

Development and validation of a quantitative food frequency questionnaire to assess nutritional status in Korean adults

Youn Ju Na and Seon Heui Lee[§]

Center for Health Promotion, Samsung Medical Center, Kangnamgu, Ilwon-dong 50, Seoul 135-710, Korea

Abstract

This study was performed to evaluate the validity of the food frequency questionnaire (FFQ), which is being used at the Samsung Medical Center. In total, 305 (190 males and 115 females) participants consented and completed the 3-day diet records and FFQ. Age, gender and energy-adjusted and de-attenuated correlations ranged from 0.317 (polyunsaturated fatty acid) to 0.748 (carbohydrate) with a median value of 0.550. The weighted kappa value ranged from 0.18 (vitamin A) to 0.57 (carbohydrate) with a median value of 0.36. More than 75% of the subjects were classified into the same or adjacent quartiles. The FFQ had reasonably good validity compared with that of another study. Therefore, our FFQ is considered a proper method to assess nutrient intake in healthy Korean adults.

Key Words: Validation, daily intakes, Korean healthy adults, diet records, food frequency questionnaire

Introduction

Evaluating the relationship between diet and chronic disease is very important in epidemiological studies. But, it is challenging to precisely measure and quantify the actual dietary intake of Koreans. Typical Korean meals are very different from Western meals. They consist of steam-cooked short-grain rice, soup, and multiple side dishes (banchan). Kimchi is served often, sometimes at every meal. Commonly used ingredients include sesame oil, doenjang (fermented bean paste), soy sauce, salt, garlic, ginger, pepper flakes, and gochujang (fermented red chili paste). Many foods are cooked using oils [1]. A meal is often served family style, and side dishes are shared with multiple individuals. Thus, Koreans may have difficulties determining their consumption frequency and portion size for a specific food item [2].

Several methods are available for measurements such as diet records (DRs), the 24-hr recall method, and the food frequency questionnaire (FFQ). The FFQ is widely used for epidemiological purposes because it is inexpensive and collects dietary information. Selected food items are listed in the FFQ, and the intake frequencies and usual portion sizes are noted. But, data need to be validated for each new questionnaire and for each new population group assessed [3]. Willett *et al.* [4] reported that multiple days of DRs over four seasons may be superior to a FFQ and has been frequently used as a reference method in many validation studies. But, 3-day DRs have been commonly used in practical settings in Korea for validation studies [5-9] and are

an acceptable validation tool [2]. Few Korean studies had been validated when we developed our FFQ validation [10-12]. Our FFQ was developed to investigate the relationship between diet and risk of chronic diseases such as diabetes, cardiovascular disease and cancer in asymptomatic Korean adults. We also wanted to assess the nutritional status and to counsel for correcting bad eating habits of healthy individuals who underwent a screening examination at our health promotion center. The purpose of this study is to evaluate the validity of the FFQ which was developed to assess the nutritional intake.

Subjects and Methods

Subjects

The subjects were recruited from participants at the health promotion center of Samsung Seoul Hospital (Seoul, Korea). We asked 898 participants to compile DRs from May 2010 to December 2010. The participants received written instructions on how to record all foods and beverages consumed on 3-day DRs. In total, 310 patients consented to and completed the 3-day DRs and the FFQ. Five patients, whose mean 3-day energy intake was lower than 1,000 kcal, were excluded. Thus, 305 subjects were enrolled, including 190 males and 115 females.

[§] Corresponding Author: Seon Heui Lee, Tel. 82-2-3410-3889, Fax. 82-2-3410-3839, Email. seonheui.lee@samsung.com

Received: February 17, 2012, Revised: September 20, 2012, Accepted: September 20, 2012

©2012 The Korean Nutrition Society and the Korean Society of Community Nutrition

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/3.0/>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

The food frequency questionnaire

The food items listed in the quantitative FFQ were based on the food records from the Korea Health and Nutrition Examination Survey in 1998 and the modified Block's Health Habit and History Questionnaire [13]. From 1996 to 1998, we used the FFQ, which included 330 food items at our health promotion center [14]. From 1998 to 2000, we used a FFQ with 161 high-frequency food items for adults aged 40 or older at our health promotion center. We excluded 23 low-frequency food items. Our foods list included 138 items (Table 1). The food items included rice (6), breads and cereals (5), potatoes (4), noodles (9), soups and stews (5), kimchi (6), meat and eggs (14), fish and shellfish (16), soybean products (3), vegetables (22), mushrooms and seaweed (3), fruit (18), milk, and dairy products (7), beverages (3), sweets and snacks (7), oils and nuts (5), and alcoholic beverages (5). Questionnaire items were arrayed in the order of breakfast, lunch, dinner, and snacks. Our FFQ consisted of 109-food based questions and 29-dish based questions. The frequency of servings was classified into nine categories. The FFQ included never, less than once per month, 2-3 times per month, 1-2 times per week, 3-4 times per week, 5-6 times per week, once per day, twice per day and three times per day. The portion size was referenced from sixth recommended dietary allowances for Koreans [15], household measures of commonly used food items [16], and a food exchange table for Korean diabetes [17]. The portion size of each food item was classified as follows: cereal and cereal products for the three meals were classified into seven steps (range, 0.3-2 times), whereas others

