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Studies on Intake and Serum Concentrations of Fatty Acids in Korean Adolescents*

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ABSTRACT

In this study, we evaluated the dietary fatty-acid pattern and serum fatty-acid composition of middle school students (total, 355 ; male, 182 ; female, 173), who are vulnerable to excessive and unbalanced food intakes such as fatty acids and energy. In serum lipid levels, total Chol ($p<0.05$) and HDL-Chol ($p<0.001$) levels of female students were significantly higher than those of male students. The average fat intake was 23 – 26 energy % which falls in with the current recommendation level (15 – 25%) for adults. Although the average P/M/S ratio of dietary fat was 1.1/1.2/1.0 which approaches the recommended ratio, the average range of ω6/ω3 fatty acid ratio of dietary fat was found to be 12.0 – 16.5, which is higher than the presently recommended range of 4 – 10. Some of the very high values found in this study were partly explained by the fact that the range of individual variation of ω6/ω3 ratios was very large. Mean daily intake of Chol was 337 – 361 mg. The ω3 fatty acid intake of middle school students was higher in the HFLM (high fish low meat) group than in the LFHM (low fish high meat) group. EPA and DHA intakes appeared to be significantly higher ($p<0.01$) in the HFLM group than in the LFHM group as expected. Dietary total ω3 fatty acids ($p<0.05$) and EPA ($p<0.01$) were also negatively associated with serum AA (ω6) levels. Interestingly, energy intakes and dietary SFAs such as 12 : 0 ($p<0.05$), 14 : 0 ($p<0.01$) and 16 : 0 ($p<0.05$) were negatively associated with serum AA (ω6) levels. To lower the ω6/ω3 ratio of dietary fatty acids for children, frequent consumption of ω3 series fatty-acid rich foods such as soy bean, bean products and fish is recommended. Detailed guidelines should be developed in recommending balanced food intake and qualitative fat intake for Korean adolescents taking heterogeneous groups into consideration. In accurately evaluating fatty acid intake, it is also necessary to have the fatty acid composition data of all foods consumed in each country.

KEY WORDS : dietary fatty acids · serum fatty acids · adolescents.

INTRODUCTION

Both the amounts and kinds of dietary fats may influence plasma and lipoprotein lipid levels, so the balance of polyunsaturated fatty acids (PUFA ; P), monounsaturated fatty acids (MUFA ; M) and saturated fatty acids (SFA ; S) is important in the quality of fat nutrition. Epidemiological studies in several populations, including Greenland Eskimos and Japanese, have indicated that habitual consumption of fish-rich diets or products from other marine animals is associated with a lower incidence of cardiovascular disease than in other populations whose daily intake of marine products is low.[1-3] Especially, docosahexaenoic acid (DHA 22 : 6 ω3), rich in fishes, has important roles in brain development and retina function.[4)5)] This is interesting since ω3 fatty acids consumption is generally low of diets of most of the populations of the world. Because of similarity in structure to linoleic acid(LA, 18 : 2 ω6) and α-linolenic acid (α-LNA 18 : 3 ω3), longer chain ω6 and ω3 PUFAs compete for enzymes involved in fatty acid elongation/desaturation, eicosanoid production and incorporation into tissue lipids. Therefore, for the maintenance of good health, it has been suggested that not only the P/M/S ratio but also the ω6/ω3 ratio of dietary fatty acids should fall within a desirable range.[3)6)]

Fat intake among Koreans is generally low. The National Nutrition Survey of Korea reported that fat intake per capita per day was 46.3g in 1995. The percentage of animal fat in total fat intake increased from 33.6% in 1984 to 46.6% in 1995 in Korea[7)]. In case of fat energy %, the current level is 19.1% (1995) which is similar to the recommended level of 20% for Koreans. Approximately 6.6% of the population obtain more than 30% of their total energy from fat, while 15.1% of the population eat less than 10% as fat. Several studies[8)9)] reported that the average fat intake was more than 30 energy % for the young population in urban areas of Korea.

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There is much epidemiological evidence to support[10-12] a direct relationship between the level of serum total cholesterol (Chol) & LDL-Chol and the incidence rate of coronary heart disease (CHD). CHD risk factors develop early in life, and risk factors tend to increase from year to year. Thus, it is necessary to identify the variables associated with this disease early in childhood so that appropriate measures can be implemented for children. It is striking that the atherogenic indices of Korean children have been reported to be higher than those of Japanese children.[13] Possible determinants for changes in lipid profile include alteration in diet. Many studies concerning total fat intake have been performed but few studies were interested in the quality of fat intake. There were difficulties in suggesting both quantitative and qualitative guidelines of fat nutrition for Koreans.

The major objectives of this study were to identify the issues and problems associated with nutrient intake, especially individual fatty acid intake of children and adolescents in Korea. The results obtained from this study may eventually help to establish guidelines for the overall health of growing Korean adolescents.

