Original Article

Contribution of specific foods to fat, fatty acids, and cholesterol in the development of a food frequency questionnaire in Koreans

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The present study identified dietary sources of fat, fatty acids, and cholesterol in Koreans residing in and near Seoul. The study also identified foods to be included in a food frequency questionnaire (FFQ) by both contribution analysis (CA) and multiple regression analysis (MRA). Three-day dietary records were collected from 224 subjects (107 men and 117 women) aged 30 to 85 years. Pork was the main source of total fat and the largest contributor to saturated fatty acids (SFA) was beef. MRA identified animal food as the primary source of between-person variance for SFA. Arachidonic acid, eicosapentaenoic acid, and docosahexaenoic acid originated primarily from marine products. About a fourth of the total cholesterol intake was derived from chickens' eggs by CA, while chickens' eggs accounted for 46% of the cholesterol intake for between-person variance by MRA. With 10 food items, the FFQ could explain more than half of total intakes except for total fat and n-3 polyunsaturated fatty acids (PUFA), and at least 65% of between-person variances. The percentage coverage in the FFQ ranged from 61% for n-6 PUFA and linoleic acid and to 90% for arachidonic acid. The value of this FFQ is that it can estimate usual dietary food patterns and nutrient intake in Koreans for epidemiological studies. It can also potentially be used to study the relationship between specific diseases and nutrient intakes of interest.

Key Words: fat, fatty acids, n-3 PUFA, n-6 PUFA, cholesterol, food frequency questionnaire, contribution analysis (CA), multiple regression analysis (MRA), Koreans

Introduction

Lipids, including fat, fatty acids, and cholesterol, have important biochemical functions, as they provide energy, essential fatty acids, structural components of cell membranes, vehicles of fat-soluble vitamins, constituents of steroid hormones and bile acids, and precursors of eicosanoids, eg. prostaglandins, thromboxanes, and leukotrienes. Lipids are also known as useful components in anti-inflammation, anti-atherogenicity, anti-thrombosis, and anti-immunosuppression.[1,2] However, the over consumption or an imbalance in the lipid amount in the body has been shown to be harmful to haemostasis, immune functions, and other aspects of health, although further research on the physiological mechanisms involved is required.[3]

From the literature related to lipids and disease prevention, not only is the total amount of fat intake in the

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diet important, but also the ratio of fatty acids should be taken into consideration.[4] For example, research topics have focused on the ratio of n-6 polyunsaturated fatty acids (PUFA) to n-3 PUFA and on the ratio of PUFA to saturated fatty acids.[4] According to the national nutrition surveys conducted in Korea during the past thirty years, fat-derived energy intake has increased gradually throughout the period; i.e, 5.7% of total energy in 1971, 9.3% in 1976, 9.6% in 1981, 13.1% in 1986, 16.6% in 1991, 18.8% in 1995, and 19.2% in 1998.[5]

Compared to Western people, the intake of fat and cholesterol by Koreans is reported to be lower. However, urban residents have made a rapid shift in terms of fat consumption, and now show consumption patterns similar to that associated with the Western diet.[6] Such phenomena have occurred comparatively recently in Korea, over the past few decades as evidenced by the explosive growth of fast-food restaurants, a remarkable increase in red meat consumption versus a comparatively consistent rate of fish/shellfish consumption. Accordingly, the intake of SFA has increased in Korea, but the consumption of n-3 PUFA has decreased.[5,6]

The blood cholesterol level of Koreans has been reported to be relatively lower than that of other Asian peoples and lower than in the Western countries.[6] However, Koreans show higher tendencies towards other disease risk factors (eg. hypertension, smoking, drinking). There has also been an accelerated shift from infectious to circulatory diseases, such as rheumatic heart disease, hypertensive disease, ischaemic heart disease, and cerebrovascular disease.[5] These changes in the pattern of disease prevalence and death rate are considered to concur with the shift in the Korean dietary pattern.

Many of these chronic diseases have long latency periods, and they may be the result of dietary factors of many years duration.[7] Food frequency questionnaires (FFQs) are one of the commonly accepted tools for assessing dietary intake, and can be readily used to determine habitual food patterns. Several FFQs are available for epidemiologic studies in Koreans,[8,9] however, to date few FFQs have been developed to assess the intake of the fatty acid subgroups, SFA, MUFA, and PUFA and that of cholesterol in the Korean diet.