were classified into six steps (range, 0.5-4 times). The participants recorded the FFQ during a personal interview. The FFQ was automatically calculated using a computer program (Samsung Medical Information Systems). The database was based on the food composition table of the Korean Nutrition Society program Can-pro 3.0 (Nutritional Assessment Program 2008 Korean Nutrition Society, Seoul, Korea).

Three-day diet records

Participants were asked to keep non-consecutive 3-day DRs (two weekdays and one weekend day or a holiday). Before the health examination, the participants received written instructions on how to record all foods and beverages consumed in 3-day DRs. The food record format allowed entry of foods and fluids. All food items, preparation methods, recipes, quantity, and portion sizes were recorded, as well as industrialized products. Intake was calculated with Can-pro 3.0.

Interview

On the day of the health examination, participants recorded on the FFQ as trained dietitians individually interviewed participants about their exact portion size using measuring cups and three-dimensional food models. The participants confirmed the portion size of the 3-day DRs using the three-dimensional food models. Dietitians checked the written diet record in a standardized way. It took 15 minute. Dietitians had a minimum 2 years experience with nutritional interviews.

Table 1. Food groups and items in the Food Frequency Questionnaire

Food group	Food items
Rice	Rice, rice with soybean, rice with mixed grain, rice cakes, Kimbab*
Bread, cereals	Bread/toast, barley powder, cereal, pizza, hamburger
Potato	Potato, fried potato, sweet potato, corn
Noodles and dumpling	Korean noodle*, Korean instant noodle (Ramyeon)*, black bean paste noodles*, Korean-style pasta soup (Naengmyeon)*, Udong*, wheat flakes soup (Sujebi)*, Mandukuk*, dumpling (Mandu)*, spaghetti, Tokkuk
Soup, stew	Soybean paste stew*, Kimchi stew*, Tofu stew*, soybean paste soup*, soup containing vegetable*
Kimchi	Kimchi (cabbage), Kimchi (cubed radish roots), Kimchi (radish leaves), Kimchi (Dongchimi), Kimchi (cucumber), Kimchi (Nabak)
Meat and its products	Beef, rib, pork, pork belly, ham (sausage), chicken (fried, stirfried, grilled), duck meat, beef soup*, chicken soup*
Fish	Raw fish (sushi), yellow croaker, anchovy, pacific saury, eel, loach soup*, fish paste, salt-fermented fish
Shellfish	Squid, octopus, clams, oysters, shrimp, crab, sea cucumber, sea squirt
Egg	Egg, egg white
Soybean	Soybean curd, soybean, soybean milk
Vegetable	Lettuce, cabbage, green pepper, garlic, welsh onion (green onion), onion, leek, carrot, perilla leaf*, kale, soybean sprout*, pumpkin*, cucumber*, radish*, spinach*, young leaves of a kind of aster*, broccoli, Chinese bellflower*, bracken*, egg plant*, water dropwort*
Mushrooms and seaweeds	Mushrooms, brown seaweed*, Laver
Fruit	Apple, pear, persimmon, citrus fruit, mandarin, orange, tomato, strawberry, peach, watermelon, musk melon, melon, grapes, plum, apricots, banana, kiwi, pineapple, fruit juice
Milk	Whole milk, low fat milk, skim milk, coffee milk, yogurt, cheese, ice cream
beverage	Coffee, green tea, cola, soda
Sweet	Sugar, candy (chocolate), honey, sweet biscuit, cake
Oil and nuts	Oil, butter, margarine, cream powder, peanuts (pine nuts, walnuts)
Alcoholic beverage	Soju (distilled liquor), beer, whiskey, Makgeolli (traditionally unrefined rice wine, Sake), wine

* Dish based

Statistical analysis

We calculated that the relevant sample size was over 246 using nQuery Advisor 4.0 ® (Statistical Solutions, Cork, Ireland). The mean nutrient intakes from the DRs were compared with the FFQ using Wilcoxon's signed-rank test. Data were analyzed after log-transformation to improve the normality of the nutrient intake distribution. Adjusted Pearson's correlations were used to identify the relationship between the FFQ and DR nutrient intakes. To correct for within person daily variability in the DR measurements, the observed correlation was multiplied by a de-attenuation factor $(1 + \bar{v}/n)^{1/2}$, where \bar{v} is the ratio of the within and between person variances [18]. The weighted kappa (κ) statistic was estimated. Throughout this study, we considered a correlation efficient greater than 0.4 as meaningfully acceptable. The statistical analysis was performed using SAS software (SAS Institute, Cary, NC, USA). A *P*-value of less than 0.05 was considered significant.

