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Original Article

The Relation between Visceral Adipose Tissue Accumulation and Biochemical Tests in University Students

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We evaluated the visceral adipose tissue accumulation in university students in Okayama prefecture, Japan. Fifty-eight Japanese university students (10 men and 48 women, age 18.4 ± 0.6 years) were enrolled in this study. Fat distribution was evaluated by visceral fat (V) and subcutaneous fat (S) areas measured with computed tomography (CT) scanning at umbilical levels. Anthropometric parameters, *i.e.*, height, weight, waist circumference, hip circumference, and body fat percentage; blood examination; and blood pressure (BP) were also measured. In 58 subjects, the V area was 23.4 ± 21.0 cm^2 and the S area was 122.5 ± 57.9 cm^2. V areas were significantly correlated with hepatic enzymes, uric acid, triglyceride, and BP in men, while they were weakly correlated with hepatic enzymes, triglyceride, and high density lipoprotein (HDL) cholesterol in women. Correlation coefficients between V areas and clinical parameters were comparatively higher than those between other body composition parameters, *i.e.*, S areas, weight, body mass index (BMI), body fat percentage, and clinical parameters. The present study suggests that visceral adipose tissue accumulation is important for hepatic enzymes, uric acid, triglyceride, and BP in university students.

Key words: visceral adipose tissue, Japanese university students, lifestyle-related disease

Excess body weight increases the risk of death from any cause and of cardiovascular disease in adults between 30 and 74 years of age. The relative risk associated with greater body weight is higher among younger subjects [1]. In addition, the regional distribution of body fat is also recognized as a critical determinant for vascular complications. The accumulation of abdominal fat, estimated from anthropometric variables such as the waist hip ratio and waist circumference, is the major risk factor for cardiovascular diseases in both men and women [2, 3]. It is now generally accepted that abdominal obesity is frequently associated with highly atherogenic metabolic complications, such as insulin resistance, hyperinsulinemia, hypertension, glucose intolerance, and dyslipidemia [4, 5].

In Japan, a visceral fat (V) area greater than 100 cm^2 was diagnosed as abdominal obesity by computed tomography (CT) [6, 7]. Nakao *et al.* reported that visceral fat accumulation evaluated by ultrasonography was closely related to fatty liver in university students [8]. However,

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the relationship between visceral fat accumulation and clinical parameters in university students has not been well evaluated in Japan. The principal objective of the present study was to assess the visceral fat accumulation of the university students in Japan by CT and to find out if there is any relation between visceral fat accumulation and clinical parameters, *i.e.*, hepatic enzymes, uric acid, total cholesterol, triglyceride, high density lipoprotein (HDL) cholesterol, and blood pressure (BP).

Subjects and Methods

Subjects. Japanese university students (n = 58) studying at a university in Okayama prefecture, aged 18–20 years (18.4 ± 0.6), were voluntarily entered into this study. Normal weight was diagnosed according to the criteria of World Health Organization [9], and the average BMI (body mass index) of all subjects was 21.7 ± 2.9 kg/m^2 (15.7–32.4). No subjects had received or was receiving any medications for diabetes, hypertension, and/or dyslipidemia.

Ethical approval for the study was obtained from the Ethical Committee, Okayama University Graduate School of Medicine and Dentistry, and all subjects gave written informed consent to participate in the study.

Visceral and Subcutaneous Fat Areas. The intra-abdominal visceral fat and the subcutaneous fat areas were measured by CT scanned at the umbilical levels [10]. All CT scans were made with subjects in the upright position using a CT scanner (SOMATOM AR. SP, SIEMENS, Munich, Germany). CT films were converted into digital images, and both visceral and subcutaneous fat areas were measured with image analysis software OPTIMAS version 6.5 (Media Cybernetics, Silver Spring, MD, USA). The intraperitoneal area with the same density as the subcutaneous fat (S) layer was defined as the V area [11, 12].

Anthropometric and Body Composition Measurements. Their anthropometric and body compositions were evaluated by using parameters such as, height, body weight, body mass index (BMI), waist circumference, hip circumference, waist hip ratio, and body fat percentage. BMI was calculated by weight / [height]^2 (kg/m^2). The waist circumference was measured midway between the lower rib margin and the iliac crest, and the hip was measured at the widest circumference over the trochanter in standing subjects after normal expiration [13, 14]. Body fat percentage was measured by the impedance method (BF-661, TANITA, Tokyo, Japan) [15].

