CORRELATION BETWEEN VISCERAL ABDOMINAL FAT WITH BODY MASS INDEX IN TYPE 2 DIABETIC PATIENT USING DEXA SCAN

By:

DR NOR FAZLIZA BT HAIRUDDUIN

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LIST OF ABBREVIATIONS

BMI	Body mass index
CT	Computed tomography
DEXA	Dual energy X-ray absorptiometry
DM	Diabetes mellitus
HUSM	Hospital Universiti Sains Malaysia
MRI	Magnetic resonance imaging
Vat	Visceral adipose tissue

ABSTRAK

Objektif: Untuk menentukan perkaitan antara tisu lemak organ abdoman dengan indeks jisim badan untuk pesakit kencing manis jenis 2 menggunakan *dual – energy X-ray absorptiometry (DEXA).*

Metodologi: Seramai 29 orang pesakit kencing manis jenis 2 dari Klinik Pakar, Hospital USM, Kelantan terlibat dalam kajian ini. Mereka merangkumi pesakit yang menghidap penyakit kencing manis jenis 2 yang berumur daripada 20 sehingga 79 tahun. Pesakit yang mengandung, mempunyai berat yang melebihi 240kg dan ketinggian yang melebihi 190cm dikecualikan daripada penyelidikan ini. Imbasan DEXA dijalankan untuk menentukan tisu lemak di organ abdomen.

Keputusan: Terdapat hubungan yang signifikan di antara tisu lemak di organ abdomen dengan indeks jisim tubuh untuk pesakit kencing manis jenis 2 (r=0.68, p=0.000). Disamping itu juga, terdapat hubungan yang signifikan di antara tisu lemak di organ abdomen dengan indeks jisim tubuh untuk pesakit kencing manis jenis 2 mengikut bangsa (Melayu: r=0.74, p=<0.001; Cina: r=0.78, p=0.007) dan jantina (Lelaki: r= 0.616, p=0.043; Perempuan: r= 0.68, p=0.002).

Kesimpulan: Indeks jisim tubuh dan DEXA adalah kaedah yang boleh digunakan sebagai cara untuk menyaring tisu lemak di organ abdomen untuk pesakit kencing manis jenis 2.

Kata kunci: tisu lemak organ abdomen, indeks jisim tubuh, DEXA

ABSTRACT

Objective: To correlate between visceral abdominal fat with body mass index (BMI) in patients with type 2 diabetis mellitus using dual – energy X-ray absorptiometry (DEXA) scan.

Methodology: Patients (n=29) were recruited from Klinik Pakar, Hospital USM, Kelantan. The inclusion criteria included type 2 diabetic patient with age ranging from 20 to 79 years. Ptients who were pregnant, weighed more than 240kg and had a height of more than 190 were excluded from the study. DEXA scan was performed to quantify the visceral abdominal fat.

Results: There was significant correlation between visceral abdominal fat with BMI in type 2 diabetic patients (r=0.68, p=0.000). There was also significant correlation between visceral abdominal fat with BMI according to gender (Malay: r=0.74, p=<0.001; Chinese: r=0.78, p=0.007) and race (Male: r= 0.616, p=0.043; Female: r= 0.68, p=0.002).

Conclusion: BMI and DEXA scan can be used as a tool for screening of visceral abdominal fat in patients with type 2 diabetis mellitus.

Keywords: *visceral abdominal fat, BMI, DEXA*

CHAPTER 1: INTRODUCTION

1.1. INTRODUCTION AND LITERATURE REVIEW

Diabetes is the leading cause of kidney disease, a major cause of heart disease and stroke and the seventh leading cause of death in the United States (1). In Malaysia, there were 19,887 adults who suffered from type 2 diabetes mellitus (DM) in 2015 (2). The prevalence of diabetes mellitus among adults of 18 years and above was 17.5% (3). The financial burden of the disease is staggering including medical costs and indirect costs such as disability, loss of work, and premature death from diabetes. The estimated cost per person with type 2 DM is USD 565.8 (2).

