Original Article

Development of a food frequency questionnaire in Koreans

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We describe the development of a data-based food frequency questionnaire (FFQ) to determine the relationship between dietary intakes and diseases among Koreans. A total of 224 individuals were recruited to participate in a three-day dietary record survey. In all, 596 food items were consumed. The intakes of 20 nutrients including energy, protein, fat, carbohydrate, vitamins, minerals, and crude fibre were calculated for each food item by multiplying the weight of food consumed by its nutrient content. Some foods, consumed less than five times in a total of three days, were deleted from the preliminary food item list. The number of foods accounting for up to 90 cumulative percentage contribution to nutrient intake was 314. One hundred and seventy seven foods that accounted for up to 0.90 cumulative multiple regression coefficients and 90 cumulative percentage contribution were then selected. By grouping foods, 94 food items were finally included in the questionnaire: Grains and their products (15 food items), potatoes and starch (4), seeds (1), soybean, soybean products and other beans (4), vegetables (22), mushrooms (2), fruits (13), meats (7), eggs (1), fish (7), shellfish (4), other fish (2), seaweed (2), milk and dairy products (4), and beverages (6). Intake frequencies were classified into eight categories. Portion size was determined from food consumption reports in the three-day records. The mean percentage coverage of the 20 nutrient intakes by the developed FFQ was 82.4%. This questionnaire may be useful for ranking diet-related risk factors in Koreans.

Key Words: food frequency questionnaire, FFQ, dietary intake methodology, dietary assessment, dietary records, Koreans

Introduction

Since the intake of nutrients is usually the product of foods and food compounds in the diet, it is necessary to investigate the effect of major contributing foods upon the intakes of specific nutrients when examining the nutrient status of individuals and groups.[1] In dietary studies, it is interesting to note that the nutrient intakes of individuals can be characterized by estimating absolute values as well as by ranking nutrient intakes within a group. To assess an individual's usual intake and to categorize this within a group, an efficient and a precise dietary instrument is needed. We generally use information on foods to determine absolute nutrient intakes and foods contributing to the between-person variances of a given nutrient.[2] Food frequency questionnaires (FFQs) are used to determine habitual dietary intake. FFQs reduce the burden on both respondents and researchers and are less expensive than food records or dietary recalls.[1,3] FFQs are very useful for ranking individuals into broad food or nutrient intake categories, such as, low, medium, and high, based on tertiles, for example. The data from FFQs have often been used in large-scale epidemiological studies to identify relationships between diet and health.

In the development of a FFQ, the selection of food items depends not only on the purpose of the research but

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also on the kinds of nutrients under study.[4] When choosing a list of foods, usually two statistical methods are involved; one is implemented on the basis of contribution analysis (CA) and the other on the basis of multiple regression analysis (MRA). The former approach is used to estimate the absolute intake of nutrients for an individual, whilst the latter is used to determine between-person variations of nutrient intakes by identifying his or her relative rank, which may be more useful when performing comparisons within a popu-lation.[5]

Some reports[6-8] are available of FFQs in Koreans, however, none of these have involved the statistical methods of CA and MRA in Koreans. In addition, little data were included on the FFQ food item lists that reflected usual dietary intake. This present study was undertaken to develop an FFQ based on a three-day dietary record using CA and MRA. It is hoped that the results of this study will help determine those factors that affect the food intake of Koreans and enable the construction of an accurate food list.

Methods

Study subjects

Before the survey was implemented, this study was reviewed and approved by the Human Subjects Committee of Seoul National University Hospital. To ensure that subjects represented the general structure of the Korean population aged 30 years and over,[9] they were stratified by age and gender. The participants residing in and near Seoul were recruited among parents or relatives of graduate students majoring in nutrition and dietetics. A total of 224 study subjects were surveyed during September – October, 2000.

Dietary records

The survey was conducted to determine the foods commonly consumed. Three-day dietary records were obtained from each respondent. Specifically, each respondent was asked to record all foods and beverages, including a description of portion sizes, which were consumed over three days (two weekdays and one weekend day), as presented on a three-day dietary record form.