Blood Sampling and Assays. We measured fasting serum levels of total cholesterol [16] and high density lipoprotein (HDL) cholesterol [17], triglycerides (L Type Wako Triglyceride・H, Wako Chemical, Osaka, Japan), uric acid (uricase method), L-aspartate: 2 oxaloglutarate aminotransferase (AST) (Wroblewski-Karmen method), L-alanine: 2-oxoglutarate aminotransferase (ALT) (Wroblewski-Karmen method), and γ-glutamyl transpeptidase (γ-GTP) (L-γ-glutamyl-3-carboxy-4-nitroanilide method).

BP Measurements. BP measurements for 58 subjects were carried out at Okayama Gakuin University after resting at least 15 min in a sitting position, using the MB-650 (SHARP, Osaka, Japan).

Statistical Analysis. Data are expressed as mean ± standard deviation (SD) values, minimum, and maximum. Simple correlation analysis was used for correlations between body composition parameters and the quantitative variables. P values less than 0.05 were considered statistically significant. The data were analyzed with the Statistical Package of Stat View version 5.

Results

Clinical profiles and parameters are summarized in Table 1. Mean V areas were 25.4 ± 22.6 cm^2, and mean S areas were 134.1 ± 78.6 cm^2. Only 1 subject (V areas: 141.2 cm^2) was diagnosed as having abdominal obesity.

The number of subjects with abnormal blood examination and BP is also summarized. Abnormal levels were noted in 1 man in AST (35 IU/l<), 1 man in ALT (40 IU/l<), 1 man in uric acid (6.5 mg/dl<), 4 women in total cholesterol (220 mg/dl≦), 1 man and 6 women in triglyceride (150 mg/dl≦), 1 man in systolic BP (SBP) (140 mmHg≦), and 1 man and 1 woman in diastolic BP (DBP) (90 mmHg≦).

The simple correlation analysis between body composition parameters and clinical parameters in 58 students (Table 2) showed that V areas were significantly correlated with AST, ALT, γGTP, uric acid, triglyceride, and SBP in all subjects. In men (n = 10), V areas were also significantly correlated with AST, ALT, γGTP, uric acid, triglyceride, SBP, and DBP. In women (n = 48), V areas were weakly correlated with AST, ALT, triglyceride, and HDL cholesterol. Fig. 1 shows the simple correlation analysis between ALT and V and S areas in

Table I Clinical profiles of subjects (n = 58)

	Mean ± SD	Min～Max
Age	18.4 ± 0.6	18～20
V area (V) (cm^2)	23.4 ± 21.0	2.1～141.2
S area (S) (cm^2)	122.5 ± 57.9	13.2～290.0
Height (cm)	159.6 ± 7.5	142.5～182.9
Weight (kg)	55.4 ± 10.1	41.0～93.6
BMI (kg/m^2)	21.7 ± 2.9	15.7～32.4
Waist circumference (cm)	67.5 ± 7.7	56～99
Hip circumference (cm)	91.6 ± 5.3	81～107
Waist hip ratio	0.74 ± 0.06	0.66～0.93
Body fat percentage (%)	26.0 ± 5.6	12.0～36.0
AST (IU/l)	17.7 ± 4.8	12～48
ALT (IU/l)	15.1 ± 15.4	5～125
γGTP (IU/l)	10.3 ± 5.5	6～47
Uric acid (mg/dl)	4.2 ± 1.0	2.5～6.7
Total cholesterol (mg/dl)	172.0 ± 32.4	103～253
Triglyceride (mg/dl)	93.4 ± 50.4	27～239
HDL cholesterol (mg/dl)	64.7 ± 15.3	42～110
SBP (mmHg)	122.5 ± 19.2	78～168
DBP (mmHg)	71.5 ± 11.4	42～92

both sexes. V areas were significantly correlated with ALT (men: r = 0.961 $P < 0.01$, women: r = 0.376, $P < 0.01$), while S areas were not significantly correlated with ALT in either sex.

Correlation coefficients between V areas and clinical parameters were comparatively higher than those between other body composition parameters, *i.e.*, S areas, weight, BMI, and body fat percentage, and clinical parameters in men. However, in women, only the correlation coefficients between V areas and AST, ALT, and triglyceride were comparatively higher than those between other body composition parameters and clinical parameters.

After we excluded a male subject with an abnormal value of V area, V area was not significantly correlated with clinical parameters (Table 3). Still, the comparative associations with clinical parameters among the anthropometric indices generally remained.

