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☐ **Original Article** ☐

The Associations of Percent Body Fat with Dietary Intake, Plasma Lipids, Lipoprotein(a), and PAI-1 in Middle Aged Korean Adults

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ABSTRACT

This study was designed to investigate the associations of the percent body fat with dietary intake, plasma lipoprotein profile, lipoprotein(a), and plasminogen activator inhibitor-1(PAI-1) concentrations of 1982 Korean subjects(men : 1000 and women : 982) between the ages of 40 and 59 years. The dietary assessment consisted of twenty-four hour dietary records and food frequency questionnaires. The subjects were identified into one of the five rating groups of % body fat : lean, underweight, normal, overweight and obese groups. The biochemical assessment included measurements of plasma total cholesterol(TC), HDL-cholesterol(HDL-C), LDL-cholesterol(LDL-C), triglyceride(TG), lipoprotein(a)(Lp(a)), and PAI-1. With respect to the ratio of percent energy intake of carbohydrate : protein : fat of the normal group of the women was 62% : 17% : 20%, respectively. Women apparently had a higher intake of carbohydrates than men(52% : 17% : 20%) did. There was a linear relationship between energy intake and % body fat in both men and women(with the exception of the underweight group of women). The relationship of % body fat of men to the protein and fat intake was higher than that of the carbohydrate intake. Of the men in the study, intakes of energy, protein and alcohol were positively correlated to % body fat. In women, energy, carbohydrate and protein intake were positively correlated to % body fat, however, the fat, cholesterol and alcohol intake did not show any correlation to the % body fat in this study. The percent energy intake of protein was positively correlated to % body fat in women. This study showed that % body fat was positively correlated with plasma TC, LDL-C, PAI-1 levels, and TG, but the % body fat was negatively correlated with plasma HDL-C level in both men and women. These results indicated that the high energy intake of obese or overweight subjects might contribute to several of the biochemical indices of coronary heart disease(CHD) risk. In conclusion, increased energy intake is associated with overweight or obesity in middle aged Korean people. There was no relationship between % energy intake of fat and % body fat in the study, in middle-aged Korean men and women. The plasma lipid profile and PAI-1 level thought to be the risk factors of CHD were positively associated with percent body fat in middle aged Korean people. (*Korean J Community Nutrition* 3(5) : 695~706, 1998)

KEY WORDS : percent body fat · dietary intake · blood lipids · lipoproteins · PAI-1.

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Introduction

In Korea, rapid economic growth has influenced Korean's life style, dietary habit and food intake since 1970. The intake of meat, fish, fruits, and milk products has been gradually increased, but the intake of cereals has been decreased(Korean Ministry of Statistics 1997). In 1995, the Korean National Nutrition Nationwide Survey reported that the nutrient intake as % of Recommended Dietary Allowances(RDA) showed 88.6% of energy, 116.7% of protein, 67% of vitamin A(lowest) and ascorbate 185.4%(highest)(Ministry of Health & Welfare 1997). These reports indicate that Korean's nutritional status has been improved.

The Korean National Nutrition Survey of 1991, 1992, and 1995 reported that 17.1%(Korean Ministry of Statistics 1993), 19.6%(Korean Ministry of Statistics 1994) and 20.5%(Ministry of Health & Welfare 1997) of the people who were over 20 years old showed a Body Mass Index(BMI) of greater than 25 kg/m^2 respectively. Obesity appears to be increasing in the young and middle aged population in Korea. Obesity is a condition where there is an abnormally high percent of body fat, or being overweight is a condition where there is an increase of body weight above a standard defined amount in relation to height. Both, the extent of being overweight and fat distribution may be useful predictors of health risks associated with obesity(Bay 1985 ; Huh 1990). A number of studies have shown that hypertension, cardiovascular diseases, and diabetes are related to obesity and also increase the death rate(Sjostorm 1992 ; Kim 1993) in Korea.

Numerous studies also showed that the composition of diet might influence energy metabolism in humans(Davis 1997 ; Dreon et al. 1988 ; Miller et al. 1990a ; Miller et al. 1994b ; Ortega et al. 1995). Miller et al. reported that obese individuals did not consume more energy than their non-obese counterparts (Miller et al. 1990a). Some animal studies showed that a high fat diet induced obesity(Hill 1990 ; Triscari et al. 1985). Some such studies used isocaloric diets in fat and carbohydrate, which offer compelling evidence that diet composition is important in the aerology of obesity(Triscari et al. 1985).

The major cause of death also has been changed from communicable diseases in 1970 to non-communicable diseases in 1980 in Korea(Kim 1993). The incidence of ischemic heart disease increased about 3 times in the last 10 years(Korean Ministry of Statistics 1997). The risk factors for the development of coronary heart disease(CHD), as determined by numerous cross-sectional and longitudinal studies, are hypertension, elevated concentrations of LDL-cholesterol, and decreased concentrations of plasma HDL-cholesterol(Anderson 1990 ; Ahn & Lee 1993). It is important to determine whether dietary intakes are associated with the incidence of obesity in middle-aged Korean adults, and furthermore if percent body fat can be possibly associated with plasma lipoprotein profiles. The purpose of this study was to investigate the relationship of percent body fat with dietary intake, and in addition, the relationship between % body fat and plasma lipids, lipoprotein(a), and PAI-1 levels in middle aged Korean men and women in the middle socioeconomic class.