SUBJECTS AND METHODS

1. Subjects

The subjects for this study were middle school students (total, 355 ; male, 182 ; female, 173), aged from 13 to 15 years. Blood sample collection, anthropometric measurements and dietary surveys were carried out during July 1994. Analysis of serum fatty acids was carried out for 57 subjects of the HFLM group (high-fish, low-meat ; total 29 ; male, 14 ; female, 15) and the LFHM group (low-fish, high-meat ; total, 28 ; male, 15 ; female, 13). The HFLM group denotes fish intake more than 125% of the mean fish intake (69 g/day) and meat intake less than 75% of the mean meat intake (116 g/day). The LFHM group denotes fish intake less than 75% of the mean value and meat intake more than 125% of the mean value.

2. Methods

1) Anthropometric measurements

Height was measured to the degree of 0.1 cm, body weight to 0.5 kg, and body mass index (BMI) was calculated. Tricep fatness was measured by caliper (Lange, Cambridge Scientific Industry, USA). Waist and hip circumferences were measured and individual waist/hip ratios (WHR) were calculated.

2) Dietary assessment

Dietary intake of nutrients for one day, especially fatty acids, was assessed by means of 24-hour recall method, using food models and other measuring tools.[14] The percentage of nutrient intake were expressed as % of RDA, and the ratios of P/S, P/M/S and $\omega 6/\omega 3$ of fatty acids were calculated by a self-developed computerized program using the Fortran language.[9)15]

3) Determination of serum lipid levels

After fasting for 12 hours, 4 ml of venal blood was collected and centrifuged for 15 min (4℃, 2,000×g). The serum was stored in sealed tubes at −20℃ until fatty acid analysis could be performed. Serum triglyceride (TG), total-Chol and HDL-Chol levels were analyzed by enzyme method using an autoanalyzer (Hitachi, 7150). LDL-Chol level was calculated by the method of Friedwald.[16]

$$\text{LDL-Chol (mg/dl)} = \text{Total-Chol (mg/dl)} - [\text{HDL-Chol (mg/dl)} + (\text{TG}/5)\text{(mg/dl)}]$$

4) Determination of total serum fatty acid compositions

Serum lipids were extracted by the modified method of Folch[17]. One milliliter of serum was mixed with a methanol-dichlolomethane mixture (1 : 2 v/v) and incubated for 12 hours at room temperature. Fatty acid methyl esters were prepared by methylation with BF_3-methanol solution.[18] Fatty acid compositions of the serum were determined by gas-liquid chromatography (Hewlett-Packard 5890 series II, USA) with a fused-silica capillary column (HP-FFAP : 25 m×0.32 mm×0.52 μm, cross-linked). Oven temperature was programmed with an initial temperature of 160℃ for 1 min, elevated 3℃/min and held for 19 min at 220℃. The temperature of the injection and detection ports was held at 230℃ and 250℃, respectively. Helium was used as a carrier gas at a column flow rate of 12 psi with a split ratio of 10 : 1. Each fatty acid methyl ester peak was identified by comparison it with the peak of a standard fatty acid methyl ester (Supelco, 4-7015, Nu-Check Prep, Inc., GLC-68A, USA).

3. Statistical analysis

All values were expressed as mean±SD. The data were analysed by SAS package and the significance between sexes and HFLM and LFHM groups was tested by Student's t-test at the level of $\alpha<0.05$, $\alpha<0.01$ and $\alpha<0.001$. Pearson correlation between serum fatty acids and dietary fatty acids was performed only for the HFLM and LFHM groups at the level of $\alpha<0.05$.

RESULTS AND DISCUSSION

1. Anthropometric data

Most of the subjects belonged to the economically upper middle class. Anthropometric measurements of subjects by sex are shown in Table 1. The average BMI values of subjects, ranging from 20.0 to 20.8, were normal. The average values of WHR ($p<0.001$) and BMI ($p<0.05$) in males were significantly higher than those in females. Conversely, the average tricep fatness of females was significantly thicker than that of males ($p<0.001$), indicating that males develop more muscle and less fat than females possibly due to the sex hormone in adolescence.

2. Serum lipid levels

Serum lipid levels of the subjects are shown in Table 2. Total Chol ($p<0.05$) and HDL-Chol ($p<0.001$) concentrations of females were significantly higher than those of males. The difference in intake levels of fish and meat in these two groups may not be large enough to cause a significant difference between them. Serum total Chol concentrations of subjects were 147 mg/dl for males and 153 mg/dl for females. These values were lower than those of American children (9 – 21 years old)[19] and in other reports of Korean adolescents, which were 162 mg/dl for males and 168 mg/dl for females.[20][21] On the basis of a recent report by the Korean Association of Pediatrics,[22] the total Chol level of subjects was below the level of risk for hyperlipidemia in adolescence, which is above 175 mg/dl. HDL-Chol levels were 48.7 – 56.5 mg/dl, and LDL-Chol levels 79.7 – 90.5 mg/dl.