Selection of foods

Nutrient compositions for dishes and foods were obtained from the Food Composition Table.[10] The nutrient intakes from the three-day dietary records were calculated using DS 24,[11] a computer software program. Descriptive statistics, contribution analysis (CA), and multiple regression analysis (MRA) were calculated for all relevant data using the Statistical Analysis System.[12] The VARCOMP procedure was applied for variance components using the MIVQUE method.[13] The distribution of the average individual nutrient intakes was tested for each nutrient, for normality using the UNIVARIATE procedure.[14]

In total, 596 foods were consumed by the study subjects. Initially, CA was then performed upon nutrients of interest. The percentage contribution of nutrient k by food I was defined as the arithmetic mean of the individual percentage contribution of nutrient k by food (IPC_{jik}), which was estimated by the following procedure:

Percentage contribution of nutrient k by food I

$$I = \frac{IPC_{jik}}{Number\ \ of\ \ Days\,(672\,)}$$

$$IPC_{jik} = (Q_{ji} / \sum_{i=1}^{596} Q_{ji} D_{ik}) \times 100$$

$$(\text{ if } \sum_{i=1}^{596} Q_{ji} D_{ik} = 0 \ \ then\ \ IPC_j\ \ was\ \ assumed\,)$$

j = 1, …, 672 days, i = 1, …, 596 foods, k = 1, …, 20 nutrient factors,
Q = grams of foods consumed, D = nutrient content per gram of food

Those food items, which were consumed less than five times in a total of three days, were deleted from the preliminary food item list. MRA was then applied by adopting the total intake of a specific nutrient as the dependent variable and the overall amounts of nutrient from 314 food items as the independent variables for the 224 individuals. The regression model arrived at by stepwise multiple regression analysis was as follows:

$$Y_i = \beta_0 + \beta_1 X_{il} + \beta_2 X_{i2} + \dots + \beta_{314} X_{i,314} + \varepsilon_i$$

Y_i : each nutrient intake (i = 1, 2, …, 20 nutrient factors)
$\beta_0, \beta_1, \beta_2, \dots, \beta_{p-1}$: regression coefficient
$X_{il}, X_{i2}, \dots, X_{i,314}$: nutrient intakes by each food (1, 2, …, 314 foods)

The selection of food items was finally considered with up to 90 cumulative percentage contribution and 0.90 cumulative multiple regression coefficient/cumulative R^2. The nutrients of interest were energy, protein, fat, carbohydrate, vitamins (including vitamins A, B_1, B_2, B_6, C, E, niacin, folate), minerals (calcium, phosphorus, iron, potassium, sodium, zinc), crude fibre, and cholesterol. One hundred and seventy seven foods with up to 0.90 cumulative multiple regression coefficients and 90 cumulative percentage contribution were chosen. Foods reported by the respondents were then grouped into conceptually similar food items. After grouping food items, 94 were finally included in the questionnaire: Grains and their products (15 food items), potatoes and starch (4), seeds (1), soybean, soybean products and other beans (4), vegetables (22), mushrooms (2), fruits (13), meats (7), eggs (1), fish (7), shellfish (4), other fish (2), seaweed (2), milk and dairy products (4), and beverages (6). Intake frequencies were classified into eight categories. The medium portion sizes were calculated for the foods from the recorded three-day dietary periods. Portion sizes in the FFQ were categorized into three: small (half as much as the medium), medium, and large (1.5 times larger than the medium).

Result

Nutrient intakes

The mean age ± standard deviation of 224 study subjects was 47.4 ± 13.4 years. Tables 1.1, 1.2, and 1.3 show the nutrient intakes of the study subjects both by gender and by age groups. Tables 2 through 5 show percentage contribution, cumulative percentage contribution, and cumulative R^2 of the top 20 foods for energy, protein, fat, and carbohydrate, respectively. As shown in Table 2, CA indicated that 38% of energy sourced from well-milled rice, followed by, Ramyon (a type of Korean fried noodle), cow's milk, and medium flour wheat. Well-milled rice, soy sauce, and soybean oil were selected as the top three foods by MRA.