Methods

1. Subjects

This study was designed to observe 1982 subjects (men : 1000, women : 982) from 40 to 59 years (men : 500 subjects in 40's, 500 in 50's & women : 553 subjects in 40's, 429 in 50's). The subjects in the study were randomly selected from healthy people for having a physical examination at the Health Promotion Center of the Samsung Medical Center during the period of January 1 to December 31 of 1997.

2. Anthropometric measurements

The mean age, height, weight, Body Mass Index (BMI), and % body fat were measured for both men and women. Height, weight, Body Mass Index(BMI) and percent body fat were measured by a bioelectric impedance analyzer(TBF-202 TANITA, Japan, which have a conversion computer program from height and weight to BMI). Subjects were identified into

one of the five groups of reference values for percent body fat(Gettman LR Standard Values for Percent Body Fat in Fitness Testing(Gettman 1993) modified from Jackson & Pollock(1978), and Jackson et al. (1980)). Percent body fat measurements were taken respect to the following five groups by ages and gender : lean, underweight, normal(average), overweight and obese. The reference values are shown in Table 1. Data and the relevant variables were analyzed by classified percent of body fat.

3. Dietary assessment

Twenty-four hour food records were taken and food frequency questionnaires were used. Nutrients, % energy intake and food intake were analyzed by a computer data analysis program.

4. Biochemical assessment

Measurements included biochemical analysis of plasma total cholesterol(TC), HDL-cholesterol(HDL-C), LDL-cholesterol(LDL-C), triglyceride(TG), lipoprotein(a), and plasminogen activator inhibitor-1(PAI-1). All blood samples were drawn after 14 hours fasting period and the blood was drawn via venipuncture. Plasma was segregated. Plasma TC, TG, and HDL-C concentrations were determined by an Hitachi-747 Automatic Chemical Analyzer. LDL-C was calculated by the Friedwald method(Friedwald et al. 1972). Lipoprotein(a) was determined by the kinetic nephelometry method, using a protein system kit(Beckman, USA). PAI-1 was measured by enzyme-linked immunosorbent assay(ELISA)(DeClerck 1988).

Table 1. Reference values for percent body fat[1] by ages and gender

Rating/Age (years)	Percent body fat(%)			
	Men		Women	
	40 – 49	50 – 59	40 – 49	50 – 59
Lean	<14	<15	<18	<19
Underweight	14 – 16	15 – 17	18 – 21	19 – 22
Normal	17 – 23	18 – 24	22 – 30	23 – 31
Overweight	24 – 26	25 – 27	31 – 33	32 – 34
Obese	>26	>27	>33	>34

1) Gettman, LR. Standard values for percent body fat in fitness testing(1993) American College of Sports Medicine Resource Manual 2nd ed. p.235

5. Clinical assessment

Physical examinations were taken to determine whether the subjects were free of serious diseases.

Macronutients, alcohol, cholesterol intake/day, % energy intake/day and lipoprotein levels were then assessed to determine whether there was any relationship between the above variables(data) and the five classified groups of % body fat.

6. Statistical analysis

All the data was analyzed and downloaded from a host computer system. Statistical analysis was performed by a Statistical Analysis System(SAS). A General Linear Model procedure was used, as well as F-test, and Scheffe's multiple range test, and Pearson's product-moment correlation coefficient test for all the variables.

Results

1. Anthropometry

1) Age and anthropometric characteristics of men and women whose ages ranged from 40 to 59

In Table 2, the mean age of men was 49.3±5.5 years(44.5±2.7 years in 40's, 54.1±2.7 years in 50's), and the mean age of women was 48.5±5.6

Table 2. Age and anthropometric characteristics of men and women

Variables	Men(n=1000)		Women(n=982)	
Age(years)	40 – 49(n=500)	50 – 59(n=500)	40 – 49(n=553)	50 – 59(n=429)
Age(years)	44.5±2.7	54.1±2.7	44.2±2.9	54.0±2.6
Body weight(kg)	70.1±8.9	69.5±8.2	56.9±7.5	58.5±7.0
Height(cm)	170.9±5.4	169.8±5.2	158.3±4.6	157.5±4.6
BMI(kg/m^2)[1]	24.0±2.6	24.1±2.5	22.7±2.8	23.6±2.6
Percent body fat(%)[2]	22.8±4.7	22.3±4.6	29.1±5.7	30.1±5.7

1) Modified classifications of the BMI by Health Analysis Canada(1988)
2) Gettman, LR. Standard values for percent body fat in fitness testing(1993) American College of Sports Medicine Resource Manual 2nd ed. p.235

years(44.2±2.9 years in 40's, 54.0±2.6 years in 50's). The mean height of men was 170.3±5.3cm, and the mean height for women was 157.9±4.6cm. The mean weight of men was 69.8±8.6kg, and the mean weight of women was 57.6±7.3kg. The mean BMI of men was 24.0±2.6kg/m^2 which is normal BMI category, but the BMI range was from 13.6kg/m^2 to 39.2kg/m^2. The mean BMI of women was 23.4±6.7kg/m^2 which is also normal BMI category(ranged from 16.1kg/m^2 to 52.9kg/m^2). The % body fat of men was 22.6±4.7% which ranged from 2.2 to 36.1%. The % body fat of men in 40's was 22.8±4.7% and 22.3±4.6% in 50's. The % body fat of women was 29.5±5.7% which ranged from 11.8 to 56.5 %. The % body fat of women in 40's was 29.1±5.7% and 30.1±5.7% in 50's.