Therefore, the purpose of this study was to report the foods contributing to the absolute intake and between-person variance in lipid intakes in the diets of Koreans. The developed FFQ was evaluated for the percentage coverage of the specific nutrients.

Subjects and methods

A total of 224 Koreans {107 males (48%) and 117 females (52%)} aged from 30 to 85 years {30-39 years, 81 persons (36%); 40-49, 53 (24%); 50-59, 41 (18%); 60-69, 30 (13%); 70+, 19 (8%)} living in or near Seoul participated in a three-day dietary record survey in the fall of 2000. The mean and standard deviation of age was 47.4 $\pm$ 13.1 years. The participants were volunteers recruited from parents or relatives of graduate students majoring in nutrition and dietetics at Seoul National University by the non-probability sampling strategy. Before the survey was implemented, this study was reviewed and approved by the Human Subjects Committee of Seoul National University Hospital. Each respondent was asked to respond to information requested on the descriptions of foods and beverages, including portion sizes in three days (two working days and one weekend day) on a three-day dietary record form.

The Korean food composition tables[10] has many missing values, especially for fatty acids and cholesterol compositions, which makes it unfeasible to try to assess accurately the fatty acid and cholesterol nutrient intakes for epidemiological studies in Koreans. In the present study, missing values were filled by using results obtained by laboratories and information from the United States Department of Agriculture's Food Composition Table[11] and from the Japanese Food Composition Table.[12]

Descriptive statistics, contribution analysis (CA), and multiple regression analysis (MRA) were used to analyze all relevant data by using Statistical Analysis System software.[13,14] CA is used to estimate the absolute intake of nutrients for an individual, whilst MRA 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 population. For each nutrient, the distribution of average individual nutrient intake was tested for normality by using the UNIVARIATE procedure.[15]

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

Percentage contribution of nutrient *k* by food *I*

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

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

$$\text{Percentage contribution of nutrient } k \text{ by food } i = \sum_{i=1}^{672} IPC_{jik} / 672$$

where j = 1, …, 672 days, i = 1, …, 596 foods, k = 1, …, 12 nutrient factors, Q = grams of foods consumed, D = nutrient content per gram of food.

MRA was applied by adopting total intake of a specific nutrient as the dependent variable and the total amount of nutrient from 314 food items as the independent variables using the selection procedure explained above.

The regression model by stepwise multiple regression analysis is as follows:

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

Y_i : each nutrient intake (i = 1, 2, …, 12 nutrient factors)

$\beta_0, \beta_1, \beta_2, \ldots, \beta_{p-1}$: regression coefficient

$X_{il}, X_{i2}, \ldots, X_{i,314}$: nutrient intakes by each food (1, 2, …, 314 foods)

Accordingly, 177 foods with up to 90 cumulative % contribution and 0.90 cumulative multiple regression coefficients were chosen. After grouping foods together, 94 food items were finally included in the questionnaire,

as follows - 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).

From the dietary survey using the three-day dietary records, the respondents' nutrient intakes were calculated in terms of energy, protein, carbohydrate, fat, fatty acids including SFA, MUFA, PUFA, n-6 PUFA, n-3 PUFA, linoleic acid, arachidonic acid, α-linolenic acid, EPA (eicosapentaenoic acid), and DHA (docosahexaenoic acid), and cholesterol. Dietary sources were also reported in the methods of CA and MRA. The percentage coverage of nutrients of interest was computed using the following formula: nutrient intakes calculated according to the developed FFQ divided by nutrient intakes consumed according to the data of three-day dietary records.

Results

Table 1 presents the intakes of energy, protein, carbohydrate, fat, fatty acids, and cholesterol for the 107 males and 117 females. Males had higher intakes of all the nutrients, except DHA. About 49 grams of fat (22% of total calories) and 38 grams of fat (21%) were consumed by males and females, respectively. The ratio of SFA to MUFA and PUFA for both genders was 1.2 : 1.5 : 1 and the ratios of n-6 to n-3 PUFA for males and females were 4.4 : 1 and 5.2 : 1, respectively.