Table 1.1. Nutrient intakes of the study subjects by gender

	All of the subjects (N = 224)	Male (N = 107)	Female (N = 117)
Energy (kcal)	1818.0 ± 667.2*	2011.0 ± 687.2	1644.5 ± 598.5
Protein (g)	74.3 ± 37.2	83.8 ± 41.3	65.7 ± 30.7
Fat (g)	42.8 ± 29.0	48.7 ± 30.3	37.5 ± 26.6
Carbohydrate (g)	281.6 ± 93.0	301.2 ± 93.5	263.9 ± 89.0
Calcium (mg)	493.4 ± 283.0	539.6 ± 308.5	451.8 ± 251.2
Phosphorus (mg)	1011.5 ± 487.0	1125.4 ± 539.0	909.3 ± 409.7
Iron (mg)	12.8 ± 5.9	14.1 ± 6.1	11.6 ± 5.4
Potassium (mg)	2493.2 ± 1142.2	2756.3 ± 1182.0	2257.0 ± 1052.1
Vitamin A (I.U.)	602.3 ± 1036.7	706.1 ± 1366.8	509.1 ± 589.1
Sodium (mg)	4034.3 ± 2145.2	4468.7 ± 2204.7	3644.0 ± 2015.0
Vitamin B_1 (mg)	1.2 ± 0.8	1.3 ± 0.9	1.0 ± 0.6
Vitamin B_2 (mg)	1.0 ± 0.6	1.2 ± 0.7	0.9 ± 0.6
Niacin (mg)	17.3 ± 9.4	19.8 ± 10.4	15.1 ± 7.8
Vitamin C (mg)	81.2 ± 58.7	92.4 ± 66.8	71.2 ± 48.3
Zinc (mg)	9.1 ± 4.2	10.0 ± 4.4	8.2 ± 3.8
Vitamin B_6 (mg)	22.4 ± 10.3	24.2 ± 10.4	20.8 ± 9.9
Folate (μg)	213.2 ± 168.1	227.3 ± 117.9	200.5 ± 202.2
Crude fibre (g)	5.7 ± 2.9	6.4 ± 3.1	5.1 ± 2.6
Vitamin E (mg)	11.9 ± 9.8	13.1 ± 10.1	10.7 ± 9.3
Cholesterol (mg)	289.9 ± 247.8	330.2 ± 272.2	253.6 ± 217.6

* mean ± standard deviation

Table 1.2. Nutrient intakes of the male subjects by age

	39 yrs (N=14)	40-49 yrs (N=28)	50-59 yrs (N=19)	60 yrs & above (N=19)
Energy (kcal)	2103.6 ± 773.4*	2044.1 ± 603.0	2007.4 ± 673.6	1767.9 ± 562.5
Protein (g)	86.3 ± 48.3	88.2 ± 42.3	81.6 ± 35.4	74.4 ± 25.2
Fat (g)	52.4 ± 30.4	49.1 ± 28.8	49.0 ± 34.4	39.6 ± 26.8
Carbohydrate (g)	313.7 ± 111.5	298.6 ± 72.6	306.3 ± 93.3	273.0 ± 70.6
Calcium (mg)	532.6 ± 336.2	583.5 ± 358.8	551.3 ± 231.3	480.9 ± 220.3
Phosphorus (mg)	1137.5 ± 610.0	1207.2 ± 593.2	1097.0 ± 431.3	1011.4 ± 347.5
Iron (mg)	14.0 ± 5.7	14.4 ± 5.3	15.3 ± 9.2	12.8 ± 3.9
Potassium (mg)	2696.3 ± 1224.0	3020.2 ± 1424.0	2770.6 ± 1004.8	2496.4 ± 748.6
Vitamin A (I.U.)	613.8 ± 438.2	680.9 ± 604.6	1078.2 ± 3030.9	569.4 ± 518.1
Sodium (mg)	4546.7 ± 2588.5	4837.6 ± 1949.1	4505.0 ± 2013.4	3740.1 ± 638.5
Vitamin B_1 (mg)	1.4 ± 0.7	1.4 ± 0.8	1.5 ± 1.4	1.0 ± 0.5
Vitamin B_2 (mg)	1.2 ± 0.5	1.2 ± 0.6	1.3 ± 1.1	1.0 ± 1.4
Niacin (mg)	19.2 ± 10.5	21.2 ± 11.4	20.2 ± 10.9	18.6 ± 8.2
Vitamin C (mg)	89.2 ± 69.1	94.0 ± 54.6	119.3 ± 89.4	70.2 ± 36.3
Zinc (mg)	10.0 ± 4.5	10.3 ± 4.5	10.7 ± 5.1	9.0 ± 3.5
Vitamin B_6 (mg)	23.8 ± 11.0	25.8 ± 9.5	23.3 ± 10.7	23.5 ± 10.3
Folate (mg)	220.2 ± 121.6	248.3 ± 118.9	217.6 ± 105.5	222.3 ± 119.2
Crude fibre (g)	5.9 ± 3.3	6.9 ± 2.6	7.1 ± 3.1	5.9 ± 2.8
Vitamin E (mg)	14.2 ± 12.4	13.0 ± 7.8	11.9 ± 6.5	12.3 ± 10.5
Cholesterol (mg)	350.1 ± 295.6	338.1 ± 298.8	325.1 ± 242.3	281.2 ± 198.6

