Relationship of Intra-Abdominal Adiposity and Peripheral Fat Distribution to Lipid Metabolism in an Island Population in Western Japan: Gender Differences and Effect of Menopause

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MANABE, E., AOYAGI, K., TACHIBANA, H. and TAKEMOTO, T. *Relationship of Intra-Abdominal Adiposity and Peripheral Fat Distribution to Lipid Metabolism in an Island Population in Western Japan: Gender Differences and Effect of Menopause.* Tohoku J. Exp. Med., 1999, 188 (3) 189-202 — Intra-abdominal adiposity is associated with unfavorable serum lipid profiles (high total cholesterol or triacylglycerol, and low high-density lipoprotein cholesterol) in obese people. However, the relation in mainly nonobese Japanese population is not well known. We examined the relationship between intra-abdominal adiposity measured by ultrasonography and body fat distribution with serum lipids in Japanese people living in an island in western Japan. Mainly nonobese healthy individuals (98 men, 72 premenopausal and 182 postmenopausal women) aged between 33 and 69 years were examined. Accumulation of intra-abdominal fat (Pmax) and abdominal subcutaneous fat (Smin) was measured by ultrasonography. We also measured triceps and subscapular skinfold thicknesses, and the concentrations of total cholesterol, triacylglycerol and high-density lipoprotein (HDL) cholesterol. In men and postmenopausal women, Pmax correlated significantly with the majority of serum lipids after adjusting for age, body mass index and smoking habit. In premenopausal women, Pmax correlated significantly with only total cholesterol, but marginally with triacylglycerol and HDL/total cholesterol ratio after adjustment. Our findings suggest that intra-abdominal adiposity is related to unfavorable lipid profile in both genders among mainly nonobese Japanese population. ——— intra-abdominal fat; ultrasonography; serum lipids; Japanese; gender differences © 1999 Tohoku University Medical Press

The body fat distribution is a significant risk factor for cardiovascular disease (Kissebah et al. 1982; Despres et al. 1985; Haffner et al. 1987; Anderson et al. 1988; Ostlund et al. 1990; Seidell et al. 1990, 1991b) and influences its incidence (Lapidus et al. 1984; Larsson et al. 1984; Donahue et al. 1987). With regard to

Received January 20, 1999; revision accepted for publication June 15, 1999.

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differences in fat distribution and their impact on lipid metabolism, several investigators (Kissebah et al. 1982; Bjorntorp 1985; Leibel and Hirsch 1987) have shown that abdominal adipose cells show enhanced lipolytic response to catecholamines compared with peripheral (femoral or gluteal) fat. In particular, intra-abdominal adipose tissue causes abnormalities of lipid metabolism because of its accessibility to the portal circulation; high free fatty acid from intra-abdominal fat cells may easily flow into the liver and disturb lipid metabolism (Ostman et al. 1979; Rebuffe-Scrive et al. 1989).

Measurements of skinfold thickness have been used widely for estimating whole body subcutaneous fat, especially in epidemiological studies (Donahue et al. 1987; Haffner et al. 1987; Seidell et al. 1990, 1991b). More recently, however, body fat distribution has been accurately estimated by computed tomography (CT) (Borkan et al. 1982; Tokunaga et al. 1983; Grauer et al. 1984; Ashwell et al. 1985) and magnetic resonance imaging (MRI) (Fowler et al. 1991; Sobol et al. 1991). Furthermore, other studies have also demonstrated the usefulness of ultrasonography for this purpose; ultrasonographically determined distribution of intra-abdominal fat correlates highly with that measured by CT (Armellini et al. 1990, 1993; Suzuki et al. 1993), as well as with serum triacylglycerol (Armellini et al. 1994).