Table 1. Nutrient intakes of the study subjects

	Male (N = 107)	Female (N = 117)
Energy	2011.0 ± 687.2*	1644.5 ± 598.5
Protein	83.8 ± 41.3	65.7 ± 30.7
Carbohydrate	301.2 ± 93.5	263.9 ± 89.0
Fat (g)	48.7 ± 30.3	37.5 ± 26.6
SFA (g)	13.6 ± 9.3	10.8 ± 8.1
MUFA (g)	17.6 ± 13.2	13.8 ± 11.5
PUFA (g)	11.6 ± 7.5	9.1 ± 7.5
n-6 PUFA (mg)	9480.0 ± 6449.2	7597.9 ± 6768.7
n-3 PUFA (mg)	2132.1 ± 2662.7	1462.7 ± 1639.8
Linoleic acid (mg)	9258.4 ± 6337.8	7432.9 ± 6659.8
α-linolenic acid (mg)	1178.7 ± 1562.8	891.5 ± 1305.3
Arachidonic acid (mg)	135.3 ± 161.2	99.2 ± 115.7
EPA (mg)	278.9 ± 689.5	158.8 ± 270.8
DHA(mg)	172.1 ± 1114.1	235.1 ± 1478.7
Cholesterol (mg)	330.2 ± 272.2	253.6 ± 217.6

* mean ± standard deviation; SFA: saturated fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids; EPA: eicosapentaenoic acid; DHA: docosahexaenoic acid

Tables 2 and 3 list the top 10 foods based on both CA and MRA analyses. For example, with 10 food items in the list, about 74% of arachidonic acid intake was explained by CA and 97% of between-person variances in α-linolenic acid intake by MRA. As for all nutrients, half of the absolute amounts could be accounted for except total fat and n-3 PUFA with the 10-item food list.

In the case of total fat, pork was the top food by both CA and MRA methods. Soybean oil was the next contributor, followed by chicken's eggs, sesame oil, and cow's milk by CA, while beef and butter were included in the top five items by MRA. SFA originated primarily from beef, cow's milk, pork, Ramyon (a type of Korean fried noodle), and rice according to CA. Foods of animal origin (including beef and pork), butter, Ramyon, and ice cream were major contributors to the variance in SFA.

In terms of MUFA, beef provided the primary intake together with pork, chickens' eggs, sesame oil, and rice. Beef and pork were also the top foods and largely explained between-person variances in terms of MUFA intake. Soybean oil, rice, sesame oil, pork, and soybean curd were listed among those foods accounting for PUFA by CA. By MRA analysis, soybean oil was also the top contributor to PUFA followed by sesame oil, pork, perilla oil, and tuna. Because it represented a substantial fraction of PUFA, the sources of n-6 PUFA were the same as those of PUFA and it was found to originate from vegetable products, such as rice, vegetable oil (soybean oil and sesame oil) and soybean curd by CA and from fish including tuna by MRA. N-3 PUFA was derived from soybean oil together with soybean curd, mackerel, perilla oil, and anchovy by CA. Perilla oil was the largest source of n-3 PUFA and its marine origins included in order- eel, soybean oil, Pacific saury, and Alaska Pollack by MRA. Rice and soybean oil were the top contributors to α-linoleic acid consumption by CA and MRA, respectively. Other vegetable products (soybean oil, sesame oil, soy-bean curd, soybean paste, dried soybean) were included in the top ten foods, irrespective of the analytic methods used.

Arachidonic acid was sourced from marine and animal origins by both analytic methods. The top source of α-linolenic acid was also sourced from soybean oil by CA and from perilla oil by MRA. Mayonnaise was included as one of the top five contributing foods based on MRA, and 83% of α-linolenic acid was attributed to perilla oil by cumulative R^2. EPA and DHA were sourced from marine products, such as, anchovy, eel, mackerel, Alaska Pollack, Pacific saury, yellow croacker, and tuna by both CA and MRA. Eel consumption explained almost half of the between-person variance in terms of EPA and DHA intake.