*mean ± standard deviation

In Table 3, according to CA, well-milled rice was the major contributor (19.7%) towards protein intake and this was followed by pork, loin (4.0%), chicken's eggs (3.7%), cow's milk (2.9%), and beef (imported cattle) (2.8%). Together, these five foods accounted for a third of the study subjects' protein intake. The top 20 foods were re-ranked by MRA to assess the contribution of each food to protein intake variations among individuals. Soy sauce, garlic, and Alaska Pollack were chosen as cumulative R^2 of the top three foods for protein. In terms of fat, as shown in Table 4, soybean oil was ranked at the top by CA, followed by chicken's eggs, cow's milk, and pork (loin). By MRA, soybean oil, pork (belly), beef (imported cattle), and pork (loin) were selected in order of

Table 1.3. Nutrient intakes of the female subjects by age

	30-39 yrs (N = 40)	40-49 yrs (N=25)	50-59 yrs (N=22)	60 yrs & above (N = 30)
Energy (kcal)	1769.0 ± 613.3*	1672.8 ± 526.0	1728.8 ± 464.6	1392.1 ± 655.4
Protein (g)	67.8 ± 27.4	70.4 ± 36.4	72.1 ± 25.2	54.0 ± 30.5
Fat (g)	42.5 ± 27.7	42.0 ± 24.3	40.8 ± 19.8	24.6 ± 27.5
Carbohydrate (g)	283.2 ± 89.1	255.4 ± 73.8	273.7 ± 83.9	238.5 ± 98.2
Calcium (mg)	472.5 ± 264.7	430.6 ± 216.4	508.5 ± 220.3	401.1 ± 273.2
Phosphorus (mg)	947.1 ± 390.6	942.9 ± 441.8	1015.9 ± 325.0	751.4 ± 423.3
Iron (mg)	12.0 ± 6.0	11.8 ± 5.0	13.4 ± 4.3	9.6 ± 5.1
Potassium (mg)	2329.8 ± 1217.5	2294.0 ± 855.7	2491.1 ± 627.6	1956.1 ± 1160.5
Vitamin A (I.U.)	619.1 ± 893.8	509.7 ± 330.7	549.1 ± 359.4	332.5 ± 265.2
Sodium (mg)	3905.9 ± 2292.9	3556.9 ± 1624.3	3876.8 ± 1639.1	3199.6 ± 118.9
Vitamin B_1 (mg)	1.1 ± 0.6	1.1 ± 0.6	1.1 ± 0.4	0.8 ± 0.6
Vitamin B_2 (mg)	1.0 ± 0.8	0.9 ± 0.4	1.0 ± 0.3	0.7 ± 0.4
Niacin (mg)	15.9 ± 7.3	16.4 ± 8.9	16.3 ± 6.5	12.1 ± 7.8
Vitamin C (mg)	73.9 ± 54.5	75.0 ± 52.1	80.1 ± 40.9	57.7 ± 38.1
Zinc (mg)	8.4 ± 3.9	8.8 ± 4.1	8.6 ± 2.7	7.3 ± 3.9
Vitamin B_6 (mg)	21.6 ± 10.3	19.3 ± 9.1	18.6 ± 9.1	22.6 ± 10.3
Folate (mg)	222.4 ± 315.7	195.7 ± 94.5	220.3 ± 90.3	160.8 ± 112.4
Crude fibre (g)	5.1 ± 2.5	5.2 ± 2.6	5.8 ± 2.1	4.7 ± 2.9
Vitamin E (mg)	12.5 ± 12.3	11.3 ± 6.7	11.9 ± 7.7	7.0 ± 6.2
Cholesterol (mg)	270.5 ± 188.8	258.1 ± 255.0	332.7 ± 257.8	169.4 ± 152.2