Results

Table 2 shows the general characteristics of the study subjects. The mean age was 54.05 ± 7.13 years, and the body mass index was 23.82 ± 0.16 . Drinkers comprised 65.79% of the total subjects, and smokers comprised 25.57% of all participants.

Table 3 shows the average nutrient intakes by the FFQ and 3-day DRs. The mean nutrients on the FFQ (energy, protein, carbohydrate, fiber, zinc, vitamin B₂) were not different from those of the 3-day DRs. Nutrient (fat, iron, sodium, vitamin A, β -carotene, vitamin B₁, vitamin E, cholesterol, polyunsaturated fatty acid) intakes on the 3-day DRs were higher than those of the FFQ.

Table 4 shows the results of crude, energy-adjusted, de-attenuated, and all-adjusted Pearson's correlation coefficients for the FFQ and 3-day DRs. The crude Pearson's correlation coefficients for nutrients ranged from 0.279 (polyunsaturated fatty acid) to 0.760 (carbohydrate) with a median of 0.501. The de-attenuated correlation coefficients ranged from 0.401 (vitamin A) to 0.877 (energy), with a median value of 0.668. Energy adjusted and de-attenuated correlation coefficients ranged from 0.323

(polyunsaturated fatty acid) to 0.835 (alcohol) with a median value of 0.571. Age, gender, energy-adjusted, and de-attenuated correlation coefficients ranged from 0.317 (polyunsaturated fatty acid) to 0.748 (carbohydrate) with a median value of 0.550. All adjusted Pearson's correlation coefficients except those for iron, zinc, vitamin A, and polyunsaturated fatty acid were greater than 0.4, indicating a good correlation.

Table 5 shows the result of quartiles for two nutrients to examine whether their levels were in agreement, and the results were analyzed by kappa statistics. The average proportions of classification into the same quartiles, adjacent quartiles, and distant quartiles between the 3-day DRs and the FFQ were 49.35%, 28.57%, and 9.09%, respectively. More than 75% of the subjects were classified into the same or adjacent quartiles. Simple kappa values ranged from 0.06 (vitamin A) to 0.43 (carbohydrate). The weighted kappa values ranged from 0.18 (vitamin A) to 0.57 (carbohydrate). Good agreements (weighted kappa value ≥ 0.4) were noted for energy, alcohol, carbohydrate, protein, fiber, phosphorus, iron, sodium, potassium, and vitamin C.

Table 3. Comparison of mean of the nutrient using 3-day diet records and the food frequency questionnaire

	Mean of 3DR	Mean of FFQ	<i>P</i> -value ¹⁾
Energy (kcal)	1888.70 \pm 395.91 ²⁾	1913.93 \pm 492.02	0.76
Alcohol (g) ³⁾	17.35 \pm 27.61	27.31 \pm 32.49	0.04
Protein (g)	79.51 \pm 20.12	79.74 \pm 20.90	0.94
Fat (g)	49.63 \pm 17.59	45.32 \pm 16.89	< 0.001
Carbohydrate (g)	265.14 \pm 56.70	261.07 \pm 59.44	0.15
Fiber (g)	24.58 \pm 7.13	24.98 \pm 7.44	0.67
Ca (mg)	624.78 \pm 190.69	757.43 \pm 273.17	< 0.001
P (mg)	1133.12 \pm 270.71	1215.10 \pm 301.32	< 0.001
Fe (mg)	14.99 \pm 3.98	13.53 \pm 3.49	< 0.001
Zn (mg)	10.50 \pm 5.94	9.44 \pm 2.37	0.34
Na (mg)	4556.52 \pm 1431.29	3642.17 \pm 1388.25	< 0.001
K (mg)	3190.01 \pm 806.72	3361.02 \pm 895.30	< 0.001
Vit A (μ g RE)	966.97 \pm 688.43	758.05 \pm 398.57	< 0.001
Retinol (μ g)	124.46 \pm 120.69	140.58 \pm 106.17	< 0.001
β -carotene (μ g)	4705.80 \pm 4059.03	3500.54 \pm 2255.36	< 0.001
Vit B ₁ (mg)	1.27 \pm 0.40	1.16 \pm 0.41	< 0.001
Vit B ₂ (mg)	1.286 \pm 0.36	1.30 \pm 0.40	0.72
Vit B ₆ (mg)	2.33 \pm 0.64	2.44 \pm 0.73	0.01
Niacin (mg)	18.04 \pm 5.57	19.66 \pm 5.61	< 0.001
Vit C (mg)	128.49 \pm 65.05	143.83 \pm 81.56	< 0.001
Folate (μ g)	297.39 \pm 103.80	343.00 \pm 139.62	< 0.001
Vit E (mg)	14.35 \pm 5.01	11.51 \pm 4.03	< 0.001
Cholesterol (mg)	298.77 \pm 134.32	235.66 \pm 108.81	< 0.001
TFA (g)	24.91 \pm 13.53	27.89 \pm 13.58	< 0.001
SFA (g)	7.72 \pm 5.33	9.37 \pm 5.44	< 0.001
MUFA (g)	9.46 \pm 6.10	11.18 \pm 5.90	< 0.001
PUFA (g)	7.73 \pm 3.47	7.34 \pm 2.92	0.04