Several studies have examined the association between intra-abdominal fat assessed by radiological imaging and serum lipids in obese subjects (Fujioka et al. 1987; Despres et al. 1989; Peiris et al. 1989; Leenen et al. 1992; Zamboni et al. 1992). For example, Williams et al. (1997) recently reported a positive correlation between intra-abdominal fat and serum lipids in healthy Western women. However, there is little information on the correlation between the pattern of fat distribution and serum lipids in the Japanese population, particularly for mainly nonobese subjects. In the present study, we examined the correlation between intra-abdominal adiposity using ultrasonography, as well as fat distribution, to serum lipids in an island population sample in western Japan, with a special reference to differences in gender and menopausal status.

SUBJECTS AND METHODS

The subjects were residents of Narao town, Nagasaki prefecture, Japan. Narao town, which is a fishery district, is located in Goto islands in Eastern China Sea. The total population is about 3700. In 1994, after detailed explanation of the purpose of the study, 425 residents aged ≥ 30 years volunteered to participate in the health assessment. All subjects who were being treated with medications known to affect lipid metabolism, or were known to have metabolic disorders, such as diabetes mellitus and thyroid disease, or have had previous abdominal surgery including uterus or ovary, were excluded from the study. Of the 425 volunteers, 352 healthy residents (98 men, 72 premenopausal and 182 postmenopausal women) aged 33 to 69 years were enrolled in the study. Data related to the 73 subjects

excluded from the study were not obtained. The average age of men and women was 59.8 ± 7.7 and 56.1 ± 8.4 years, respectively. All subjects gave informed consent prior to the examination.

Height and weight were measured and body mass index (BMI) was calculated as weight (kg)/height (m)². The skinfold thickness at the triceps and subscapular regions was measured twice on the right side by using an Eiken skinfold caliper (Yagami Inc., Nagoya) and the average value was calculated, as was the subscapular-to-triceps skinfold ratio (STR). The waist circumference at the level of the umbilicus and hip circumference at the widest part of the hip were measured twice in the standing position and the average value was calculated, as was the waist-to-hip ratio (WHR).

Using ultrasonography (EUB-405, Hitachi, Tokyo), with a convex array probe (3.5 Mz, 40 Radius), we measured the maximum thickness of the preperitoneal fat (Pmax), an indicator of intra-abdominal fat, and the minimum thickness of subcutaneous fat (Smin), an indicator of abdominal subcutaneous fat depots. Using these two parameters, we calculated the ratio of Pmax to Smin (Pmax/Smin) (Suzuki et al. 1993). All ultrasonographic measurements were performed once by a single investigator (E.M.). In addition, the same investigator conducted the test-retest of measurements for another group of 14 volunteer subjects (seven men and seven women) who were of similar age to the test subjects. Correlations between the two measurements was excellent ($r=0.96$ for Pmax, $r=0.98$ for Smin).

Individual information on menopausal status and current smoking habit (yes/no) was recorded during an interview. We also measured the concentration of serum lipids using serum samples drawn after an overnight fast. Total cholesterol and triacylglycerol were measured by an enzymatic assay and high-density lipoprotein (HDL) cholesterol by the precipitation technique. We also calculated the HDL cholesterol to total cholesterol ratio (HDL/total cholesterol) representing the atherogenic index.

Statistical analysis

Since the data were not normally distributed, natural logarithmic transformation was carried out before statistical analysis of STR, Pmax/Smin ratio, HDL cholesterol, triacylglycerol and HDL/total cholesterol ratio. Differences between men and women, and premenopausal and postmenopausal women, were examined for statistical significance using the Student's *t*-test for continuous variables, and χ^2 test for categorical variable, respectively. Pearson's product-moment correlations and partial correlations were calculated using univariate and multiple linear regression analyses. All statistical analyses were computed using the SAS statistical package (Cary, NC, USA). Two-sided *p*-values less than 0.05 were adopted as statistically significant.

RESULTS

Differences in body fat composition and serum lipids based on gender and menopausal status

We divided the subjects into 5 groups based on their BMI: underweight (≤ 20 kg/m²), normal weight (> 20 to ≤ 25 kg/m²), overweight (> 25 to ≤ 30 kg/m²), obese (> 30 to ≤ 35 kg/m²) and very obese (> 35 kg/m²) (Anderson and Felson 1988). Table 1 shows that approximately 60% of men and 50% of women were of normal weight and that only small percentages of men and women were obese or very obese.

