 kcal ; protein 68.1 g ; fat 27.6 g ; and carbohydrate 324.5 g, respectively. Males had a higher nutrient consumption than females in all nutrients.

Table 1. Intake of interested nutrients in KHANES data

	Males (n=1,213)	Females (n=1,501)	Total (n=2,714)
Energy (kcal)*	2,098±902	1,658±713	1,855±832
Protein(g)*	79.1±56.0	59.2±42.0	68.1±49.8
Fat (g)*	33.4±31.5	22.9±21.8	27.6±27.1
Carbohydrate (g)*	349.2±141.7	304.4±131.5	324.5±138.0
Fiber (g)*	7.36±4.64	6.36±4.81	6.81±4.76
Ca (mg)*	510.1±425.2	417.4±408.6	458.8±418.6
Phosphorus (mg)*	1,120±567	875±452	985±521
Fe (mg)*	13.7±9.7	11.01±9.49	12.2±9.7
Na (mg)*	5,318±3516	4,100±2901	4,644±3247
K (mg)*	2,649±1488	2,168±1383	2,383±1451
Vitamin A (R.E)*	593.0±733.8	458.6±605.4	518.7±669.0
Retinol (R.E)	50.5±111.0	41.7±237.7	45.6±191.8
β-carotene (ug)*	3,209±4245	2,450±3241	2,789±3742
Vitamin B_1(mg)*	1.32±0.81	1.03±0.60	1.16±0.72
Vitamin B_2 (mg)*	0.96±0.68	0.73±0.54	0.83±0.62
Niacin (mg)*	17.1±12.2	12.7±9.1	14.64±10.83
Vitamin C (mg)	115.4±96.8	110.4±114.0	112.6±106.7

*Mean value of nutrients were significantly different between sexes ($p < 0.001$).

Among the 989 reported food items, 249 and 254 were each selected by cPC and cMRC. The number of food items that covered 90% of total intake of individual nutrients as estimated by cPC was as follows : energy 92, protein 118, fat 90, carbohydrate 38, fiber 58, calcium 112, phosphorus 124, iron 113, sodium 32, potassium 110, vitamin A 42, retinol 32, β-carotene 30, vitamin B_1 92, vitamin B_2 127, niacin 113 and vitamin C 31. The number of food items after consideration of 90% between-person variability was as follows : energy 73, protein 64, fat 163, carbohydrate 31, fiber 131, calcium 46, phosphorus 182, iron 157, sodium 17, potassium 62, vitamin A 66, retinol 17, β-carotene 54, vitamin B_1 123, vitamin B_2 188, niacin 181 and vitamin C 17 (Table 2).

Table 2. Number of foods contributing to 17 nutrients with up to 90 cumulative % contribution and 0.90 cumulative R^2

Nutrients	Cumulative % contribution	Cumulative R^2
Energy	92	73
Protein	118	64
Fat	90	163
Carbohydrate	38	31
Fiber	58	131
Ca	112	46
Phosphorus	124	182
Fe	113	157
Na	32	17
K	110	62
Vitamin A	42	66*
Retinol	32	17*
β-carotene	30	54*
Vitamin B_1	92	123
Vitamin B_2	127	188
Niacin	113	181
Vitamin C	31	17

*Calculation was stopped when cumulative R^2 was not reached at 0.9. (vitamin A : 0.73, retinol : 0.22, carotene : 0.76)

Percent contribution, cumulative percent contribution and cumulative R^2 of the top 20 for macronutrients, minerals and vitamins are presented in Table 3-5. Well-milled rice (rice) contributed by more than half to total energy intake. Soju, a liquor distilled from fermented mash of rice (or sweet potato), sweet potato, ramen and pork belly followed in order. Each of these contributed a much smaller portion to total energy intake than rice. Rice, soybean oil, Soju, garlic and sweet potato were selected by cMRC in the order of contribution.

The highest contributing food to protein intake was rice, but Kimchi, one of the most popular Korean foods, tofu and soybean were selected by cPC. Six plant foods (garlic, rice, onion, Shoyu (Japanese soy sauce), green onion (large), and gochujang (red pepper paste)), however, were among the ten highest contributing foods when selected by cMRC, that were quite different from the selections by cPC except rice. Rice, soybean oil, pork belly, pork loin and sesame oil contributed to about one-third of fat intake when estimated with cPC. Pork belly, corn oil, soybean oil and sesame oil accounted for 50 percent of the between-person variation. Rice contributed to over 68 percent of carbohydrate intake, and accounted for 49 percent of the variation of carbohydrate intake.