2) Percent body fat

Gettman's(1993) 'Standard values for percent body fat' which was based on Jackson et al.'s(1978, and 1980) rating system was used to find out the distribution of men and women in the five rating groups of reference values of the % body fat. Subjects were identified into one of five rating groups of the reference values of % body fat. In Table 3, the results showed that in men, 547 subjects(54.7%) were in the normal range and 336 subjects(33.6%) were overweight and obese. In women, 544 subjects(55.4%) were in the normal range and 350 subjects(35.6%) were overweight and obese. This results of the % body fat of >28% in men were 14.4% of total subjects that showed lower than that of the women whose % body fat were >34%. Body fat may be one of the useful predictors of health risks associated with obesity. Obesity also seems to occur more frequently among those Koreans belonging to the middle or the upper economic class.

2. The relationship between daily intake of nutrients and percent body fat of men and women

In Table 4, with respect to the mean daily energy intake of the men subjects, the levels of daily energy intake appeared to increase as values of % body fat increased. The daily intake of energy for men in the

Table 3. Distribution of men and women in the five rating groups of the % body fat[1)]

Rating/Age(years)	Men(n=1000)			Women(n=982)		
	40 – 49	50 – 59	Total	40 – 49	50 – 59	Total
Leann(%)	18(3.6)	27(5.4)	45(4.5)	12(2.2)	13(3.0)	25(2.5)
Underweightn(%)	29(5.8)	43(8.6)	72(7.2)	35(6.3)	28(6.5)	63(6.4)
Normaln(%)	248(49.6)	299(59.8)	547(54.7)	317(57.3)	227(52.9)	544(55.4)
Overweightn(%)	114(22.8)	78(15.6)	192(19.2)	102(18.4)	82(19.1)	184(18.7)
Obesen(%)	91(18.2)	53(10.6)	144(14.4)	87(15.7)	79(18.4)	166(16.9)

1) Gettman, LR. Standard values for percent body fat in fitness testing(1993) American College of Sports Medicine Resource Manual 2nd ed. p.235, modified from Jackson AS, Pollock ML : Generalized equations for predicting body density of men. Br J Nutr, 40 : 497-504, 1978. Jackson AS, Pollock ML, and Ward A : Generalized equations for predicting body density of women. Med Sci Sports Exerc 12 : 175-182, 1980

Table 4. Daily intake of macronutrients, alcohol and cholesterol by men in the % body fat[1)]

% body fat rating	Men(n=1000)				
Nutrient intake/day	Lean (n=45)	Underweight (n=72)	Normal (n=547)	Overweight (n=192)	Obese (n=144)
Energy(kcal)	1977.2±451.5^{b}	2037.6±471.5^{b}	2221.6±586.6^{ab}	2275.8±668.9^{ab}	2358.5±762.7^{a}
Carbohydrate(g)	250.0± 60.9^{a}	277.4± 60.1^{a}	277.2± 72.0^{a}	268.3± 71.7^{a}	267.1± 73.8^{a}
Protein(g)	90.2± 30.8^{ab}	86.8± 27.9^{b}	95.0± 29.5^{ab}	98.2± 31.0^{ab}	101.9± 33.5^{a}
Fat(g)	46.5± 23.9^{a}	42.2± 18.7^{a}	49.7± 29.7^{a}	48.1± 27.4^{a}	52.9± 37.1^{a}
Alcohol(g)	104.0±193.9^{a}	157.6±325.4^{a}	185.0±314.9^{a}	233.9±384.4^{a}	247.5±334.1^{a}
Cholesterol(mg)	224.4±147.6^{a}	262.0±185.7^{a}	266.1±175.3^{a}	279.6±165.5^{a}	297.2±178.6^{a}

1) Gettman, LR. Standard values for percent body fat in fitness testing(1993) American College of Sports Medicine Resource Manual 2nd ed. p.235

^{abc}, Means within the same row with different superscript differ significantly by Scheffe's multiple range test(α=0.05) in men

normal(17~24% body fat range) group was 2221.6±586.6kcal/day. Of the men in the study, the energy intake for the obese(2358.5±762.7kcal/day) group was significantly higher than that of the underweight (2037.6±471.5kcal/day) and lean(1977.2±451.5 kcal/day) groups $\alpha=0.05$. Of the men, the protein intake for the obese(101.9±33.5g/day) group in the study was significantly higher than that of the underweight(86.8±27.9g/day) group at $\alpha=0.05$. The daily intakes of carbohydrates, fat, alcohol, and cholesterol of the men subjects appeared to increase as the values of % body fat increased, although, the five rating groups of % body fat showed no significant differences in the carbohydrates, fat, alcohol and cholesterol consumed.

