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RESEARCH ARTICLE

The Correlation of Body Mass Index with Visceral and Subcutaneous Adipose Tissue Volume in Patients that Performed Abdominal CT scan at RSUP H. Adam Malik Medan

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Abstract: Cardiometabolic risk factors include visceral and subcutaneous adipose tissue (VAT and SAT and excess body mass index (BMI). BMI only describes the general ratio of body weight to height. An abdominal CT scan is a gold standard in examining VAT and SAT volumes. This study explores the relationship between BMI, VAT, and SAT in patients with abdominal CT scans. This cross-sectional study included 60 patients who underwent CT scans of the abdominal region at the RSUP H. Adam Malik Medan's Radiology Department between July and August 2022. The BMI was calculated using 3D intelligent segmentation from CT scans of the abdominal region at the fourth lumbal level, as was the volume of VAT and SAT. Males made up 51.7% of the samples. The average age and BMI are 49.,3 12.18 years and 25.58 kg/m2, respectively. The average VAT and SAT volume values are 678.1,3 436.09 cm3 and 1708.76 1068.99 cm3, respectively. With P<0.001, a moderate positive correlation exists between BMI and VAT (r=0.687) and BMI and SAT (r=0.669).

Keywords: Abdominal CT scan, body mass index, subcutaneous adipose tissue, visceral adipose tissue

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INTRODUCTION

Obesity awareness and modernity have a direct impact on lifestyle changes.[1,2] Previous research has found that having a high BMI, or being obese, can increase your risk of heart disease. However, not all obese patients suffer from hypertension, diabetes, or dyslipidaemia.[3] VAT and SAT have a significant impact on cardiometabolic events.[4] VAT is fat surrounding the internal organs, including the mesentery and omentum. It is bounded by the parietal peritoneum transversal fascia, whereas SAT is fat that lies beneath the skin.[5-8]

BMI measurements alone cannot determine the visceral and subcutaneous fat present. CT Scan is an accessible and gold standard modality. CT scan measurements can be made using single or volumetric slices.[3,5] Excess free fatty acids will initially be stored as subcutaneous fat tissue due to the positive energy balance that directly leads to obesity. When the SAT storage capacity is reached, or there is interference, the accumulated fat is transferred to areas other than the subcutaneous space, including VAT.[9-10]

Medical personnel can provide some advice to prevent the cardiometabolic syndrome, particularly for patients at risk of cardiovascular disease, by knowing the state of a person's VAT and SAT. Furthermore, the VAT value can help prevent clinical worsening for those helpful already have metabolic disorders. Although abdominal CT Scan examinations are relatively common, VAT and SAT volumetric measurements are still uncommon. As a result, his daisy study examines the relationship between BMI, VAT and SAT in patients with abdominal CT scans.

METHODS

This study uses data from BMI, VAT, and SAT measurements. This research aims to determine the relationship between BMI, VAT and SAT in patients undergoing abdominal region CT scans. The Health Ethical Research Committee Universitas Sumatera Utara issued ethical clearance with issue number 600/KEPK/USU/2022. The Director of Employees, Academics, and General of the RSUP, H. Adam Malik Medan, issued a research license. The population consisted of patients who came to the Radiology Department to undergo a CT scan of the abdomen (CT Scan of the abdomen, CT Scan Liver 3 Phases, CT scan Pelvic, CT scan Lumbal, CT Angiography Abdomen) at the Radiology Department RSUP H. Adam Malik Medan. The inclusion criteria were age 20 to 70 years, willingness to participate in the study, and registration in medical records. Patients with intra-abdominal tumour masses surged immensely, which impacted the digestive process (gastrectomy, jejunostomy, duodenostomy, and colostomy), ascites, anatomical abnormalities of the abdominal cavity, and malignancy were all excluded. Clinical data were extracted from electronic health records and reviewed manually.