Korean cabbage Kimchi also contributed to total calcium intake and ordinary milk ranked fourth by cPC. Soybean curd was an important calcium supplier in

Koreans. Rice was the top contributor of phosphorus, as well. Boiled radish leaf was the best iron source and soybean curd followed. Cow blood accounted for about 13 percent of iron intake variation. The main contributors of sodium were Korean cabbage Kimchi and table salt. They accounted for about 40 percent of total sodium intake. Korean cabbage Kimchi was also the top contributor of potassium, followed by rice and instant coffee and sea mustard, which accounted for 20 percent of potassium intake.

Seven food items (red pepper powder, Korean cabbage Kimchi, spinach, carrot, seasoned laver, perilla leaf, chicken egg) accounted for 48.5 percent of total vitamin A intake and seven other food items (perilla leaf, spinach, carrot, red pepper powder, mallow, Korean lettuce Kimchi, seasoned-toasted laver) accounted for

Table 3. Percent contribution, cumulative % contribution and cumulative R^2 of the top 20 for macronutrients

Energy

Food	Cumulative % contribution	Rank	Food	% contribution	Cumulative R^2
Well-milled rice	52.8	1	Well-milled rice	52.79	0.32
Soju (Distilled liquor)	54.8	2	Soybean oil	0.94	0.39
Sweet potato	56.5	3	Soju (Distilled liquor)	1.97	0.45
Ramen	58.0	4	Garlic	0.25	0.49
Pork, belly	59.2	5	Sweet potato	1.72	0.52
Mandarin	60.3	6	Noodles (etc.)	0.70	0.54
Kimchi, Korean cabbage	61.3	7	White sugar	0.76	0.57
Pork, loin	62.2	8	Wheat flour, medium	0.85	0.59
Soybean oil	63.2	9	Ginseng tea	0.18	0.61
Wheat flour, medium	64.0	10	Onion	0.17	0.63
Tofu	64.8	11	Corn oil	0.26	0.65
Somyon (Noodle)	65.6	12	Chicken egg	0.78	0.67
Soybean, black	66.4	13	Pork, belly	1.16	0.68
Beef, brisket	67.2	14	Ramen	1.53	0.69
Chicken egg	68.0	15	Mandarin	1.10	0.71
White sugar	68.7	16	Somyon (Noodle)	0.79	0.72
Chinese noodle	69.5	17	Rice gruel	0.24	0.73
Noodles (etc.)	70.2	18	Beer	0.40	0.73
Milk (Ordinary)	70.8	19	Milk (Ordinary)	0.64	0.74
Soybean paste	71.4	20	Black rice	0.39	0.75

Protein

Food	Cumulative % contribution	Rank	Food	% contribution	Cumulative R^2
Well-milled rice	26.8	1	Blue crab	6.17	0.43
Blue crab	33.0	2	Garlic	0.51	0.48
Kimchi, Korean cabbage	36.0	3	Well-milled rice	26.8	0.53
Beef, brisket	38.9	4	Onion	0.13	0.57
Pork, loin	41.3	5	Chicken egg	1.69	0.59
Tofu	43.6	6	Flatfish	0.61	0.62
Soybean, black	45.5	7	Common squid, dried	0.70	0.64
Mackerel	47.2	8	Shoyu	0.48	0.66
Chicken egg	48.9	9	Green onion, large type	0.19	0.68
Pork, belly	50.5	10	Gochujang (Fermented red pepper paste)	0.29	0.69
Chicken meat	51.9	11	Tofu	2.34	0.70
Common squid, raw	53.1	12	Pork, belly	1.64	0.71
Soybean paste	54.4	13	Mackerel	1.73	0.72
Alaska pollack, frozen	55.5	14	Noodles (etc.)	0.62	0.73
Beef, loin	56.6	15	Chicken meat	1.34	0.74
Yellow croaker, raw	57.7	16	Bastard halibut	0.43	0.75
Soybean sprout	58.6	17	Beef, brisket	2.93	0.75
Hair tail	59.6	18	Common squid, raw	1.29	0.76
Milk (Ordinary)	60.5	19	Yellow croaker, salt-cured and dried	0.74	0.77
Ramen	61.4	20	Pork, loin	2.35	0.78

Table 3. (Continued···)

