HANG TUAH MEDICAL JOURNAL

www.journal-medical.hangtuah.ac.id

Research article

Correlation Between Visceral Fat, Muscles Mass, and Blood Sugar Levels in Adults

PUTU SARASWATI LAKSMI DEWI[1*], I MADE PANDE DWIPAYANA[2]

[1]Mahasiswa PPDS1 Ilmu Penyakit Dalam, Fakultas Kedokteran Universitas Udayana

[2] Divisi Penyakit Endokrin dan Metabolik, Fakultas Kedokteran Universitas Udayana

*Email corresponding author : saraswatilaksmi@yahoo.com

Abstract

The correlation between visceral fat levels (VF) or muscle mass and resistance to insulin or type-2 diabetes mellitus has been studied extensively elsewhere, particularly in urban-dwelling populations. The current study aimed to assess the association of VF or muscle mass with the level of blood glucose randomly (RBG) among the rural population. A study was conducted in Buleleng Regency. One hundred five samples were enrolled in the study and obtained through a systematic interview, random blood glucose measurement, anthropometry, and bioelectrical impedance analysis. Spearman's correlation test was used to determine the correlation between visceral fat levels (VF) or muscle mass with RBG levels. A partial correlation test was used to control confounding variables (age, muscle mass, body mass index, body weight, waist circumference, and hip circumference). Most of the samples (61.9%) were female, with a mean age was 53,48 ± 13,03. The statistical analysis results show VF had a significant correlation with RBG (r= 0.363, p<0.001 but neither as role of muscle mass in which the r= -0.073, p=0.461). There was no significant correlation found on the partial correlation test between VF and RBG. In conclusion, although the correlation between VF levels and RBG was weak, the clinician should be aware of VF's role in developing insulin resistance or type-2 diabetes mellitus.

Keywords: VF, muscle mass, random blood glucose.

Abstrak
Korelasi antara kadar lemak visceral (VF) atau massa otot dan resistensi insulin atau diabetes mellitus tipe-2 telah dipelajari secara ekstensif di dunia khususnya pada populasi yang tinggal di perkotaan. Penelitian ini bertujuan untuk mengevaluasi hubungan VF atau massa otot dengan glukosa darah acak (RBG) di antara penduduk pedesaan. Penelitian ini adalah penelitian analitik yang dilakukan di Kabupaten Buleleng. Sebanyak 105 sampel dipilih kemudian dilakukan wawancara sistematis, pengukuran glukosa darah acak, antropometri, dan analisis impedansi bioelektrik. Uji analisis yang dipakai adalah korelasi Spearman, untuk mengetahui hubungan antara kadar lemak visceral (VF) atau massa otot dengan kadar RBG. Uji korelasi parsial digunakan untuk mengontrol variabel pengganggu (usia, massa otot, indeks massa tubuh, berat badan, lingkar pinggang, lingkar pinggul). Sebagian besar sampel (61,9%) berjenis kelamin perempuan, dengan rerata usia 53,48 ± 13,03. Hasil analisis statistik menunjukkan VF memiliki korelasi yang signifikan dengan RBG (r= 0,363, p<0,001 tetapi tidak berhubungan dengan massa otot dengan r= -0,073, p=0,461). Tidak ada korelasi signifikan yang ditemukan pada uji korelasi parsial, antara VF dan RBG. Kesimpulannya, meskipun terdapat korelasi lemah antara kadar VF dan RBG, klinisi harus menyadari peran VF dalam perkembangan resistensi insulin atau diabetes mellitus tipe-2.

Kata kunci: VF, massa otot, glukosa darah acak.

INTRODUCTION

Visceral fat (VF) correlated with decreased insulin sensitivity and type 2 diabetes mellitus (DMT2) incidence. Generally, there is an increase in lipolysis and a mild increase in inflammation of visceral adipocytes. This inflammatory process will trigger insulin resistance in obesity (Usui et al., 2010). Pathological abnormality in adipose tissue will change blood circulation and enlargement and dysfunction of adipocytes. It will produce adipokines or adipocyte cytokines such as tumor necrosing factor-alpha (TNF-α), interleukin 6 (IL-6), and C-reactive protein (CRP) (Lafontan, 2014). Adipocytes undergoing adipocyte senescence, necrosis, or death are associated with the infiltration of immune cells and macrophages in obesity. This may exacerbate inflammation and triggers adipocyte dysfunction and death.

