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The Relationships Among Body Fat Distribution, Blood Pressure, Blood Lipids and Exercise in Healthy Men and Women

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Abstract

A variety of studies show that a centralized rather than a generalized pattern of subcutaneous fat distribution is more directly associated with disorders of carbohydrate and lipid metabolism, as possibly hypertension. This study was an attempt to observe the relationship of body fat distribution, blood lipids, blood pressure and exercise in 85 healthy men and women. Within this group there was a gradation of fat distribution progressing from LBSO and UBSO defined on the basis of WHR. This paper reports the relationship of body fat distribution defined by WHR to plasma glucose, lipids, blood pressure, and exercise in this population. Although the obesity indices (RBW and BMI) were slightly higher in the UBSO group, significant differences existed between UBSO and LBSO groups with respect to WHR, blood pressure, and total cholesterol concentration in female. WHR values were substantially different and this was primarily due to greater degrees of differences in waist as opposed to hips circum ference. Although no significant differences existed between UBSO and LBSO groups with respect to age, body weight, and hips circumference, energy intake, total cholesterol, LDL-cholesterol and WHR values were substantially different in male. Positive, significant correlations were found between WHR and both systolic and diastolic blood pressure and between WHR and the total plasma cholesterol concentration and age. When 26 pairs of exercise and nonexercise groups were matched according to sex, age and body weight, blood pressure and blood lipids were significantly lower in the exercise groups than those in the nonexercise groups. In conclusion, these findings suggest that an altered blood lipid profiles will manifast in men and women with upper body obese. Furthermore these findings suggest that exercise and physical activity may be beneficial for controlling blood lipids and blood pressure in healthy adults.

Key words : blood glucose, blood lipids, blood pressure, body fat distribution, WHR, exercise.

Introduction

Obesity is implicated as a risk factor glucose intolerance, hyperinsulinemia, and insulin resistance[1]. A recent study suggested that not only the degree of obesity but also the localization

of fat is a risk factor for health. Numerous studies[2, 3] have shown that a high accumulation of abdominal fat associated with metabolic complications such as glucose intolerance, hyperinsulinemia[4], diabetes[5], hypertension[6-8], and hyperlipidemia[9], and with an increased risk of coronary disease[10-11].

Fat mass located predominantly on the upper body has been termed android, male, upper body segment, since obesity in men favors distribution above the waist. Gynoid, female, lower body segment locations are so termed because of predilection for adipose accumulation in the lower abdomen, buttocks, hips, and thighs in women. These reports confirmed early observations reported more than 30 years ago by Vague [12], who first suggested that the measurement of the regional distribution of body fat could be useful in assessing the risk of developing diabetes and atherosclerosis. Recent epidemiologic studies suggest that a centralized fat pattern, in which a greater proportion of adipose tissue is distributed on the trunk compared with the extremities, may be more strongly associated with diabetes[13], heart disease, and stroke[14, 15], than is total adiposity, and it has been suggested that adipose distribution may confound the association of obesity with disease[16]. Also other recent study observed that a high accumulation of deep adbominal fat was associated with disturbances in glucose-insulin homeostasis and in plasma lipid transport, suggesting an increased risk of diabetes and cardiovascular heart disease (CHD) risk profile[17]. According to Maugh, women who are fat primarily in the upper body are eight times more likely to develop diabetes than normal women[31].

Both genetic and environmental factors appear to contribute to upper body fat. Smoking, low amounts of exercise, and stress have been associated with upper body distribution[18, 19].

The number of obese in the Korea is increasing and its complications are now thought to be one of the most important health problems in Korea. To date there have been few studies investigated the relationship between body fat distribution, blood lipids, blood glucose and blood pressure[20-22].

Exercise has been demonstrated to modify favorably many of the metabolic alterrations associated with obesity, including peripheral insulin resistance, and hyperinsulinemia[23], hypertriglyceridemia[24], and low plasma HDL-cholesterol[25]. Such change would be expected to be of importance in the prevention and treatment of maturity-onset diabetes and atherosclerotic disease. Recently, Williams et al. reported that exercise training induced weight loss was associated with a reduction in the mass of small LDL that showed contribute to reduce the risk of CHD in exercise-trained individuals[26-32].

The aim of the present study was to investigate the relationship of body fat distribution defined by WHR to fasting plasma lipids, glucose level and blood pressure. Also this paper determined the effects of physical activity level and exercise on the WHR, plasma lipids, glucose level and blood pressure.

Materials and Methods

1) Study subjects.