Almost a fourth of the total cholesterol intake was attributed to chickens' eggs, which was the highest ranked item by both CA and MRA. Marine products were the next ranked items and these were followed by animal foods irrespective of the analytic methods used. From Tables 2 and 3, the top 10 food items selected could account for at least 50% of total intakes except for total fat and n-3 PUFA by CA and more than 65% of between-person variances by MRA. Table 4 shows that the percentage coverage of fat, fatty acids, and cholesterol by the food frequency questionnaire, compared to absolute total intakes of nutrients reported in the three-day dietary records. The percentage ranged from 61% for n-6 PUFA and linoleic acid to 90% for arachidonic acid.

Discussion

In this study, about 49 grams of total fats (22% of total energy) and 38 grams (21%) were consumed by males and females, respectively, which were similar to the amounts (47 grams in males and 36 grams in females) found by the national nutrition survey,[5] but were lower than found in other Korean adult studies.[9,16] Few Korean studies have calculated specific fat profiles by categorising fat consumption as SFA, MUFA, n-6 PUFA, and n-3 PUFA.[9,17] In terms of cholesterol intake, the subjects in this study were found to consume more than those in another Korean study,[16] but less than in a Japanese study[18] and much less than subjects in Western countries.[19]

According to the results of the present study, the top five sources of total fat intake are pork, soybean oil, chickens' eggs, sesame oil, and cow's milk. The first contributing item in the national nutrition survey was also pork, and this was followed by beef, soybean oil, egg, and rice.[5,20] In another study conducted in Korean adults, rice and beef were found to be the largest sources by CA and beef was ranked as the top item by MRA.[9] In a female collegian's study, soybean oil, cookies, and milk were found to supply a third of total fat intake,[21] while in a junior high school student's study, cereal was found to contribute 40% of the total intake.[22] In the elderly, noodles were the largest source of fat,[23] and in other studies conducted in middle-aged

Table 2. Cumulative % contribution of the top 10 foods for total fat, fatty acids, and cholesterol

Rank	Food	Cumulative %contribution	Rank	Food	Cumulative % contribution
Total fat				SFA	
1	Pork, raw	8.2	1	Beef, raw	16.4
2	Soybean oil	14.4	2	Cow's milk, ordinary liquid milk	24.0
3	Chicken's egg, whole egg, fresh	20.2	3	Pork, raw	31.4
4	Sesame oil	25.6	4	Ramyon, instant	36.5
5	Cow's milk, ordinary liquid milk	30.6	5	Rice, paddy rice, well-milled rice, Japonica type	41.3
6	Ramyon, instant	34.7	6	Chicken's egg, whole egg, fresh	46.1
7	Rice, paddy rice, well-milled rice, Japonica type	37.8	7	Coffee whitener	49.9
8	Mackerel, raw	40.5	8	Soybean oil	52.8
9	Beef, raw	42.7	9	Coffee, coffee mix	55.3
10	Soybean curd, pressed	44.7	10	Mackerel, raw	57.4
MUFA			PUFA		
1	Beef, raw	18.2	1	Soybean oil	11.8
2	Pork, raw	27.6	2	Rice, paddy rice, well-milled rice, Japonica type	22.8
3	Chicken's egg, whole egg, fresh	34.8	3	Sesame oil	31.4
4	Sesame oil	40.9	4	Pork, raw	38.1
5	Rice, paddy rice, well-milled rice	46.2	5	Soybean curd, pressed	42.2
6	Soybean oil	50.7	6	Mackerel, raw	45.2
7	Cow's milk, ordinary liquid milk	55.1	7	Mayonnaise	48.2
8	Ramyon, instant	59.2	8	Chicken's egg, whole egg, fresh	51.1
9	Mackerel, raw	61.9	9	Ramyon, instant	53.8
10	Chicken, meat and skin, raw	64.1	10	Soybean, black soy bean, raw	56.3
n-6 PUFA			n-3 PUFA		
1	Rice, paddy rice, well-milled rice, Japonica type	13.3	1	Soybean oil	10.3
2	Soybean oil	25.9	2	Soybean curd, pressed	16.8
3	Sesame oil	36.1	3	Mackerel, raw	23.0
4	Pork, raw	43.5	4	Perilla oil	28.1
5	Soybean curd, pressed	47.5	5	Anchovy, boiled-dried	33.1
6	Chicken's egg, whole egg, fresh	50.8	6	Rice, paddy rice, well-milled rice, Japonica type	36.7
7	Mayonnaise	53.9	7	Yellow croaker, raw	40.0
8	Ramyon, instant	56.9	8	Mayonnaise	42.6
9	Soybean, black soybean, raw	59.6	9	Soybean paste	45.1
10	Soybean paste	62.2	10	Beef, raw	47.4