* mean ± standard deviation

Table 2. Percentage contribution, cumulative percentage contribution, and cumulative R^2 of the top 20 foods for energy

Rank	Food	% Contribution	Cumulative % contribution	Rank	Food	Cumulative R2
1	Rice, paddy rice, well-milled rice (domestic), Japonica type, Il Pum	38.0	38.0	1	Rice, paddy rice, well-milled rice (domestic), Japonica type, Il Pum	0.15
2	Ramyon, instant	2.7	40.7	2	Soy sauce, shoyu (Japanese style)	0.25
3	Cow's milk, ordinary liquid milk	2.2	42.9	3	Soybean oil	0.32
4	Wheat, medium flour	1.9	44.8	4	So Ju (Distilled liquor),alcohol 25%	0.36
5	Pork, loin, raw	1.9	46.6	5	Sugar, white sugar	0.39
6	Chicken's egg whole egg, fresh	1.9	48.5	6	Carbonated beverages, cola	0.43
7	Grape, campbell's early	1.5	50.0	7	Onion, raw, domestic	0.46
8	Soybean oil	1.4	51.3	8	Beer, alcohol 4.5%	0.49
9	Loaf bread, loaf bread	1.4	52.7	9	Pork, belly	0.52
10	Pork, belly	1.3	53.9	10	Beef, imported cattle, ribs, raw	0.54
11	Apple, raw, Fuji	1.3	55.2	11	Ramyon, instant	0.56
12	Sugar, white sugar	1.0	56.2	12	Cow's milk, ordinary liquid milk	0.58
13	Sesame oil	0.9	57.1	13	Pork, loin, raw	0.60
14	Soybean curd, pressed	0.9	58.0	14	Grape, campbell's early	0.62
15	Beef, imported cattle, brisket, raw	0.8	58.8	15	Orange, raw juice	0.64
16	So Ju (Distilled liquor), alcohol 25%	0.8	59.6	16	Rice, glutious rice, milled	0.65
17	Beef, imported cattle, ribs, raw	0.8	60.4	17	Wheat, medium flour	0.66
18	Kimch'i, Korean cabbage	0.8	61.2	18	Doughnuts, ring type	0.67
19	Mackerel, raw	0.8	61.9	19	Chicken, meat and skin, raw	0.68
20	Barley, barley, rolled barley	0.8	62.7	20	Chicken's egg whole egg, fresh	0.69

cumulative R^2. Well-milled rice contributed more than half to the carbohydrate intake, followed by Ramyon, medium flour wheat, and grapes according to CA (Table 5). Also well-milled rice was the top food by MRA. Together, white sugar, onion, and orange juice were ranked at the next top foods by MRA.

Table 6 presents the number of foods required to achieve a cumulative contribution of 90% and a cumulative R^2 of 0.9 for each of the 20 nutrients analyzed. The number of foods by CA ranged from 4 for vitamin B_6 to 147 for iron. By MRA, the ranges were between 1 for vitamin B_6 and 114 for potassium. Table 7 shows the percentage coverage by 20 nutrients on the food list, assuming that all 596 foods are a unit. The percentage ranged from 61.6% for sodium to 97.3% for vitamin B_6.