Forty-four men, aged from 36 to 62 yr (mean 42.7±9.3) and forty-one women, aged 33 to 64 yr (mean 47.7±12.7) were recruited. Recruitment for this study was based on the willingness of participants in the study to become involved in an investigation of such variables, blood lipids, body fat distribution, blood glucose, blood pressure, and interview for nutrient intake. Subjects with self reported documentation of no kno

wn major medical illnesses. None was taking medications. Height and weight were measured, and BMI(body mass index : body weight(Kg)/height (Cm^2)) was determined. With the subjects standing, the abdominal circumferences was measured at the level of the umbilicus and the hip circumference at the point of maximum protuberance of the buttocks, and WHR(waist-to hip circumference ratio) was calculated. A convenient method was used for measurement of dietary food intake[33]. Physical activity level was determined in three different levels : low, middle, high. Individuals who exercise more than two times per week and one session lasts more than 60 minutes are regarded as an exercise group.

After overnight 12 hr fast, venous blood was withdrawn for measurements of total plasma lipids and glucose by enzymatic methods. Subsequently, 11 men in the highest quartile of the WHR range(0.92 to 1.05) were compared to 11 men in the lowest quartile of the WHR range(0.76 to 0.84). Also 10 women in the highest quartile of WHR range(0.89 to 1.02) were compared to 10 women in the lowest quartile of the WHR range(0.73 to 0.79). The two groups had body fat accumulation predominantly in the upper and lower body segments and were designated UBSO and LBSO groups, respectively. This was done to ascertain whether subjects in the outer quartiles of body fat distribution differed to any appreciable extent. The data were collected between February 1992 and May 1992.

2) Statistical analysis

Data were analyzed by computer using the SAS (Statistical Analysis System). Values are presented as mean ± SD. Correlation coefficients were determined by Pearson correlation coefficient. Significance of the difference between mean values of LBSO and UBSO groups was determined by Student's t test.

Results and Discussion

Vital statistics of the 44 men are presented in Table 1.

Table 1. Vital statistics of study group of men

	Total Subjects (N=44)	LBSO[1] (N=11)	UBSO[2] (N=11)	LBSO vs UBSO P value
Age(Yr)	42.7 ± 9.4	40.1 ± 3.6	42.4 ± 5.1	NS[3]
Body Weight(Kg)	64.6 ± 8.4	60.9 ± 11.4	67.3 ± 9.8	NS
Height(Cm)	168.3 ± 4.9	166.3 ± 5.0	168.1 ± 5.5	NS
Waist(Cm)	84.8 ± 7.9	77.9 ± 7.2	88.8 ± 6.0	*[4]
Hip(Cm)	94.5 ± 7.7	93.8 ± 6.7	92.3 ± 7.0	NS
RBW	105.4 ± 12.1	102.0 ± 11.3	109.6 ± 10.8	NS
BMI	22.8 ± 2.6	21.9 ± 2.7	23.7 ± 2.6	NS
WHR	0.88 ± 0.06	0.81 ± 0.05	0.94 ± 0.06	*

Values are mean ± SD. ; numbers of subjects in parentheses.

[1] LBSO subjects in the lowest quartile of the WHR range.

[2] UBSO subjects in the highest quartile of the WHR range.

[3] NS ; significantly not different at p value 0.05.

[4] * ; significantly different at p value 0.05.

Table 2. Fasting plasma lipids, glucose, and blood pressure in men

	Total Subjects (N=44)	LBSO[1] (N=11)	UBSO[2] (N=11)	LBSO vs UBSO P value
Systolic blood pressure(mmHg)	120.0 ± 16.7	118.9 ± 20.2	122.8 ± 19.5	NS[3]
Diastolic blood pressure(mmHg)	76.2 ± 18.8	75.9 ± 15.3	73.5 ± 13.7	NS
GOT	25.4 ± 2.8	25.4 ± 1.9	25.1 ± 2.7	NS
GPT	22.1 ± 2.7	22.3 ± 1.9	21.6 ± 2.6	NS
Total cholesterol(mg%))	201.8 ± 43.0	172.8 ± 36.0	202.5 ± 33.0	*[4]
Trigyceride(mg/dl)	74.3 ± 31.4	76.7 ± 31.7	74.0 ± 34.2	NS
HDL-cholesterol(mg/dl)	37.2 ± 6.2	38.5 ± 2.7	38.2 ± 4.1	NS
LDL-cholesterol(mg/dl)	173.4 ± 41.2	137.6 ± 28.4	173.0 ± 27.3	*
Blood glucose (mg/dl)	92.7 ± 17.6	89.5 ± 10.1	92.7 ± 8.5	NS
Energy Intake(Kcal)	2220 ± 505	2265 ± 696	2149 ± 365	NS

Values are mean ± SD. ; numbers of subjects in parentheses.

