

Retrospective Study

Factors associated with visceral fat accumulation in the general population in Okinawa, Japan

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Abstract

AIM: To investigate the clinical and biochemical factors associated with visceral fat accumulation in the general population.

METHODS: We enrolled 1004 subjects who underwent a medical health checkup between April 2008 and March 2009. The medical health checkup included the following tests: Height, body weight, waist circumference (WC), systolic blood pressure, diastolic blood pressure, urinalysis, blood-cell counts, blood chemistry, electrocardiography, chest radiography, and abdominal computed tomography (CT) for visceral fat accumulation. The patients' medical history and lifestyle factors were collected privately by nurses using a self-administered questionnaire, and they included questions regarding physical activity, sleep duration, dietary habits, smoking, and alcohol consumption. Visceral fat area (VFA) was defined as the sum of the intraperitoneal fat area at the level of the umbilicus with CT density in the range of -150 to -50 Hounsfield units.

RESULTS: The mean age and body mass index (BMI) of the study subjects were 57.0 years and 24.4 kg/m². In both male and females, VFA was significantly and

positively correlated with WC ($r = 0.532$, $P < 0.01$; $r = 0.612$, $P < 0.01$). Subjects with high levels of VFA were primarily male with significantly higher age, height, body weight, BMI, systolic blood pressure (BP), diastolic BP, and hemoglobin in all subjects ($P < 0.05$). A multivariate logistic regression analysis revealed that VFA had a positive relationship with age ≥ 56 , BMI ≥ 25 kg/m², and triglyceride level ≥ 149 in males ($P < 0.05$), whereas it had a positive relationship with age ≥ 58 , BMI ≥ 24.4 kg/m², high-density lipoprotein cholesterol level < 40 mg/dL, and current drinking in females ($P < 0.05$).

CONCLUSION: These results suggest that gender differences exist in the clinical and biochemical parameters associated with visceral fat accumulation.

Key words: Visceral fat accumulation; Computed tomography; Metabolic syndrome; Alcohol consumption; Waist circumference

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Core tip: Although close association between visceral fat accumulation and metabolic syndrome has been established, little is known about what clinical and biochemical parameters affect visceral fat accumulation. We analyzed the clinical and biochemical parameters of the health checkup subjects and assessed the visceral fat area (VFA). A multivariate logistic regression analysis revealed that VFA had a positive relationship with age, body mass index (BMI), and triglyceride level in males, whereas it had a positive relationship with age, BMI, and current drinking in females. These results suggest that gender differences exist in the clinical and biochemical parameters associated with visceral fat accumulation.

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INTRODUCTION

Visceral fat accumulation is closely related to atherogenic disorders and metabolic syndrome (MS), including diabetes mellitus, hypertension, and dyslipidemia^[1]. It also leads to obesity-related complications. MS further increases the risks for cardiovascular diseases and thus is an important therapeutic target. Although computed tomography (CT) has been applied widely as the gold standard method to evaluate visceral fat accumulation^[2], little is known about what clinical and biochemical parameters affect visceral fat accumulation.

The aim of this study is to investigate the clinical and biochemical parameters potentially associated with visceral fat accumulation.

MATERIALS AND METHODS

Study population

We searched the database to find 1151 subjects who underwent abdominal fat CT scans for visceral fat area (VFA), and blood tests for a routine health checkup between 1 April 2008 and 31 March 2009 at Okinawa Health Promotion Foundation, Okinawa, Japan. The health checkups were provided as part of a medical health initiative to promote public health through the early detection of chronic diseases and the evaluation of associated underlying risk factors. Subjects were included if they fulfilled the following criteria: (1) absence of markers for hepatitis B virus infection [hepatitis B surface antigen (HBsAg)] and hepatitis C virus (HCV) infection (anti-HCV antibodies); and (2) absence of excess drinking of alcohol defined as consumption of > 280 g/wk. Among the 1151 subjects, 147 subjects were positive for either HBsAg or anti-HCV, or were defined as excess drinkers. The data for the remaining 1004 people were included in the analysis. All subjects provided written informed consent for the use of their anonymized data for an epidemiological study. The study design was approved by the Ethics Committee of University of the Ryukyus. The study was conducted in accordance with the Declaration of Helsinki.

Measurements of clinical and laboratory parameters

The medical health checkup included the following tests: Height, body weight, waist circumference (WC), systolic blood pressure (SBP), diastolic BP (DBP), urinalysis, blood-cell counts, blood chemistry, electrocardiography, chest radiography, and abdominal CT for VFA. The patients' medical history and lifestyle factors were collected privately by nurses using a self-administered questionnaire, and they included questions regarding physical activity, sleep duration, dietary habits, smoking, and alcohol consumption. For our study purposes, individuals who consumed at least one alcoholic beverage per week were defined as a "current drinker". Patients who reported alcohol consumption of > 280 g/wk were identified as "excess drinkers"^[3]. Alcohol consumption was evaluated by asking the participants about the amount and type of alcoholic beverages they consumed per week, an estimated total alcohol intake was calculated in grams. Blood samples were taken after > 10 h of overnight fasting. Laboratory tests were performed with standard laboratory methods and included measurements of hemoglobin (HGB), platelet count (PLT), aspartate aminotransferase, alanine aminotransferase, γ -glutamyl transferase, alkaline phosphatase, cholinesterase, total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein-cholesterol (LDL-C), triglycerides (TG), fasting plasma glucose, glycosylated hemoglobin