There is evidence that the distribution and type of excess fat may be an important prognostic indicator for disease risk (4). Unlike subcutaneous fat whose main function is energy storage, visceral fat cells are metabolically active and impact a wide variety of clinical risk factors including fasting glucose levels, serum triglycerides, and cholesterol. Visceral abdominal fat occurs within the envelope formed by the abdominal muscles, principally within the greater and lesser omentum that connects the abdominal organs, and in mesenteric fat. A small amount is also found retroperitoneally. Visceral abdominal fat is more dangerous than subcutaneous fat because visceral fat cells release proteins that contribute to inflammation, atherosclerosis, dyslipidemia, and hypertension (4). Visceral fat is associated with metabolic risk factors and all-cause mortality in men, and is therefore considered a pathogenic fat depot. Increased leptin is associated with the inflammatory process and possibly the entire increased morbidity of obesity (4). Individuals with leptin insensitivity and high levels of leptin have parallel comorbidities chronic inflammation, type II diabetes, hypertension, and myocardial injury. Visceral fat is more metabolically active, more sensitive to lipolysis, more resistant to insulin, and has a greater capacity to take up glucose and generate free fatty acids (5). VAT mass measured by DEXA has been shown to be associated with multiple cardiometabolic risk factors such as hypertension, diabetes and metabolic syndrome (6).

BMI is used to quantify the amount of tissue mass (muscle, fat, and bone) in an individual, and then categorized that person as underweight, normal weight, overweight, or obese based on that value. According to Malaysia Clinical Practice Guidelines of obesity (2004) (7), BMI classified as underweight (BMI<18.5kg/m²), normal range (BMI 18.5 – 22.9kg/m²), overweight (BMI ≥ 23kg/m²), pre-obese (23.0 – 27.4kg/m²), obese I (27.5 – 34.9kg/m²), obese II (35.0 – 39.9kg/m²) and obese III (≥40.0kg/m²). With an increased of BMI value, the risk of co morbidities are also increased (obesity cpg). There was a study by Anjana et al (2004) (8) showed that BMI in diabetic patients were higher as compared to non diabetic patients. According to Malaysia Clinical Practice Guidelines on management of type 2 DM (2009) (9), lifestyle modification included healthy food and exercise were the non pharmacological management of type 2 DM. Lifestyle modification with ensuing weight loss are sufficient for glycemic control in newly diagnosed type DM (9). A study showed patient with type 2 DM who had exercise and diet modification showed improved level of peripheral insulin sensitivity, fasting glucose and free fatty acids (10).

Currently, the most commonly used imaging technique for measuring visceral fat is abdominal computed tomography (CT). It is not optimal as a screening tool for visceral fat because of high radiation dose. Dual-energy X-ray absorptiometry (DEXA) can accurately measure body composition, low X-ray exposure, and short-scanning time. The effective radiation dose is 0.96 µSV (5). DEXA uses an X-ray tube combined with a switch or filter to generate a larger flux of photons, yielding greater precision and shorter scan times (10).A study by Kaul et al (2012) (5) showed that DEXA and CT were effective imaging in quantification of visceral fat. Vat measured by DEXA has similar or greater association with insulin resistance and high density lipoprotein as compared with Vat measured by CT scan (5). DEXA abdominal fat and BMI were all significantly associated with type 2 DM and hypertension (11). VAT measured by DEXA was most consistently and strongly associated with type 2 DM and hypertension (11). MRI also has a role in quantification of visceral abdominal fat. MRI has the advantage of no ionizing radiation. However, it has drawbacks that make it inappropriate for incorporation into use for routine screening including expense, procedure time, and availability of systems.

DEXA scan are widely available, least costly, and deliver a small fraction of the radiation dose compared with CT. Furthermore, existing whole body scan utilized in clinical medicine and in research studies, can be reanalyzed with the new visceral fat application. In this study, we want to assess whether BMI and DEXA scan is correlated in the setting of our population in type 2 DM.

CHAPTER 2: OBJECTIVES OF THE STUDY

2.1. GENERAL OBJECTIVE

To determine correlation between visceral abdominal fat and body mass index (BMI) in type 2 diabetic patient using DEXA scan.

2.2 SPECIFIC OBJECTIVES

1. To determine the mass of visceral abdominal fat and body mass index (BMI) in type 2 DM.
2. To determine correlation between mass of visceral abdominal fat with BMI according to gender and race.

CHAPTER 3: MANUSCRIPT

3.1. TITLE: CORRELATION BETWEEN VISCERAL ABDOMINAL FAT WITH BODY MASS INDEX IN TYPE 2 DIABETIC PATIENT USING DEXA SCAN

Author:

Dr Nor Fazliza bt Hairudduin

Department of Radiology, School of Medical Sciences, Universiti Sains Malaysia

16150, Kubang Kerian, Kelantan.

Corresponding author:

Associate Professor Dr Mohd Shafie b Abdullah,

Dr Nor Fazliza bt Hairudduin,

Department of Radiology, School of Medical Sciences, Universiti Sains Malaysia,

16150, Kubang Kerian, Kelantan.