Table 1. Anthropometric measurements of subjects

	Male (n=182)	Female (n=173)
Height (cm)	160.7±0.73	156.7±0.49***
Weight (kg)	54.0±0.89	49.3±0.70***
Triceps (mm)	15.4±0.43	19.0±0.45***
BMI (kg/m²)	20.8±0.26	20.0±0.25*
WHR	0.8±0.00	0.7±0.00***

Values are Means±SD
BMI (Body Mass Index) : Body Weight (kg)/(Height (m) × Height (m))
WHR (Waist Hip Ratio) : Waist (cm)/Hip (cm)
* : Significantly different from the value for male at $p<0.05$, *** : $p<0.001$

Table 2. Serum lipid levels of subjects (Unit : mg/dl)

	Male (n=182)	Female (n=173)	HFLM (n=28)	LFHM (n=29)
TG	92.8±66.2	90.5±27.9	89.8±51.2	74.5±37.8
Total-Chol	146.9±30.0	153.3±23.0*	144.3±36.2	148.3±28.1
HDL-Chol	48.7±11.0	56.5±14.1***	51.0±12.1	51.3±12.3
LDL-Chol	79.7±24.2	90.5±44.6	75.3±27.2	81.1±25.1

Values are Means±SD
* : Significantly different from the value for male at $p<0.05$, *** : at $p<0.001$
HFLM : Fish intakes ≥125% of mean fish intakes & meat intakes ≤ 75% of mean meat intakes
LFHM : Fish intakes ≤75% of mean fish intakes & meat intakes ≥ 125% of mean meat intakes

In general, total Chol and LDL-Chol levels tended to be higher in LFHM-group subjects than HFLM-group subjects. Hayes and Khosla[23] reported that the important determinants of serum Chol in humans whose Chol consumption was below 400 mg/day were mystric and linoleic acids. Failor *et al.*[24] observed a significant reduction in total Chol and LDL-Chol levels in hyperlipidemic subjects consuming ω3 and ω6 PUFAs in place of saturated fatty acids. Kinsella *et al.*[25] suggested that the effects of the consumption of ω6 and ω3 PUFAs and MUFA on serum LDL-Chol and HDL-Chol levels conflict with the results of previous other studies because of differences in dosage, compositions of the dietary fatty acids, plasma lipid concentration of subjects and the duration of the study. Oh *et al.*[26] and Kim *et al.*[27] observed that serum lipid levels of adults were more closely correlated with factors such as body weight, age, sex, drinking, smoking, etc. than with dietary fatty acids.

The average serum TG level was 91.7 mg/dl. Serum TG levels of middle school students reported by Cha *et al.*[28] were 88 mg/dl for males and 93 mg/dl for females, which agrees with our result. Sung *et al.*,[29] however, reported that the average TG concentration of adolescents aged from 10 to 20 years, was 107 mg/dl and a little higher than this results. All these reported values fell within the normal range of Korean adolescents,[22] 55 – 139 mg/dl. Our previous[30] concerning elementary school students indicated that serum TG concentrations tended to increase with age and were already similar to the level of adults. There was no difference between the HFLM and LFHM groups in serum TG concentrations, suggesting that the difference in the amount of ω3 fatty acids in the diet was not large enough to affect the serum TG level in this study.

3. Intake of fat and fatty acids

Mean calorie intake per day of males and females were 2130 Kcal and 2088 Kcal, respectively. The calorie intake of males was 89% of the RDA.[31] Fat intakes of males and females were found to be 56.5 g and 60.0g, which constituted 23 – 26 energy % (Fig. 1). The percentages of energy intake from carbohydrate, protein and fat were 60.4 : 17.0 : 22.6 for males, and 57.6 : 16.6 : 25.8 for females. The ratio proposed by the Korean Nutritional Society is 65 : 15 : 20[31] for adults. The percentage of energy intake coming from fat is increasing, especially for children, and the average value of fat intake in the National Nutrition Survey was 19.1 energy % in 1995.[7] The percentage of energy contributed by fat was 25.3% in Japan (1992).[32] Energy % from fat in the LFHM group was higher than in the HFLM group (Fig. 1). Similar results for elementary school students[30] have already been reported.

Intakes of fatty acids ; 16 : 0, 18 : 1, 18 : 2ω6 and 20 : 4ω6 were found to be significantly different between the sexes (Table 3, 4). Total PUFA and MUFA intake also showed significantly different values between the sexes. For total PUFA intake, males consumed more than females ($p<0.001$) ; linoleic acid (LA 18 : 2ω6) intake of males was higher than that of females. In total MUFA intakes, males also consumed more than females ($p<0.05$) ; oleic acid (OA 18 : 1ω9) intake of males was like wise higher than that of females. These differences can be partly explained by the differences in kinds and preferences of foods consumed by male and female students.