Fat

Food	Cumulative % contribution	Rank	Food	% contribution	Cumulative R^2
Well-milled rice	11.2	1	Pork, belly	6.70	0.18
Soybean oil	18.4	2	Corn oil	1.98	0.32
Pork, belly	25.1	3	Soybean oil	7.16	0.46
Pork, loin	29.6	4	Sesame oil	3.99	0.50
Sesame oil	33.5	5	Garlic	0.004	0.53
Ramen	37.4	6	Chicken egg	3.57	0.56
Chicken egg	41.0	7	Pork, loin	4.47	0.58
Tofu	43.4	8	Ramen	3.86	0.60
Beef, brisket	45.8	9	Chicken meat	2.32	0.63
Milk (Ordinary)	48.1	10	Pork, ribs	0.75	0.65
Chicken meat	50.5	11	Beef, shank	1.42	0.67
Beef, loin	52.7	12	Beef, loin	2.26	0.68
Soybean, black	54.8	13	Beef, ribs	1.51	0.70
Kimchi, Korean cabbage	56.8	14	Milk (Ordinary)	2.35	0.72
Corn oil	58.8	15	Pork, shank	1.14	0.73
Mackerel	60.6	16	Mackerel	0.20	0.74
Coffee whitener	62.5	17	Mayonnaise	0.48	0.75
Beef, ribs	64.0	18	Beef, brisket	2.40	0.76
Beef, shank	65.4	19	Chinese cabbage, young	0.001	0.77
Soybean paste	66.6	20	Peanut, roasted	0.61	0.78

Carbohydrate

Food	Cumulative % contribution	Rank	Food	% contribution	Cumulative R^2
Well-milled rice	68.1	1	Well-milled rice	68.1	0.49
Sweet potato	70.5	2	Sweet potato	2.38	0.55
Mandarin	72.1	3	Noodles (etc.)	0.84	0.59
Ramen	73.5	4	Wheat flour, medium	1.01	0.63
White sugar	74.5	5	Ginseng tea	0.27	0.65
Wheat flour, medium	75.5	6	Mandarin	1.61	0.68
Somyon (Noodle)	76.5	7	White sugar	1.05	0.70
Persimmon, hard	77.4	8	Rice gruel	0.30	0.72
Chinese noodle	78.2	9	Somyon (Noodle)	0.96	0.73
Noodles (etc.)	79.1	10	Ramen	1.35	0.74
Apple, fuji	79.8	11	Chinese noodle	0.85	0.76
Pear	80.4	12	Steamed rice bread with shredded red bean	0.48	0.77
Persimmon, soft	81.1	13	Persimmon, hard	0.88	0.78
Glutinous rice, milled	81.6	14	Persimmon, soft	0.65	0.79
Steamed rice bread with shredded red bean	82.1	15	Black rice	0.46	0.80
Potatoes	82.6	16	Apple, fuji	0.71	0.81
Black rice	83.0	17	Bread with small red bean	0.43	0.82
Starch vermicelli	83.5	18	Glutinous rice, milled	0.51	0.82
Bread with small red bean	83.9	19	Pear	0.66	0.83
Rod shaped rice cake	84.3	20	Glutinous flour	0.30	0.84

over 51 percent of vitamin A intake. Retinol reached only 0.22 of cumulative R^2 because of the variable selection procedure. Chicken egg contributed on top of the retinol intake and eel accounted for the variation of over 10 percent. β-carotene also accounted for over 50 percent based on six food items. Red pepper powder and perilla leaf were the main contributors. Rice was also the top contributor of vitamin B_1. The various regions of pork were major suppliers of vitamin B_1. For vitamin B_2, Korean cabbage Kimchi ranked first based on cPC, followed by rice and chicken egg. Chicken egg, dried laver and red pepper powder were chosen by cMRC. Niacin was supplied about one quarter of total intake based on rice. Instant coffee accounted for between-person variations on the top. Vitamin C con- tributors were mostly fruits and vegetables. Because the survey

Table 4. Percent contribution, cumulative % contribution and cumulative R^2 of the top 10 for minerals