Table 1 Baseline characteristics of the 1004 subjects in this study

Gender (M/F)	540/464
Age (yr)	55.6 ± 11.6
Height (cm)	159.7 ± 9.1
Body weight (kg)	63.8 ± 11.7
BMI (kg/m ²)	24.9 ± 3.4
WC (cm)	88.0 ± 8.4
SBP (mmHg)	123.1 ± 14.5
DBP (mmHg)	76.9 ± 9.6
VFA (cm ²)	99.3 ± 50.5
HGB (g/dL)	14.3 ± 1.4
PLT (× 10 ⁴ /μL)	22.2 ± 4.9
AST (IU/L)	23.1 ± 8.3
ALT (IU/L)	25.4 ± 16.0
GGT (IU/L)	34.6 ± 30.7
ALP (IU/L)	226.1 ± 64.2
ChE (IU/L)	355.1 ± 65.9
TC (mg/dL)	206.5 ± 31.7
LDL-C (mg/dL)	126.1 ± 29.0
HDL-C (mg/dL)	56.0 ± 13.2
TG (mg/dL)	121.0 ± 74.3
FPG (g/dL)	99.7 ± 16.1
HbA1c (%)	5.3 ± 0.5
UA (mg/dL)	5.73 ± 1.4
Alcohol consumption (non/current drinkers)	561/443

Data are expressed as means ± standard deviation or numbers where appropriate. BMI: Body mass index; WC: Waist circumference; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; VFA: Visceral fat area; HGB: Hemoglobin; PLT: Platelet; AST: Aspartate aminotransferase; ALT: Alanine aminotransferase; GGT: γ -glutamyl transferase; ALP: Alkaline phosphatase; ChE: Cholinesterase; TC: Total cholesterol; LDL-C: Low-density lipoprotein cholesterol; HDL-C: High-density lipoprotein cholesterol; TG: Triglycerides; FPG: Fasting blood glucose; HbA1c: Hemoglobin A1c; UA: Uric acid.

A1c, serum uric acid, HBsAg, and anti-HCV.

Measurement of visceral fat areas

Abdominal visceral fat distribution was assessed with a single-slice CT image taken at the level of the umbilicus by a helical CT scanner (Siemens, Germany). The area of visceral fat was defined as the sum of the intraperitoneal fat area with CT density in the range of -150 to -50 Hounsfield units.

Statistical analysis

Descriptive statistics (means and standard deviations) were calculated for all continuous variables. Differences between the two groups were compared using χ^2 test. The comparisons of continuous variables between the 2 groups were performed using the Student *t* test. The linear association of WC and VFA was evaluated by the Spearman's rank correlation. The statistical analyses were performed using SPSS 19.0 (SPSS Inc, Chicago, IL, United States). Statistical significance was achieved at $P < 0.05$.

RESULTS

Clinical and biochemical characteristics

The clinical and biochemical characteristics of 1004

Table 2 Clinical parameters associated with visceral fat accumulation of all subjects by univariate analysis

	VFA ≥ 100 (<i>n</i> = 459)	VFA < 100 (<i>n</i> = 545)	<i>P</i> value
Gender (M/F)	384/111	192/353	< 0.001
Age (yr)	56.9 ± 11.5	54.5 ± 11.5	0.319
Height (cm)	162.61 ± 8.6	157.3 ± 8.8	< 0.001
Body weight (kg)	70.1 ± 11.1	58.5 ± 9.4	< 0.001
BMI (kg/m ²)	26.5 ± 3.4	23.6 ± 2.6	< 0.001
WC (cm)	91.9 ± 7.9	84.8 ± 7.3	< 0.001
SBP (mmHg)	126.5 ± 13.6	120.3 ± 14.6	< 0.001
DBP (mmHg)	79.1 ± 9.2	75.0 ± 9.5	< 0.001
HGB (g/dL)	14.8 ± 1.2	13.9 ± 1.3	< 0.001
PLT (× 10 ⁴ /μL)	22.0 ± 4.9	23.3 ± 8.5	0.24
AST (IU/L)	22.8 ± 7.9	25.4 ± 10.2	0.32
ALT (IU/L)	24.6 ± 15.2	25.9 ± 16.7	0.19
GGT (IU/L)	32.5 ± 27.3	36.3 ± 33.3	0.048
ALP (IU/L)	226.4 ± 62.6	225.9 ± 65.7	0.88
ChE (IU/L)	357.8 ± 67.2	352.8 ± 64.7	0.23
TC (mg/dL)	208.5 ± 31.7	204.9 ± 31.7	0.07
LDL-C (mg/dL)	126.8 ± 29.6	125.4 ± 28.6	0.45
HDL-C (mg/dL)	56.5 ± 13.9	55.5 ± 12.6	0.23
TG (mg/dL)	119.5 ± 58.2	122.3 ± 79.1	0.56
FPG (g/dL)	98.7 ± 14.5	100.5 ± 17.3	0.07
HbA1c (%)	5.2 ± 0.47	5.3 ± 0.59	0.11
UA (mg/dL)	5.7 ± 1.4	5.8 ± 1.3	0.09
Alcohol consumption (non/current drinkers)	254/205	307/238	0.401