OA and LA were the most abundant fatty acids in the diet ; 10.8 - 13.3 g of OA and 7.8 - 12.1 g of LA in a day. The average DHA intake of all subjects was 0.24 - 0.29 g/day. It is higher than the 0.06 g[9] and 0.13 g[8] of Korean female college students and lower than the 0.54 g of Korean adults.[26] Eicosapentaenoic acid (EPA 20 : 5ω3) and DHA were the only fatty acids showing significant differences ($p<0.01$) in intake levels between the HFLM and LFHM groups.

The average intake of fatty acids for all subjects were 8.9 - 13.2 g (4.8 - 5.7 energy %) for PUFA, 11.7 - 14.1 g (5.9 - 7.1% energy %) for MUFA and 11.1 - 11.8 g (5.5 - 6.0% energy %) for SFA which were all higher than those of middle school students in Kanghwa Island reported

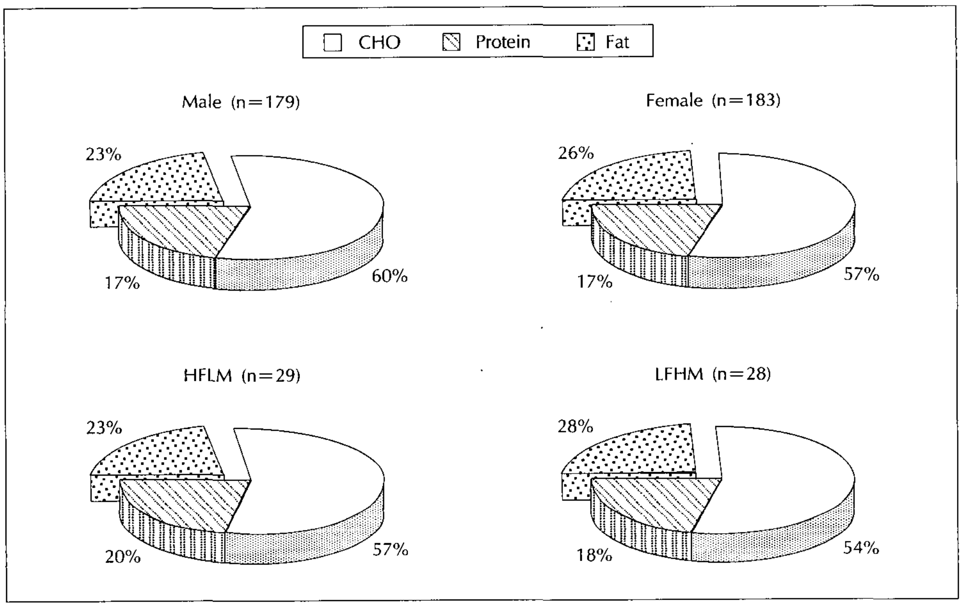

Fig. 1. Energy compositions of the diet consumed by subjects.

Table 3. Cholesterol intake, P/M/S and ω6/ω3 ratios of subjects

	Male (n=182)	Female (n=173)	HFLM (n=29)	LFHM (n=28)
Cholesterol (mg)	361.3±343.1	337.3±299.3	409.0±361.1	353.8±226.9
PUFA (g)	13.2±10.81	8.9±8.69***	13.5±7.6	12.7±16.4
MUFA (g)	14.1±9.74	11.7±11.69*	13.6±10.3	15.8±12.3
SFA (g)	11.8±7.77	11.1±10.14	12.8±8.8	12.8±8.5
P/S	1.2±0.64	1.1±0.69	1.3±0.7	1.0±0.5
P/M/S	1.2/1.2/1.0	1.1/1.2/1.0	1.3/1.1/1.0	1.0/1.3/1.0
ω3 (g)	1.2±1.36	1.1±1.45	1.8±1.7	0.8±1.03**
ω6 (g)	11.5±8.96	7.8±8.14***	11.5±7.8	8.9±7.4
ω6/ω3	16.5±11.80	12.0±9.89***	12.6±12.0	15.6±10.8