3DR, 3 day diet records; FFQ, food-frequency questionnaire; Vit, Vitamin; TFA, Total fatty acid; SFA, Saturated fatty acid; MUFA, Monounsaturated fatty acid; PUFA, Polyunsaturated fatty acid

¹⁾ Wilcoxon Signed Rank Test for nutrient intake between the 3DR and FFQ

²⁾ Mean \pm SD

³⁾ n = 200

Table 2. Characteristics of the study subjects

	Male	Female	Total
Number	190	115	305
Age (yrs)	53.74 \pm 0.50 ¹⁾	54.59 \pm 0.69	54.05 \pm 7.13
(range 38-78)			
Height (cm)	170.58 \pm 0.42	157.85 \pm 0.50	165.78 \pm 8.37
Weight (kg)	71.37 \pm 0.64	56.59 \pm 0.73	65.80 \pm 0.63
BMI (kg/m ²)	24.50 \pm 0.18	22.70 \pm 0.26	23.82 \pm 0.16
(range 17.33-36.26)			
Drinker (%)	153(80.53) ²⁾	47(40.87)	200(65.79)
Smoker (%)	73(23.93)	5(1.64)	78(25.57)

¹⁾ Mean \pm SD

²⁾ Number(column percentage, %)

Table 4. Correlation coefficients between 3-day diet records and the food frequency questionnaire

	Crude correlation	De-attenuated correlation	Energy adjusted correlation	Energy adjusted and de-attenuated correlation	Age, sex, energy adjusted and de-attenuated correlation
Energy (kcal)	0.720	0.877			
Alcohol (g)	0.686	0.875	0.654	0.835	0.737
Protein (g)	0.580	0.726	0.410	0.514	0.526
Fat (g)	0.453	0.636	0.405	0.569	0.579
Carbohydrate (g)	0.760	0.866	0.675	0.769	0.748
Fiber (g)	0.570	0.668	0.548	0.642	0.597
Ca (mg)	0.501	0.638	0.474	0.604	0.565
P (mg)	0.621	0.754	0.523	0.635	0.611
Fe (mg)	0.450	0.511	0.313	0.356	0.339
Zn (mg)	0.386	0.548	0.276	0.392	0.367
Na (mg)	0.598	0.703	0.510	0.600	0.608
K (mg)	0.678	0.784	0.656	0.762	0.737
Vit A (μ g RE)	0.308	0.401	0.291	0.379	0.377
Retinol (μ g)	0.375	0.697	0.349	0.648	0.648
β -carotene (μ g)	0.340	0.439	0.340	0.438	0.441
Vit B ₁ (mg)	0.506	0.643	0.479	0.608	0.560
Vit B ₂ (mg)	0.505	0.643	0.436	0.556	0.538
Vit B ₆ (mg)	0.532	0.682	0.369	0.473	0.471
Niacin (mg)	0.570	0.738	0.393	0.508	0.503
Vit C (mg)	0.618	0.720	0.617	0.719	0.691
Folate (μ g)	0.494	0.590	0.481	0.573	0.541
Vit E (mg)	0.337	0.474	0.343	0.482	0.435
Cholesterol (mg)	0.482	0.730	0.431	0.652	0.654
TFA (g)	0.321	0.562	0.246	0.430	0.426
SFA (g)	0.402	0.683	0.370	0.629	0.625
MUFA (g)	0.311	0.609	0.229	0.449	0.439
PUFA (g)	0.279	0.411	0.220	0.323	0.317
Median	0.501	0.668	0.408	0.571	0.550