[1] LBSO subjects in the lowest quartile of the WHR range.

[2] UBSO subjects in the highest quartile of the WHR range.

[3] NS ; significantly not different at P value 0.05.

[4] * ; significantly different at P value 0.05.

Among the subjects, 19% were obese, the mean ideal body weight was 105% and their mean of BMI was 22.8. The average WHR was 0.88± 0.06, with a range of 0.76 to 1.04 and a median value of 0.88.

The mean ideal body weight of the LBSO group was 102% and their mean of BMI was 21.9. The average WHR was 0.815 ± 0.05, with a range of 0.76 to 0.84 in the LBSO group. The mean ideal body weight of the UBSO group was approximately 110% and their mean of BMI was 23.7. In this instance, the average WHR was 0.94 ± 0.04, with a range of 0.92 to 1.05 in the UBSO group. There were no significant differences between the LBSO and the UBSO groups in respect to age, body weight, RBW, and BMI. However, WHR values were substantially different, as anticipated by the selection process.

This was primarily due to greater degrees of difference in waist as opposed to hips circumference.

The clinical characteristics of the 44 healthy men are shown in Table 2.

Mean valuse of blood parameters and energy intake are presented in Table 2 along with the average calculated for the 44 men. The eleven men in the lower 25% of the WHR range(LBSO) were compared to the eleven in the upper 25% of the WHR range(UBSO). This table shows that the concentrations of plasma total and LDL-cholesterol were significantly higher in the UBSO group than those in the LBSO group. No significant differences existed between the UBSO and LBSO groups in respect to blood pressure and fasting blood glucose concentration. The daily energy intake average did not distinguish between the LBSO and UBSO groups.

Vital statistics of the 41 healthy women are presented in Table 3.

Table 3. Vital statistics of study group of women

	Total Subjects (N=41)	LBSO[1] (N=10)	UBSO[2] (N=10)	LBSO vs UBSO P value
Age(Yr)	47.7 ± 12.7	35.7 ± 5.6	55.0 ± 11.3	*
Body weight(Kg)	57.2 ± 9.3	48.3 ± 7.4	61.5 ± 5.6	*[3]
Height(Cm)	154.8 ± 4.7	154.1 ± 4.2	152.3 ± 5.5	NS[4]
Waist(Cm)	80.4 ± 9.7	69.7 ± 4.1	88.2 ± 8.1	*
Hip(Cm)	92.8 ± 7.8	89.6 ± 4.6	90.0 ± 5.6	NS
RBW	116.1 ± 17.9	99.5 ± 12.3	131.7 ± 13.4	*
BMI	23.8 ± 3.6	20.3 ± 2.7	26.5 ± 82.9	*
WHR	0.85 ± 0.05	0.76 ± 0.94	0.95 ± 0.04	*

Values are mean ± SD. ; numbers of subjects in parentheses.

[1] LBSO subjects in the lowest quartile of the WHR range.

[2] UBSO subjects in the highest quartile of the WHR range.

[3] * ; significantly different at P value 0.05.

[4] NS ; significantly not different at p value 0.05.

Table 4. Fasting plasma lipids, glucose and blood pressure in women

	Total Subjects (N=41)	LBSO[1] (N=10)	UBSO[2] (N=10)	LBSO vs UBSO P value
Systolic pressure(mmHg)	121.2 ± 17.7	108.4 ± 15.0	133.8 ± 16.0	*[3]
Diastolic pressure(mmHg)	71.6 ± 11.1	63.6 ± 8.2	78.6 ± 5.1	*
GOT	24.0 ± 2.2	23.3 ± 1.4	24.7 ± 3.9	NS[4]
GPT	20.9 ± 2.6	19.8 ± 2.2	21.8 ± 3.5	NS
Total cholesterol(mg %)	199.7 ± 25.3	185.5 ± 20.7	206.4 ± 22.3	*
Triglyceride(mg/dl)	68.3 ± 38	51.3 ± 18	71.0 ± 31	NS
HDL-cholesterol(mg/dl)	38.2 ± 5.6	36.5 ± 3.8	36.3 ± 3.7	NS
LDL-cholesterol(mg/dl)	173.2 ± 26	160.5 ± 23	180.4 ± 21	NS
Blood glucose(mg/dl)	88.9 ± 11.7	81.6 ± 5.1	88.3 ± 9.3	NS
Energy Intake (Kcal)	2094 ± 501	2004 ± 500	1941 ± 561	NS

Values are mean ± SD. ; numbers of subjects in parentheses.