Values are Means±SD
* : Significantly different from the value for male or HFLM group at $p<0.05$, ** : $p<0.01$, *** : $p<0.001$
HFLM : Fish intakes ≥125% of mean fish intakes & meat intakes ≤75% of mean meat intakes
LFHM : Fish intakes ≤75% of mean fish intakes & meat intakes ≥125% of mean meat intakes

previously.[33] When adjusted by calorie intake, intakes of PUFA, MUFA and SFA were 4.1 - 5.4 g/kcal, 5.2 - 5.7 g/kcal and 4.9 g/kcal, respectively. As mentioned above, in absolute amounts of PUFA and MUFA intake, there existed a significant difference between the sexes, but no significant difference was found in PUFA, MUFA and SFA intake when expressed on the basis of calorie intake. The average P/M/S ratio was 1.1/1.2/1.0, which was similar to the desirable ratio of 1.0 - 1.5/1.0 - 1.5/1.0.[31] The corresponding ratios for college female students reported by Kim & Paik[8] and Oh *et al.*[9] were 0.78/1.23/1.0 and 0.82/0.96/1.0, respectively, which were somewhat lower than our results. Some other studies[26][34] showed that the P/M/S ratio was 1.3/1.1/1.0 for healthy adult subjects and 1.6/1.5/1.0 for industry workers, which also falls in the suggeted range.

Table 4. Individual fatty acids intakes of subjects (Unit : g)

Fatty acid	Male (n=182)	Female (n=173)	HFLM (n=29)	LFHM (n=28)
12 : 0	0.16±0.02	0.19±0.03	0.24±0.33	0.12±0.18
14 : 0	0.85±0.06	0.94±0.09	1.16±1.25	1.80±1.59
16 : 0	7.86±0.36	6.58±0.45*	8.28±5.16	8.36±5.80
16 : 1	0.67±0.04	0.69±0.06	0.71±0.67	0.86±0.41
18 : 0	2.63±0.15	2.65±0.20	2.53±1.83	3.21±2.29
18 : 1	13.26±0.68	10.75±0.83*	12.59±9.52	14.81±11.95
18 : 2ω6	12.06±0.76	7.76±0.61**	11.81±7.32	11.84±15.94
18 : 3ω3	0.72±0.06	0.67±0.08	0.57±0.51	0.66±0.98
20 : 0	0.06±0.01	0.07±0.01	0.07±0.10	0.07±0.08
20 : 1	0.10±0.02	0.14±0.02	0.18±0.37	0.08±0.06
20 : 4ω6	0.10±0.01	0.08±0.01*	0.12±0.14	0.08±0.07
20 : 5ω3	0.09±0.02	0.12±0.02	0.31±0.48	0.01±0.02**
22 : 0	0.01±0.00	0.01±0.00	0.01±0.01	0.01±0.01
22 : 1	0.04±0.02	0.06±0.03	0.08±0.41	0.01±0.01
22 : 5ω3	0.00±0.00	0.00±0.00	0.00±0.01	0.00±0.01
22 : 6ω3	0.24±0.05	0.29±0.05	0.69±1.02	0.04±0.07**
24 : 0	0.00±0.00	0.00±0.00	0.01±0.00	0.01±0.00

Values are Means±SD

* : Significantly different from the value for HFLM group at $p<0.05$, ** : at $p<0.01$

HFLM : Fish intakes ≥125% of mean fish intakes & meat intakes ≤ 75% of mean meat intakes

LFHM : Fish intakes ≤75% of mean fish intakes & meat intakes ≥ 125% of mean meat intakes

The mean intake of ω6 fatty acids is shown to be 11.5 g for males and 7.8 g for females, respectively. For ω3 fatty acids, the mean intakes were 1.2 g in males and 1.1 g in females. When compared with the Canadian RDA (1990),[35] intakes of ω3 fatty acids of males and females was lower than the Canadian RDA, while male ω6 fatty acid intake was higher than Canadian RDA. The intake levels of ω3 fatty acids reported in Korea[8][9][26] were lower when compared with the values reported in other countries, including Japan.[32][36] This difference found in these studies may partly be caused by the differences in dietary survey methodology and in the database used for the study. The average ratio of ω6/ω3 fatty acids was found