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Based on sample size calculations ting to BMI, VAT, and SAT, 60 patients are sampled sequentially until the sample is complete. The measuring tool is a weight and height scale calibrated by Security Centres Health Facilities Medan to obtain BMI data. We use CT Philips Ingenuity 128 or CT Scan GE Bright speed 16 with volumetry software called clip 3D intelligent segment each in CT Philips Ingenuity 128 workstation to measure the VAT and SAT volume. Measurements were taken at the fourth lumbal, a predetermined fat landmark determined by density evaluation between -30 and -250 HU, and the book was determined and reported in cm^3. The thickness of the slice is 5 mm. The data is entered into the manual form and master table. The researchers conducted the analysis (DRS and NDL). The interclass correlation coefficients (95% CI) for VAT are 86% and 83%, respectively. We can see from the Kolmogorov Smirnov's that the BMI distribution is parametric ($p > 0.05$), but the VAT and SAT distributions are nonparametric (p 0.05), so we use the SPSS software to analyse the correlation between BMI and VAT and SAT.

RESULTS

This research was completed in August 2022. This numerical, cross-sectional study with correlation analysis employs a non-probability sampling technique, namely consecutive sampling. There are 31 men (51.7%) among the 60 people, and the average age is 49.3 12.18 years. Table 1 displays the sample characteristics. The average body mass index (BMI) was 25.58 4.14 kg/m^2. The average SAT volume was 1708.761068.99 cm^3, while the average VAT volume was 678.13 436.09 cm^3. Table 2 showed the BMI values, VAT, and SAT volume for each sex when we classified it by gender.

Table 1. Samples Characteristics

Characteristics	Result
Sex (n, %)	
Male	31 (51,7 %)
Female	29 (48,3%)
BMI Classification (n, %)	
Underweight	1 (1,7%)
Normal	16 (26,7%)
Overweight	13 (21,7%)
Obesity Grade I	22 (36,7%)
Obesity Grade II	8 (13,3%)
Age (μ ± SD, tahun)	49,3 ± 12,18
Body weight (μ ± SD, kg)	65,95 ± 13,04
Body Height (μ ± SD, cm)	160,21 ± 6,46
BMI (μ ± SD, kg/m²)	25,58 ± 4,14
VAT (μ ± SD, cm³)	678,13 ± 436,09
SAT (μ ± SD, cm³)	1708,76 ± 1068,99

μ = average value

The average age of the 60 samples was 50 years, with 31 people falling into this category. The majority, 17 people, were men of that age. The number of representatives from the under-50 age group was 29, with the majority of these samples, 16 people, also being men.

Table 2 Distribution of BMI, VAT, and SAT based on sex

Parameters	Male	Female
BMI (kg/m²)	25,59 ± 4,14	25,57 ± 4,22
VAT (cm³)	735,91 ± 538,31	616,35 ± 605,90
SAT (cm³)	1404,18 ± 861,25	2034,35 ± 1847,20

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The sample age group of 61-70 years occupied the highest frequency in this study, namely 17 people, with the majority being men, ten people, and seven women. Figure 1 depicts data on the sample's age distribution based on age group and sex to VAT and SAT volume in quartiles of age group, sex with BMI, VAT, and SAT.

