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# Association between abdominal fat distribution and atherosclerotic changes in the carotid artery

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**KEYWORDS**
Carotid intima-media thickness;
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Abdominal subcutaneous fat;
Body fat distribution;
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**Summary**
*Aim:* We aimed to evaluate the association between abdominal fat distribution (e.g., abdominal visceral fat area [VFA], subcutaneous fat area [SFA], and total fat area [TFA]), waist circumference (WC), or body mass index (BMI) and atherosclerotic changes in the carotid artery after adjusting for common risk factors.
*Methods:* The present study is a hospital-based, cross-sectional study. Study participants included 223 Japanese individuals who underwent a medical health checkup at Juntendo University Hospital, Tokyo, between December 2005 and August 2011. Multivariate logistic regression analysis was used to examine the association between abdominal VFA, SFA, TFA, the VFA/SFA ratio, WC, or BMI and intima-media thickness [IMT] (mean IMT $\geq$ 1.1 mm or maximum IMT $\geq$ 1.2 mm) as atherosclerotic changes in the carotid artery.
*Results:* Multivariate logistic regression analysis showed that VFA (OR for $\geq$150 $cm^2$ versus <100 $cm^2$, 3.88; 95% CI, 1.39—10.85), BMI (OR for $\geq$27.6 $kg/m^2$ versus <25 $kg/m^2$, 5.22; 95% CI, 1.69—16.16), and TFA (OR for 200—285 $cm^2$ versus <200 $cm^2$, 4.15; 95% CI, 1.34—12.86: OR for $\geq$285 $cm^2$ versus <200 $cm^2$, 5.53; 95% CI, 1.76—17.35) were significantly associated with atherosclerotic changes in men. After adjustment for BMI, only TFA (OR for $\geq$285 $cm^2$ versus <200 $cm^2$, 3.76; 95%CI, 1.03—13.79) in men was significantly associated with atherosclerotic changes in the carotid artery.

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*Conclusions:* Our results indicate that VFA, TFA, and BMI are independently associated with atherosclerotic changes in Japanese men. TFA may be considered as a valuable measure of atherosclerotic changes.


## Introduction

Obesity is an increasing worldwide concern that seriously affects all-cause mortality as well as atherosclerotic outcomes [1—4]. Among the many barometers of cardiovascular health, abdominal visceral fat accumulation has received considerable attention as it has been associated with an increased risk of metabolic syndrome and cardiovascular events, and all-cause mortality [5—19]. However, it is unclear whether visceral fat is a better measure of obesity-related disease than BMI [12,16,17]. On the other hand, the contribution of subcutaneous fat remains controversial as it has been reported to be both a beneficial factor [7,20—22] and risk factor [6,8—10] for atherosclerosis. In addition, a few studies have evaluated abdominal total fat area (TFA: the sum of subcutaneous fat area [SFA] and visceral fat area [VFA]) and reported a strong correlation with insulin resistance [23], metabolic syndrome [24], or coronary artery calcification [25]. Therefore, the association between abdominal fat distribution and atherosclerosis needs further evaluation.

In Japan, voluntary health checkups are common, including various examinations such as abdominal computed tomography (CT), carotid artery ultrasonography, and other atherosclerosis-related diagnostic methods. By assessing those data, it provides opportunities to improve early detection and treatment of atherosclerosis. In the present study, we aimed to determine the characteristics of abdominal fat composition (i.e., VFA, SFA, TFA, and the VFA/SFA ratio) using CT and the association between abdominal fat composition, body mass index (BMI), or waist circumference (WC) and atherosclerotic changes as evaluated by carotid intima-media thickness (IMT).

## Participants and methods

### Study participants

The present cross sectional study included 237 Japanese participants who underwent an inpatient medical health checkup at Juntendo University Hospital, Tokyo, between December 2005 and August 2011. Among these participants, 14 were excluded due to missing abdominal CT and carotid artery ultrasonography data. A total of 223 participants were thus included in the study.

### Anthropometry and laboratory tests

Height (m) and weight (kg) were each measured in a standing position, and BMI (weight [kg]/height $[m]^2$) was calculated. WC was measured with a non-stretchable tape at the level of the umbilicus in a standing position and during late expiration [26]. Blood pressure was measured using a standard mercury sphygmomanometer from the right or left arm after the subject had rested for at least 10 min in a sitting position. Venous blood samples were collected following overnight fasting, and blood glucose, haemoglobin A1c (HbA1c), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), and triglyceride (TG) levels were measured. Participant medical history and lifestyle was assessed using a self-administered questionnaire.

### Abdominal fat area measurements

Abdominal fat areas were measured from CT scans taken at the level of the umbilicus while in the supine position and during late expiration according to Japanese guidelines for obesity treatment (Japan Society for the Study of Obesity, in Japanese) [27]. Aquilion 16 and Aquilion 64 scanners (Toshiba Medical Systems Corporation, Tokyo) were used to obtain 122 CT scans and 101 CT scans, respectively, acquiring 4 mm thick slices (120 kVp; 300 mAs; 300 mA $\times$ 1 s). According to Blitman et al., there are no significant differences between visceral abdominal fat measurements obtained on a 16-MDCT scanner and 64-MDCT scanner [28] in a paediatric population. One hundred fifteen abdominal fat areas were measured manually, whereas 108 were computed automatically using commercial software (Toshiba Aquilion 64 Ver3.35 JR007). In the manual method, the attenuation for fat was defined as the range with mean attenuation plus or minus 2 standard deviations (SD) [29]. We manually