Ca

Food	Cumulative % Contribution	Rank	Food	Percent contribution	Cumulative R^2
Kimchi, Korean cabbage	10.6	1	Red frog crab, salt-fermented	3.19	0.31
Soybean curd	17.2	2	Sea mustard, dried	3.85	0.40
Anchovy, boiled-dried, large	22.1	3	Soybean curd	6.57	0.46
Milk (ordinary)	26.7	4	Loach	1.14	0.51
Sea mustard, dried	30.5	5	Boiled radish leaf	3.72	0.56
Boiled radish leaf	34.2	6	Milk (ordinary)	4.56	0.61
Red frog crab, salt-fermented	37.4	7	Anchovy, boiled-dried, large	4.89	0.65
Well-milled rice	40.5	8	Anchovy, boiled-dried, larvae	2.23	0.67
Chinese cabbage	42.8	9	Anchovy, boiled-dried, medium	1.87	0.70
Anchovy, boiled-dried, larvae	45.0	10	Eel	0.38	0.72

Phosphorus

Food	Cumulative % Contribution	Rank	Food	Percent contribution	Cumulative R^2
Well-milled rice	28.7	1	Well-milled rice	28.7	0.11
Kimchi, Korean cabbage	34.8	2	Garlic	0.79	0.20
Chicken egg	37.0	3	Chicken egg	2.22	0.27
Soybeans, black	38.9	4	Onion	0.28	0.32
Milk (ordinary)	40.7	5	Shoyu	0.67	0.35
Soybean curd	42.4	6	Common squid, dried	0.58	0.39
Beef, brisket	44.2	7	Black rice	0.54	0.42
Anchovy, boiled-dried, large	45.9	8	Anchovy, boiled-dried, medium	0.98	0.45
Pork, loin	47.3	9	Ko Chu Jang (Fermented red pepper paste)	0.48	0.47
Soybean paste	48.6	10	Milk (ordinary)	1.78	0.49

Fe

Food	Cumulative % Contribution	Rank	Food	Percent contribution	Cumulative R^2
Boiled radish leaf	12.6	1	Boiled radish leaf	12.6	0.20
Soybean curd	17.4	2	Beef, edible viscera, blood	2.74	0.36
Sea mustard, dried	20.7	3	Sea mustard, dried	3.37	0.42
Sea lettuce, raw	24.0	4	Sword fish, salt-fermented	0.01	0.46
Yellow croaker, salt-cured and dried	26.9	5	Yellow croaker, salt-cured and dried	2.84	0.49
Spinach	29.7	6	Steamed rice bread with shredded red bean	1.96	0.52
Beef, edible viscera, blood	32.4	7	Soybean curd	4.77	0.54
Well-milled rice	34.8	8	Anchovy, boiled-dried, medium	0.85	0.57
Soybeans, black	37.0	9	Loach	0.94	0.59
Steamed rice bread with shredded red bean	38.9	10	Sea lettuce, raw	3.29	0.62

Na

Food	Cumulative % Contribution	Rank	Food	Percent contribution	Cumulative R^2
Kimchi, Korean cabbage	25.6	1	Table salt	14.7	0.22
Table salt	40.3	2	Kimchi, small radish	7.20	0.41
Kimchi, small radish	47.5	3	Kimchi, Korean cabbage	25.6	0.56
Soybean paste	53.7	4	Shoyu	5.40	0.62
Shoyu	59.1	5	Dong Chi Mi(Watery radish Kimchi)	3.53	0.65
Soy sauce, Korean style	62.9	6	Chong Kuk Jang (Fermented soybean)	2.47	0.68
Dong Chi Mi(Watery radish Kimchi)	66.4	7	Soybean paste	6.21	0.70
Chong Kuk Jang (Fermented soybean)	68.9	8	Soy sauce, Korean style	3.81	0.73
Ramen	70.9	9	Sea mustard, stem	0.34	0.75
Kkak Du Ki (Seasoned cubed radish)	72.9	10	Common squid, salt-fermented	0.78	0.77

Table 4. (Continued···)

K

Food	Cumulative % Contribution	Rank	Food	Percent contribution	Cumulative R^2
Kimchi, Korean cabbage	13.0	1	Coffee, instant	2.24	0.10
Well-milled rice	23.6	2	Sea mustard, dried	2.60	0.19
Sweet potato	27.4	3	Sweet potato	3.77	0.28
Korean radish	30.4	4	Red pepper powder	1.55	0.35
Sea mustard, dried	33.0	5	Kimchi, Korean cabbage	13.0	0.41
Kkak Du Ki (Seasoned cubed radish)	35.6	6	Spinach	1.93	0.46
Mandarin	38.0	7	Garlic	1.08	0.49
Coffee, instant	40.2	8	Sea tangle, dried	0.69	0.52
Chinese cabbage	42.2	9	Pumpkin, mature	1.00	0.55
Spinach	44.2	10	Onion	0.56	0.57