The characteristics of subjects are presented in Table 2, grouped by gender, and by menopausal status in women. BMI was not different between genders. Triceps skinfold thickness was smaller in men than in women, and subscapular skinfold thickness was higher in premenopausal women than in postmenopausal women. Smin was smaller in men than in women, but there were no significant differences in Pmax, therefore men had a higher mean Pmax/Smin ratio than women.

Comparison of serum lipids showed that men had lower concentrations of total cholesterol and HDL cholesterol but higher concentrations of triacylglycerol compared to women. Premenopausal women had larger skinfold thickness at subscapular region than postmenopausal women in spite of similar BMI. Conversely, WHR was higher in postmenopausal women than in premenopausal women. The ratios of Pmax/Smin and HDL/total cholesterol were higher in premenopausal women than in postmenopausal women.

About half of men smoked currently, but few women did. A significant difference was found in smoking habit between men and women, but no difference between premenopausal and postmenopausal women.

Simple correlations among body fat composition variables

The correlation between BMI and waist circumference was the strongest

TABLE 1. *Distribution of body mass index according to gender and menopausal state*

(Body mass index range)	Men		Premenopausal Women		Postmenopausal Women	
	Number	%	Number	%	Number	%
Underweight (≤ 20)	8	8.2	12	16.7	20	11.0
Normal weight (> 20 to ≤ 25)	60	61.2	36	50.0	97	53.3
Overweight (> 25 to ≤ 30)	29	29.6	20	27.8	58	31.9
Obese (> 30 to ≤ 35)	1	1.0	4	5.6	6	3.3
Very obese (> 35)	0	0.0	0	0.0	1	0.5
Total	98	100.0	72	100.0	182	100.0

TABLE 2. *Characteristics of subjects*

Variable	Men (<i>n</i> = 98)	Women (<i>n</i> = 254)	<i>p</i> - value ^a	Women (<i>n</i> = 254)		<i>p</i> - value ^b
				Pre menopausal women (<i>n</i> = 72)	Post menopausal women (<i>n</i> = 182)	
Age(year)	59.8 (7.7)	56.1 (8.4)	***	45.7 (4.2)	60.3 (5.5)	***
Anthropometric variables						
Height (cm)	164.4 (6.6)	152.4 (5.1)	***	154.0 (5.2)	151.7 (4.9)	**
Weight (kg)	63.8 (9.1)	55.5 (8.6)	***	56.1 (8.4)	55.2 (8.7)	N.S.
BMI (kg/m ²)	23.5 (2.6)	23.9 (3.6)	N.S.	23.7 (3.6)	24.0 (3.6)	N.S.
Skinfold thicknesses (mm)						
Triceps	8.0 (2.5)	14.0 (4.0)	***	14.5 (3.7)	13.8 (4.1)	N.S.
Subscapular	12.5 (4.0)	12.9 (4.1)	N.S.	14.0 (4.6)	12.4 (3.8)	**
Skinfold ratio						
STR	1.62 (0.46)	0.97 (0.40)	***	1.00 (0.34)	0.96 (0.42)	N.S.
Circumferences (cm)						
Waist	84.4 (7.8)	84.0 (10.6)	N.S.	81.0 (10.4)	85.2 (10.5)	**
Hip	91.2 (5.5)	92.0 (6.2)	N.S.	91.5 (5.6)	92.3 (6.5)	N.S.
WHR	0.92 (0.05)	0.91 (0.07)	N.S.	0.88 (0.08)	0.92 (0.07)	***
Ultrasonographic variables						
Pmax (mm)	8.7 (4.0)	9.6 (4.3)	N.S.	9.9 (4.1)	9.5 (4.3)	N.S.
Smin (mm)	6.4 (3.2)	13.0 (5.0)	***	12.3 (4.6)	13.3 (5.1)	N.S.
Pmax/Smin	1.55 (0.83)	0.80 (0.37)	***	0.87 (0.37)	0.78 (0.36)	*
Serum lipid profiles						
Total cholesterol (mg/100 ml)	200.8 (34.5)	213.0 (34.4)	**	208.8 (34.2)	214.7 (34.3)	N.S.
HDL-cholesterol (mg/100 ml)	54.4 (16.7)	60.8 (15.6)	***	62.8 (14.6)	60.0 (15.9)	N.S.
Triacylglycerol (mg/100 ml)	113.8 (85.5)	92.7 (51.3)	*	92.2 (62.5)	92.9 (46.2)	N.S.
HDL/total cholesterol	0.28 (0.09)	0.29 (0.08)	N.S.	0.31 (0.09)	0.28 (0.08)	*
Smoking habit (%)	46.9	2.4	***	2.8	2.2	N.S.