BMI: Body mass index; WC: Waist circumference; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; VFA: Visceral fat area; HGB: Hemoglobin; PLT: Platelet; AST: Aspartate aminotransferase; ALT: Alanine aminotransferase; GGT: γ -glutamyl transferase; ALP: Alkaline phosphatase; ChE: Cholinesterase; TC: Total cholesterol; LDL-C: Low-density lipoprotein cholesterol; HDL-C: High-density lipoprotein cholesterol; TG: Triglycerides; FPG: Fasting blood glucose; HbA1c: Hemoglobin A1c; UA: Uric acid.

subjects are summarized in Table 1. The subjects were predominantly middle-aged (55.6 ± 11.6 years; range 25–88 years), and 53.8% were male. The mean BMI of all subjects was 24.9 ± 3.4 kg/m², and 44.8% of the subjects met the criteria for obesity (BMI ≥ 25 kg/m²).

Waist circumference and visceral fat accumulation

Figure 1 shows the relationship between WC and VFA of all subjects, indicating a significant positive correlation (Figure 1; $r = 0.536$, $P < 0.01$). In both males and females, VFA was significantly positively correlated with WC ($r = 0.532$, $P < 0.01$; $r = 0.612$, $P < 0.01$), respectively. VFA in females was more strongly correlated with WC than in males.

Comparison between high and low levels of VFA

We divided the sample using a cut-off point of VFA (100 cm²)^[4]. Subjects with high levels of VFA had primarily male with a significantly higher height, body weight, BMI, SBP, DBP, and HGB in all subjects ($P < 0.05$, Table 2). In male subjects, TC were also significantly higher in high VFA group ($P < 0.05$, Table 3), whereas PLT were significantly higher in females with high VFA group ($P < 0.05$, Table 4). Of note, the rate of current drinking was significant lower in females with

Table 3 Clinical parameters associated with visceral fat accumulation of male subjects by univariate analysis

	VFA ≥ 100 (n = 348)	VFA < 100 (n = 192)	P value
Age (yr)	55.3 ± 11.7	50.6 ± 12.9	< 0.001
Height (cm)	166.1 ± 6.0	166.2 ± 6.4	0.93
Body weight (kg)	72.1 ± 9.9	66.7 ± 8.2	< 0.001
BMI (kg/m ²)	26.1 ± 3.0	24.1 ± 2.4	0.001
WC (cm)	90.7 ± 7.0	84.9 ± 6.7	< 0.001
SBP (mmHg)	126.6 ± 14.1	121.8 ± 14.2	< 0.001
DBP (mmHg)	79.8 ± 9.5	77.0 ± 8.8	0.001
HGB (g/dL)	15.2 ± 1.0	15.1 ± 1.1	0.29
PLT (× 10 ⁴ /μL)	21.4 ± 4.4	21.5 ± 4.2	0.76
AST (IU/L)	22.9 ± 8.0	23.4 ± 8.7	0.51
ALT (IU/L)	24.4 ± 15.9	25.8 ± 16.6	0.34
GGT (IU/L)	32.3 ± 29.3	25.8 ± 16.6	0.29
ALP (IU/L)	227.0 ± 64.1	228.2 ± 72.2	0.84
ChE (IU/L)	359.0 ± 68.5	353.9 ± 68.2	0.41
TC (mg/dL)	209.6 ± 32.8	203.4 ± 32.7	0.03
LDL-C (mg/dL)	127.1 ± 31.0	124.5 ± 30.1	0.35
HDL-C (mg/dL)	57.4 ± 13.7	55.3 ± 13.4	0.09
TG (mg/dL)	118.4 ± 68.3	118.8 ± 79.1	0.95
FPG (g/dL)	98.6 ± 15.3	101.4 ± 19.6	0.07
HbA1c (%)	5.2 ± 0.5	5.3 ± 0.7	0.06
UA (mg/dL)	5.6 ± 1.4	5.7 ± 1.2	0.28
Alcohol consumption (non/current drinkers)	209/139	119/73	0.37

BMI: Body mass index; WC: Waist circumference; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; VFA: Visceral fat area; HGB: Hemoglobin; PLT: Platelet; AST: Aspartate aminotransferase; ALT: Alanine aminotransferase; GGT: γ -glutamyl transferase; ALP: Alkaline phosphatase; ChE: Cholinesterase; TC: Total cholesterol; LDL-C: Low-density lipoprotein cholesterol; HDL-C: High-density lipoprotein cholesterol; TG: Triglycerides; FPG: Fasting blood glucose; HbA1c: Hemoglobin A1c; UA: Uric acid.