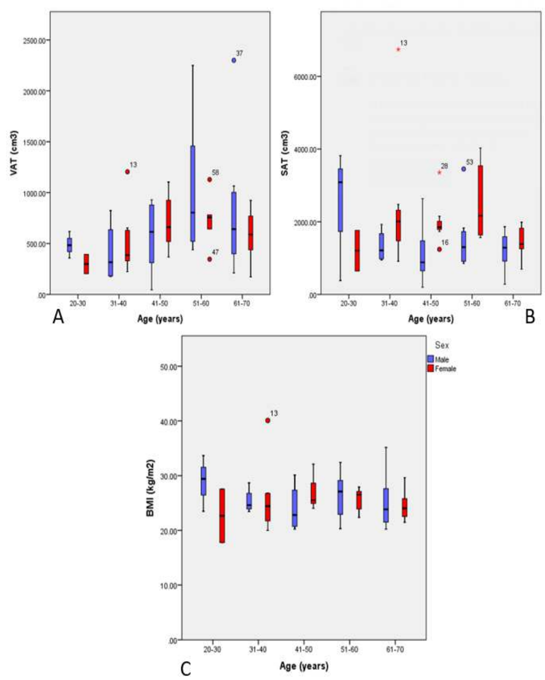

Figure 1. Quartil of age with A)VAT B)SAT, and C) BMI

Figures 2–5 show the VAT and SAT measurement results using the innovative segmentation method.

Statistical analysis using Spearman's correlation test revealed a moderately significant positive correlation between BMI and VAT, as well as between BMI and SAT (p 0.001), as shown in Table 3. Figure 6 depicts a scatter plot of BMI with VAT versus BMI with SAT.

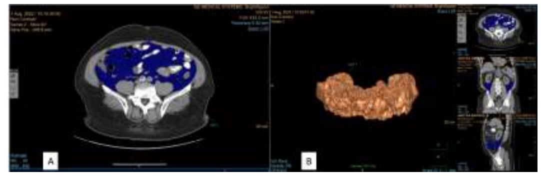

Figure 2. The volume measurement of VAT in a patient with BMI 30.53 kg/m^2. A) Segmentation VAT at L4 level with intelligent segmentation (blue colour)). B) Clip 3D showed the result of VAT measurement in cm^3 (gold colour).

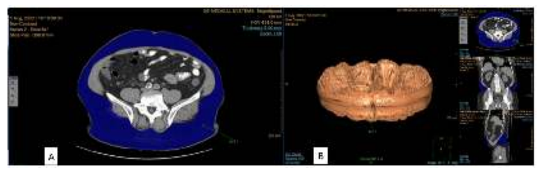

Figure 3. The volume measurement of SAT in a patient with a BMI of 30.53 kg/m^2. A) Segmentation SAT at L4 level with intelligent segmentation (blue colour). B) Clip 3D showed the result of SAT measurement in cm^3 (gold colour).

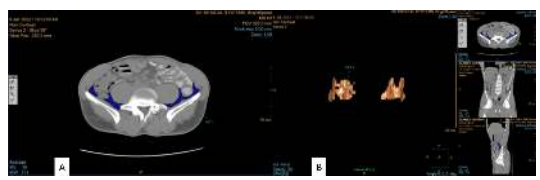

Figure 4. The volume measurement of VAT in a patient with a BMI of 20.73 kg/m^2. A) Segmentation VAT at L4 level with intelligent segmentation (blue colour). B) Clip 3D showed the result of VAT measurement in cm^3 (gold colour).

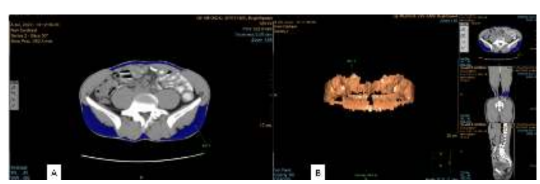

Figure 5. The volume measurement of SAT in a patient with a BMI of 20.73 kg/m^2. A) Segmentation SAT at L4 level with intelligent segmentation (blue colour). B) Clip 3D showed the result of SAT measurement in cm^3 (gold colour).