In Table 5, the daily intake of energy for women in the normal(22~31% body fat range) group was 1747.0±445.7kcal/day. Of the women in the study, the carbohydrate intake of the overweight group(285.5±74.6g/day) was significantly higher than that of the normal(266.6±67.8g/day) and underweight(258.5±71.1g/day) groups, and the protein intake of the overweight group(78.9±30.3g/day) was significantly higher than that of the normal(72.0±23.7g/day), underweight(67.6±22.9g/day) and lean(71.6±23.3 g/day) groups at $\alpha=0.05$. Of the women in the study, the five rating groups of % body fat showed no significant differences in energy, fat, and alcohol and cholesterol consumption.

3. The relationship between daily intake of % energy and percent body fat of men and women

The daily intake of energy for men in the normal (17~24% body fat range) group was 2221.6±586.6 kcal/day. In Table 6, the % energy intake of carbohydrates : protein : fat of the normal group of men showed a ratio of 52 : 17 : 20, respectively. Of the men group in the study, the % energy intake of carbohydrate showed that the underweight group(55.9 ±11.3g/day) was significantly higher than that of the obese group(48.1±14.0g/day) and overweight group(49.5±14.4g/day) at $\alpha=0.05$. The percent en-

Table 5. Daily intake of macronutrients, alcohol and cholesterol by women in the % body fat[1)]

% body fat rating	Women(n=982)				
Nutrient intake/day	Lean (n=25)	Underweight (n=63)	Normal (n=544)	Overweight (n=184)	Obese (n=166)
Energy(kcal)	1733.0±437.6[a]	1667.7±416.9[a]	1747.0±445.7[a]	1864.3±522.6[a]	1750.6±467.1[a]
Carbohydrate(g)	272.7± 63.4[ab]	258.5± 71.1[b]	266.6± 67.8[b]	285.5± 74.6[a]	271.8± 78.1[ab]
Protein(g)	71.6± 23.3[b]	67.6± 22.9[b]	72.0± 23.7[b]	78.9± 30.3[a]	74.4± 25.4[ab]
Fat(g)	35.8± 20.5[a]	36.0± 19.4[a]	39.0± 19.6[a]	40.1± 22.7[a]	36.1± 17.0[a]
Alcohol(g)	11.0± 42.1[a]	31.5±193.5[a]	25.5±123.9[a]	19.1± 87.3[a]	10.3± 51.4[a]
Cholesterol(mg)	240.0±211.1[a]	199.6±171.2[a]	207.9±156.2[a]	218.5±191.1[a]	215.5±167.5[a]

1) Gettman, LR. Standard values for percent body fat in fitness testing(1993) American College of Sports Medicine Resource Manual 2nd ed. p.235

[abc], Means within the same row with different superscript differ significantly by Scheffe's multiple range test($\alpha=0.05$) in women

Table 6. Composition of percent energy intake by men in the % body fat[1)]

% body fat rating	Men(n=1000)				
% energy intake/day	Lean (n=45)	Underweight (n=72)	Normal (n=547)	Overweight (n=192)	Obese (n=144)
Carbohydrate(%)	52.1±12.9[ab]	55.9±11.3[a]	51.7±12.9[ab]	49.5±14.4[b]	48.1±14.0[b]
Protein(%)	18.2± 3.9[a]	17.0± 3.7[a]	17.3± 4.0[a]	17.7± 4.8[a]	17.7± 4.2[a]
Fat(%)	20.8± 7.8[a]	18.4± 5.4[a]	19.5± 7.5[a]	18.5± 6.9[a]	19.4± 8.1[a]
Alcohol(%)	6.8±12.5[a]	7.2±11.0[a]	9.8±13.1[a]	12.6±15.3[a]	13.2±15.4[a]

1) Gettman, LR. Standard values for percent body fat in fitness testing(1993) American College of Sports Medicine Resource Manual 2nd ed. p.235

[abc], Means within the same row with different superscript differ significantly by Scheffe's multiple range test($\alpha=0.05$) in men

Table 7. Composition of percent energy intake by women in the % body fat[1]

% body fat rating	Women(n=982)				
% energy intake/day	Lean (n=25)	Underweight (n=63)	Normal (n=544)	Overweight (n=184)	Obese (n=166)
Carbohydrate(%)	63.6±8.2[a]	62.5±9.3[a]	61.6±8.8[a]	62.1±8.9[a]	62.3±8.2[a]
Protein(%)	16.6±3.6[a]	16.2±3.3[a]	16.5±3.3[a]	16.8±3.5[a]	17.1±4.1[a]
Fat(%)	17.8±6.5[a]	18.8±7.0[a]	19.6±6.5[a]	18.7±6.1[a]	18.3±5.6[a]
Alcohol(%)	0.4±1.6[a]	1.1±6.3[a]	0.9±3.7[a]	0.8±3.7[a]	0.8±4.0[a]

1) Gettman, LR. Standard values for percent body fat in fitness testing(1993) American College of Sports Medicine Resource Manual 2nd ed. p.235

[abc], Means within the same row with different superscript differ significantly by Scheffe's multiple range test(α=0.05) in women

ergy intake of carbohydrate in overweight or obese men was less than in normal, underweight, or lean men. Of the men in the study, the five rating groups of % body fat showed no significant differences in % energy intakes of protein, fat and alcohol.