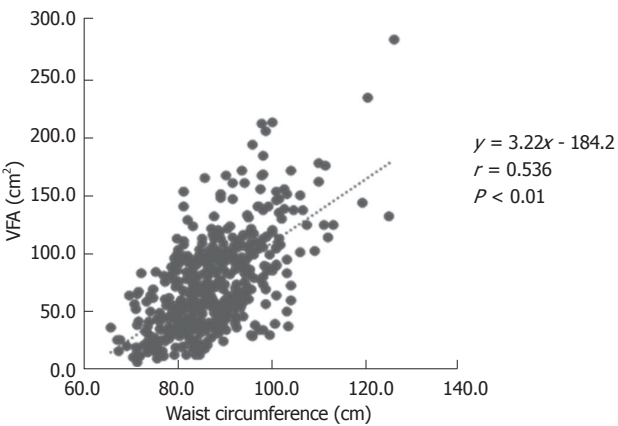


Figure 1 Relationship between waist circumference and visceral fat area of all subjects, showing a significant positive correlation of both parameters ($r = 0.536$, $P < 0.01$). VFA: Visceral fat area.

high VFA group.

Factors affecting visceral fat accumulation

We further evaluated the risk factors for VFA using the multivariate logistic regression analysis. VFA showed positive relationships with age ≥ 56 , male gender, BMI ≥ 24.4 kg/m², BP ≥ 149 and/or 90 mmHg, TG ≥ 149 mg/dL, and current drinking in all subjects (P

Table 4 Clinical parameters associated with visceral fat accumulation of female subjects by univariate analysis

	VFA ≥ 100 (n = 111)	VFA < 100 (n = 353)	P value
Age (yr)	62.1 ± 9.4	56.7 ± 10.0	< 0.001
Height (cm)	151.4 ± 5.6	152.5 ± 5.5	0.07
Body weight (kg)	63.9 ± 12.2	54.1 ± 6.7	< 0.001
BMI (kg/m ²)	27.8 ± 4.4	23.3 ± 2.7	< 0.001
WC (cm)	95.6 ± 9.5	84.7 ± 7.6	< 0.001
SBP (mmHg)	126.0 ± 11.9	119.4 ± 14.8	< 0.001
DBP (mmHg)	76.9 ± 8.0	74.0 ± 9.7	0.004
HGB (g/dL)	13.6 ± 1.1	13.3 ± 0.9	0.02
PLT (× 10 ⁴ /μL)	24.1 ± 5.9	22.9 ± 5.1	0.03
AST (IU/L)	22.5 ± 7.6	23.3 ± 8.4	0.38
ALT (IU/L)	25.3 ± 12.8	26.0 ± 16.8	0.67
GGT (IU/L)	33.0 ± 20.2	36.9 ± 30.3	0.21
ALP (IU/L)	224.8 ± 57.8	224.6 ± 61.9	0.97
ChE (IU/L)	354.0 ± 62.8	352.2 ± 62.8	0.79
TC (mg/dL)	204.8 ± 27.9	205.7 ± 31.1	0.77
LDL-C (mg/dL)	125.8 ± 24.7	125.9 ± 27.7	0.98
HDL-C (mg/dL)	53.8 ± 14.2	55.6 ± 12.2	0.2
TG (mg/dL)	123.1 ± 68.0	124.1 ± 79.1	0.9
FPG (g/dL)	98.9 ± 11.7	100.1 ± 15.9	0.5
HbA1c (%)	5.2 ± 0.4	5.3 ± 0.5	0.11
UA (mg/dL)	5.7 ± 1.4	5.8 ± 1.3	0.66
Alcohol consumption (non/current drinkers)	45/66	188/165	0.01

BMI: Body mass index; WC: Waist circumference; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; VFA: Visceral fat area; HGB: Hemoglobin; PLT: Platelet; AST: Aspartate aminotransferase; ALT: Alanine aminotransferase; GGT: γ -glutamyl transferase; ALP: Alkaline phosphatase; ChE: Cholinesterase; TC: Total cholesterol; LDL-C: Low-density lipoprotein cholesterol; HDL-C: High-density lipoprotein cholesterol; TG: Triglycerides; FPG: Fasting blood glucose; HbA1c: Hemoglobin A1c; UA: Uric acid.

< 0.05, Table 5). In male subjects, VFA was positively associated with age ≥ 56 , BMI ≥ 25.0 kg/m², and TG ≥ 149 mg/dL ($P < 0.05$, Table 6), whereas in female subjects positive associations were observed with age ≥ 58 , BMI ≥ 24.4 kg/m², HDL-C < 40 mg/dL, and current drinking ($P < 0.05$, Table 7).

DISCUSSION

This study was conducted in Okinawa is a subtropical island with 1.4 million population located in the southwest of Japan. BMI of 24.9 ± 3.4 kg/m² in this study was higher than that (23.0 ± 3.3 kg/m²) of a multicenter large health checkup study conducted in the main land Japan^[5]. United States ruled Okinawa for 27 years after the World War II, thus a westernized food and life styles have been popular in Okinawa^[6]. This westernization may attribute to the obesity (higher BMI) in Okinawa.