Discussion

The food items in the final FFQ list were selected based on both their cumulative percentage contribution to nutrient intake and on the cumulative proportion of total variance in nutrient intake explained by multiple regression analysis. Contribution analysis is useful for identifying the foods that are the main sources of specific nutrients for the group under study and also for making energy and nutrient adjustments if appropriate. In contrast, multiple regression analysis is primarily useful for identifying foods that contribute to differences in nutrient intake between individuals and may, therefore, be more useful if the primary purpose of the FFQ is to categorize individuals in a group rather than to assess the level of nutrient intake.[5,15] Most of the food items selected by CA included those by MRA in the food list, which turned out to be consistent with the findings by Tokudome *et al*.[5] Since the selection of food items in the list is usually made based on these two approaches (both CA and MRA), the food items in the final list should be determined from the total food item list by MRA.[16] The number of foods required to account for the variation in nutrients among persons differs considerably by nutrient.[17,18] For example, 90% of the variance between individuals for sodium, vitamins A, B_1, B_6 was accounted for by 20 foods or less, a result which is in agreement with the study findings of Byers *et al.*[19] The above implies that fewer foods are needed to account for a proportion of the between-person intake variances, than are needed to explain the same proportion of the study subjects' total intake.

Similarly, as mentioned by Stryker *et al.*,[20] a limited number of foods explained a greater proportion of the between-person variance than it could explain of the individuals' total intake. For example, a list of 10 foods selected by stepwise regression could explain a greater proportion of between-person variance than 10 foods selected by their percentage contribution to total intake. In the present study, analogous tendency to the Stryker's results in protein and fat; for protein, 43% and 54%; for fat, 43%, 61%. However, the opposite tendency was found in total carbohydrate; 68% and 65%, respectively. And also 10 food items selected by CA and MRA explained 54% of the absolute total energy intake with the same percentage of the between-person variance.

Greater numbers of food items in the listing indicates that nutrient intakes can be derived from more food items, that is, smaller numbers of food items imply lower numbers of major contributing foods.[20] Found in Table 6, a smaller number of food items in the list seemed to

Table 3. Percentage contribution, cumulative % contribution, and cumulative R^2 of the top 20 foods for protein

Rank	Food	% contribution	Cumulative % contribution	Rank	Food	Cumulative R2
1	Rice, paddy rice, well-milled rice (domestic), Japonica type, Il Pum	19.7	19.7	1	Soy sauce, shoyu (Japanese style)	0.23
2	Pork, loin, raw	4.0	23.7	2	Garlic, bulb, raw	0.30
3	Chicken's egg whole egg, fresh	3.7	27.4	3	Alaska pollack, dried	0.36
4	Cow's milk, ordinary liquid milk	2.9	30.3	4	Chicken's egg whole egg, fresh	0.39
5	Beef, imported cattle, brisket, raw	2.8	33.1	5	Eel, conger eel, raw	0.42
6	Kimch'i, Korean cabbage	2.3	35.4	6	Pork, loin, raw	0.45
7	Soybean curd, pressed	2.2	37.6	7	Chicken, meat and skin, raw	0.47
8	Ramyon, instant	1.8	39.4	8	Beef, imported cattle, ribs, raw	0.50
9	Beef, Korean cattle, brisket	1.8	41.2	9	Beef, Korean cattle, rump	0.52
10	Pork, belly	1.6	42.8	10	Tuna, bluefin yellow-fin tuna, canned in oil	0.54
11	Chicken, meat and skin, raw	1.4	44.2	11	Fast foods, pizza	0.56
12	Wheat, medium flour	1.4	45.6	12	Yellow croaker, raw	0.58
13	Yellow croaker, raw	1.4	47.0	13	Welsh onion, large type	0.60
14	Beef, imported cattle, ribs, raw	1.4	48.4	14	Pork, belly	0.62
15	Mackerel, raw	1.3	49.7	15	Beef, imported cattle, brisket, raw	0.64
16	Anchovy boiled-dried, small snchovy	1.3	51.0	16	Beer, alcohol 4.5%	0.65
17	Alaska pollack, dried	1.2	52.2	17	Common squid, raw	0.67
18	Soybean, black soybean, raw, dried	1.2	53.5	18	Pork, ribs, raw	0.68
19	Beef, Korean cattle, loin	1.2	54.7	19	Beef, Korean cattle, loin	0.69
20	Soybean paste, soybean paste	1.1	55.8	20	Soybean, black soybean,raw,dried	0.70