The daily intake of energy for women in the normal group was 1764.1±464.7kcal per day. In Table 7, the ratio of % energy of carbohydrates : protein : fat of the normal group of the women showed a ratio of 62 : 17 : 20, respectively. This appears to show that women had a higher intake of carbohydrates than men did. In Table 7, the five rating groups of % body fat showed no significant differences in % energy intakes of carbohydrate, protein, fat and alcohol of the women subjects. The % energy intake of alcohol was 9.8±13.1% of the men in the study, but the women's % energy intake was 0.9±3.7%. Thus, it appears that men in the study have shown a much higher alcohol intake than women. However, the ratio of % energy intake of fat in middle class Korean of the normal group of men and women in the study appeared lower than any other country where such measurements have been taken.

4. The correlation between % body fat and the daily intake of nutrients, cholesterol and alcohol

The relationship between the nutrient intake and % body fat data is shown in Table 8. In men, the percent body fat was positively and significantly related to energy intake($r=0.16$ at $p<0.001$), protein intake($r=0.15$ at $p<0.001$), fat intake($r=0.06$ at $p<0.05$), cholesterol intake($r=0.10$ at $p<0.01$), and alcohol intake($r=0.10$ at $p<0.001$). The percent energy intake of protein and fat were not related to % body fat. The relationship of % body fat of men to the protein and fat intake was stronger than that of the carbohydrate intake. A strong positive correlation was observed between the % body fat of men and there intake of energy, protein, and alcohol in the study. It showed that the intake of energy in overweight(including obese) subjects was 89% and 88% of the energy for Korean RDA(1995) for men and women of same ages, respectively.

Table 8. Pearson's correlation coefficients between % body fat and nutrients intake, cholesterol and alcohol

	Men	Women
Energy intake(kcal)	0.158***	0.071*
Carbohydrate(g)	—	0.075*
Carbohydrate(%)	−0.124***	—
Protein(g)	0.146***	0.088**
Protein(%)	—	0.063*
Fat(g)	0.063*	—
Fat(%)	—	—
Cholesterol(mg)	0.098**	—
Alcohol(g)	0.102***	—

*$p<0.05$ **$p<0.01$ ***$p<0.001$

In women, the energy intake($r=0.07$ at $p<0.05$), carbohydrate intake($r=0.08$ at $p<0.05$) and protein ($r=0.09$ at $p<0.01$) intake were positively and significantly correlated to their % body fat, however, the fat, cholesterol, and alcohol intake did not show any correlation to the % body fat in this study. The percent energy intake of carbohydrate and fat were not related to % body fat in women. The percent energy intake of protein($r=0.06$ at $p<0.05$) was positively correlated to % body fat. The data suggest that energy,

protein, carbohydrate intake and % energy intake of protein may play a role in adiposity in women.

5. The relationship between plasma lipid levels and % body fat of men and women

1) Total cholesterol(TC)

In Table 9, of the men in the study, the obese group showed that their plasma TC level(5.53±0.91 mmol/L) was significantly higher than that of the normal group(5.15±0.86mmol/L), the underweight group(4.91±0.88mmol/L) and the lean(4.89±0.81 mmol/L) at $\alpha=0.05$. In Table 10, of the women in the study, the obese(5.39±0.92mmol/L) or overweight(5.22±0.92mmol/L) groups showed that their plasma TC levels were significantly higher than that of the normal group(4.97±0.91mmol/L) or the underweight group(4.94±0.91mmol/L) and the lean group(4.67±0.82mmol/L) at $\alpha=0.05$.

2) HDL-Cholesterol

In Table 9, of the men in the study, the obese(1.20±0.22mmol/L), the overweight(1.19±0.28 mmol/L) and the normal(1.23±0.28mmol/L) groups showed that their plasma HDL-C levels were significantly lower than that of the lean group(1.47±0.36mmol/L) or the underweight group(1.39±0.39 mmol/L) at $\alpha=0.05$. In Table 10, of the women in the study, the obese(1.37±0.34mmol/L) and the overweight(1.40±0.32mmol/L) groups showed that their plasma HDL-C levels were significantly lower than that of the underweight(1.61±0.37mmol/L) and lean(1.64±0.44mmol/L) groups. In the women, the normal(1.47±0.34mmol/L) group was significantly lower than that of the underweight(1.61± 0.37mmol/L) and lean(1.64±0.44mmol/L) groups at $\alpha=0.05$.