Mean (S.D.). STR, subscapular-to-triceps-skinfold ratio; WHR, waist-to-hip-circumference ratio; Pmax, maximum thickness of preperitoneal fat; Smin, minimum thickness of subcutaneous fat.

^aStudent's *t*-test for continuous variables and chi square test for categorical variable between men and women.

^bStudent's *t*-test for continuous variables and chi square test for categorical variable between pre- and post-menopausal women.

N.S., not significant.

p* < 0.05, *p* < 0.01, ****p* < 0.001.

among body fat composition variables (0.87 in men, 0.88 in premenopausal and 0.90 in postmenopausal women) (Table 3). In men, Pmax correlated significantly with the majority of body fat composition variables (with the exception of STR). In pre and postmenopausal women, Pmax correlated significantly with all other body fat composition variables. Furthermore, among the correlations, Pmax correlated significantly with BMI, waist and hip circumference in both genders. On the other hand, Pmax/Smin did not correlate with most body fat composition variables in both genders.

Simple and partial correlations between body fat composition and serum lipids

Pearson correlation coefficients of serum lipids for age and body fat composition variables are presented in Table 4. In men, most body fat composition variables (except for STR and Pmax/Smin) correlated inversely with HDL cholesterol and HDL/total cholesterol. In premenopausal women, the majority of body fat composition variables (with the exception of triceps skinfold thickness, hip circumference and Pmax/Smin) correlated significantly with each type of serum lipids. In postmenopausal women, Pmax and WHR correlated significantly with each type of serum lipids. In addition, BMI, waist and hip circumference in these women also correlated with serum lipids except for total cholesterol.

Previous studies indicated that certain parameters may be confounding factors influencing fat distribution and serum lipids (Seidell et al. 1991a; Slattery et al. 1992; Imamura et al. 1996). Accordingly, we adjusted for age, BMI and smoking habit in order to examine the independent contribution of body fat distribution on serum lipids. The significant partial correlation coefficients are shown in parentheses in Table 4. After adjustment for the above confounding factors, most of the statistically significant relationships observed in univariate regression analysis diminished considerably or became insignificant. However, Pmax was still inversely correlated with HDL cholesterol and HDL/total cholesterol, and positively correlated with triacylglycerol in men. Furthermore, Pmax also significantly correlated with total cholesterol, triacylglycerol and HDL/total cholesterol in postmenopausal women, but only to total cholesterol in premenopausal women. The partial correlations between Pmax and triacylglycerol or HDL/total cholesterol in premenopausal women were 0.21 ($p=0.081$), -0.22 ($p=0.065$), respectively. The marginal correlations between intra-abdominal fat and triacylglycerol and HDL/total cholesterol in this group may be explained by a low statistical power since there were fewer subjects in premenopausal women than the other two groups. Subscapular skinfold thickness and STR in premenopausal women, and waist circumference and WHR in postmenopausal women still significantly correlated with serum lipids but not with HDL cholesterol.