TFA, Total fatty acid; SFA, Saturated fatty acid; MUFA, Monounsaturated fatty acid; PUFA, Polyunsaturated fatty acid

Discussion

Our FFQ was developed to assess personal nutritional status and food intake habits in participants at a health promotional center. Previous Korean studies have used 3-day DRs rather than the 24-hour recall method [5-7,9]. In this study, we evaluated the relative validity of this FFQ using 3-day DRs. Our study recruited 305 participants, which satisfied the relevant sample size. Our study had a larger sample size than that of previous studies [6,19,20]. Statistical methods such as energy-adjusted and de-attenuated correlation coefficients [6,19], and kappa values [5,7] were also used in previous studies. Correlations are the most applied statistical procedures, and they should be adjusted for different variables, particularly energy, age, and gender. De-attenuating the correlation is critical to reduce its dependency on between-person variation [21]. From our data, de-attenuation to correct for intra-individual variability improved the median value (0.501-0.668). According to Willett [22], adjusting for energy increases the correlation coefficients when the variability in nutrient consumption is related to energy intake. However, correlation coefficients decrease when the variability in nutrient

consumption depends on systematic errors of overestimation and underestimation. In our data, energy adjusting to correct for intra-individual variability did not improve the median value (0.501-0.408). Energy adjustment and de-attenuating the correlation are critical statistical methods used in dietary intake validation studies [21]. From our data, energy adjusting and de-attenuation to correct for intra-individual variability improved the median value (0.501-0.571).

The Japanese diet is similar to that of Koreans, and a review of Japanese studies showed that the median value of correlation coefficients between DRs and FFQs ranged from 0.31 to 0.56. Relatively poor validity was found in FFQ estimates for consumption of sodium, niacin, and polyunsaturated fatty acid [23]. From a Chinese report, correlation coefficients ranged from 0.38 to 0.64 for macronutrients, 0.33 to 0.58 for micronutrients, and 0.35 to 0.72 for food groups [24]. In Western studies, correlations ranged from 0.40 to 0.60 (median, 0.53) [25], from 0.25 (fiber) to 0.90 (alcohol) [26], and from 0.55 to 0.85 [27].

Several Korean validation studies have been conducted [5-9, 11,12,19,28-31]. Kim *et al.* [31] reported on the validation of a FFQ for Korean-Americans. After the correlations were energy-

Table 5. Kappa value between 3-day diet records and the food frequency questionnaire

Nutrients	Percent agreement			Kappa	Weighted Kappa
	same quartile	Adjacent quartile	Distant quartile		
Energy (kcal)	63.64	24.68	2.60	0.36	0.52 (0.46-0.60)
Alcohol (g)	60.71	28.57	0.00	0.29	0.40 (0.31-0.49)
Protein (g)	68.83	22.08	0.00	0.27	0.40 (0.33-0.48)
Fat (g)	54.55	23.38	9.09	0.18	0.31 (0.24-0.39)
Carbohydrate (g)	40.26	31.17	9.09	0.43	0.57 (0.50-0.63)
Fiber (g)	55.84	20.78	6.49	0.24	0.41 (0.33-0.48)
Ca (mg)	55.84	27.27	10.39	0.22	0.35 (0.27-0.43)
P (mg)	51.95	31.17	2.60	0.23	0.41 (0.34-0.48)
Fe (mg)	49.35	28.57	10.39	0.26	0.40 (0.32-0.47)
Zn (mg)	48.05	24.68	3.90	0.16	0.29 (0.21-0.37)
Na (mg)	54.55	27.27	5.19	0.26	0.42 (0.34-0.49)
K (mg)	61.04	20.78	5.19	0.31	0.48 (0.41-0.55)
Vit A (μ g RE)	36.36	28.57	11.69	0.06	0.18 (0.10-0.26)
Retinol (μ g)	41.56	29.87	12.99	0.12	0.23 (0.15-0.31)
β -carotene (μ g)	42.86	20.78	11.69	0.17	0.25 (0.16-0.33)
Vit B ₁ (mg)	48.05	32.47	6.49	0.21	0.36 (0.28-0.44)
Vit B ₂ (mg)	50.65	28.57	10.39	0.24	0.37 (0.30-0.45)
Vit B ₆ (mg)	49.35	28.57	7.79	0.21	0.36 (0.28-0.44)
Niacin (mg)	49.35	24.68	11.69	0.27	0.39 (0.31-0.47)
Vit C (mg)	61.04	18.18	6.49	0.29	0.46 (0.39-0.53)
Folate (μ g)	57.14	29.87	6.49	0.21	0.33 (0.26-0.41)
Vit E (mg)	37.66	33.77	11.69	0.19	0.28 (0.20-0.36)
Cholesterol (mg)	48.05	29.87	6.49	0.17	0.33 (0.26-0.41)
TFA (g)	40.26	29.87	10.39	0.16	0.26 (0.18-0.34)
SFA (g)	38.96	27.27	14.29	0.22	0.30 (0.22-0.38)
MUFA (g)	37.66	28.57	16.88	0.17	0.27 (0.19-0.35)
PUFA (g)	41.56	24.68	12.99	0.11	0.19 (0.10-0.27)
Median	49.35	28.57	9.09	0.215	0.36

