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Relationship Between Common Carotid Intima-Media Thickness and Abdominal Visceral Adipose Tissue, Abdominal Subcutaneous Adipose Tissue, and Neck Subcutaneous Adipose Tissue as Measured by Ultrasonography

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ABSTRACT

Background: Obesity and overweight are major health problems associated with metabolic disorders and cardiovascular diseases. Body fat distribution is associated with subclinical atherosclerosis. The present study aimed to determine the association of abdominal visceral and subcutaneous fat and the neck subcutaneous fat, measured by ultrasound, with the intima-media thickness of the common carotid artery in obese individuals.

Material and Methods: This study was performed on 160 individuals (82 men and 78 women; age: 20-70 years) to determine the association of abdominal visceral and subcutaneous fat and the neck subcutaneous fat as predictors of atherosclerosis based on ultrasound with the intima-media thickness of the common carotid artery.

Results: Based on the multiple linear regression analysis results, the neck adipose tissue was generally a better predictor of subclinical atherosclerosis (P=0.007, beta coefficient=0.414)**.** Besides, men had a higher visceral adipose tissue than women (P=0.003). It was found that the visceral adipose tissue (P=0.018, beta coefficient=0.537) in men and the neck adipose tissue (P=0.027, beta coefficient=0.472) in women were more strongly associated with the intima-media thickness.

Conclusion: The results of this study suggest that abdominal visceral adipose tissue and subcutaneous neck adipose tissue measured by ultrasonography are correlated with subclinical carotid artery atherosclerosis in men and women, respectively.

Keywords: *Subcutaneous fat, Intra-abdominal fat, Ultrasonography, Atherosclerosis*

BACKGROUND

Obesity has become a global epidemic, increasing the prevalence and burden of related diseases (1). This disease is associated with various chronic conditions and is recognized as a risk factor for cardiovascular and cerebrovascular diseases and diabetes mellitus (2). Although the total body fat and body mass index (BMI) are directly associated with the risk of cardiovascular complications, recent studies have shown that the location and distribution of.

fat in the body are better predictors of obesity complications (3, 4) Recently, more attention has been paid to the relationship between fat distribution in different parts of the body and vascular atherosclerosis and cardiovascular and metabolic diseases. Numerous studies have shown that the visceral adipose tissue (VAT) and the neck circumference are more significantly associated with cardiovascular and metabolic diseases as compared to the abdominal subcutaneous adipose tissue (SAT) (5-8).

Magnetic resonance imaging (MRI) and computed tomography (CT) scan are standard methods for assessing and measuring visceral and subcutaneous fat (9, 10). Nevertheless, studies suggest a strong correlation between these methods and the indices measured by ultrasound for determining the amount of fat in different parts of the body (6, 11). Therefore, due to the lack of ionizing radiation, availability, and low cost, ultrasound can be a suitable method for determining fat in different parts of the body (12).

The intima-media thickness (IMT) of the carotid artery is a surrogate indicator for subclinical atherosclerosis, and its association with atherosclerosis-related diseases (e.g., stroke, myocardial infarction, and peripheral arterial disease) has been previously reported (10, 13). This marker can be easily measured by ultrasound as a non-invasive method; accordingly, it was used to assess atherosclerosis in this study. The present study aimed to assess the association of abdominal VAT, abdominal SAT, and subcutaneous nuchal adipose tissue (NAT) with the IMT of the common carotid artery.

MATERIAL AND METHODS

Study population

The study population of this cross-sectional study included patients (age: 20-70 years) referred as outpatients to the radiology ward of Taleghani Hospital in Tehran, Iran, mainly for gastrointestinal or gynecological symptoms. This study was conducted between October 2020 to March 2021. Patients with cardiovascular disease or atherosclerotic plaques in the carotid artery were excluded from the study. To prevent interference with ultrasound measurements, patients with a history of abdominal or neck surgery were also excluded from the study. The weight and height of the patients were measured as standard (14).

Before recruitment in the study, informed consent was obtained from all the patients (15). The study protocol was approved by the research ethics committee of Shahid Beheshti University of Medical Sciences and Health Services (ethical code: IR.SBMU.MSP.REC.1398.467), and the study was performed according to the principles of the Declaration of Helsinki.