3) LDL-Cholesterol(LDL-C)

In Table 9, of the men in the study, the obese group showed that their plasma LDL-C level(3.35±0.88mmol/L) was significantly higher than that of the normal(3.09±0.79mmol/L), underweight(2.90±0.73mmol/L) and lean(2.90±0.69mmol/L) groups at $\alpha=0.05$. In Table 10, of the women in the study, the obese(3.29±0.81mmol/L) and the overweight(3.19±0.79mmol/L) groups showed that their plasma LDL-C level were significantly higher than that of the normal(2.94±0.81mmol/L), the underweight(2.90±0.78mmol/L) and the lean(2.58±0.66mmol/L) groups at $\alpha=0.05$.

Table 9. Lipoprotein profiles of men in the five rating groups of % body fat[1)]

% body fat Blood variables	Lean	Underweight	Normal	Overweight	Obese
Total cholesterol (mmol/L)	4.89± 0.81^{b} (n=45)	4.91± 0.88^{b} (n=72)	5.15± 0.86^{b} (n=547)	5.24± 0.84^{ab} (n=192)	5.53± 0.91^{a} (n=143)
HDL-cholesterol (mmol/L)	1.47± 0.36^{a} (n=45)	1.39± 0.39^{a} (n=72)	1.23± 0.28^{b} (n=547)	1.19± 0.28^{b} (n=192)	1.20± 0.22^{b} (n=143)
LDL-cholesterol (mmol/L)	2.90± 0.69^{b} (n=45)	2.90± 0.73^{b} (n=72)	3.09± 0.79^{b} (n=543)	3.17± 0.76^{ab} (n=189)	3.35± 0.88^{a} (n=143)
Triglyceride (mmol/L)	1.14± 0.54^{b} (n=45)	1.35± 0.67^{b} (n=72)	1.84± 1.01^{a} (n=547)	2.00± 1.13^{a} (n=192)	2.13± 0.92^{a} (n=143)
Lipoprotein(a) (mg/dl)	24.0 ±22.9^{a} (n=45)	22.2 ±17.7^{a} (n=72)	20.6 ±20.3^{a} (n=547)	16.3 ±15.8^{a} (n=192)	21.4 ±21.4^{a} (n=143)
PAI-1 (ng/ml)	18.1 ±13.5^{c} (n=45)	22.4 ±13.8^{c} (n=72)	31.0 ±18.5^{b} (n=547)	40.5 ±26.6^{a} (n=192)	45.1 ±25.2^{a} (n=143)
Systolic blood pressure(mmHg)	1.15± 0.14^{c} (n=45)	1.20± 0.15^{bc} (n=72)	1.24± 0.15^{ab} (n=547)	1.25± 0.14^{ab} (n=192)	1.28± 0.14^{a} (n=144)
Diastolic blood pressure(mmHg)	0.78± 0.10^{b} (n=45)	0.82± 0.10^{b} (n=72)	0.85± 0.10^{ab} (n=547)	0.86± 0.10^{a} (n=192)	0.88± 0.11^{a} (n=144)

1) Gettman, LR. Standard values for percent body fat in fitness testing(1993) American College of Sports Medicine Resource Manual 2nd ed. p.235

^{abc}, Means within the same row with different superscript differ significantly by Scheffe's multiple range test($\alpha=0.05$) in men

4) Triglyceride(TG)

In Table 9, of the men in the study, the obese(2.13±0.92mmol/L), overweight(2.00±1.13mmol/L) and normal(1.84±1.01mmol/L) groups showed that their plasma TG level were significantly higher than that of the underweight(1.35±0.67mmol/L) and lean(1.14±0.54mmol/L) groups at $\alpha=0.05$. In Table 10, of the women in the study, the obese group showed that their plasma TG level(1.58±0.96mmol/L) was significantly higher than that of the normal(1.23±0.84mmol/L), the underweight(0.94±0.39 mmol/L) and the lean(0.98±0.38mmol/L) groups, and the overweight group showed that their plasma TG level(1.40±1.19mmol/L) was significantly higher than that of the underweight group(0.94±0.39 mmol/L) at $\alpha=0.05$.

These data show that the levels of plasma TG, TC, and LDL-C appeared to increase as values of % body fat increase, while levels of HDL-C appeared to decrease as values of % body fat increased which concur with Thelle et al.'s finding(1983).

5) Lipoprotein(a)

In Table 9, of the men in the study, the plasma lipoprotein(a) level showed no significant differences among the five rating groups of the % body although the lean group showed that their plasma lipoprotein(a) level was higher than that of the normal, underweight, overweight, and obese groups. There was no significant difference of the lipoprotein(a) levels of the women in the study(Table 10).

6) Plasminogen activator inhibitor-1(PAI-1)

In Table 9, of the men in the study, the obese group showed that their plasma PAI-1 level(45.1±25.ng/ml) was significantly higher than that of the normal group(31.0±18.5ng/ml), the underweight group(22.4±13.8ng/ml) and lean(18.1±13.5ng/ml) group at $\alpha=0.05$. Of the men in the study, the overweight group showed that their plasma PAI-1 level (40.5±26.6ng/ml) was significantly higher than that of the normal group(31.0±18.5ng/ml), the underweight group(22.4±13.8ng/ml) and lean(18.1±13.5 ng/ml) group at $\alpha=0.05$. In Table 10, of the women in the study, the obese(36.5±22.3ng/ml) and overweight(30.9±18.8ng/ml) groups showed that their plasma PAI-1 level were significantly higher than that of the normal(25.1±16.5ng/ml), the underweight(18.6±12.9ng/ml) and lean(18.6±8.1ng/ml) group at $\alpha=0.05$.