TABLE 3. Simple correlation coefficients among body fat composition variables

	BMI	TST	SST	STR	Waist c.	Hip c.	WHR	Pmax	Smin
Men									
TST	0.64***								
SST	0.66***	0.56***							
STR	0.09	...	...						
Waist c.	0.87***	0.63***	0.63***	0.07					
Hip c.	0.77***	0.45***	0.43***	0.03	0.81***				
WHR	0.59***	0.54***	0.56***	0.07	...	...			
Pmax	0.72***	0.46***	0.56***	0.15	0.73***	0.60***	0.53***		
Smin	0.54***	0.56***	0.44***	-0.44	0.55***	0.37***	0.47***	0.41***	
Pmax/Smin	0.19	-0.03	0.09	0.10	0.18	0.25*	0.03	...	...
Premenopausal women									
TST	0.61***								
SST	0.71***	0.47***							
STR	0.28*	...	...						
Waist c.	0.88***	0.53***	0.73***	0.37**					
Hip c.	0.87***	0.66***	0.59***	0.12	0.82***				
WHR	0.69***	0.32***	0.67***	0.48***	...	...			
Pmax	0.56***	0.45***	0.55***	0.25*	0.62***	0.47***	0.60***		
Smin	0.74***	0.42***	0.71***	0.43***	0.78***	0.63***	0.72***	0.51***	
Pmax/Smin	-0.15	0.05	-0.08	-0.13	-0.11	-0.12	-0.09	...	...
Postmenopausal women									
TST	0.47***								
SST	0.61***	0.56***							
STR	0.16*	...	...						
Waist c.	0.90***	0.53***	0.60***	0.10					
Hip c.	0.90***	0.45***	0.50***	0.09	0.84***				
WHR	0.63***	0.46***	0.53***	0.09	...	...			
Pmax	0.60***	0.32***	0.45***	0.16*	0.59***	0.53***	0.47***		
Smin	0.61***	0.55***	0.49***	-0.02	0.65***	0.57***	0.55***	0.45***	
Pmax/Smin	0.01	-0.18*	-0.03	0.13	-0.05	0.02	-0.11	...	...

TST, triceps skinfold thickness; SST, subscapular skinfold thickness; STR, subscapular-to-triceps-skinfold ratio; WHR, waist-to-hip-circumference ratio; Pmax, maximum thickness of preperitoneal fat; Smin, minimum thickness of subcutaneous fat.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

TABLE 4. Correlation coefficients of age, anthropometric and ultrasonographic values in relation to metabolic variables in men, premenopausal and postmenopausal women

	Metabolic variables			
	Total cholesterol	HDL-cholesterol	Triacylglycerol	HDL/Total cholesterol
Men (n=98)				
Age	-0.13	-0.03	-0.16	0.04
BMI	0.07	-0.26*	0.13	-0.28**
Triceps skinfold	0.08	-0.31**	0.04	-0.34**
Subscapular skinfold	0.05	-0.32**	0.18	(-0.22)*
STR	-0.07	-0.04	0.14	(-0.21)*
Waist circumference	0.01	-0.33**	0.19	0.01
Hip circumference	<0.01	-0.28**	0.13	-0.32**
WHR	0.04	-0.23*	0.17	-0.27**
Pmax	-0.05	-0.37**	0.30**	-0.23*
Smin	-0.06	-0.30**	0.12	-0.33**
Pmax/Smin	-0.03	-0.10	0.14	(-0.21)*
Premenopausal women (n=72)				
Age	0.24*	-0.22	0.15	(0.29)**
BMI	0.30*	-0.46**	0.42**	-0.31**
Triceps skinfold	0.11	-0.24*	0.11	-0.54**
Subscapular skinfold	0.45**	-0.40**	0.55**	-0.26*
STR	0.40**	-0.26*	0.47**	(0.39)**
Waist circumference	0.34**	-0.46**	0.42**	(0.39)**
Hip circumference	0.22	-0.34**	0.27*	-0.57**
WHR	0.37**	-0.44**	0.43**	-0.40**
Pmax	0.48**	-0.26*	0.40**	-0.57**
Smin	0.33**	-0.46**	0.41**	(-0.29)*
Pmax/Smin	0.20	-0.22	0.05	(-0.27)*
Postmenopausal women (n=182)				
Age	-0.07	-0.14	0.10	-0.10
BMI	0.09	-0.29**	0.21**	-0.33**
Triceps skinfold	0.13	-0.15	0.17*	-0.22**
Subscapular skinfold	0.22**	-0.10	0.13	-0.22**
STR	0.08	-0.03	-0.06	-0.01
Waist circumference	0.14	-0.29**	0.27**	(0.16)*
Hip circumference	0.03	-0.29**	0.16*	-0.36**
WHR	0.21**	-0.20**	0.29**	-0.29**
Pmax	0.20**	-0.25**	0.26**	(0.31)**
Smin	0.21**	-0.14	0.16*	(0.19)*
Pmax/Smin	<0.01	-0.12	0.08	(-0.22)**