Sonographic measurements

All measurements were carried out by an experienced radiologist, using a Samsung WS80A ultrasound machine. The VAT was measured using a curved probe (1-6 MHz), and SAT, NAT, and IMT were measured using a linear probe (3-12 MHz). All measurements were performed while the patient was in the supine position. An ultrasound probe was placed one centimeter above the umbilicus to measure VAT and SAT. Measurements were performed without probe pressure on the abdomen by holding the probe vertically during the expiratory phase of respiration. The abdominal SAT was measured as the maximum distance between the skin-fat interface and the linea alba (16). The abdominal VAT was also defined as the distance between the anterior wall of the aorta and the posterior wall of the rectus abdominis muscle.

To measure the IMT, a longitudinal view of the common carotid artery was obtained, and the IMT was measured at a distance of 1 cm from the bifurcation of the common carotid artery in the far wall using an automated IMT measurement system. The laryngeal prominence was used as a superficial anatomical landmark for the measurement of NAT, which is typically at the vertebral body level of C5. The probe was held vertically to the skin, and multiple measurements were performed on the right side of the neck (anterior, lateral, and posterior aspects) between the fat-skin interface and the deep cervical fascia; the thickest measurement was used for further analysis.

Statistical analysis

The sample size of this study was calculated using the Power Analysis and Sample Size Software (PASS 15; NCSS, LLC., Kaysville, Utah, USA) at an alpha level of 1% and a power of 95%. Statistical analysis was performed using SPSS version 26 for Windows (SPSS Inc., Chicago, IL, USA). Descriptive data were presented as mean±SD, frequency, and percentage. The relationship between different variables and IMT was examined using Pearson's correlation coefficient test and linear regression analysis. In the multiple linear regression analysis, IMT was considered a dependent variable, and sex, age, BMI, SAT, VAT, and NAT were considered as independent variables. A P-value less than 0.05 was considered significant.

RESULTS

Of 160 patients, 82 were male (51.2%), and 78 were female (48.8%). The characteristics of the patients are presented in Table 1. Men had a higher VAT than women (P=0.003), while there was no significant difference between women and men in terms of age, SAT, NAT, BMI, and IMT (P>0.05).

TABLE 1: The demographic characteristics of the participants in this study (n=160)

	Male (n= 82)	**Female (n=78)**	**Total (n=160)**
	Mean (SD)	Mean (SD)	Mean (SD)
Age (years)	36.9 (8.1)	38.7 (9.1)	37.8 (8.6)
Height (cm)	173.4 (7.4)	162.3 (7.3)	168.3 (9.2)
Weight (kg)	78.1 (16.8)	68.6 (16.4)	73.4 (17.2)
BMI (kg/m^2)	27.3 (4.8)	25.0 (4.1)	26.2 (4.6)
SAT (mm)	22.8 (13.0)	22.5 (8.5)	22.7 (11.0)
VAT (mm)	76.9 (19.4)	65.8 (19.5)	71.3 (20.1)
NAT (mm)	2.82 (0.76)	3.0 (0.9)	2.92 (0.8)
IMT (mm)	0.37 (0.08)	0.40 (0.1)	0.40 (0.1)

*BMI: Body mass index, SAT: Subcutaneous adipose tissue, VAT: Visceral adipose tissue, NAT: Neck adipose tissue, IMT: Intima-media thickness.

There was a significant positive correlation between SAT and IMT in women (r=0.241, P=0.047), while there was no significant correlation between SAT and IMT in men (r=0.129, P=0.306). There was also a significant positive relationship between VAT and IMT in both men (r=0.277, P=0.028) and women (r=0.463, P<0.01). Besides, there was a significant positive relationship between NAT and IMT in both men (r=0.256, P=0.037) and women (r=0.483, P<0.01). Without adjustments for sex, there was no significant correlation between SAT and IMT (r=0.167, P=0.054), while a positive correlation was observed between IMT and VAT (r=0.282, P<0.01) and between IMT and NAT (r=0.408, P<0.001).

TABLE 2: The correlation of IMT with SAT, VAT, and NAT

	IMT					
	Male (n= 82)		Female (n=78)		Total	
	r	P	r	P	r	P
SAT	0.129	0.306	0.241	0.047	0.167	0.054
VAT	0.277	0.028	0.463	<0.01	0.282	<0.01
NAT	0.256	0.037	0.483	<0.01	0.408	<0.01

*SAT: Abdominal subcutaneous adipose tissue, VAT: Abdominal visceral adipose tissue, NAT: Neck subcutaneous adipose tissue, IMT: Intima-media thickness.

In the multiple linear regression analysis, in which IMT was considered as a dependent variable, and sex, age, BMI, SAT, VAT, and NAT were considered as independent variables, NAT was generally a better predictor of subclinical atherosclerosis (P=0.030, beta coefficient=0.033). It was shown that 28.8% of the IMT was described by sex, age, BMI, SAT, VAT, and NAT (R-Square = 0.288, P < 0.019, F = 2.89) (Table 3).