Table 5. Percent contribution, cumulative % contribution and cumulative R^2 of the top 10 for vitamins

Vitamin A

Food	Cumulative % Contribution	Rank	Food	Percent contribution	Cumulative R^2
Red pepper powder	10.2	1	Perilla leaf	5.15	0.16
Kimchi, Korean cabbage	19.8	2	Spinach	8.35	0.28
Spinach	28.1	3	Carrot	6.50	0.37
Carrot	34.6	4	Red pepper powder	10.2	0.41
Laver, seasoned, toasted	40.5	5	Mallow	1.25	0.45
Perilla leaf	45.7	6	Kimchi, Korean lettuce	1.65	0.48
Chicken egg	48.5	7	Laver, seasoned, toasted	5.90	0.51
Kimchi, young radish	51.1	8	Laver, dried	2.16	0.53
Welsh onion, large type	53.6	9	Kimchi, young radish	2.63	0.56
Ko Chu Jang (Fermented red pepper paste)	56.1	10	Red pepper leaf	0.27	0.58

Retinol

Food	Cumulative % Contribution	Rank	Food	Percent contribution	Cumulative R^2
Chicken egg	30.2	1	Eel	10.4	0.13
Milk (ordinary)	41.0	2	Chicken egg	30.2	0.18
Eel	51.5	3	Loach	2.91	0.20
Hagfish	58.7	4	Milk (ordinary)	10.8	0.21
Chicken meat	63.2	5	Chicken meat	4.47	0.21
Beef, edible viscera, liver	66.3	6	Cat fish	1.75	0.22
Loach	69.2	7	Mackerel	2.28	0.22
Mackerel	71.5	8	Pork, belly	0.86	0.22
Cat fish	73.2	9	Beef, brisket	1.63	0.22
Beef, brisket	74.9	10	Granulated ark shell	0.57	0.22

β-carotene

Food	Cumulative % Contribution	Rank	Food	Percent contribution	Cumulative R^2
Red pepper powder	11.4	1	Perilla leaf	5.75	0.18
Kimchi, Korean cabbage	22.2	2	Spinach	9.30	0.32
Spinach	31.5	3	Carrot	7.25	0.40
Carrot	38.7	4	Red pepper powder	11.4	0.45
Laver, seasoned, toasted	45.3	5	Mallow	1.39	0.49
Perilla leaf	51.0	6	Kimchi, Korean lettuce	1.83	0.53
Welsh onion, large type	53.9	7	Laver, seasoned, toasted	6.57	0.56
Ko Chu Jang (Fermented red pepper paste)	56.6	8	Laver, dried	2.41	0.59
Kimchi, small radish	59.2	9	Red pepper leaf	0.30	0.62
Green pepper	61.7	10	Kimchi, young radish	2.17	0.63

Table 5. (Continued···)

Vitamin B_1

Food	Cumulative % Contribution	Rank	Food	Percent contribution	Cumulative R^2
Well-milled rice	31.4	1	Pork, belly	3.83	0.13
Kimchi, Korean cabbage	36.6	2	Yoghurt, liquid type	2.49	0.24
Mandarin	40.7	3	Pork, loin	3.74	0.32
Pork, belly	44.5	4	Well-milled rice	31.4	0.39
Pork, loin	48.3	5	Ramen	3.52	0.45
Ramen	51.8	6	Mandarin	4.10	0.51
Yoghurt, liquid type	54.3	7	Pork, ribs	0.95	0.56
Kkak Du Ki (Seasoned cubed radish)	56.1	8	Garlic	0.40	0.58
Sweet potato	57.9	9	Sweet potato	1.79	0.60
Soybean sprout	59.3	10	Pork, tender loin	0.55	0.62

Vitamin B_2

Food	Cumulative % Contribution	Rank	Food	Percent contribution	Cumulative R^2
Kimchi, Korean cabbage	7.3	1	Chicken egg	4.63	0.11
Well-milled rice	14.0	2	Laver, dried	1.11	0.18
Chicken egg	18.7	3	Red pepper powder	2.26	0.24
Ramen	22.0	4	Mackerel	2.73	0.29
Milk (ordinary)	25.3	5	Spinach	2.70	0.34
Mandarin	28.4	6	Milk (ordinary)	3.28	0.38
Laver, seasoned, toasted	31.4	7	Pork, belly	2.34	0.41
Mackerel	34.1	8	Welsh onion, large type	0.76	0.45
Spinach	36.8	9	Mandarin	3.09	0.48
Pork, belly	39.2	10	Laver, seasoned, toasted	2.98	0.51