Values in parentheses indicate significant partial correlations after adjusting for age, BMI and smoking (currently yes/no).

STR, subscapular-to-triceps-skinfold ratio; WHR, waist-to-hip-circumference ratio; Pmax, maximum thickness of preperitoneal fat;

Smin, minimum thickness of subcutaneous fat.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

DISCUSSION

In the present study, we examined the association of intra-abdominal adiposity and body fat distribution with serum lipids among a Japanese population sample. Subcutaneous skinfold thickness (Despres et al. 1985; Donahue et al. 1987; Haffner et al. 1987; Seidell et al. 1990, 1991b) and circumferences (Lapidus et al. 1984; Larsson et al. 1984; Haffner et al. 1987; Anderson et al. 1988; Ostlund et al. 1990; Seidell et al. 1990, 1991b) have been the main parameters used for estimating fat distribution in previous studies. Although these anthropometric measurements are relatively easy to measure and do not need expensive equipment, they are indirect methods for quantification of the amount of adipose tissue in each body region. Furthermore, they cannot be used to estimate accumulation of fat in deep locations, such as intra-abdominal adipose tissue. CT and MRI have been previously used for the measurement of body fat (Borkan et al. 1982; Tokunaga et al. 1983; Grauer et al. 1984; Ashwell et al. 1985; Fowler et al. 1991; Sobol et al. 1991; Zamboni et al. 1992), intra-abdominal and subcutaneous fat. The use of these methods has established a close association between intra-abdominal fat and lipid metabolism (Fujioka et al. 1987; Despres et al. 1989; Peiris et al. 1989; Zamboni et al. 1992). However, these imaging methods are not commonly used for the assessment of fat accumulation in epidemiological studies or population-based health examination because of cost and/or associated risk of exposure to ionizing radiation. Ultrasonography is effective in the assessment of intra-abdominal adiposity in population-based studies, since the device is portable, and the methods is noninvasive, economic and comparatively easy to perform.

The flow of high free fatty acid from intra-abdominal fat tissue into the liver through the portal vein increases hepatic synthesis of very low density lipoprotein (VLDL), resulting in elevation of serum triacylglycerol concentrations and reduction of HDL cholesterol concentrations (Seidell et al. 1991b). Previous studies using CT in mainly extremely obese men and women (mean BMI, 34.1–39.0 kg/m²) have confirmed the significant association between intra-abdominal adiposity and serum lipids (Fujioka et al. 1987; Despres et al. 1989; Zamboni et al. 1992). In this study, intra-abdominal fat accumulation (Pmax) also showed a positive association with triacylglycerol and negative association with atherogenic index (HDL/total cholesterol) in both men and women. We also demonstrated a negative association between intra-abdominal fat accumulation and HDL cholesterol in men, after adjusting for age, BMI and smoking. These findings suggest that intra-abdominal fat depots may influence lipid metabolism in not only obese patients but also in nonobese individuals.

It is not clear whether the intra-abdominal to subcutaneous abdominal fat ratio correlates better with lipid metabolism than the absolute amount of intra-abdominal fat. A number of investigators (Fujioka et al. 1987; Suzuki et al.