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Table 3. Correlation Analysis (*Spearman's Correlation Coefficient* (r)) between BMI with VAT and BMI with SAT)

	Volume		
	BMI-VAT	BMI-SAT	
r	0,687	0,669	p < 0,001

BMI: Body Mass Index, *VAT: Visceral Adipose Tissue, SAT: Subcutaneous Adipose Tissue*

DISCUSSION

Not all patients classified as obese based on their BMI will develop metabolic syndrome. Atherosclerosis factors strongly influenced by VAT play a significant role in developing cardiometabolic syndrome.[11-13] The distribution of samples based on individual characteristics shown in table 1 shows that the average age was 49.3 12.18 years based on the data obtained. This demonstrates that the average age of this research sample remains within the age range of previous studies, such as that conducted in Japan by So et al. in 2017, namely 30-59 years.[14] We used a fairly broad age range in this study, namely 20-70 years old, because we wanted to obtain the characteristics of various age groups and pay close attention to the research results presented by Yoo et al., taking into account that the VAT value increases until the age of 60 and then decreases. At each stage of life, the SAT score tends to rise steadily.[10] This may explain the Yoo and Eastwood theory, according to which men's adipose tissue increases after the age of 50.[15-17]

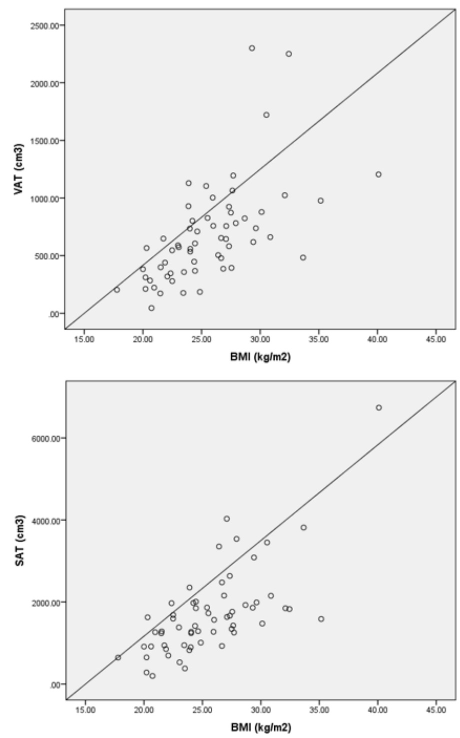

Figure 6. Scatter plot between A) BMI with VAT, B) BMI with SAT

Male samples outnumbered females in this study for the age groups 51-60 and 61-70. According to the researchers, this enables VAT numbers to be discovered to decrease by the age group trend. This study also found that the average SAT score was still higher than the average VAT score. Yoo et al. 2020 .'s research uses an age range of 20-50 years for both men and women, with the assumption that the average VAT value increases with increasing age of the research sample until it is past the age of 50 for the female model and decreases after the age of 50 for the male sample. 14 Because the study sample is mostly male between the ages of 61 and 70, this can support the findings of lower VAT volume in the overall sample.

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This study employs the VAT and SAT measurement methods and L4 intelligent segmentation. This is consistent with the theory that the L4 area can represent total body fat and be visualised well because organs like the kidneys and intestines do not disturb it. The L4 size also effectively depicts the difference between the SAT and VAT. In this case, an abdominal CT scan has the same accuracy as an MRI but is still superior to an MRI regarding tool availability.[5,18-21] The software used here is a component of the Philips Ingenuity 128 workstation, and all abdominal CT Scan data were first repeated with a slab thickness of 5 mm.[22]

Unlike William and Lear's research, this study's sample included people who were not in good health. Diabetes and hypertension were among the diseases studied in this study's models. Diabetes causes insulin resistance and lipolysis, as is well known. Of course, there is a change in the amount of fat stored in the body.[4,23-27] The sizeable biological variation is one of the reasons for the abnormal distribution in this study (nonparametric). Nonparametric data cannot be used to draw research conclusions from more extensive population coverage. Data from an investigation must be distributed normally to represent a larger scale (parametric). As a result, more stringent inclusion criteria will be established on the next occasion to minimise biological variations.[28-29,31]

Because there was no race problem taken into account in this study, and the dominant sample was Malay ethnicity and currently suffering from disease, we have a smaller value when compared to the average values of BMI, VAT, and SAT obtained between this study and Fox et al., as well as So et al.[9,14] Nonetheless, the Scatter plot in Figure 6 shows that an increase in BMI is followed by the rise in VAT and SAT, indicating a positive correlation. There is also an extreme point whose distribution differs significantly from that of the other data, which tends to be near the diagonal, namely a powerful value for VAT, SAT, and BMI because one of the samples was Africans.[28-29]