Table 2. continued..... Cumulative % contribution of the top 10 foods for total fat, fatty acids, and cholesterol

Rank	Food	Cumulative % contribution	Rank	Food	Cumulative % contribution
Linoleic acid			Arachidonic acid		
1	Rice, paddy rice, well-milled rice, Japonica type	13.7	1	Pork, raw	19.8
2	Soybean oil	26.5	2	Chicken's egg, whole egg, fresh	37.7
3	Sesame oil	36.8	3	Cow's milk, ordinary liquid, milk	52.0
4	Pork, raw	44.0	4	Beef, raw	58.0
5	Soybean curd, pressed	48.0	5	Mackerel, raw	63.8
6	Mayonnaise	51.2	6	Yellow croaker, raw	66.6
7	Chicken's egg, whole egg, fresh	54.3	7	Chicken, meat and skin, raw	69.2
8	Ramyon, instant	57.3	8	Anchovy, boiled-dried	71.3
9	Soybean, black soybean, raw	60.1	9	Tuna, bluefin tuna, canned in oil	72.8
10	Soybean paste	62.8	10	Load bread	73.9
α-linolenic acid			EPA		
1	Soybean oil	13.9	1	Anchovy, boiled-dried	23.1
2	Soybean curd, pressed	23.4	2	Yellow croaker, raw	30.7
3	Perilla oil	29.6	3	Mackerel, raw	40.7
4	Rice, paddy rice, well-milled rice, Japonica type	35.4	4	Alaska pollack, dried	46.4
5	Soybean paste	39.1	5	Common squid, raw	51.8
6	Beef, raw	42.6	6	Tuna, bluefin tuna, canned in oil	55.1
7	Mayonnaise	46.0	7	Fish paste, fried	57.7
8	Soybean, black soybean, raw	49.4	8	Chicken, meat and skin, raw	59.9
9	Mackerel, raw	51.8	9	Crab, raw	61.6
10	Red pepper powder	54.1	10	Clam, meat, raw	63.3
DHA			Cholesterol		
1	Anchovy, boiled-dried	24.4	1	Chicken's egg, whole egg, fresh	24.1
2	Chicken's egg, whole egg, fresh	36.9	2	Anchovy, boiled-dried	32.1
3	Mackerel, raw	47.1	3	Pork, raw	38.3
4	Yellow croaker, raw	54.4	4	Beef, raw	43.5
5	Common squid, raw	58.4	5	Cow's milk, ordinary liquid milk	47.3
6	Alaska pollack, dried	61.6	6	Common squid, raw	50.3
7	Tuna, bluefin tuna, canned in oil	64.3	7	Mackerel, raw	52.7
8	Fish paste, fried	66.5	8	Yellow croaker, raw	55.0
9	Pacific saury, raw	67.9	9	Dumpling, frozen	56.7
10	Crab, blue crab, raw	69.2	10	Chicken, meat and skin, raw	58.3

SFA:Saturated Fatty Acids; MUFA:Monounsaturated Fatty Acids; PUFA:Polyunsaturated Fatty Acids; EPA:Eicosapentaenoic acid; DHA: Docosahexaenoic acid

subjects, rice was found to be the top contributing food.[8,9] On the other hand, in the US general population, fat intake was found to be mainly from hamburgers and hotdogs, while in the Japanese, fat intake was from chickens' eggs, vegetable oils, milk, and mayonnaise in order.[18] Olive oil was found to account for one third of the fat intake of Italians.[24] In terms of SFA, in the present study, rice was included in one of the top five contributors by cumulative % contribution. Rice is also one of the major sources of total fat, SFA, and PUFA, because it is a very important component of the Korean diet,[9] as in the Japanese.[18] The main source of SFA in elderly Italians was found to be cheese, while in the US elderly beef was the primary source of SFA.[24]