Niacin

Food	Cumulative % Contribution	Rank	Food	Percent contribution	Cumulative R^2
Well-milled rice	24.8	1	Coffee, instant	3.07	0.12
Kimchi, Korean cabbage	30.5	2	Beef, edible viscera, blood	1.20	0.23
Beef, brisket	34.0	3	Mackerel	2.91	0.29
Coffee, instant	37.1	4	Ko Chu Jang (Fermented red pepper paste)	0.59	0.35
Pork, loin	40.1	5	Well-milled rice	24.8	0.40
Mackerel	43.0	6	Welsh onion, large type	0.22	0.43
Pork, belly	44.9	7	Tuna, canned	0.69	0.46
Red pepper powder	46.4	8	Pork, loin	2.96	0.49
Mandarin	47.8	9	Black rice	0.69	0.52
Chicken meat	49.2	10	Red pepper powder	1.46	0.54

Vitamin C

Food	Cumulative % Contribution	Rank	Food	Percent contribution	Cumulative R^2
Mandarin	15.1	1	Mandarin	15.1	0.28
Kimchi, Korean cabbage	28.1	2	Persimmon, hard	11.0	0.50
Persimmon, hard	39.2	3	Chinese cabbage	8.45	0.63
Chinese cabbage	47.6	4	Spinach	4.67	0.70
Spinach	52.3	5	Sweet potato	4.28	0.75
Korean radish	56.8	6	Persimmon, soft	2.47	0.78
Sweet potatoes	61.1	7	Kimchi, Korean cabbage	13.0	0.80
Kkak Du Ki (Seasoned cubed radish)	63.7	8	Kumquat	1.42	0.82
Persimmon, soft	66.2	9	Korean radish	4.56	0.83
Dong Chi Mi (Watery radish Kimchi)	68.3	10	Kkak Du Ki (Seasoned cubed radish)	2.58	0.84

was done in autumn, the main contributing fruits were mandarin oranges and persimmons.

When the food items commonly selected by both methods were disposed of, 310 food items remained in

the listing. They were then combined into 98 groups based on the similarity of their nutrient contents. However, alcohol, oils and seasonings such as soy sauce, gochujang and red pepper powder were excluded because it is difficult to estimate the amounts consumed using FFQ methods, even though their consumption frequencies might be very high. After excluding three alcohols because the questionnaire for alcohol was in another section, added were foods such as fruits (peach, strawberry, grapefruit, tomato and watermelon), bracken/sweet potato stalk, coffee sugar and coffee creamer that are obviously consumed often but were missing from the list due to seasonal variations and other reasons. Finally, 103 food items were included in the questionnaire as follows : rice and other cereals (7), noodles and breads (10), vegetables (23), potatoes (3), mushrooms (2), soybean, soybean products and other beans (4), common fish (7), other fish and shellfish (8), meats (9), seaweeds (2), eggs (1), milk and dairy products (5), fruits (12), beverages (5), snacks (3), nuts (1), and fats (1)(see Appendix).

The frequency of servings was arbitrarily classified into nine categories : never or seldom, once a month, 2-3 times a month, 1-2 times a week, 3-4 times a week, 5-6 times a week, once a day, twice a day, or 3 times or more every day. The portion size was determined depending on the median value of each food determined from the 24-hr recall data. The portion size of each food item was classified as follows : 'small', 'medium' or 'large.' The median portion size was determined after the portion sizes taken by the study subjects were ranked, and was designated as 'medium' size. Thus, 'small' size represented one half, and 'large' was one and a half times the median portion size.