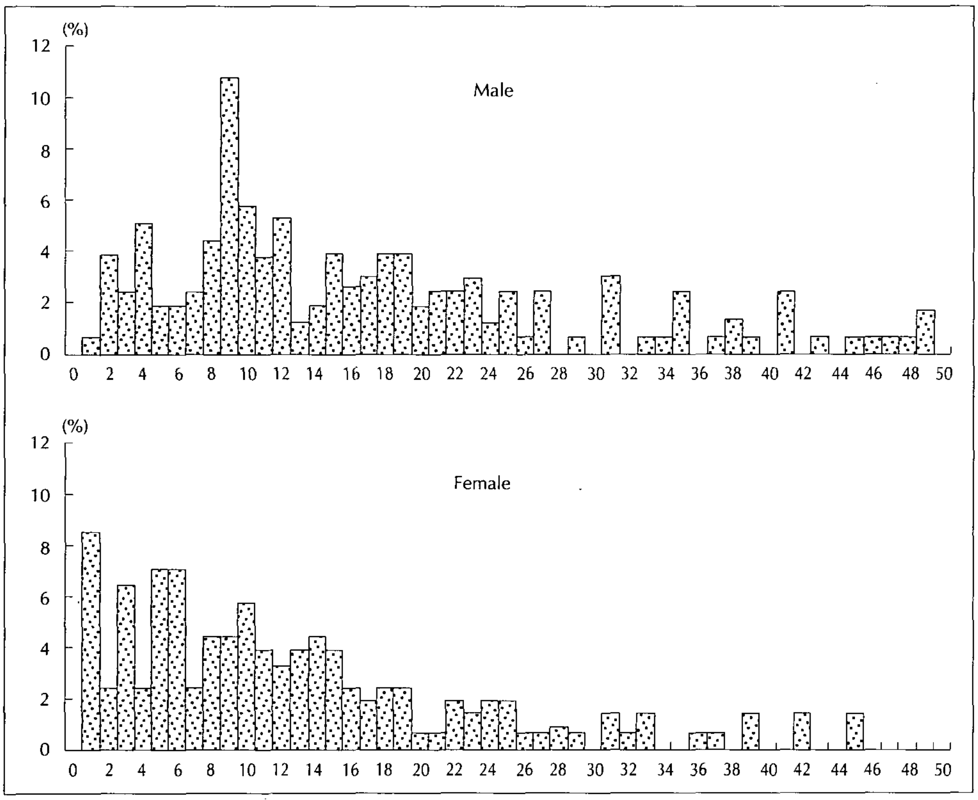

Fig. 2. Distribution of ω6/ω3 ratios of fatty acid intakes for subjects.

to be in the range of 12.0 – 16.5 which is higher than the recommended range of 4/1 – 10/1 for Koreans and 6/1 for Canadians. Such a high ratio observed here can be partly explained by a very wide distribution of individual ω6/ω3 ratio data (Fig. 2). The ω6/ω3 fatty acid ratio of dietary fat for elementary school children (1st to 6th grade) was found to be as high as 14.6.[30] On the other hand, according to recent data, the ω6/ω3 ratio was 6.0/1.0 and 8.9/1.0 for 599 healthy adult subjects[26] and industry workers,[34] respectively. It is advisable that ω3 fatty-acid rich foods, such as bean products, perilla seeds, fishes, green leafy vegetables and unrefined cereals should be consumed more often by Korean adolescents. At the same time, a more detailed database for fatty acids in all foods consumed be made.

Mean daily intakes of Chol for students were 361.3 mg for males and 337.3 mg for females (Table 3). These values were higher than the recommended value of less than 250 – 300 mg/day.[31)37] According to our previous report on elementary school students,[30] Chol intake tends to increase with age. Chol intake of Korean female college students, on the other hand, were reported as 216 mg[9] and 219 mg,[8] and that of Korean adults[26] was 150 mg. Chol intake of middle school students in Kangwha Island was 55 – 61 mg,[33] which is very low. Judging from these average values surveyed, the quality of fat nutrition ingested by Koreans adults reveals no serious problem yet. But this trend becomes more serious for children who are exposed to the western-style energy-rich fast foods.

Fatty acid intake of the HFLM and LFHM groups are shown in Table 3 and 4. The ω3 series fatty acid intakes are shown to be higher in the high fish (HFLM) group than in the low fish (LFHM) group as expected ($p<0.01$). Intake of ω3 series fatty acids, especially EPA ($p<0.01$) and DHA ($p<0.01$) in the HFLM group appeared to be significantly higher than those in the LFHM group. For ω6 series fatty acids, there was no difference found between the two groups, but intake of ω6 series fatty acids in the LFHM group tended to be higher than in the HFLM group. The average ratio of ω6/ω3 fatty acids was lower in the HFLM group (12.6) than in the LFHM group (15.6), but the difference was not significant. The difference between male (16.5) and female (12.0) intake was significant ($p<0.001$).

4. Comparison of serum fatty acids compositions between HFLM & LFHM group

Serum fatty acid compositions of the HFLM & LFHM are shown in Table 5. On the whole, there was no difference between groups except for 18 : 3ω6 compositions in serum. Intake of fish and meats had little effect on serum individual fatty acids and fatty acid ratios. In Oh's report,[9] which was a comparison study of total serum fatty acid composition by fish intake, there was no significant difference in PUFA, MUFA, SFA composition and P/S ratio. 16 : 0 was the major SFA in serum (56 – 71% of total SFA) and 18 : 1 (ω9) was the predominant MUFA (89% of total MUFA). LA, AA and DHA were the major PUFA and consisted of 73 – 74%, 11.9 – 12.6% and 5.0 – 5.4% of total PUFA, respectively.