TFA, Total fatty acid; SFA, Saturated fatty acid; MUFA, Monounsaturated fatty acid; PUFA, Polyunsaturated fatty acid

adjusted and de-attenuated, they ranged from 0.45 (carbohydrate) to 0.84 (potassium) [31]. Ahn *et al.* [19] reported that FFQ correlation coefficients ranged from 0.23 (vitamin A) to 0.64 (carbohydrate) with a median for nutrients of 0.39 after adjusting for energy and de-attenuation. Sodium was not mentioned.

In this study, the median exact agreement was 49.35% and the average exact agreement was 49.81% and more than 75% of the subjects were classified into the same or adjacent quartiles. Other studies in Korea that compared 3-day DRs or 24-hr recall and FFQs presented median or average agreements that were lower than those in our study [6,19,32].

Previous Korean studies had several features. Participants had difficulties remembering events over the course of a full year [2,20] and might have trouble remembering consumption frequency or the amount of food consumed in a year [20]. Additionally, participants might overestimate food intake, in part, because the answers were taken as multiple choices of frequencies at discrete intervals [6]. Intakes of energy and carbohydrate in FFQ are significantly higher than those in DRs [5,8,9,19]. Ahn *et al.* [19] and Bae *et al.* [6] reported that carbohydrate consumption may be overestimated in FFQ because rice is the

staple food of Korean; grains and noodles are also included as food items. Furthermore, Koreans may have low perception of portion size and have difficulties answering about the consumption frequency of a specific item, particularly in unprepared dishes [19]. Participants confound real portion size and color photographs of median-sized food portions.

In our study, we checked the FFQ within 3 months or a season so that participants could easily remember events. Comparing the two methods, energy and carbohydrate intake were not different in our study (Table 3). It is possible that a questionnaire of food items about grain and noodles was easy to answer as they were arrayed in the order of meals. Portion size was subdivided the six or seven sections, and trained dietitians checked the actual portion size using three-dimensional food models in a personal interview.

Intakes of nutrients from seasonings and cooking oils have been underestimated in a food-based FFQ [33]. A dish based FFQ could have advantages over a food-based FFQ, which has been developed and validated in Korea [34]. A dish based FFQ includes ingredients such as seasonings, spices, and cooking oils. Seasonings are a major contributor to sodium intake, as cooking

oils are to polyunsaturated fatty acid intake [35]. This type of analysis would allow for a more accurate estimate of antioxidant vitamins, phytochemicals, and fatty acids [34]. Excluding seasonings and oils to assess nutrient intake underestimates total energy, vegetable fat, vitamin E, and sodium intake. We must be cautious about the interpreting studies that do not include seasonings and oils [33]. Our FFQ reflected seasonings and cooking oils by conducting a more dish-based questionnaire. For example, food-based questions were calculated to include only bean sprouts, whereas the dish-based questionnaire was calculated to include bean sprouts with seasonings and oils.

Checking the calories of alcoholic beverages may influence energy intake. Some individuals drink no alcohol, whereas others consume large amounts [23]. Thus, we added alcoholic beverages to the FFQ. Validation studies for alcoholic beverages are rare in Korea [12], but in the foreign countries, checking alcoholic beverages is common [23,27,36,37]. Other Korean studies did not mention alcoholic beverages [5,6,9,11,19,28,29]. According to our study, the rate of alcoholic beverages intake was 80.53% in men and 40.87% in women. Thus, including alcoholic beverage on the FFQ was helpful for checking calories.

Our FFQ had some limitations. First, all subjects were recruited from a health promotion center for a medical check-up. Less than 80% of the subjects resided within a big city; thus, subjects were more concerned about their health and nutritional status. Second, seasonal variability was not reflected in this study. Third, biomarkers were not introduced to validate food intake measurements. Fourth, the reproducibility of the FFQ was not checked.