[1] LBSO subjects in the lowest quartile of the WHR range.

[2] UBSO subjects in the highest quartile of the WHR range.

[3] * ; significantly different at P value 0.05.

[4] NS ; significantly not different at p value 0.05.

The mean ideal body weight of women was 116% and their mean of BMI was 23.8. The average WHR was 0.85 ± 0.05, with a range of 0.72 to 1.02 and a median value of 0.86 in women. Table 3 reveals that although the obesity indices (RBW, BMI) and age were significantly higher

Table 5. Significant correlations between WHR and other measured parameters

Parameter(N=85)	r	P values vs WHR
Systolic blood pressure	0.29	0.01
Total cholesterol	0.21	0.05
Age	0.31	0.001
BMI	0.43	0.001
RBW	0.39	0.05

in the UBSO group than in the LBSO group, WHR values were significantly different. This was primarily due to greater degrees of differences in waist.

Table 4 shows the fasting plasma glucose, lipids and blood pressure in healthy women. Ten women in the lower 25% of the WHR range(LBSO) were compared to ten in the upper 25% of the WHR range(UBSO). Table 4 reveals that the plasma total cholesterol and blood pressure were significantly higher in the UBSO group than in the LBSO group. No significant differences existed between UBSO and LBSO groups in respect to fasting plasma glucose, triglyceride concentration and energy intake.

In Table 5, significant correlations between WHR and other measured parameters are presented. In subjects between 33 and 64 years of age, WHR values correlated significantly with blood pressure, total plasma cholesterol, age, BMI and RBW.

Despite the very small sample size, these results demonstrate that the blood pressure and total cholesterol of middle-aged Korean men and women are associated with centrally deposited body fat. The present study supports previous work[17] indicating the abdominal fat assesses by WHR may be better at predicting alteration in blood pressure and lipid profile.

In females between 37 and 59 years of age, WHR does increase with age. Age and WHR showed a somewhat correlation, both to each other and to blood pressure. Fasting plasma glucose did not relate to WHR in healthy adults.

Figure 1 and 2 present the relationship of physical activity, triglyceride and blood pressure in persons 33-64 years of age for both men and women. These results demonstrated that the blood pressure and triglyceride concentration of middle-aged Koreans are more directly associated with physical activity. Figure 3 presents the relationship of total cholesterol concentration and blood pressure. There was a postive relationship between blood pressure and plasma cholesterol concentration in healthy men and women. These findings are consistent with earlier studies[51].

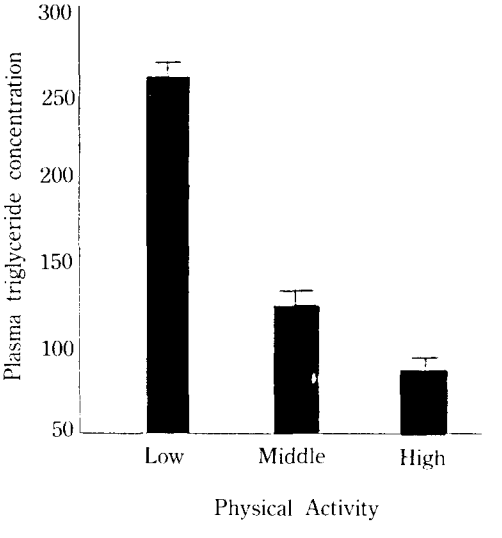

Fig. 1. Effect of physical activity on plasma triglyceride concentration.

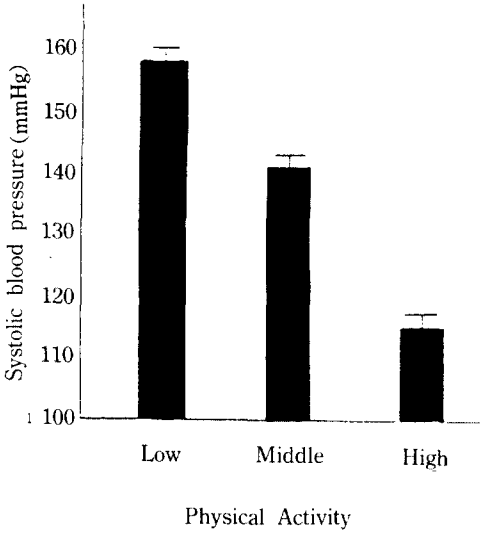

Fig. 2. Effect of physical activity on blood pressure.