In addition, there was an association between pathological fat mass and the recruitment of fat cell progenitor cells that can develop and distinguish into healthy small fat cells to compensate for cell death and maintain the numbers of adipocytes. Impaired angiogenesis, increasing the fibrotic process, can trigger irreversible chronic inflammation. Excess body fat will increase free fatty acids, affecting insulin sensitivity and increasing blood sugar levels (Usui et al., 2010). Meanwhile, muscle mass has an inverse relationship with insulin sensitivity. In another study examining the relationship between relative muscle mass (RMM) in young people in Korea, wound RMM was inversely correlated with type 2 DM (Hong et al., 2017). This study aimed to determine the correlation between VF, muscle mass, and blood sugar levels, particularly among the urban population.

METHODS

The design of this study was an analytical cross-sectional study conducted among adults in Busungbiu village, Buleleng district, in 2019. We enrolled 105 subjects by consecutive sampling method. Data collection was carried out after obtaining informed consent from the subject. Subjects aged 18-60 years were included in the study. Exclusion criteria in this study were malignancy, acute infection, moderate-severe cognitive impairment, and inability to be interviewed due to socio-linguistic problems and aphasia.

Data were collected through interviews, anthropometric measurements, Bioelectrical Impedance Analysis (BIA) measurement, and an examination of blood sugar levels. Data collection was carried out directly by the researcher in one stage. The independent variables in this study were the amount of visceral fat (VF) and muscle mass. In contrast, the dependent variable was blood sugar levels. This study's confounding variables controlled by the analysis were age, body mass index (BMI), height, weight, waist circumference, hip circumference, and muscle mass. VF and muscle mass were measured using Omron's BIA and expressed in percentage (%). Visceral fat is the amount of fat covering the organs in the abdomen. In this study, several components of muscle mass were measured: total body muscle mass, trunk muscle mass, upper extremity muscle mass, and lower extremity muscle mass. A blood sugar meter Accu-check using capillary blood was used to measure random blood sugar with units of mg/dL. BMI was calculated by dividing weight by height (in meters) squared. Bodyweight (BW) was measured using a body scale expressed in kilograms (kg). Waist and hip circumference were measured using a cloth tape, expressed in centimeters (cm).

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 25.0. The mean and standard deviation were reported to present numeric variables. We conducted a univariate analysis to present data on the frequency and percentage of categorical variables. The Spearman correlation test was used to analyze the bivariate correlation between the independent and dependent variables. A partial correlation test was performed for multivariate analysis to control confounding variables affecting the correlation between independent and confounding variables. The confidence interval (CI) used was 95%, and the p-value <0.05 was considered significant.

RESULTS

The total subjects were 105 people, with most females (61.9%). From examining random blood sugar levels, most samples (72 [68,6%]) had normal blood sugar levels. Blood sugar status classified as pre-diabetes was 22 (21%) samples, and as diabetes was 11 (10.5%) samples. The number of subjects with obesity was 51 (48.6%) samples. The characteristics of the subjects are presented in Table 1.

Table 1. Characteristics of subjects (n=105)

Characteristics	Value
Age (year)	53,48 ± 13,03
BMI (kg/m^2)	24,91 ± 4,44
Height (cm)	160 (132-180)
Weight (kg)	61,66 ± 13,64
Waist circumference (cm)	
Male	85,5 ±12,48
Female	82,95 ± 11,83
Hip circumference (cm)	
Male	90,26 ± 11,22
Female	89,33 ± 10,96
Muscle mass (%)	
Total muscle mass	25,01 ± 4,68
Truncal muscle mass	18,20 (3,8-32,9)
Upper extremity muscle mass	28,27 ± 8,12

Lower extremity muscle mass	37,9 (3,1-53,1)
Random blood sugar (mg/dl)	123 (87-477)
Visceral fat	9 (0,5-75)

Table 2 shows the results of the Spearman correlation test. BMI had a significant positive correlation with random blood sugar levels (r=0,303, p=0,002). Bodyweight showed a significant positive correlation with blood sugar levels when (r=0,261, p=0,007), waist circumference had a significant positive correlation with blood sugar levels (r=0,301, p=0,002), hip circumference (r=0,314, p =0.001) and visceral fat had a significant positive correlation with blood sugar levels (r=0.363, p=0.000) although all correlations were weak.