Table 4. Percentage contribution, cumulative % contribution, and cumulative R^2 of the top 20 foods for fat

Rank	Food	% Contribution	Cumulative % contribution	Rank	Food	Cumulative R2
1	Soybean oil	6.2	6.2	1	Soybean oil	0.15
2	Chicken's egg whole egg, fresh	5.8	12.0	2	Pork, belly	0.27
3	Sesame oil	5.4	17.4	3	Beef, imported cattle, ribs, raw	0.36
4	Cow's milk, ordinary liquid milk	5.0	22.4	4	Pork, loin, raw	0.44
5	Pork, loin, raw	5.0	27.5	5	Butter	0.47
6	Ramyon, instant	4.1	31.6	6	Beef, Korean cattle, shank	0.51
7	Rice, paddy rice, well-milled rice (domestic), Japonica type, Il Pum	3.1	34.7	7	Orange, raw juice	0.53
8	Pork, belly	3.1	37.8	8	Chicken, meat and skin, raw	0.56
9	Mackerel, raw	2.7	40.5	9	Sesame oil	0.59
10	Beef, imported cattle, brisket, raw	2.2	42.7	10	Cake, pound cake, butter	0.61
11	Soybean curd, pressed	2.0	44.7	11	Ramyon, instant	0.63
12	Beef, imported cattle, ribs, raw	1.9	46.6	12	Doughnuts, ring type	0.65
13	Beef, Korean cattle, brisket	1.7	48.3	13	Hamburger, cheeseburger	0.67
14	Mayonnaise	1.7	50.0	14	Pork, shank, raw	0.69
15	Beef, Korean cattle, shank	1.5	51.5	15	Chicken's egg whole egg, fresh	0.71
16	Beef, Korean cattle, loin	1.5	53.1	16	Beef, Korean cattle, loin	0.72
17	Coffee whitener	1.5	54.7	17	Cow's milk, ordinary liquid milk	0.74
18	Kimch'i, Korean cabbage	1.4	56.1	18	Fast foods, pizza	0.75
19	Chicken, meat and skin, raw	1.4	57.5	19	Pork, ribs, raw	0.76
20	Soybean, black soybean, raw, dried	1.3	58.8	20	Pork, tender loin, raw	0.77

Table 5. Percentage contribution, cumulative % contribution and cumulative R2 of the top 20 foods for carbohydrate

Rank	Food	% Contribution	Cumulative % contribution	Rank	Food	Cumulative R2
1	Rice, paddy rice, well-milled rice (domestic), Japonica type, Il Pum	51.6	51.6	1	Rice, paddy rice, well-milled rice (domestic), Japonica type, Il Pum	0.32
2	Ramyon, instant	2.8	54.4	2	Sugar, white sugar	0.41
3	Wheat, medium flour	2.8	57.2	3	Onion, raw, domestic	0.45
4	Grape, campbell's early	2.4	59.6	4	Orange, raw juice	0.48
5	Apple, raw, Fuji	2.0	61.6	5	Fast foods, pizza	0.51
6	Sugar, white sugar	1.7	63.3	6	Rice, glutious rice, milled	0.54
7	Loaf bread, loaf bread	1.5	64.8	7	Wheat, medium flour	0.56
8	Cow's milk, ordinary liquid milk	1.1	65.9	8	Ramyon, instant	0.59
9	Barley, barley, rolled barley	1.1	67.0	9	Grape, campbell's early	0.62
10	Somyon, dried	1.0	68.0	10	Apple, raw, Fuji	0.65
11	Coffee, Maxim coffee mix, Dong suh	0.9	68.8	11	Pear, raw, domestic	0.67
12	Starch vermicelli	0.9	69.7	12	Cereals, almond flakes	0.68
13	Udong, raw	0.8	70.5	13	Buckwheat Naeng Myon (Buckwheat vermicelli)	0.69
14	Ko Ch'u Jang (Fermented 5% red pepper soybean paste)	0.8	71.3	14	Rice cakes, Song Pyon (pine flavoured rice pastry) with small red bean	0.71
15	Sweet potatoes, raw	0.8	72.1	15	Citrus fruit, mandarin	0.72
16	Noodles, dried	0.7	72.8	16	Udong, raw	0.72
17	Rice, glutious rice, milled	0.7	73.5	17	Cow's milk, ordinary liquid milk	0.73
18	Kimch'i, Korean cabbage	0.7	74.2	18	Cake, pound cake, butter	0.74
19	Potatoes, raw	0.6	74.8	19	Coffee,Maxim coffee mix,Dong suh	0.75
20	Rice cakes, Ka Rae Ddok (plain rod shaped)	0.6	75.4	20	Orange, canned, juice	0.76