In terms of PUFA, in this study, vegetable oils (soybean oil and sesame oil) were the top food items by CA, and perilla oil and tuna were ranked by MRA. In a study con-ducted upon Korean adults, rice and Bibimbap (rice cooked with assorted vegetables with or without meat)

Table 3. Cumulative R^2 of the top 10 foods for total fat, fatty acids, and cholesterol

Rank	Food	Cumulative R2	Rank	Food	Cumulative R2
Total fat			SFA		
1	Pork, raw	0.20	1	Beef, raw	0.24
2	Soybean oil	0.35	2	Pork, raw	0.36
3	Beef, raw	0.48	3	Butter	0.42
4	Butter	0.51	4	Ramyon, instant	0.48
5	Orange, raw juice	0.53	5	Ice cream	0.54
6	Chicken, meat and skin, raw	0.56	6	Yogurt, curd type	0.59
7	Sesame oil	0.59	7	Cow's milk, ordinary liquid milk	0.63
8	Cake, pound cake, butter	0.61	8	Cake, pound cake, butter	0.67
9	Ramyon, instant	0.63	9	Chicken, meat and skin, raw	0.70
10	Doughnuts, ring type	0.65	10	Eel, conger eel, raw	0.72
MUFA			PUFA		
1	Beef, raw	0.34	1	Soybean oil	0.36
2	Pork, raw	0.48	2	Sesame oil	0.47
3	Soybean oil	0.55	3	Pork, raw	0.56
4	Sesame oil	0.60	4	Perilla oil	0.61
5	Chicken, meat and skin, raw	0.64	5	Tuna, bluefin tuna, canned in oil	0.66
6	Eel, conger eel, raw	0.67	6	Mayonnaise	0.70
7	Yogurt, curd type	0.69	7	Eel, conger eel, raw	0.73
8	Doughnuts, ring type	0.71	8	Soybean, black soybean, raw	0.75
9	Chicken's egg, whole egg, fresh	0.73	9	Corn oil	0.77
10	Ramyon, instant	0.74	10	Yogurt, curd type	0.79
n-6 PUFA			n-3 PUFA		
1	Soybean oil	0.39	1	Perilla oil	0.33
2	Sesame oil	0.52	2	Eel, conger eel, raw	0.56
3	Pork, raw	0.64	3	Soybean oil	0.60
4	Tuna, bluefin tuna, canned in oil	0.69	4	Pacific saury, raw	0.63
5	Mayonnaise	0.73	5	Alaska pollack, dried	0.65
6	Corn oil	0.76	6	Yellow croaker, raw	0.66
7	Yogurt, curd type	0.79	7	Soybean, black soybean, raw	0.67
8	Soybean, black soybean, raw	0.81	8	Spanish mackerel, raw	0.68
9	Chicken, meat and skin, raw	0.83	9	Tuna, bluefin tuna, canned in oil	0.69
10	Muffins, with whole milk	0.85	10	Common squid, raw	0.70
Linoleic acid			Arachidonic acid		
1	Soybean oil	0.40	1	Pork, raw	0.41
2	Sesame oil	0.53	2	Eel, conger eel, raw	0.59
3	Pork, raw	0.64	3	Beef, raw	0.68
4	Mayonnaise	0.69	4	Chicken's egg, whole egg, fresh	0.71
5	Tuna, bluefin tuna, canned in oil	0.73	5	Chicken, meat and skin, raw	0.73
6	Corn oil	0.77	6	Doughnuts, ring type	0.74
7	Yogurt, curd type	0.79	7	Tuna, bluefin tuna, canned in oil	0.75
8	Soybean, black soybean, raw	0.81	8	Butter	0.76
9	Muffins, with whole milk	0.84	9	Chum salmon, raw	0.77
10	Chicken, meat and skin, raw	0.85	10	Cow's milk, ordinary liquid milk	0.78
α-linolenic acid			EPA		
1	Perilla oil	0.83	1	Eel, conger eel, raw	0.48
2	Soybean oil	0.91	2	Alaska pollack, dried	0.53
3	Soybean, black soybean, raw	0.93	3	Pacific saury, raw	0.58
4	Mayonnaise	0.94	4	Yellow croaker, raw	0.60
5	Soybean curd, pressed	0.95	5	Tuna, bluefin tuna, canned in oil	0.61
6	Pork, raw	0.95	6	Common squid, raw	0.62
7	Muffins, with whole milk	0.96	7	Spanish mackerel, raw	0.63
8	Yogurt, curd type	0.96	8	Crab, blue crab, raw	0.64
9	Pacific saury, raw	0.97	9	Chum salmon, raw	0.65
10	Salad dressing	0.97	10	Bastard halibut, raw	0.66