After controlling the BMI, body weight, waist circumference, and hip circumference, there was no significant correlation between visceral fat and blood sugar levels (p=0.96). This study did not perform a partial correlation test between muscle mass and blood sugar levels, considering no significant correlation between these two variables was not significant in a bivariate test.

Table 2. The correlation between age, BMI, weight, waist circumference, hip circumference, muscle mass, and visceral fat affects blood sugar levels.

Variables	Random blood sugar level	
	r	p-value
Age	-0,003	0,976
BMI	0,303	0,002*
BW	0,267	0,007*
Waist circumference	0,301	0,002*
Hip circumference	0,314	0,001*
Muscle mass		
Total muscle mass	-0,073	0,461
Truncal muscle mass	-0,161	0,101
Upper extremity muscle mass	-0,123	0,212
Lower extremity muscle mass	-0,001	0,990
Visceral fat	0,363	<0,001*

*significant p-value (p<0,05)

Table 3. Partial correlation between visceral fat, BMI, weight, waist circumference, hip circumference, and blood sugar levels

Variable	Random blood sugar level	
	r	p-value
Visceral fat	-0,039	0,695
BMI	0,183	0,062
BW	0,167	0,089
Waist circumference	0,153	0,119
Hip circumference	0,212	0,030*

*significant p-value (p<0,05)

DISCUSSION

Fat tissue is the main organ that regulates energy homeostasis in the body. Changes in adipocyte size and number alter adipokine secretion, fatty acid flux, and adipocyte death. Fat cell hypertrophy, especially VF in obese patients, causes an increase in free fatty acids and proinflammatory cytokines and a decrease in serum adiponectin and insulin sensitivity, which causes endothelial dysfunction and leads to insulin resistance (Min and Stephen, 2015; Castro et al., 2014; Hocking et al., 2013).

This study aimed to determine the correlation between visceral fat, muscle mass, and random blood sugar levels. In the bivariate correlation test, visceral fat had a weak positive significant correlation with blood sugar levels. However, the correlation became insignificant after controlling for confounding variables. These results contradicted several previous studies. Visceral fat has also been reported to be positively correlated with fasting hyperglycemia and HbA1C levels in type 2 DM patients after adjustment for gender, BMI, duration of DM, ethnicity, and subcutaneous fat 9Borel et al., 2015). Visceral excess fat may increase flux-free fatty acids, insulin resistance, and gluconeogenesis.

A study in Indonesia by Kurniawan *et al.* 2018 also reported that each body weight, BMI, waist circumference, hip circumference, and VF strongly correlated with insulin resistance at a young and healthy age. The results of this study, where visceral fat did not correlate with blood sugar levels after controlling for the weight, BMI, waist, and hip circumference variable, are postulated to occur because all these variables may contribute to the increase in blood sugar levels. Compared with overseas studies, the difference in results may be affected by differences in ethnicity, sex, and age of the sample. The difference in results of this study and the previous study in Indonesia may be affected by the age 63% of the sample in this study was ≥50 years old. In contrast, the other study was conducted on young and healthy men (Kurniawan et al., 2018).

This study had no correlation between muscle mass and random blood sugar levels. A Korean study previously reported that muscle mass was negatively associated with developing diabetes in young and healthy adults (Hong et al., 2017). Meanwhile, another study reported that good muscle mass was associated with better insulin sensitivity and a lower risk of developing pre-diabetes mellitus (Srikanthan and Karlamangla, 2011). Muscle mass affects the increase in blood sugar levels because of low levels of myokines and proinflammatory cytokines such as interleukin IL-6 and IL-15. Increased myokine was found in contracting muscles. Muscle mass is a significant site of glucose deposition and uptake and plays an essential role in blood sugar regulation. Therefore, low muscle mass is a risk for insulin resistance and type 2 DM (Han et al., 2018).