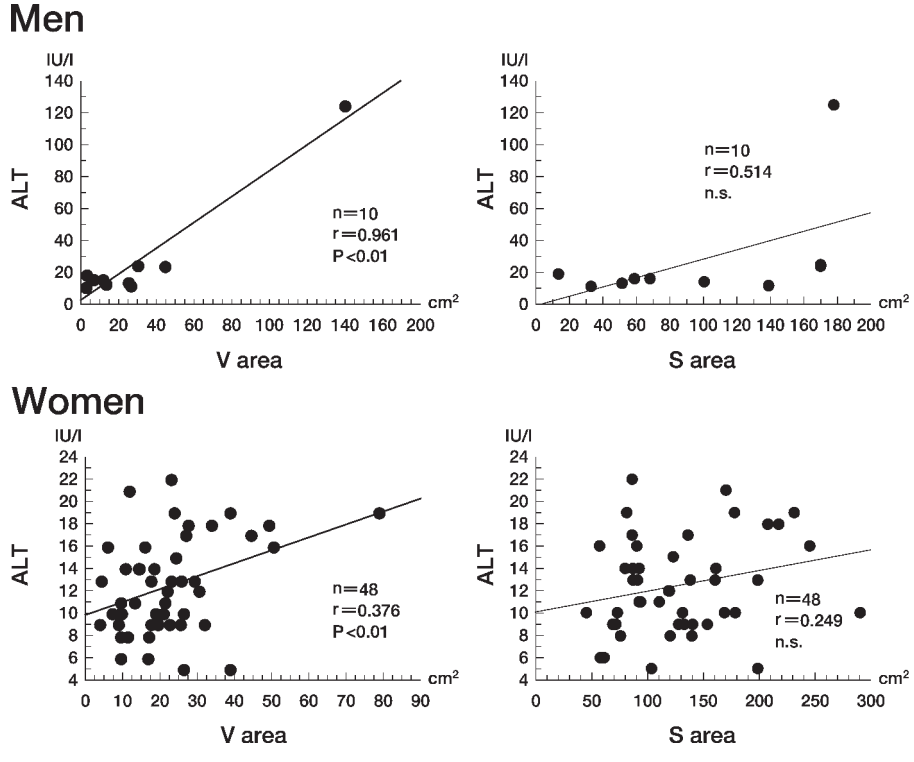

Fig. 1 Simple correlation analysis between ALT and V and S areas in university students at Okayama prefecture, Japan. n.s., not significant.

Table 2 Simple correlation analysis between body composition and clinical parameters

	V areas		S areas		Weight		BMI		Body fat %	
	r	*P*	r	*P*	r	*P*	r	*P*	r	*P*
All (n = 58)										
AST (IU/l)	0.737**		0.119		0.441**		0.438**		0.006	
ALT (IU/l)	0.784*		0.179		0.594**		0.571**		0.086	
γGTP (IU/l)	0.714**		0.071		0.517**		0.468**		0.018	
Uric acid (mg/dl)	0.420**		0.200		0.436**		0.503**		0.214	
Total cholesterol (mg/dl)	0.296*		0.173		−0.033		0.076		0.253	
Triglyceride (mg/dl)	0.439**		0.333*		0.134		0.227		0.272*	
HDL cholesterol (mg/dl)	−0.258		0.115		−0.301*		−0.361**		−0.125	
SBP (mmHg)	0.459**		0.232		0.588**		0.499**		0.090	
DBP (mmHg)	0.391**		0.254		0.413**		0.441**		0.182	
Men (n = 10)										
AST (IU/l)	0.929**		0.410		0.629		0.795**		0.509	
ALT (IU/l)	0.961**		0.514		0.744*		0.873**		0.629	
γGTP (IU/l)	0.940**		0.469		0.703		0.828**		0.605	
Uric acid (mg/dl)	0.699*		0.583		0.530		0.673*		0.568	
Total cholesterol (mg/dl)	0.552		0.086		0.277		0.336		0.232	
Triglyceride (mg/dl)	0.896**		0.549		0.681*		0.769**		0.608	
HDL cholesterol (mg/dl)	−0.230		−0.487		−0.486		−0.445		−0.510	
SBP (mmHg)	0.825**		0.393		0.627*		0.586		0.598	
DBP (mmHg)	0.741**		0.542		0.713*		0.691*		0.722*	
Women (n = 48)										
AST (IU/l)	0.341*		0.089		0.023		0.031		−0.039	
ALT (IU/l)	0.376**		0.249		0.300*		0.287*		0.224	
γGTP (IU/l)	0.155		0.080		0.045		−0.006		−0.020	
Uric acid (mg/dl)	0.259		0.207		0.253		0.385**		0.399**	
Total cholesterol (mg/dl)	0.277		0.148		0.045		0.085		0.163	
Triglyceride (mg/dl)	0.354*		0.270		0.127		0.151		0.166	
HDL cholesterol (mg/dl)	−0.317*		−0.154		−0.155		−0.323*		−0.288*	
SBP (mmHg)	0.046		0.172		0.297*		0.284*		0.206	
DBP (mmHg)	0.155		0.134		0.165		0.263		0.169	