Table 3. continued..... Cumulative R^2 of the top 10 foods for total fat, fatty acids, and cholesterol

Rank	Food	Cumulative R2	Rank	Food	Cumulative R2
DHA			Cholesterol		
1	Eel, conger eel, raw	0.48	1	Chicken's egg, whole egg, fresh	0.46
2	Pacific saury, raw	0.52	2	Eel, conger eel, raw	0.57
3	Yellow croaker, raw	0.55	3	Common squid, raw	0.63
4	Spanish mackerel, raw	0.58	4	Alaska Pollack, dried	0.68
5	Alaska Pollack, dried	0.60	5	Dumpling, frozen	0.72
6	Tuna, bluefin tuna, canned in oil	0.62	6	Beef, raw	0.76
7	Common squid, raw	0.64	7	Yellow croaker, salt-cured, dried	0.78
8	Chum salmon, raw	0.65	8	Anchovy, boiled-dried	0.80
9	Bastard halibut, raw	0.66	9	Chicken, meat and skin, raw	0.81
10	Fish paste, fried	0.67	10	Sponge cake, with wheat flour	0.82

SFA:Saturated Fatty Acids;MUFA:Monounsaturated Fatty Acids;PUFA:Polyunsaturated Fatty Acids;EPA:Eicosapentaenoic acid;DHA:Docosahexaenoic

Table 4. Percentage coverage of total fat, fatty acids, and cholesterol by the FFQ

	Coverage (%)
Total fat	72
SFA	85
MUFA	78
PUFA	63
N-6 PUFA	61
N-3 PUFA	68
Linoleic acid	61
α-linolenic acid	63
Arachidonc acid	90
EPA	66
DHA	69
Cholesterol	84

SFA:Saturated Fatty Acids; MUFA:Monounsaturated Fatty Acids; PUFA:Polyunsaturated Fatty Acids; EPA:Eicosapentaenoic acid; DHA: Docosahexaenoic acid

were the largest source of PUFA by CA and MRA, respectively.[9] On the other hand, the Japanese top source of PUFA was vegetable oil (salad oil by CA and safflower oil by MRA),[18] which is similar to the result obtained by an Italian study.[24] In terms of linoleic acid consumption, rice was also the major source by CA and mayonnaise and tuna were included in the list by MRA. Vegetable oils were also the largest sources of linoleic acid in Italians and Japanese, while mayonnaise and margarine accounted for about 28% of the linoleic intake in Americans.[18,24]

It can be implied that fewer foods are needed to account for a proportion of the between-person variance in intake, than are needed to explain the same proportion of the study subjects' total intake. The result of this study concurs with the findings of Byers *et al*.[25] Similarly, as mentioned by Stryker *et al*.,[26] a limited number of foods can better explain between-person variance than the individuals' total intake. For example, a list of 10 foods selected by stepwise regression were able to explain between-person variance better than 10 foods selected by their percentage contribution to total intake.

From the results of this study and the Korean national nutrition survey, although the absolute total fat intake was relatively low and consumption of marine products comparatively high compared with developed Western countries, PUFA/SFA ratio of Koreans seems to deviate from the ideal.[19,27] The PUFA/SFA ratio in this study was 0.81 – 0.85, which is similar to the results of several other studies[9,17] and higher than that found in the U.S.,[28,29] but lower than that found in the Japanese.[18] However, the fat-derived energy intake of Koreans has continued to increase during the recent couple of decades.[6] In addition, based on reports about preferred cooking methods in young Koreans, the young tend to favour French fries (39% of total energy) more than boiled potatoes (0.5%).[22] Considering the trend of dietary patterns, it is important that we develop well-designed food frequency questionnaires that allow large-scaled epidemiological research for assessing usual food intakes of fat and fat-related nutrients.

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