Table 6. Percent coverage of 17 nutrients by the FFQ

Nutrients	Coverage (%)	
	KHANES(n=2,714)	Diet record(n=326)
Energy	81.1	86.9
Protein	81.8	90.1
Fat	67.1	83.9
Carbohydrate	87.5	90.9
Fiber	77.7	81.9
Ca	71.4	86.9
Phosphorus	81.4	88.7
Fe	82.2	85.0
Na	65.9	63.9
K	80.0	85.4
Vitamin A	72.4	77.2
Retinol	81.9	92.1
β-carotene	71.7	74.6
Vitamin B_1	84.1	88.4
Vitamin B_2	75.7	87.0
Niacin	79.4	88.9
Vitamin C	86.8	90.5
Average	78.1	84.8

As shown in Table 6, the developed food list covered 84.8% of the intake of 17 nutrients in the dietary record data of the Ansan and Ansung study subjects. Protein, carbohydrate, retinol, and vitamin C accounted for over 90% based on this SQFFQ. But sodium (63.9%), vitamin A (77.2%), and β-carotene (74.6%) were accounted for much less than the average coverage rate. For KHANES data, the average coverage rate was 78.1%, ranging from 65.9% for sodium to 87.5% for carbohydrate. Fat (67.1%) and sodium (65.9%) had the lowest coverage rates.

DISCUSSION

The SQFFQ described herein was developed on the basis of dietary data of a fairly large number of average Koreans for the purpose of assessing the general dietary pattern of middle-aged adults who live in middle-sized cities and rural areas of Korea. An SQFFQ designed on the basis of dietary survey data may have two important built-in functions, i.e., the abilities to rank and to estimate absolute nutrient levels[17]. To do so, we used two methods for selecting food items. With cPC, we could select foods that contributed to the absolute amount of total intake of each nutrient of interest[5], and with cMRC, we were able to find foods that were most 'discriminating'[4]. Based on previous reports that the feature of the three-level portion size could strengthen the correlation with one-day diet records[17] and that it could improve the validity and clarity of the questionnaire[18], we also designed it into our FFQ. However, this type of questionnaire had some weaknesses as well. Our approach was based on the nutrient contributions of food materials but not dishes. An FFQ consisting of food materials may underestimate total nutrient intake when compared to a dish-based FFQ. The reason is that the dish-based FFQ contains the nutrient values of ingredient foods, which the FFQ food-list does not include.

Several other shortcomings originate from KHANES data we used. First, it would be impossible to estimate within-person variations with one-day 24-hr recall data, which is the method KHANES used. The season when the survey was conducted (from November through December) also poses problems. The contributions of several fruits might be overestimated and those of other foods underestimated or totally overlooked. Since the contribution ranking of some nutrients would be quite different from those described in the specific data we used if the survey had been conducted in another season,

we, therefore, needed to add some foods to the list that were obviously among important sources of selected nutrients for Koreans.

Rice, the undisputed staple food of the Korean diet, was the top contributor of several nutrients such as energy, carbohydrate, protein, fat, phosphorus, vitamin B_1, and niacin. It was also the main source for nutrients related to energy metabolism (such as vitamin Bs). Koreans usually consume 2-3 bowls of cooked rice a day. Kimchi was the main source of fiber, calcium, sodium, potassium, vitamin A, β-carotene, vitamin B_1, vitamin B_2, niacin, and vitamin C and is usually served with cooked rice. Garlic ranked high in the list selected by cMRC but not in that by cPC. Garlic is usually served in various seasonings and is one of the ingredients in Kimchi. Therefore, its consumption frequency was very high but the consumption amount was not.

Seasonings including table salt, red pepper powder, soy sauce and soy pastes, and oils could be selected by either procedure, but it was difficult to measure them in a qualitative or quantitative manner because these foods were usually consumed mixed with other main foods. It has previously been described that total nutrient intake, especially of energy, fat, iron and β-carotene, were underestimated when seasonings and oils were not counted in the questionnaire[19]. To minimize this limitation, we devised a complementary questionnaire about seasonings and oils, though it was not designed to quantify the subjects' intake. FFQ developed in Japan have similar problems. As in the case of the Korean diet, seasonings such as Shoyu, the Japanese soy sauce, are important dietary elements and their intake is difficult to measure in FFQ[19], although they account for a small proportion of total dietary intake. The main difference between the Korean and Japanese diets is that seasonings available in a wide variety in Korean dishes, for example, some oils used more often as seasonings than for cooking, are the main sources for both sodium and β -carotene, whereas those in Japanese dishes are the main source of sodium alone.