Table 5. Effect of fish and meat intake on the individual fatty acid composition of serum (Unit : Area %)

Fatty Acid	HFLM	LFHM
C12 : 0	0.16±0.13	0.18±0.23
C14 : 0	0.86±0.40	0.84±0.53
C15 : 0	0.16±0.04	0.16±0.06
C16 : 0	23.75±1.87	23.92±2.40
C16 : 1	2.23±0.75	2.49±0.72
C18 : 0	8.33±0.65	8.05±0.95
C18 : 1	22.34±2.70	22.65±2.36
C18 : 2 (ω6)	30.33±4.00	30.15±3.06
C18 : 3 (ω6)	0.40±0.19	0.31±0.12*
C18 : 3 (ω3)	0.47±0.22	0.44±0.17
C20 : 0	0.07±0.04	0.06±0.03
C20 : 1	0.16±0.06	0.16±0.04
C20 : 2 (ω6)	0.26±0.05	0.26±0.06
C20 : 3 (ω6)	1.44±0.36	1.50±0.36
C20 : 4 (ω6)	4.94±1.28	5.14±1.12
C20 : 4 (ω3)	0.05±0.03	0.05±0.03
C20 : 5 (ω3)	0.45±0.19	0.48±0.28
C22 : 1	0.33±0.21	0.31±0.15
C22 : 4 (ω6)	0.18±0.06	0.20±0.09
C22 : 5 (ω6)	0.14±0.05	0.13±0.05
C22 : 5 (ω3)	0.42±0.12	0.46±0.17
C22 : 6 (ω3)	2.26±0.49	2.06±0.68
PUFA	41.5±4.36	40.9±3.92
MUFA	25.1±3.10	25.6±2.53
SFA	33.3±2.62	33.0±2.76
P/S	1.3±0.20	1.3±0.17
M/S	0.8±0.10	0.8±0.10
ω6	37.9±4.23	37.6±3.60
ω3	3.7±0.78	3.5±0.96
ω6/ω3	10.9±2.71	11.5±3.25

Values are Means±SD
* : Significantly different from the value of HFLM group at $p<0.05$
HFLM : Fish intakes ≥125% of mean fish intakes & meat intakes ≤ 75% of mean meat intakes
LFHM : Fish intakes ≤75% of mean fish intakes & meat intakes ≥ 125% of mean meat intakes

5. Correlations between dietary fatty acids and serum fatty acid compositions

The relationship between dietary fatty acid and serum fatty acid composition was analyzed by Pearson corre-

Table 6. Correlation coefficients of fatty acids in the diet and in serum of the subjects

48 Serum fatty acid / Dietary fatty acid	12 : 0	14 : 0	16 : 0	18 : 0	18 : 2ω6	18 : 3ω3	20 : 4ω6	20 : 5ω3	22 : 6ω3	PUFA	MUFA	SFA	P/S	ω3	ω6	ω6/ω3
Energy	-0.006	-0.090	0.038	-0.099	0.084	-0.105	-0.287*	-0.010	-0.098	-0.006	0.033	-0.027	-0.006	-0.106	-0.005	0.072
Fat	0.071	-0.019	-0.016	0.042	0.044	-0.155	-0.130	-0.034	-0.048	-0.000	0.033	-0.013	-0.000	-0.077	0.005	0.063
Cholesterol	-0.062	0.002	0.040	-0.011	-0.108	-0.127	-0.063	-0.041	0.051	-0.074	0.108	0.036	-0.071	-0.023	-0.093	-0.055
12 : 0	0.165	0.226	0.086	0.124	-0.027	-0.179	-0.283*	-0.205	-0.041	-0.050	-0.033	0.184	-0.124	-0.202	-0.028	0.202
14 : 0	0.165	0.207	0.093	0.103	-0.026	-0.152	-0.387**	-0.200	-0.117	-0.056	-0.032	0.173	-0.126	-0.071	-0.038	0.148
16 : 0	0.146	0.100	0.052	0.010	0.049	-0.068	-0.268*	-0.252	-0.119	-0.005	-0.050	0.108	-0.066	-0.061	0.016	0.128
18 : 0	0.136	0.090	0.051	0.011	0.036	-0.113	-0.241	-0.192	-0.131	-0.013	-0.031	0.086	-0.057	-0.159	0.007	0.120
18 : 1ω9	0.168	0.096	0.073	-0.058	0.076	-0.117	-0.184	-0.167	-0.086	0.019	-0.094	0.106	-0.047	-0.135	0.042	0.097
18 : 2ω6	0.141	0.051	0.008	-0.055	0.140	0.007	-0.096	-0.192	-0.086	0.078	-0.117	0.032	0.031	-0.121	0.101	0.133
18 : 3ω3	0.123	0.055	0.078	-0.125	0.021	0.054	-0.209	-0.091	-0.026	-0.049	0.064	0.070	-0.063	-0.046	-0.101	-0.017
20 : 4ω6	-0.100	-0.037	0.022	0.026	-0.122	-0.090	-0.232	-0.100	0.075	-0.068	0.107	0.035	-0.073	0.022	-0.088	-0.112
20 : 5ω3	-0.041	0.074	0.103	0.114	-0.055	-0.046	-0.390**	-0.039	0.148	-0.029	-0.062	0.144	-0.083	0.088	-0.062	-0.137
22 : 6ω3	-0.063	0.031	0.038	0.094	0.021	-0.020	-0.340	-0.052	0.153	0.029	-0.084	0.078	-0.013	0.090	-0.002	-0.118
PUFA	0.139	0.057	0.018	-0.052	0.137	0.006	-0.142	-0.199	-0.071	0.074	-0.117	0.045	0.022	-0.112	0.092	0.116
MUFA	0.160	0.097	0.081	-0.043	0.064	-0.120	-0.200	-0.161	-0.072	0.010	-0.091	0.115	-0.058	-0.122	0.030	0.082
SFA	0.166	0.139	0.072	0.026	0.030	-0.111	-0.295*	-0.251	-0.142	-0.028	-0.036	0.133	-0.092	-0.189	-0.005	0.154
P/S	0.081	-0.028	-0.078	-0.015	0.158	0.196	-0.013	0.176	0.031	0.156	-0.160	-0.054	0.130	0.114	0.131	-0.093
ω3	0.029	0.055	0.086	0.076	0.023	-0.009	-0.403*	-0.106	0.099	0.006	-0.074	0.140	-0.060	0.039	0.016	-0.016
ω6	0.148	0.075	0.069	-0.059	0.087	0.134	-0.252	-0.165	-0.130	-0.000	-0.052	0.097	-0.050	-0.110	-0.024	0.110
ω6/ω3	-0.045	-0.073	-0.079	-0.079	0.007	0.035	0.086	0.046	-0.256	-0.075	0.114	-0.105	-0.015	-0.162	-0.008	0.227