The Japanese Visceral Fat Syndrome Study Committee of the Ministry of Health and Welfare of Japan was organized to establish the diagnostic criteria of obesity disease and the importance of visceral fat accumulation among the multiple obesity-related cardiovascular risk factors^[4]. They also demonstrated that among the various anthropometric parameters measured in

Table 5 Clinical parameters associated with visceral fat accumulation of all subjects by multivariate logistic regression analysis

Variable	β	SE	Wald	P value	OR	95%CI
Age (≥ 56 yr)	0.692	0.165	17.714	< 0.001	1.999	1.448-2.759
Male gender	1.746	0.202	74.406	< 0.001	5.73	3.854-8.52
BMI (≥ 24.4 kg/m ²)	1.621	0.158	105.265	< 0.001	5.06	3.712-6.897
BP ($\geq 149/90$ mmHg)	0.415	0.196	4.503	0.034	1.515	1.032-2.223
HGB (≥ 14.3 g/dL)	0.251	0.193	1.696	0.193	1.286	0.881-1.876
PLT ($\geq 22.2 \times 10^4/\mu\text{L}$)	-0.014	0.187	0.006	0.938	0.986	0.683-1.422
TC (≥ 219 mg/dL)	-0.206	0.234	0.775	0.379	0.814	0.514-1.288
TG (≥ 149 mg/dL)	0.473	0.203	5.416	0.02	1.604	1.077-2.389
HDL-C (≥ 40 mg/dL)	-0.197	0.279	0.499	0.48	0.821	0.475-1.42
LDL-C (≥ 139 mg/dL)	0.184	0.242	0.574	0.449	1.201	0.747-1.932
AST (≥ 30 IU/L)	-0.191	0.276	0.477	0.49	0.826	0.481-1.42
ALT (≥ 30 IU/L)	0.075	0.238	0.099	0.753	1.078	0.676-1.72
GGT (≥ 51 IU/L)	-0.324	0.233	1.927	0.165	0.724	0.458-1.143
ALP (≥ 325 IU/L)	0.156	0.305	0.263	0.608	1.169	0.643-2.126
ChE (≥ 350 IU/L)	-0.065	0.165	0.155	0.694	0.937	0.678-1.294
UA (≥ 5.8 mg/dL)	-0.117	0.177	0.439	0.508	0.89	0.629-1.257
FPG (≥ 110 g/dL)	-0.473	0.257	3.369	0.066	0.623	0.376-1.033
HbA1c ($\geq 6.2\%$)	-0.205	0.45	0.208	0.649	0.814	0.337-1.969
Current drinking	0.371	0.171	4.713	0.03	1.449	1.037-2.026

BMI: Body mass index; WC: Waist circumference; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; VFA: Visceral fat area; HGB: Hemoglobin; PLT: Platelet; AST: Aspartate aminotransferase; ALT: Alanine aminotransferase; GGT: γ -glutamyl transferase; ALP: Alkaline phosphatase; ChE: Cholinesterase; TC: Total cholesterol; LDL-C: Low-density lipoprotein cholesterol; HDL-C: High-density lipoprotein cholesterol; TG: Triglycerides; FPG: Fasting blood glucose; HbA1c: Hemoglobin A1c; UA: Uric acid; SE: Standard error.

Table 6 Clinical parameters associated with visceral fat accumulation of male subjects by multivariate logistic regression analysis

Variable	β	SE	Wald	P value	OR	95%CI
Age (≥ 56 yr)	0.688	0.21	10.734	0.001	1.99	1.319-3.004
BMI (≥ 25 kg/m ²)	1.459	0.204	51.055	< 0.001	4.301	2.883-6.417
BP ($\geq 149/90$ mmHg)	0.418	0.247	2.859	0.091	1.518	0.936-2.464
Hb (≥ 15.1 g/dL)	0.293	0.203	2.098	0.148	1.341	0.902-1.995
Plt ($\geq 20.9 \times 10^4/\mu\text{L}$)	-0.324	0.236	1.874	0.171	0.724	0.455-1.15
TC (≥ 219 mg/dL)	-0.104	0.316	0.108	0.743	0.901	0.485-1.674
TG (≥ 149 mg/dL)	0.602	0.273	4.862	0.027	1.826	1.069-3.117
HDL-C (≥ 40 mg/dL)	0.218	0.341	0.408	0.523	1.243	0.637-2.427
LDL-C (≥ 139 mg/dL)	0.037	0.322	0.013	0.908	1.038	0.552-1.952
AST (≥ 30 IU/L)	-0.161	0.343	0.22	0.639	0.851	0.434-1.669
ALT (≥ 30 IU/L)	0.022	0.302	0.005	0.942	1.022	0.566-1.847
GGT (≥ 51 IU/L)	-0.003	0.309	0	0.992	0.997	0.544-1.828
ALP (≥ 325 IU/L)	0.124	0.37	0.113	0.737	1.132	0.548-2.34
ChE (≥ 350 IU/L)	-0.049	0.217	0.052	0.819	0.952	0.622-1.455
UA (≥ 5.8 mg/dL)	-0.085	0.232	0.133	0.716	0.919	0.583-1.448
FPG (≥ 110 g/dL)	-0.485	0.327	2.201	0.138	0.615	0.324-1.169
HbA1c ($\geq 6.2\%$)	-0.162	0.532	0.093	0.761	0.85	0.3-2.414
Current drinking	0.345	0.222	2.421	0.12	1.412	0.914-2.18