In conclusion, our FFQ had special characteristics. All adjusted Pearson's correlation coefficients between the FFQ and the 3-day DRs ranged from 0.317 to 0.748 (median for all nutrients, 0.550). All nutrients were mentioned and alcohol and fatty acid were added. Energy and carbohydrate of the FFQ were not different from those of the 3-day DRs. Previously known poorly validated nutrients such as fat, sodium, cholesterol, niacin, and saturated fatty acid are more meaningful when compared to those of other Korean studies. This FFQ may be a useful tool for assessing nutritional status, investigating the relationship diet and risk of chronic disease and correcting for the bad eating habits in healthy Korean adults.

References

1. Wikipedia [Internet]. Korea cuisine. 2012 [cited 2012 jun 26]. Available from: http://en.wikipedia.org/wiki/Korean_cuisine.
2. Yang YJ, Kim MK, Hwang SH, Ahn Y, Shim JE, Kim DH. Relative validities of 3-day food records and the food frequency questionnaire. *Nutr Res Pract* 2010;4:142-8.
3. Patterson RE. *Methods and Tools for Dietary Intake Assessment in Individuals vs. Groups*. Boca Raton, Florida: CRC Press; 2002. p.523-8.
4. Willett WC, Sampson L, Stampfer MJ, Rosner B, Bain C, Witschi J, Hennekens CH, Speizer FE. Reproducibility and validity of a semiquantitative food frequency questionnaire. *Am J Epidemiol* 1985;122:51-65.
5. Hong S, Choi Y, Lee HJ, Kim SH, Oe Y, Lee SY, Nam M, Kim YS. Development and validation of a semi-quantitative food frequency questionnaire to assess diets of Korean type 2 diabetic patients. *Korean Diabetes J* 2010;34:32-9.
6. Bae YJ, Choi HY, Sung MK, Kim MK, Choi MK. Validity and reproducibility of a food frequency questionnaire to assess dietary nutrients for prevention and management of metabolic syndrome in Korea. *Nutr Res Pract* 2010;4:121-7.
7. Yim KS, Lee TY, Park HS. The development and validation of a food frequency questionnaire to assess diets of Korean adolescents. *Korean J Community Nutr* 2003;8:149-59.
8. Ji SK, Kim HS, Choi HM. A study on development and validation of food frequency questionnaire for estimating energy intake of women in child-bearing age. *Korean J Community Nutr* 2008;13:111-24.
9. Ahn Y, Lee JE, Cho NH, Shin C, Park C, Oh BS, Kimm K. Validation and calibration of semi-quantitative food frequency questionnaire: with participants of the Korean Health and Genome Study. *Korean J Community Nutr* 2004;9:173-82.
10. Lim Y, Oh SY. Development of a semi-quantitative food frequency questionnaire for pre-school children in Korea. *Korean J Community Nutr* 2002;7:58-66.
11. Lee HJ, Park SJ, Kim JH, Kim CI, Chang KJ, Yim KS, Kim KW, Choi HM. Development and validation of a computerized semi-quantitative food frequency questionnaire program for evaluating the nutritional status of the Korean elderly. *Korean J Community Nutr* 2002;7:277-85.
12. Won HS, Kim WY. Development and validation of a semi-quantitative food frequency questionnaire to evaluate nutritional status of Korean elderly. *Korean J Nutr* 2000;33:314-23.
13. Block G, Coyle LM, Hartman AM, Scoppa SM. Revision of dietary analysis software for the Health Habits and History Questionnaire. *Am J Epidemiol* 1994;139:1190-6.
14. Ok KJ. *Computerized Nutrient Data Base System and the Development of a Nutritional Analysis Software Program for Koreans*. Seoul: Ministry of Health and Welfare; 1998.
15. Korean Nutrition Society. *Recommended Dietary Allowances for Koreans*, 6th revision. Seoul; 1995.
16. Korea Food Industry Association. *Household Measures of Common Used Food Items*. Seoul; 1998.
17. Korean Diabetes Association. *Dietary Food Exchange*, 2nd edition. Seoul; 1995.
18. Rosner B, Willett WC. Interval estimates for correlation coefficients corrected for within-person variation: implications for study design and hypothesis testing. *Am J Epidemiol* 1988;127:377-86.
19. Ahn Y, Kwon E, Shim JE, Park MK, Joo Y, Kimm K, Park C, Kim DH. Validation and reproducibility of food frequency questionnaire for Korean genome epidemiologic study. *Eur J Clin Nutr* 2007;61:1435-41.
20. Song NY, Park MK, Paik HY, Joung H, Kim JS, Park SH. Comparison of frequency and amount of dishes reported in semi-quantitative dish-based frequency questionnaire vs. 12-day dietary records. *Korean J Nutr* 2010;43:638-52.
21. Xia W, Sun C, Zhang L, Zhang X, Wang J, Wang H, Wu L. Reproducibility and relative validity of a food frequency questionnaire developed for female adolescents in Suihua, North China. *PLoS One* 2011;6:e19656.
22. Willett W. *Nutritional Epidemiology*, 2nd edition. New York:

- Oxford University Press; 1998.
23. Wakai K. A review of food frequency questionnaires developed and validated in Japan. *J Epidemiol* 2009;19:1-11.
 24. Villegas R, Yang G, Liu D, Xiang YB, Cai H, Zheng W, Shu XO. Validity and reproducibility of the food-frequency questionnaire used in the Shanghai men's health study. *Br J Nutr* 2007;97:993-1000.
 25. Van Dongen MC, Lentjes MA, Wijckmans NE, Dirckx C, Lemaître D, Achten W, Celis M, Sieri S, Arnout J, Buntinx F, Siani A, Cappuccio FP, de Lorgeril M, Iacoviello L, Dagnelie PC; European Collaborative Group of the IMMIDIET Project. Validation of a food-frequency questionnaire for Flemish and Italian-native subjects in Belgium: The IMMIDIET study. *Nutrition* 2011;27:302-9.
 26. Deschamps V, de Lauzon-Guillain B, Lafay L, Borys JM, Charles MA, Romon M. Reproducibility and relative validity of a food-frequency questionnaire among French adults and adolescents. *Eur J Clin Nutr* 2009;63:282-91.
 27. Horn-Ross PL, Lee VS, Collins CN, Stewart SL, Canchola AJ, Lee MM, Reynolds P, Clarke CA, Bernstein L, Stram DO. Dietary assessment in the California Teachers Study: reproducibility and validity. *Cancer Causes Control* 2008;19:595-603.
 28. Shim JS, Oh KW, Suh I, Kim MY, Sohn CY, Lee EJ, Nam CM. A study on validity of a semi-quantitative food frequency questionnaire for Korean adults. *Korean J Community Nutr* 2002;7:484-94.
 29. Lee HJ, Lee HS, Ha MJ, Kye SH, Kim CI, Lee CW, Yoon JS. The development and evaluation of a simple semi-quantitative food frequency questionnaire to assess the dietary intake of adults in large cities. *Korean J Community Nutr* 1997;2:349-65.
 30. Kim J, Kim Y, Ahn YO, Paik HY, Ahn Y, Tokudome Y, Hamajima N, Inoue M, Tajima K. Development of a food frequency questionnaire in Koreans. *Asia Pac J Clin Nutr* 2003;12:243-50.
 31. Kim J, Chan MM, Shore RE. Development and validation of a food frequency questionnaire for Korean Americans. *Int J Food Sci Nutr* 2002;53:129-42.
 32. Kim SH, Choi HN, Hwang JY, Chang N, Kim WY, Chung HW, Yang YJ. Development and evaluation of a food frequency questionnaire for Vietnamese female immigrants in Korea: the Korean Genome and Epidemiology Study (KoGES). *Nutr Res Pract* 2011;5:260-5.
 33. Yun SH, Choi BY, Kim MK. The effect of seasoning on the distribution of nutrient intakes by a food-frequency questionnaire in a rural area. *Korean J Nutr* 2009;42:246-55.
 34. Kim YO, Kim MK, Lee SA, Yoon YM, Sasaki S. A study testing the usefulness of a dish-based food-frequency questionnaire developed for epidemiological studies in Korea. *Br J Nutr* 2009;101:1218-27.
 35. Imaeda N, Tokudome Y, Ikeda M, Kitagawa I, Fujiwara N, Tokudome S. Foods contributing to absolute intake and variance in intake of selected vitamins, minerals and dietary fiber in middle-aged Japanese. *J Nutr Sci Vitaminol (Tokyo)* 1999;45:519-32.
 36. Barrett JS, Gibson PR. Development and validation of a comprehensive semi-quantitative food frequency questionnaire that includes FODMAP intake and glycemic index. *J Am Diet Assoc* 2010;110:1469-76.
 37. Kesse-Guyot E, Castetbon K, Touvier M, Hercberg S, Galan P. Relative validity and reproducibility of a food frequency questionnaire designed for French adults. *Ann Nutr Metab* 2010;57:153-62.