High plasma PAI-1 activity was found in obese and overweight groups of men and women subjects.

Table 10. Lipoprotein profiles of women in the five rating groups of % body fat[1)]

% body fat Blood variables	Lean	Underweight	Normal	Overweight	Obese
Total cholesterol (mmol/L)	4.67± 0.82^{b} (n=25)	4.94± 0.91^{b} (n=63)	4.97± 0.91^{b} (n=542)	5.22± 0.92^{a} (n=184)	5.39± 0.92^{a} (n=164)
HDL-cholesterol (mmol/L)	1.64± 0.44^{a} (n=25)	1.61± 0.37^{a} (n=63)	1.47± 0.34^{b} (n=542)	1.40± 0.32^{bc} (n=184)	1.37± 0.34^{c} (n=164)
LDL-cholesterol (mmol/L)	2.58± 0.66^{b} (n=25)	2.90± 0.78^{b} (n=63)	2.94± 0.81^{b} (n=541)	3.19± 0.79^{a} (n=183)	3.29± 0.81^{a} (n=164)
Triglyceride (mmol/L)	0.98± 0.38^{bc} (n=25)	0.94± 0.39^{c} (n=63)	1.23± 0.84^{b} (n=542)	1.40± 1.19^{ab} (n=184)	1.58± 0.96^{a} (n=164)
Lipoprotein(a) (mg/dl)	20.8 ±19.8^{a} (n=25)	22.7 ±18.5^{a} (n=63)	21.9 ±20.8^{a} (n=542)	22.1 ±20.2^{a} (n=184)	23.4 ±20.7^{a} (n=164)
PAI-1 (ng/ml)	18.6 ± 8.1^{b} (n=25)	18.6 ±12.9^{b} (n=63)	25.1 ±16.5^{b} (n=541)	30.9 ±18.8^{a} (n=184)	36.5 ±22.3^{a} (n=164)
Systolic blood pressure (mmHg)	1.18± 0.14^{bc} (n=25)	1.15± 0.13 c (n=63)	1.21± 0.15^{bc} (n=544)	1.23± 0.16^{b} (n=184)	1.29± 0.18^{a} (n=166)
Diastolic blood pressure	0.74± 0.09^{c}	0.75± 0.10^{bc}	0.79± 0.11^{bc}	0.81± 0.11^{b}	0.85± 0.12^{a}

1) Gettman, LR. Standard values for percent body fat in fitness testing(1993) American College of Sports Medicine Resource Manual 2nd ed. p.235

^{abc}, Means within the same row with different superscript differ significantly by Scheffe's multiple range test($\alpha=0.05$) in women

Table 11. Pearson's correlation coefficients between % body fat and plasma lipids and blood pressure

	Men	Women
Total cholesterol	0.197***	0.206***
HDL-cholesterol	−0.216***	−0.199***
LDL-cholesterol	0.165***	0.218***
Triglycerides	0.233***	0.193***
Lipoprotein(a)	—	—
PAI-1	0.332***	0.317***
Systolic blood pressure	0.171***	0.251***
Diastolic blood pressure	0.201***	0.275***

*$p<0.05$ **$p<0.01$ ***$p<0.0001$

6. The correlation between plasma lipids and % body fat

The relationship between blood variables and % body fat is shown in Table 11. In men and women, % body fat was significantly and positively correlated with blood variables. Of the men in the study, % body fat is significantly and positively correlated with plasma TC($r=0.20$ at $p<0.0001$), LDL-C($r=0.17$ at $p<0.0001$), TG($r=0.23$ at $p<0.0001$), PAI-1($r=0.33$ at $p<0.0001$), and negatively correlated with HDL-C($r=-0.22$ at $p<0.0001$). Of the women in the study, % body fat is significantly and positively correlated with TC($r=0.21$ at $p<0.0001$), LDL-C($r=0.22$ at $p<0.0001$), TG($r=0.19$ at $p<0.0001$), PAI-1 ($r=0.32$ at $p<0.0001$), and negatively correlated wi-th HDL-C($r=-0.20$ at $p<0.0001$).

The plasma triglyceride(TG), total cholesterol(TC), LDL-cholesterol(LDL-C) and plasminogen activator inhibitor-1(PAI-1) concentrations were significantly higher(at $p<0.05$), whereas plasma HDL-cholesterol (HDL-C) concentration was significantly lower($p<0.05$) in overweight or obese subjects than that of normal and underweight or lean subjects.

Lipoprotein(a) was not related to percent body fat. These data suggest that % body fat may relate to a risk factor of cardiovascular disease through its association with high PAI-1 activity and TC, TG levels in overweight and obese subjects.