Bivariate and multivariate analysis in this study found that hip circumference had a weak positive correlation with blood sugar levels. This result was in line with the results of previous studies. In contrast, a component of the waist-to-hip ratio, the greater the hip circumference, the risk of developing insulin resistance in women also increases, in a similar mechanism to VF (Benites-Zapata et al.,2019). This result is because most of the sample (61.9%) were women.

This study has several limitations. First, this study is a cross-sectional study, not a longitudinal study that can strongly analyze causal relationships. Second, the study population is limited to rural areas in Buleleng Regency and is not compared with other populations, so generalizations are limited considering differences in race, topography, and lifestyle. Third, the dependent variable in this study only uses a blood sugar test when various factors can influence its result. Lastly, there was no control over drugs that respondents might be consumed, such as antihypertensives, oral anti-diabetic drugs, or insulin.

Related to the limitations of the study, further longitudinal studies with larger and broader sample sizes are necessary, and a better approach to research methods so those causal relationships are identified and can be generalized to the population. In a follow-up study, it is considered to replace the variable random blood sugar levels with more specific DM markers such as fasting blood sugar and blood sugar 2 hours after eating, HbA1C and HOMA-IR, as well as control for confounding variables such as consumption of antihypertensive drugs, oral anti-diabetic drugs, and insulin.

CONCLUSION

This study has not proven the correlation between VF and muscle mass on random blood sugar levels. Further studies with better study methods and larger and broader sample sizes are necessary to determine the relationship between VF muscle mass and random blood sugar levels or more specific markers of insulin resistance.

REFERENCES

Benites-Zapata VA, Toro-Huamanchumo CJ, Urrunaga-Pastor D, Guarnizo-Poma M, Lazaro-Alcantara H, Paico-Palacios S, et al, 2019. High waist-to-hip ratio levels are associated with insulin resistance markers in normal-weight women. Diabetes Metab Syndr Clin Res Rev.,13(1):636–642

Borel AL, Nazare JA, Smith J, Aschner P, Barter P, Van Gaal L, et al, 2015. Visceral, subcutaneous abdominal adiposity and liver fat content distribution in normal glucose tolerance, impaired fasting glucose and impaired glucose tolerance. Int J Obes., 39(3):495–501.

Castro AVB, Kolka CM, Kim SP, Bergman RN., 2014. Obesity, insulin resistance and comorbidities? Mechanisms of association. Arq Bras Endocrinol Metabol., 58(6):600–609.

Han SJ, Boyko EJ, Kim S-K, Fujimoto WY, Kahn SE, Leonetti DL., 2018. Association of thigh muscle mass with insulin resistance and incident type 2 diabetes mellitus in Japanese Americans. Diabetes Metab J., 42(6):488–495.

Hocking S, Samocha-Bonet D, Milner K-L, Greenfield JR, Chisholm DJ, 2013. Adiposity and insulin resistance in humans: the role of the different tissue and cellular lipid depots. Endocr Rev., 34(4):463–500.

Hong S, Chang Y, Jung H-S, Yun KE, Shin H, Ryu S., 2017. Relative muscle mass and the risk of incident type 2 diabetes: a cohort study. PLoS One., 12(11).

Kurniawan LB, Bahrun U, Hatta M, Arif M, 2018. Body mass, total body fat percentage, and visceral fat level predict insulin resistance better than waist circumference and body mass index in healthy young male adults in Indonesia. J Clin Med.,7(5):96.

Lafontan M., 2014. Adipose tissue and adipocyte dysregulation. Diabetes Metab.,40(1):16–28.

Min T, Stephens JW, 2015. Targeting abdominal obesity in diabetes. Diabetes Manag.,5(4):301.

Srikanthan P, Karlamangla AS, 2011. Relative muscle mass is inversely associated with insulin resistance and pre-diabetes. Findings from the third National Health and Nutrition Examination Survey. J Clin Endocrinol Metab.,96(9):2898–903.

Usui C, Asaka M, Kawano H, Aoyama T, Ishijima T, Sakamoto S, et al., 2010. Visceral fat is a strong predictor of insulin resistance regardless of cardiorespiratory fitness in non-diabetic people. J Nutr Sci Vitaminol (Tokyo), 56(2):109–16.