TABLE 3: The linear regression model of IMT was considered as a dependent variable, and sex, age, BMI, SAT, VAT, and NAT were considered independent variables

Items		B	Standardized Beta	P-value	95.0% Confidence Interval for B	
					Lower Bound	Upper Bound
Model	(Constant)	0.082		0.415	-0.119	0.282
	Gender	0.049	0.283	0.101	-0.010	0.108
	Age	0.002	0.200	0.198	-0.001	0.005
	BMI	-0.001	-0.046	0.807	-0.009	0.007
	SAT	-0.001	-0.057	0.740	-0.005	0.003
	VAT	0.001	0.250	0.145	0.000	0.002
	NAT	0.033	0.314	0.030	0.003	0.062

DISCUSSION

The present study investigated the association of regional adiposity and fat distribution in the body with the risk of subclinical atherosclerosis. The findings showed that without sex adjustments, the IMT had a positive correlation with NAT and VAT. We compared the present findings with previous studies and tried to determine the reason for our findings.

So far, numerous studies have reported an association between the neck circumference (NC) with IMT and cardiovascular disease (17-19). Moreover, some studies have shown an association between the NAT measured by optical lipometry and the risk of cardiovascular and metabolic complications (17, 20). In a study by Torriani et al., the amount of NAT measured on CT was significantly associated with the risk of cardiac and metabolic complications, especially in women (20). The results of our study also showed that the NAT measured by ultrasonography has a significant positive relationship with IMT in both women and men.

A study by Mangge et al. showed that an increase in the NAT was associated with an increase in the low molecular weight/total adiponectin ratio (21). In another study by these researchers, a strong positive relationship was found between an increase in the low molecular weight/total adiponectin ratio and IMT (22). Therefore, an increase in the NAT could increase the risk of atherosclerosis by changing inflammatory and anti-inflammatory factors (23); this finding was consistent with the results of the present study.

Previous studies indicated a direct association between VAT and the risk of atherosclerosis and cardiovascular disease (7, 24), which is in line with the present study. In this regard, a study by Kawamoto et al. showed that in addition to traditional risk factors, VAT is also significantly associated with IMT (25). The findings of this study showed that VAT was positively associated with IMT in both women and men. This association might be related to the higher lipolytic activity of abdominal visceral fat and the direct release of free fatty acids into the portal venous circulation. Besides, a study by Liu et al. showed a weak positive association between SAT and IMT in women (26). The findings of their study are also consistent with our results, and the current study shows that NAT in women is a better predictor of the risk of subclinical atherosclerosis. NAT had a stronger correlation with IMT in females than males. Gender dissimilarities in body fatness or regional adipose tissue distribution are well demonstrated. Generally, men are prone to abdominal fat deposition, especially in the abdominal cavity, described as visceral obesity whereas a more unique body fat content generally represents in females with preferential adipose tissue accumulation in the other body parts such as gluteofemoral region. Compatible with these observations, males in the current study had higher mean VAT than females for a given level of BMI, whereas females had more NAT volume (26).

This study had some limitations. First, the sample size was relatively small; therefore, a larger study population is needed to confirm the present findings. Second, ultrasound was used in this study as a low-cost and accessible method, without ionizing radiation to measure the adipose tissue in different parts of the body, however this method has limitations in measuring VAT, particularly in patients with severe obesity. Third, in this study, IMT was used as the only dependent variable to investigate the vascular effects of fat distribution in the body. Therefore, further studies are needed to evaluate other metabolic and cardiovascular effects of fat distribution in different body parts.

CONCLUSIONS

This study showed that fat distribution in different body compartments is associated with subclinical atherosclerosis. Neck subcutaneous adipose tissue and abdominal visceral adipose tissue are associated with an increased risk of subclinical atherosclerosis.

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Authors' Contributions

Study concept: Pooneh Dehghan and Taraneh Faghihi. Study design: Dina Jalalvand and Solmaz Davand. Recruitment and data collection: Sajedeh Kouchaki. Data analysis, interpretation and manuscript writing: Mehdi Eshaghzadeh. All author's read and approved the final manuscript.

Conflict of Interest

There is no conflict of interest.

Ethical Approval

The Ethics Committee of the Research Institute of Shahid Beheshti University of Medical Sciences (Tehran, Iran) approved the protocol of this study.

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