BMI: Body mass index; WC: Waist circumference; BP: Blood pressure; VFA: Visceral fat area; HGB: Hemoglobin; PLT: Platelet; AST: Aspartate aminotransferase; ALT: Alanine aminotransferase; GGT: γ -glutamyl transferase; ALP: Alkaline phosphatase; ChE: Cholinesterase; TC: Total cholesterol; LDL-C: Low-density lipoprotein cholesterol; HDL-C: High-density lipoprotein cholesterol; TG: Triglycerides; FPG: Fasting blood glucose; HbA1c: Hemoglobin A1c; UA: Uric acid; SE: Standard error.

their study, WC showed the closest relationship with VFA in both men and women. WC is used as an index of visceral fat accumulation in the diagnosis of MS because of its ease of measurement. According to the modified National Cholesterol Education Program's Adult Treatment Panel III (NCEP-ATP) guidelines^[7], the prevalence of MS in Japan and China was 20.6% and 27.6%, respectively^[8,9]. In this study, the CT-evaluated visceral fat accumulation also correlated with WC; our findings confirm that WC is a reliable surrogate measure-

ment for visceral fat accumulation, and the findings are in concordance with results from previous studies conducted within the Japanese population^[10-12].

We focused on gender differences and the relationship between visceral fat accumulation and other clinical parameters. It is well known that visceral fat accumulation exhibits age, sex, and race differences in both prevalence and severity^[13]. Age and gender differences are further affected by country-specific differences in the prevalence of obesity and lifestyle-

Table 7 Clinical parameters associated with visceral fat accumulation of female subjects by multivariate logistic regression analysis

Variable	β	SE	Wald	P value	OR	95%CI
Age (≥ 58 yr)	0.793	0.259	9.349	0.002	2.211	1.33-3.676
BMI (≥ 24.4 kg/m ²)	2.074	0.298	48.386	< 0.001	7.957	4.436-14.275
BP ($\geq 149/90$ mmHg)	0.576	0.346	2.768	0.096	1.78	0.902-3.509
Hb (≥ 14.3 g/dL)	0.39	0.26	2.25	0.134	1.477	0.887-2.457
Plt ($\geq 22.2 \times 10^4/\mu\text{L}$)	0.186	0.295	0.399	0.528	1.205	0.676-2.146
TC (≥ 219 mg/dL)	-0.297	0.388	0.586	0.444	0.743	0.347-1.59
TG (≥ 149 mg/dL)	0.148	0.334	0.196	0.658	1.16	0.602-2.233
HDL-C (≥ 40 mg/dL)	-0.83	0.465	4.463	0.035	0.374	0.15-0.931
LDL-C (≥ 139 mg/dL)	0.355	0.4	0.791	0.374	1.427	0.652-3.122
AST (≥ 30 IU/L)	-0.137	0.489	0.078	0.78	0.872	0.334-2.275
ALT (≥ 30 IU/L)	0.247	0.394	0.392	0.531	1.28	0.591-2.773
GGT (≥ 51 IU/L)	-0.928	0.393	5.567	0.018	0.395	0.183-0.855
ALP (≥ 325 IU/L)	-0.093	0.571	0.027	0.87	0.911	0.298-2.787
ChE (≥ 350 IU/L)	-0.106	0.267	0.158	0.691	0.899	0.533-1.517
UA (≥ 5.8 mg/d)	-0.011	0.285	0.001	0.97	0.989	0.566-1.729
FPG (≥ 110 g/dL)	-0.567	0.412	1.895	0.169	0.567	0.253-1.272
HbA1c ($\geq 6.2\%$)	0.225	0.824	0.075	0.785	1.252	0.249-6.299
Current drinking	0.574	0.285	4.062	0.044	1.776	1.016-3.104

BMI: Body mass index; WC: Waist circumference; BP: Blood pressure; VFA: Visceral fat area; HGB: Hemoglobin; PLT: Platelet; AST: Aspartate aminotransferase; ALT: Alanine aminotransferase; GGT: γ -glutamyl transferase; ALP: Alkaline phosphatase; ChE: Cholinesterase; TC: Total cholesterol; LDL-C: Low-density lipoprotein cholesterol; HDL-C: High-density lipoprotein cholesterol; TG: Triglycerides; FPG: Fasting blood glucose; HbA1c: Hemoglobin A1c; UA: Uric acid; SE: Standard error.