Regarding fat volume distribution by sex, women tend to store more fat in the lower body, whereas men tend to store more fat in the upper body. For VAT fat, superior fat distribution is more critical. Differences in hormone levels also play a role (the physiological action of oestrogen versus testosterone). Women's fat distribution differs from men's, owing primarily to the need to facilitate reproduction and provide adequate nutritional intake for the foetus. The current study's SAT scores appear to be higher in women than men, consistent with Fox et al. felt al.' that women have a higher percentage of adipose tissue than men.[9,25] In line with the above theory, we discovered that the average VAT in men was higher than in women in this study. Furthermore, males have a higher state of acquired BMI than females. The female sample had a higher average SAT than the male sample. This is very interesting because, even though the data for SAT

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and VAT are nonparametrically distributed, it can resemble the theoretical situation in which SAT retention is higher in women due to their physiological function.

So et al. in Japan conducted a correlation analysis of BMI with VAT and SAT volumes at levels as high as L4-L5 using MRI modalities. The results were consistent with this study, where the correlation of BMI with VAT was 0.61, and the correlation of BMI with SAT was 0.64.[14.] According to Storz C, the value of adipose tissue is higher in people with a high BMI. Storz C et al. discovered correlations between BMI, SAT and BMI and VAT (r=0.64). His study's correlation coefficient was similar to that obtained by So et al. and Storz et al., namely moderate positive, as shown in Table 3.

VAT and SAT are known to have relatively strong correlations with metabolic risk factors and to show individual risk profiles due to various compartments that conventional measurements such as BMI and waist circumference cannot reflect. As a result, the actual value must be determined.[3,11-13] Researchers used volumetrics in this study, whereas many previous studies used area. However, there is a strong correlation between volumetric and single-slice space. [15,19] One of the most intriguing aspects of this study is the ability to calculate volumetric fat content using 3D clips and segmentation, which is not available in all CT scan modalities. Furthermore, this study directly used anthropometric data from patients upon arrival and measured the volume on the spot. The advantage of volumetric imaging over single slices is the ability better to analyse the fat compartment in patients with high BMI, resulting in a lower bias rate.[3] In conclusion, this study's analysis using Spearman's correlation test revealed a moderately significant positive correlation between BMI and VAT and between BMI and SAT. Because the Spearman's correlation coefficient (r) is 0.5 r 0.7, a positive correlation means that every increase in BMI is followed by a moderate rise in VAT and SAT.[30]

Several limitations were discovered in this study, including measurements performed on sick patients. Furthermore, in this study, sample selection was not based on the patient's race or the age range of objects ranging from 20 to 70 years, so biological variation in the data cannot be avoided. As a result, the data were not distributed normally. The inclusion criteria only include age limits, implying that many other biological factors could influence the data distributions. In the future, the inclusion criteria must be tightened so that the data obtained does not vary too much biologically.[31] In developing the study, we also propose that more research be conducted to investigate the relationship between various cardiometabolic factors such as gender, age, DM status, lipid profile, and physical activity with SAT and VAT values.

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CONCLUSIONS

Medical personnel can provide some advice to prevent cardiometabolic syndrome by knowing the state of a person's VAT and SAT, especially for patients with cardiovascular risk. Furthermore, VAT and SAT values can help prevent clinical worsening for those with metabolic disorders. A CT scan of the abdomen is very common, and it can be used to predict a person's cardiometabolic state more accurately than traditional anthropometries, such as BMI. Unfortunately, CT scans are still rarely used for this purpose. According to this study, men are more likely than women to develop VAT, especially as they age. According to the findings of this study, there is a moderate positive correlation between BMI and VAT and SAT.

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