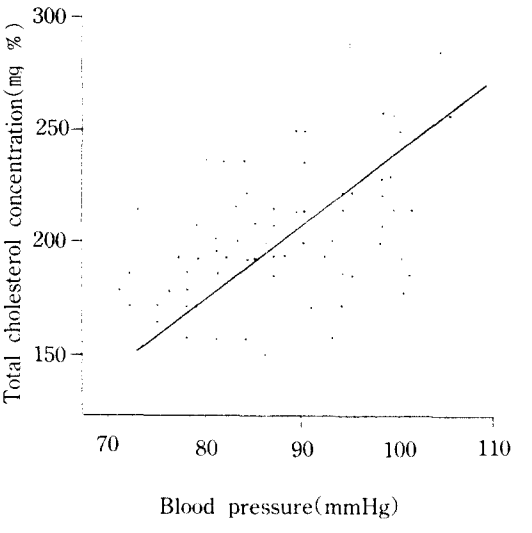

Fig. 3. The relationsip of total cholesterol concentration and blood pressure.

Table 6. Athropometric measurements in age and body weight matched of exercise and nonexercise groups

	Exercise	Nonexercise	P value
	Mean SD	Mean SD	
Age(yr)	50.9 ± 8.7	50.2 ± 8.9	NS
Body Weight(Kg)	64.0 ± 6.8	63.3 ± 7.2	NS
Height(Cm)	161.7 ± 6.1	161.3 ± 5.7	NS
Waist(Cm)	82.9 ± 7.4	83.3 ± 7.4	NS
Hip(Cm)	96.9 ± 8.4	96.2 ± 8.1	NS
WHR	0.85 ± 0.06	0.86 ± 0.07	NS
RBW	116.5 ± 10.3	117.2 ± 9.9	NS
BMI	24.5 ± 2.1	24.2 ± 2.1	NS

Values are mean± SD.

Anthropometric measurements in age and body weight were controlled in exercise and nonexercise groups. This is represented in Table 6. As anticipated by the selection process, there were no significant differences between exercise and nonexercise groups in respect to age, body weight, WHR, BMI, RBW, and energy intake.

In the men's nonexercise group, the mean WHR was 0.89 with a range of 0.80 to 0.94, in the women's nonexercise group, the mean WHR 0.867 with a range of 0.75 to 1.02. In the exercise groups, the mean WHR was 0.846 with a range of 0.76 to 0.92 in men, and the mean WHR was 0.874 with a range of 0.74 to 0.99 in women.

Table 7. Comparison of blood lipids, glucose, and blood pressure of exercise and nonexercise groups

Variables	Exercise	Nonexercise	P value
	Mean± SD	Mean± SD	
Systolic pressure(mmHg)	120.7 ± 16.7	130.3 ± 17.0	*
Diastolic pressure(mmHg)	81.3 ± 11.3	86.7 ± 12.1	NS
Blood Glucose(mg/dl)	91.2 ± 22.5	98.3 ± 23.7	NS
Total cholesterol (mg%)	204.6 ± 23.2	221.1 ± 26.4	*
Triglyceride(mg/dl)	75.1 ± 23.0	89.1 ± 23.2	*
HDL-Cholesterol(mg/dl)	38.0 ± 4.5	40.1 ± 4.2	NS
LDL-Cholesterol(mg/dl)	163.7 ± 23.1	179.5 ± 23.1	*

Values are mean ± SD.

* ; significantly different at P value 0.05.

Table 8. Comparison of exercise and nonexercise group of average nutrient intake

Variables	Exercise	Nonexercise	P value
	Mean± SD	Mean± SD	
Energy(Kcal)	2297 ± 539	2281 ± 588	NS
Protein(gm)	79.9 ± 15.3	74.9 ± 18.9	NS
Fat(gm)	46.6 ± 16.5	43.7 ± 18.8	NS
Carbohydrate(gm)	389.3 ± 60.4	397.0 ± 78.4	NS
Fe(mg)	13.1 ± 4.6	14.0 ± 2.6	*
Ca(mg)	619 ± 235	632 ± 159	NS
Vit A(RE)	1199 ± 601	1225 ± 394	NS
Vit B_1 (mg)	1.05 ± 0.20	1.20 ± 0.21	NS
Vit B_2 (mg)	1.03 ± 0.40	1.03 ± 0.26	NS
Niacin (mg)	17.17 ± 2.8	19.07 ± 4.7	NS
Vit C(mg)	60.03 ± 11.4	62.7 ± 12.5	NS

Values are mean ± SD.