* : Significantly correlated between fatty acid intakes and serum fatty acid composition at $p<0.05$, ** : $p<0.01$
Test was performed only for HFLM & LFHM group

lation test at $\alpha<0.05$. The results are summarized in Table 6. Energy intake and dietary SFAs such as 12 : 0 ($p<0.05$), 14 : 0 ($p<0.01$) and 16 : 0 ($p<0.05$) were negatively associated with serum arachidonic acid (AA 20 : 4ω6) levels expressed as a percentage of the total fatty acids. Dietary EPA (ω3) and total ω3 fatty acids were also negatively associated with serum AA (ω6) composition. These results indicate that ω6 and ω3 PUFA compete for incorporation into serum and tissue lipids and for elongation and desaturation processes because of similarity in structure. The effects of dietary saturated fatty acids on ω6 arachidonic acid in serum need to be properly assessed. Fatty acid composition in plasma total lipid or subfractions of lipids, such as phospholipid and cholesterol ester, reflects the pattern of recent fatty acid intakes. Bjerve *et al.*[38] reported that ω3 fatty acids intakes positively associated with EPA and DHA concentrations of serum phospholipids.

SUMMARY AND CONCLUSION

The major objectives of this study were to identify issues and problems associated with nutrient intake, especially individual fatty acids of children and adolescents in Korea.

1) In serum lipid levels of Korean adolescents, total Chol ($p<0.05$) and HDL-Chol ($p<0.001$) levels of females were significantly higher than males.

2) The average fat intake of Korean adolescents was 23 – 26 energy %, which agrees with the current recommendation (15 – 25%) for adults.

3) Although the average dietary P/M/S ratio of fat ingested was 1.1/1.2/1.0, which is close to an ideal ratio, the average dietary ω6/ω3 fatty acid ratio was found to be 12.0 – 16.5, which is higher than the presently recommended range of 4 – 10. Mean daily intake of Chol was 337 – 361 mg.

4) Energy intake and dietary SFAs such as 12 : 0 ($p<0.05$), 14 : 0 ($p<0.01$) and 16 : 0 ($p<0.05$) were negatively associated with serum AA (ω6) levels. Dietary total ω3 fatty acids ($p<0.05$) and EPA ($p<0.01$) were also negatively associated with serum AA levels.

Improvements in total income and an increase in western-style commercial food-service systems make Korean children and adolescents vulnerable to excessive and unbalanced food intake such as fatty acids and energy. It is recommended that ω3 series fatty acid rich-foods such as soy bean, bean products and fishes should be eaten more frequently to bring down the dietary ω6/ω3 ratios to the desirable range of 4/1 – 10/1. In accurately evaluating fatty acid intake, it is imperative to have the fatty acid composition data of all foods consumed in each country.

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