Discussion

The finding of this study was that energy intake was one of the important factors associated with overweight or obesity in both men and women. The animal model studies indicated that diet composition, particularly dietary fat intake, could significantly affect the amount of body fat(Hill 1990 ; Triscari 1985). Some studies in developed countries indicated that obese subjects ingested about the same amount of energy as normal and lean subjects but their % energy intake of fat was greater in normal and lean subjects than that of obese subjects(Davis 1997 ; Dreon et al. 1988 ; Miller et al. 1990a ; Miller et al. 1994b ; Ortega et al. 1995). Colditz et al.(1990) reported that there was no relationship between percent energy intake of fat and obesity, but they also stated that a positive association between previous weight gain and relatively high fat intake. The finding of the present study indicated that percent energy intake of fat was not related to % body fat in men and women. The positive association between energy intake and % body fat was specifically in men in the study. In general, Koreans consume more carbohydrates and less fat than that of Western people. In this study, the ratio of % energy intake of carbohydrate : protein : fat was 52% : 17% : 20% in men and 62% : 17% : 20% in women. There was a positive correlation between percent energy intake of protein and % body fat in women. The chinese population in dietary survey showed similar results as this study(Yian et al. 1995).

The incidence of overweight or obesity has increased rapidly in Korean adults(Korean Ministry of Statistics 1997 ; Samsung Medical Center 1997). The relation between body fat and the development of CHD as well as risk factors for the diseases are well established(Ahn & Lee 1993 ; Lamon-Fava et al. 1994 ; Tucker et al. 1992). Several studies have shown that plasma concentrations of TG, TC, and LDL-C tended to be positively related to obesity, while concentration of HDL-C was shown to be opposite (Van Gaal et al. 1989 ; Eriksson et al. 1998 ; Juhan-Vague et al. 1987 ; Williams et al. 1986). Some studies(Choi et al. 1995 ; Cho & Kim 1995) illustrated the relationship between dietary intake and plasma lipid concentrations in middle-aged or younger Korean subjects. Cho & Kim(1995) reported that body

fat was positively correlated with serum lipid and was significantly and positively correlated with TG concentration. Choi(1995) showed that body weight, and BMI were significantly and positively correlated with plasma TG, and also showed that food with high dietary fiber decrease the concentrations of total cholesterol, triglyceride and artherogenic index. Our study showed that % body fat was positively correlated with plasma TG, TC, LDL-C concentrations, and blood pressure, and % body fat was negatively correlated with plasma HDL-C concentration in both men and women. Some of those results(Choi et al. 1995 ; Cho & Kim 1995) are similar to ours. These results imply that high energy intake shown in obese subjects, which may attribute to the several biochemical indices of CHD risk.

Lipoprotein(a) [Lp(a)] level was affected by various factors, such as alcohol drinking, body fat, and age, and is not only correlated with lipid levels but also with hemostatic factors such as fibrinogen and PAI-1(Nato et al. 1995). Duell et al.(1994) suggested the possibility that serum concentrations of Lp(a) may be modulated by a complex interplay between obesity, insulin action and exercise. Lecerf et al.(1996) found that Lp(a) was low in upper body obese women ($p<0.05$) and they suggested that Lp(a) is a better indicator of body fat distribution than HDL-cholesterol or apo A1. However, this study showed that there was no correlation between Lp(a) concentration and % body fat in both men and women.

High plasma plasminogen activator inhibitor-1(PAI-1) activity is frequently found in obesity, and both PAI-1 and obesity are risk factors for cardiovascular disease. Several studies(Eriksson et al. 1998 ; Sundell et al. 1989 ; Vague et al. 1989) observed the significant correlation between PAI-1 level and obesity. Juhan-Vague et al.(1987) reported that the PAI-1 activity was positively correlated with BMI, insulin, and triglyceride. The results of the study are similar with other investigators(Eriksson et al. 1998 ; Juhan-Vague 1987 ; Sundell et al. 1989 ; Vague et al. 1989) studies showing that overweight and obese people had significantly higher plasma PAI-1 levels than that of normal, underweight and lean subjects in men and women. The PAI-1 level was positively and significantly correlated with the % body fat in men and women.

Conclusion

This study investigates the associations of the percent body fat with dietary intake, plasma lipid profile, and PAI-1 levels of 1982 subjects between the ages of 40 and 59 years of men and women in Korea. With respect to the percent energy intake of carbohydrate, the normal group of the women had a higher intake(62%) than that of the men(52%). There was a linear relationship between energy intake and % body fat in both men and women(with exception of underweight group of women). The increased energy intake was affecting the overweightedness obesity in middle aged Korean adults of the middle socioeconomic class. Although the percent energy intake of fat was not directly associated with the incidence of obesity in this study. This study showed that % body fat was positively correlated with plasma TC, LDL-C, PAI-1 levels, and TG, but the % body fat was negatively correlated with plasma HDL-C levels in both men and women. The plasma lipid profile and PAI-1 level, and the risk factors of CHD, were positively associated with % body fat. Therefore, the results of this study support that reducing % body fat is an important factor in maintaining a healthy blood lipid profile and PAI-1, and can decrease some of the risk factors of CHD.

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