related diseases^[14]. In the present multivariate logistic regression analysis, current drinking was significantly associated with VFA in females but not in male subjects. These differences may be a result of alcoholic drink choice, such as beer vs liquor. The effect of alcohol on fat metabolism remains controversial. In a cross-sectional study of healthy South Korean men, Kim *et al.*^[15] reported that alcohol consumption showed a significant association with increased VFA, which was independent of other factors. On the other hand, Fan *et al.*^[16] have reported that current alcohol consumption was associated with a lower prevalence of MS, irrespective of alcohol intake, and alcohol consumption had a favorable influence on HDL-C and WC in a Shanghai study. Excessive alcohol consumption is known to cause alcoholic liver diseases; however, Moriya *et al.*^[3] from Japan reported that light to moderate alcohol consumption by men was likely to protect individuals against fatty liver over time. Most recently, Takahashi *et al.*^[17] from Japan showed clearly in a cohort study that alcohol had a biphasic effect on fatty liver. Although the available evidence is conflicting, moderation of alcohol consumption is still a consistent recommendation for a healthy lifestyle^[18].

The strengths of our study are the large sample size and the direct assessment of VFA using a CT scan which allowed for the precise determination of the WC component^[12]. In addition, the study subjects were representative of the general population undergoing a health checkup. There are some limitations of this study. First, because of the cross-sectional design of this study, we could not identify the causal relationship between VFA and the various parameters in depth. Second, the self-administered questionnaire on alcohol consumption may have resulted in under-reported alcohol intake for some subjects. Third, this study lacks data regarding

patient medication use, nutritional intake, and physical fitness, all variables that can influence visceral fat accumulation. There was a possibility of selection bias because subjects were volunteers who opted to complete a health checkup. Thus, it is possible the study subjects also had an increased awareness of healthy behaviors.

In conclusion, despite these limitations, the present study showed gender differences in the clinical and biochemical parameters associated with visceral fat accumulation in the general population in Okinawa, Japan. Visceral obesity is probably the most important target for future interventions in MS. Future studies are needed to clarify preventive methods among different gender and age groups.

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COMMENTS

Background

Visceral fat accumulation is closely related to atherogenic disorders and metabolic syndrome (MS), including diabetes mellitus, hypertension, and dyslipidemia. It also leads to obesity-related complications. MS further increases the risks for cardiovascular diseases and thus is an important therapeutic target.

Research frontiers

Although computed tomography has been applied widely as the gold standard method to evaluate visceral fat accumulation, little is known about what clinical and biochemical parameters affect visceral fat accumulation. The aim of this study is to investigate the clinical and biochemical parameters potentially associated with visceral fat accumulation.

Innovations and breakthroughs

The present study showed gender differences in the clinical and biochemical

parameters which associated with visceral fat accumulation in the general population in Okinawa, Japan.

Applications

Visceral obesity is probably the most important target for future interventions in MS.

Terminology

Visceral fat accumulation is defined as the sum of the intraperitoneal fat area with computed tomography (CT) density in the range of -150 to -50 Hounsfield units.

Peer-review

The authors retrospectively analyzed data of 1004 check up patients. They found that visceral fat area measured by CT is correlated with waist circumference and metabolic parameters in both sex.