*$P < 0.05$, **$P < 0.01$

Table 3 Simple correlation analysis between body composition and clinical parameters in men with normal visceral fat area (n = 9)

	V areas		S areas		Weight		BMI		Body fat %	
	r	*P*	r	*P*	r	*P*	r	*P*	r	*P*
AST (IU/l)	0.139		−0.128		−0.321		−0.078		−0.382	
ALT (IU/l)	0.554		0.558		0.490		0.682*		0.331	
γGTP (IU/l)	0.259		0.151		0.112		0.164		0.121	
Uric acid (mg/dl)	0.461		0.435		0.176		0.372		0.317	
Total cholesterol (mg/dl)	0.055		−0.257		−0.255		−0.359		−0.199	
Triglyceride (mg/dl)	0.533		0.354		0.221		0.213		0.234	
HDL cholesterol (mg/dl)	−0.147		−0.456		−0.502		−0.518		−0.501	
SBP (mmHg)	0.520		0.537		0.468		0.493		0.723*	
DBP (mmHg)	0.552		0.698		0.821*		0.721*		0.932**	

*$P < 0.05$, **$P < 0.01$

Discussion

We measured the visceral fat accumulation by using CT and biochemical measures in university students. V area was strongly correlated with hepatic enzymes, uric acid, triglyceride, and BP in men, and it was also weakly correlated with AST, ALT, triglyceride, and HDL cholesterol in women, suggesting that visceral fat might be a key risk factor in lifestyle-related disease in Japanese young adults. Exclusion of a male subject with abnormal value of V area substantially reduced the levels of correlation coefficients. The finding may stress the clinical significance of an abnormal level of V area.

In Japan, abdominal obesity is diagnosed according to the criterion of exceeding the level of 100 cm^2 in V areas measured by CT scanned at the umbilical levels. Subjects with abdominal obesity are closely linked with obesity-related diseases [6]. Despres also reported that subjects with a level of V area in excess of 100 cm^2 have more atherogenic risk factors [7]. When the adipose tissue becomes enlarged, several bioactive compounds are produced in the adipose tissue, *i.e.*, free fatty acids, tumor necrosis factor alpha (TNF-α), leptin, and plasminogen activator inhibitor-1 (PAI-1). These compounds may be directly involved in the pathogenesis of some of the complications commonly seen in obesity such as insulin resistance and atherosclerosis [18].

Sex differences in body fat and abdominal fat distribution are well documented. Compared with men, women are generally characterized by a greater body fat content, and women show a preferential accumulation of subcutaneous fat [19, 20]. Previous studies had reported sex differences in fasting plasma lipoprotein-lipid concentrations, including lower triglyceride and higher HDL cholesterol levels in women than in men [21, 22]. Despres *et al.* reported that differences in the plasma lipid profile between men and women were largely explained by differences in visceral adipose tissue [23]. In the present results, correlation coefficients between V area and clinical parameters were relatively higher in men than in women, although the differences became ambiguous after we excluded a male subject with an abnormal value of V area. The sex difference could be explained by the importance of sex difference in visceral fat lipolysis, since increased release of free fatty acids from visceral fat to the liver by the portal venous system is thought to cause several metabolic complications due to obesity, such as fatty liver and glucose intolerance [24].

The main finding of this study was that visceral fat accumulation measured by CT was strongly correlated with hepatic enzymes, blood lipid, and BP in university students. The small number of subjects, especially men, is a limitation of this study. Thus, it is necessary to further evaluate more students to support the present study. In conclusion, the present findings suggest a possibility of visceral fat as a predictive marker of lifestyle-related disease in young adults.

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