* ; significantly different at P value 0.05.

Table 7 shows that effects of exercise on blood pressure and lipids. There were significant effects on blood pressure, total cholesterol, and LDL-cholesterol concentration due to exercise.

Recent studies indicate that levels of high-density lipoprotein cholesterol(HDL) may be inversely related to the development of cardiovascular disease. Conversely, levels of low-density lipoprotein(LDL) appear to be positively related to the risk for cardiovascular disease. The increased HDL/LDL ratio in this study might be protective to some degree even in the absence of change in HDL-cholesterol concentration.

In this study, fasting blood glucose did not differ between exercise and nonexercise groups with similar energy intake and WHR. It is impor-

tant to note in this study that exercise per se has an effect of controlling the blood pressure and blood lipids without changing WHR. These findings suggest that blood lipids and blood pressure are independently effected by exercise. A recent study reported differences in sex in the way in which body fat is mobilized by exercise ; men appear to lose weight in their abdominal area more easily than do women and women lose weight more easily in their hips[35]. Studies of exercise have shown similar effects, with better mobilization of both total body fat and abdominal body fat in men than in women[36]. In a recent study, participants in an intensive exercise program had a 20% decrement in intra-abdominal obesity and chest abdominal subcutaneous obesity. In contrast, WHR decreased by only 2%. The differences in WHR in the present study were higher in men and statistically significant, but not in women. The present data also suggests there may be a threshold for women for the amount of exercise necessary to produce change in WHR.

This result agreed with earlier studies and suggest that exercise may be beneficial for controlling blood lipids and blood pressure in healthy middle-aged healthy men and women.

Table 8 shows that the average nutrient intake of exercise and nonexercise groups. The mean daily energy intake was in the usual range for adult men and women performing moderate levels of habitual physical activity[34]. A commonly-held belief regarding exercise and appetite is that regular exercise increases appetite and food intake sufficiently to counterbalance the increased energy expenditure. This belief is not consistent with the findings here and these findings are in agreement with some previous studies in humans[5].

Conclusion and Summary

Numerous recent studies proved that a high accumulation of abdominal fat was associated with an increased risk of coronary heart disease, hypertension, diabetes and with changes in plasma triglyceride and plasma cholesterol. These metabolic changes may contribute to the risk of cardiovascular disease that is associated with an altered distribution of body fat. However, most previous studies have used RBW and/or BMI to estimate obesity in Korean people. A recent study observed that a high accumulation of abdominal fat was associated with disturbances in glucose-insulin homeostasis and in plasma lipid transport. This suggests an increased risk of diabetes and cardiovascular heart disease in individuals with high levels of abdominal fat.

The present study examined the relationships among blood lipids, blood glucose, blood pressure and body fat distribution. The effect of exercise and physical activity levels were studied in a sample of 85 men and women, aged 34 to 64 years. Results of the present study are as follows :

1. The average WHR was 0.87 ± 0.06, with a range of 0.76 to 1.04 in men. The average WHR was 0.85 ± 0.05, with a range of 0.72 to 1.02 in women.

2. Although the obesity indices (RBW and BMI) were higher in the UBSO group, significant differences between UBSO and LBSO groups in respect to WHR, blood pressure, and total cholesterol concentration existed in women.

3. Significant differences between UBSO and LBSO groups in respect to WHR, total cholesterol and LDL-cholesterol existed in men.

4. WHR correlated significantly with blood pressure, total plasma cholesterol, age and BMI, but fasting plasma glucose did not relate to WHR in healtht adults.

5. When 26 pairs of exercise and nonexercise groups were matched according to sex, age and body weight, blood pressure and lipids were significantly lower in the exercise group than those in the nonexercise group.

6. The levels of plasma triglyceride and blood pressure were effected by physical activity.

7. The blood glucose level correlated significantly with cholesterol and triglyceride levels.

Higher physical activity levels were related to lower plasma triglyceride and blood pressure levels.

In conclusion, these findings suggest that an altered blood lipid profiles will manifast in men and women with upper body obese. Furthermore, these findings suggest that exercise and physical activity may be beneficial for controlling blood lipids and blood pressure in healthy adults. Finally, this study suggests that blood lipids and blood pressue are required to observe significant associations in body fat distribution in healthy middle-aged Koreans.

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