The coverage rate of selected nutrients by the FFQ was 84.8% overall, ranging from 63.9% for sodium to 92.1% for retinol in the diet record data of Ansan and Ansung, which was lower than Tokudome et al.'s figure (94%)[15]. Because Koreans' dietary patterns are unique, have a great seasonal variation and our data were collected in the winter, vitamin A supplied by yellow green vegetables and fruits had a low coverage rate. The coverage rate for vitamin C, however, was not low, as Koreans' daily requirement of vitamin C was satisfied by Kimchi or soybean sprouts during the winter season. Low coverage rates of fat and sodium were most likely due to the fact that our food list did not include seasonings and oils, which are clearly among the main sources of fat, sodium and β-carotene for Koreans[19].

This study was carried out to develop a semi-quantitative food frequency questionnaire for assessment of the baseline diet in conjoint prospective community-based cohort studies. One of the sites at Ansung represents a typical rural area and the other at Ansan is a medium-sized city. The study cohorts consisted of the general population (age 40 and older but younger than 70) of selected villages in Ansung, or subjects of the same age group randomly selected from the population of Ansan.

The coverage of our dietary record data collected during the winter season was higher than that in the KHANES data collected in the autumn. This indicated that our FFQ was developed quite suitably for Ansan and Ansung conjoint cohort studies. A validation study employing four-season dietary intake and biochemical assays is underway, and is expected to provide measures to amend the shortcomings of our FFQ, which originate from the exclusion of seasonings and oils and from the seasonal dietary variation. One strong point of this particular FFQ is that it was developed based on nationwide dietary data, and therefore, can be used for any dietary or epidemiological surveys planned for assessing the dietary patterns of middle-aged Korean adults in any middle-sized city or rural area in Korea, with only minor modifications.

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■ Appendix ■

List of foods in semi-quantitative food frequency questionnaire

[Rice and other cereals (7items)]
Cooked rice, well milled
Cooked rice with barely
Cooked rice with other cereals
Parched cereal powder
Cereals
Rice cake (plain rod shape)
Other rice cake

[Noodles and breads (10items)]
Ramen
Noodles with soup
Chajangmyon
Buckwheat vermicelli/Buckwheat noodle
Dumpling
Loaf bread
Bread with small red bean
Other breads
Pizza/Fast food
Cakes

[Snacks (3items)]
Snacks
Candy/Chocolate
Coffee sugar

[Fats (1items)]
Butter/Margarine

[Potatoes (3items)]
Potatoes
Sweet potatoes
Starch vermicelli

[Soybean, soybean products and other beans (4items)]
Legumes
Tofu
Stew with soybean pastes
Starch jelly

[Nuts (1items)]
Nuts

[Vegetables (23items)]
Kimchi, Korean cabbage
KKakduki/small radish Kimchi
Kimchi with liquid

Other Kimchi (Green onion/Kodulbbagi/Mustard leaves)
Green pepper
Red pepper leaves
Spinach
Lettuce
Perilla leaf
Leek/Water dropwort
Green yellow vegetables
Radish/Salted radish
Doraji/Deoduck(kinds of white root)
Onion
Cabbages
Cucumber
Bean sprouts
Carrot
Pumpkin gruel/Pumpkin juice
Pumpkin, immature
Vegetable juice
Bracken/Sweet potato stalk
Pickles

[Mushrooms (2items)]
Oyster mushroom
Other mushrooms

[Fruits (12items)]
Persimmon, hard/Persimmon, dried
Citrus fruit
Muskmelon/Melon
Banana
Pear
Apple/Apple juice
Orange/Orange juice
Watermelon
Peach/Plum
Strawberry
Grape/Grape juice
Tomato/Tomato juice

[Meats (9items)]
Dog meat
Chicken/Chicken leg/Chicken wing
Pan roast pork
Pork, belly
Braised pork
Ham/Sausage
Pan roast beef ribs
Thick beef soup/Hard boiled beef ribs
Edible viscera

[Eggs (1items)]
Eggs

[Common Fish (7items)]
Sushi
Hair tail
Eel
Yellow croaker
Alaska pollack
Mackerel/Pacific saury/Spanish mackerel
Dried anchovy

[Other fish and shellfish (8items)]
Cuttlefish/Octopus
Tuna, canned
Fish paste/Crab flavored
Crab
Clam (Small ark shell/Little neck clam/Clam meat)
Oyster
Shrimp
Salt-fermented fish

[Seaweeds (2items)]
Laver, dried
Kelp/Sea mustard

[Milk and dairy products (5items)]
Whole milk
Yogurt
Ice cream
Cheese
Coffee cream

[Beverages (5items)]
Carbonated drinks
Coffee
Green tea
Soybean milk
Other drinks