REFERENCES

- 1 **Matsuzawa Y**, Funahashi T, Nakamura T. The concept of metabolic syndrome: contribution of visceral fat accumulation and its molecular mechanism. *J Atheroscler Thromb* 2011; **18**: 629-639 [PMID: 21737960 DOI: 10.5551/jat.7922]
- 2 **Ryo M**, Kishida K, Nakamura T, Yoshizumi T, Funahashi T, Shimomura I. Clinical significance of visceral adiposity assessed by computed tomography: A Japanese perspective. *World J Radiol* 2014; **6**: 409-416 [PMID: 25071881 DOI: 10.4329/wjr.v6.i7.409]
- 3 **Moriya A**, Iwasaki Y, Ohguchi S, Kayashima E, Mitsumune T, Taniguchi H, Ando M, Yamamoto K. Roles of alcohol consumption in fatty liver: a longitudinal study. *J Hepatol* 2015; **62**: 921-927 [PMID: 25433160 DOI: 10.1016/j.jhep.2014.11.025]
- 4 **Examination Committee of Criteria for 'Obesity Disease' in Japan**; Japan Society for the Study of Obesity. New criteria for 'obesity disease' in Japan. *Circ J* 2002; **66**: 987-992 [PMID: 12419927 DOI: 10.1253/circj.66.987]
- 5 **Eguchi Y**, Hyogo H, Ono M, Mizuta T, Ono N, Fujimoto K, Chayama K, Saibara T. Prevalence and associated metabolic factors of nonalcoholic fatty liver disease in the general population from 2009 to 2010 in Japan: a multicenter large retrospective study. *J Gastroenterol* 2012; **47**: 586-595 [PMID: 22328022 DOI: 10.1007/s00535-012-0533-z]
- 6 **Sugama C**, Isa K, Okumura K, Iseki K, Kinjo K, Ohya Y. Trends in the incidence of stroke and cardiovascular risk factors on the isolated island of Okinawa: the Miyakojima study. *J Stroke Cerebrovasc Dis* 2013; **22**: e118-e123 [PMID: 23122721 DOI: 10.1016/j.jstrokecerebrovasdis.2012.08.016]
- 7 **Grundey SM**, Cleeman JI, Daniels SR, Donato KA, Eckel RH, Franklin BA, Gordon DJ, Krauss RM, Savage PJ, Smith SC, Spertus JA, Costa F. Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement. *Circulation* 2005; **112**: 2735-2752 [PMID: 16157765 DOI: 10.1161/CIRCULATIONAHA.105.169404]
- 8 **Takami H**, Nakamoto M, Uemura H, Katsuura S, Yamaguchi M, Hiyoshi M, Sawachika F, Jutta T, Arisawa K. Inverse correlation between coffee consumption and prevalence of metabolic syndrome: baseline survey of the Japan Multi-Institutional Collaborative Cohort (J-MICC) Study in Tokushima, Japan. *J Epidemiol* 2013; **23**: 12-20 [PMID: 23047663 DOI: 10.2188/jea.JE20120053]
- 9 **Xi B**, He D, Hu Y, Zhou D. Prevalence of metabolic syndrome and its influencing factors among the Chinese adults: the China Health and Nutrition Survey in 2009. *Prev Med* 2013; **57**: 867-871 [PMID: 24103567 DOI: 10.1016/j.ypmed.2013.09.023]
- 10 **Ishibashi E**, Eguchi Y, Eguchi T, Matsunobu A, Oza N, Nakashita S, Kitajima Y, Kuroki S, Ozaki I, Kawaguchi Y, Ide Y, Yasutake T, Iwakiri R, Mizuta T, Ono N, Fujimoto K. Waist circumference correlates with hepatic fat accumulation in male Japanese patients with non-alcoholic fatty liver disease, but not in females. *J Gastroenterol Hepatol* 2008; **23**: 908-913 [PMID: 18373563 DOI: 10.1111/j.1440-1746.2008.05366.x]
- 11 **Oka R**, Kobayashi J, Yagi K, Tanii H, Miyamoto S, Asano A, Hagishita T, Mori M, Moriuchi T, Kobayashi M, Katsuda S, Kawashiri MA, Nohara A, Takeda Y, Mabuchi H, Yamagishi M. Reassessment of the cutoff values of waist circumference and visceral fat area for identifying Japanese subjects at risk for the metabolic syndrome. *Diabetes Res Clin Pract* 2008; **79**: 474-481 [PMID: 18031862 DOI: 10.1016/j.diabres.2007.10.016]
- 12 **Matsushita Y**, Nakagawa T, Shinohara M, Yamamoto S, Takahashi Y, Mizoue T, Yokoyama T, Noda M. How can waist circumference predict the body composition? *Diabetol Metab Syndr* 2014; **6**: 11 [PMID: 24472677 DOI: 10.1186/1758-5996-6-11]
- 13 **Camhi SM**, Bray GA, Bouchard C, Greenway FL, Johnson WD, Newton RL, Ravussin E, Ryan DH, Smith SR, Katzmarzyk PT. The relationship of waist circumference and BMI to visceral, subcutaneous, and total body fat: sex and race differences. *Obesity* (Silver Spring) 2011; **19**: 402-408 [PMID: 20948514 DOI: 10.1038/oby.2010.248]
- 14 **Yatsuji S**, Hashimoto E, Tobari M, Tokushige K, Shiratori K. Influence of age and gender in Japanese patients with non-alcoholic steatohepatitis. *Hepatol Res* 2007; **37**: 1034-1043 [PMID: 17610504 DOI: 10.1111/j.1872-034X.2007.00156.x]
- 15 **Kim KH**, Oh SW, Kwon H, Park JH, Choi H, Cho B. Alcohol consumption and its relation to visceral and subcutaneous adipose tissues in healthy male Koreans. *Ann Nutr Metab* 2012; **60**: 52-61 [PMID: 22327000 DOI: 10.1159/000334710]
- 16 **Fan JG**, Farrell GC. VAT fat is bad for the liver, SAT fat is not! *J Gastroenterol Hepatol* 2008; **23**: 829-832 [PMID: 18565017 DOI: 10.1111/j.1440-1746.2008.05474.x]
- 17 **Takahashi H**, Ono M, Hyogo H, Tsuji C, Kitajima Y, Ono N, Eguchi T, Fujimoto K, Chayama K, Saibara T, Anzai K, Eguchi Y. Biphasic effect of alcohol intake on the development of fatty liver disease. *J Gastroenterol* 2015; **50**: 1114-1123 [PMID: 25733100 DOI: 10.1007/s00535-015-1058-z]
- 18 **Traversy G**, Chaput JP. Alcohol Consumption and Obesity: An Update. *Curr Obes Rep* 2015; **4**: 122-130 [PMID: 25741455 DOI: 10.1007/s13679-014-0129-4]

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