1993) reported that the above ratio strongly correlated with serum lipids, but others (Leenen et al. 1992; Zamboni et al. 1992) concluded that the absolute amount of intra-abdominal fat was more closely associated with lipid concentrations. In the present study, after adjustment for age, BMI and smoking, Pmax/Smin ratio showed only a weak association with total cholesterol in premenopausal women, and no association in men as well as post-menopausal women. Based on the results of multiple regression analysis, Pmax in this study was a significant independent predictor of HDL cholesterol and triacylglycerol in men, total cholesterol in premenopausal women, and triacylglycerol and atherogenic index (HDL/total cholesterol) in postmenopausal women. These findings indicate that intra-abdominal to subcutaneous abdominal fat ratio is not a better predictor of lipid metabolism than the absolute amount of intra-abdominal fat depots.

We also showed that intra-abdominal fat was closely associated with serum lipids in all the three groups. However, the relative contribution of body fat distribution to alterations in lipid profiles varied from one group to another. Namely, accumulation of intra-abdominal fat correlated with majority of serum lipids in both men and postmenopausal women, whereas subcutaneous adiposity at the subscapular region in premenopausal women correlated with the majority of serum lipids. Such differences between men and postmenopausal and premenopausal women may be accounted for by differences in the lipolytic response to catecholamines in intra-abdominal and subcutaneous abdominal fat. Rebuffe-Scrive et al. (1989) showed higher rates of lipolysis in the portal than in non-portal adipose tissue in men whereas the reverse was noted in premenopausal women. Moreover, these differences in lipolysis between portal and non-portal adipose tissue disappeared after menopause.

A few epidemiological studies have been conducted in Japan to examine the associations of body fat distribution with serum lipids. Our results showed that WHR and BMI correlated with serum lipids, which was consistent with previous reports on Japanese subjects (Iso et al. 1991; Sakurai et al. 1995; Nakamura et al. 1998). Furthermore, Pmax strongly correlated with BMI or waist circumference, and waist circumference also correlated strongly with BMI in both genders. Recently, waist circumference has been considered to be a convenient and simple measurement, and to be an approximate index of intra-abdominal fat mass and total body fat (World Health Organization 1997).

The prevalence of obesity in Japanese is lower compared with that in Caucasians (Yanai et al. 1997). Recent nationwide surveys on the population in Japan aged 35–64 years revealed that the age-standardized prevalence of obesity (for BMI >30) was 1.9% in men, and 2.9% in women (Yoshiike et al. 1998), which were similar to our results. There are racial and cultural differences between Japanese and Caucasians. It is possible that the frequency of pathogenic polymorphism of β_3 -adrenergic receptor, which is known to be associated with

increased body weight (Fujisawa et al. 1998), is different between Japanese and Caucasians (Yuan et al. 1997; Buettner et al. 1998), and most Japanese take low fat and low energy diet compared with Caucasians. The nutritional intakes of men in the study district were 53 g/day in fat and 2170 kcal/day in energy, and those of women were 44 g/day and 1685 kcal/day in energy (Ohmura et al. 1998). Our study was carried out in mainly nonobese Japanese population sample. Although our subjects might not be representative of the Japanese general population, the racial and cultural differences between Japanese and Caucasians may in part influence their lipid metabolism, including body fat distribution and serum lipids.

We showed that intra-abdominal adiposity is related to unfavorable lipid profiles in both genders among mainly nonobese Japanese population. Non-pharmacological treatment of obesity is the most effective method for reducing the risk of cardiovascular disease, with dietary changes and increased physical activity being the ideal combination (Williams et al. 1997). The assessment of individual fat distribution and serum lipid concentrations among general population could detect abnormalities of lipid metabolism in individuals at an early stage, leading to an effective intervention aimed at reducing morbidity and mortality of cardiovascular diseases.

Acknowledgments

The author thank Dr. Kokichi Arisawa (Department of Preventive Medicine and Health Promotion, Nagasaki University School of Medicine) and Sumihisa Honda (Department of Radiation Epidemiology, Atomic Bomb Disease Institute, Nagasaki University School of Medicine) for their insightful thoughts and helpful suggestions.

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