perform better for vitamin B_6, vitamin A, sodium, vitamin C than iron, phosphorus, potassium, and vitamin B_2. In general, we consider that the number of food items containing mineral sources appear to be greater than the number of food items acting as vitamin sources.

Several Korean reports have compared the total intake based on the top 20 foods for specific nutrients, specifically, in terms of energy, protein, fat, and carbohydrate.[6,8,21] Similarities were found for fat and carbohydrate sources based on CA of the top 20 foods, while differences were found for energy and protein. Vegetable oils and cow's milk were included in the five top foods. Similar food products have been reported in several studies; for example in a survey conducted on Korean adults,[8] cow's milk and instant noodles (e.g., Ramyon) were reported; in a survey on Korean female students,[6] vegetable oils, biscuit, and cow's milk; in a study on the elderly,[21] in which noodles, cow's milk, and chickens' eggs were ranked as the major foods.

Table 6. Number of foods contributing with up to 90% cumulative contribution and with up to 0.9 cumulative R^2

	with up to 90% cumulative contribution	with up to 0.9 cumulative R^2
Energy	119	71
Protein	123	63
Fat	100	62
Carbohydrate	68	50
Calcium	83	59
Phosphorus	136	84
Iron	147	67
Potassium	133	114
Vitamin A	54	20
Sodium	56	17
Vitamin B_1	116	19
Vitamin B_2	131	50
Niacin	116	54
Vitamin C	57	26
Zinc	127	54
Vitamin B_6	4	1
Folate	119	25
Crude fibre	82	46
Vitamin E	116	64
Cholesterol	64	25

Table 7. Percentage coverage of 20 nutrients by the food list

Energy	84.9
Protein	86.5
Fat	72.0
Carbohydrate	87.9
Calcium	80.0
Phosphorus	85.1
Iron	84.6
Potassium	85.3
Vitamin A	75.0
Sodium	61.6
Vitamin B_1	86.1
Vitamin B_2	84.8
Niacin	85.8
Vitamin C	89.8
Zinc	87.9
Vitamin B_6	97.3
Folate	83.7
Crude fibre	81.8
Vitamin E	63.8
Cholesterol	84.2

Table 7 presents the percentage coverage of nutrient intakes by the food list - the figures range from 61.6% for sodium to 97.3% for vitamin $B_{6,}$ with an average of 82.4%, which are lower than those of a middle-aged Japanese survey.[5] If the present study had involved setting a cut-off point for selecting food items above 90 cumulative percentage contribution and higher than 0.9 cumulative R^2, the percentage coverage would have been higher than is shown in Table 7. However, with shifting a cut-off point by a slight increase of cumulative R^2, the number of food items in the food list would have been greater.[16] The drawback of using a larger number of food items in a food list is that it increases the burden placed on both respondents and researchers and this may reduce participation rates and efficiency.[22] Therefore, the nutrient intakes of individuals need to be accurately assessed by developing FFQs containing well-placed but limited numbers of food items, which are focused on specific nutrients rather than by developing FFQs containing higher numbers of food items, though they do increase coverage.[23] In particular, a well-designed simplified FFQ may be used commonly in large-scaled epidemiological studies. Such an FFQ could be achieved by collapsing a range of food items into a smaller number of items, which are similar in terms of nutrient content per serving size.

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