Email: fazz_eliz@yahoo.com

3.2. ABSTRACT

Objective: To correlate between visceral abdominal fat with body mass index (BMI) in patients with type 2 diabetis mellitus using dual – energy X-ray absorptiometry (DEXA) scan.

Methodology: Patients (n=29) were recruited from Klinik Pakar, Hospital USM, Kelantan. The inclusion criteria included type 2 diabetic patient with age ranging from 20 to 79 years. Ptients who were pregnant, weighed more than 240kg and had a height of more than 190 were excluded from the study. DEXA scan was performed to quantify the visceral abdominal fat.

Results: There was significant correlation between visceral abdominal fat with BMI in type 2 diabetic patients (r=0.68, p=0.000). There was also significant correlation between visceral abdominal fat with BMI according to gender (Malay: r=0.74, p=<0.001; Chinese: r=0.78, p=0.007) and race (Male: r= 0.616, p=0.043; Female: r= 0.68, p=0.002).

Conclusion: BMI and DEXA scan can be used as a tool for screening of visceral abdominal fat in patients with type 2 diabetis mellitus.

Keywords: *visceral abdominal fat, BMI, DEXA*

3.3. INTRODUCTION

Type 2 diabetes mellitus (DM) affected approximately 8% of adult in the United States (1). In Malaysia, total adult population of type diabetes mellitus (DM) is 19,887 in 2015 (2). The prevalence of diabetes mellitus among adults of 18 years and above was 17.5% (3). The financial burden of the disease is staggering including medical costs and indirect costs such as disability, loss of work, and premature death from diabetes. The estimated cost per person with type 2 DM is USD 565.8 (2).

There are many risk factors that associate with type 2 DM. Obesity is a major contributing factor to DM. Obesity is an epidemic affecting at least 70 million people in the United States and over 300 million individuals worldwide (11). In Malaysia, according to Malaysia Obesity CPG, 2003 (7), 15.1% of adult males were overweight and 2.9% obese while adult females, 17.9% were overweight and 5.7% obese.

Obesity is an important risk factor for cardiometabolic disease such as hypertension, type 2 DM, metabolic syndrome and cardiovascular disease (12). The distribution of fat is important than the amount of fat (5). Android distribution of fat has shown to have more often association with metabolic syndrome, diabetes and cardiovascular disease. There is evidence that the distribution and type of excess fat can be an important prognostic indicator for disease risk. Unlike subcutaneous fat whose main function is energy storage, visceral fat cells are metabolically active and impact a wide variety of clinical risk factors including fasting glucose levels, serum triglycerides, and cholesterol. Visceral fat is more dangerous than subcutaneous fat because visceral fat cells release proteins that contribute to inflammation, atherosclerosis, dyslipidemia and hypertension (13). Visceral fat is associated with metabolic risk factors and all-cause mortality in men, and is therefore considered a pathogenic fat depot. Visceral obesity is an independent risk factor for metabolic syndrome and the quantity of the fat is a prognostic factor (4).

There are few studies on the distribution of fat in relation to diabetes such as Shuster et al (2012) (4), Hariri et al (2013)(13). Visceral fat volume had stronger association with BMI, so if CT and MRI were not available, BMI may surrogate measure of Vat (4). Hariri et al (2013) (13), BMI showed strong association with android and gynoid fat measured by DEXA. Thus, the objective of this study is to see any correlation between visceral abdominal fat with body mass index (BMI) in type 2 DM patient. There are many techniques in measuring visceral fat such as dual energy X-ray absorptiometry (DEXA) scan, CT scan and magnetic resonance imaging (MRI). CT scan is the gold standard of imaging technique for measuring visceral fat. However, CT scan produce higher radiation dose than DEXA scan and it is also not cost effectives as compared to DEXA scan (5).

DEXA scan can accurately measures body composition with low X-ray exposure, and short-scanning time (5). It also widely available, least costly and delivers small fraction of radiation dose as compared to CT scan. The precision of DEXA scan and CT scan are similar. The radiation dose is 0.96 µSV as compared to CT scan which is 3,100µSV (5). DEXA subdivides the soft tissue into lean and fat compartments in order to allow whole body and regional measurement of body composition (5).MRI also has a role in measurement visceral fat. However, it is not appropriate screening tool as it is not cost effective, long procedure time and not widely available.

3.4. METHODOLOGY

This is a cross sectional study in which a total of 29 patients were recruited. Patients with type 2 DM who were under follow up at Hospital Universiti Sains Malaysia (HUSM) were selected. Type 2 DM who met the selection criteria were enrolled in the study. . Patients were diagnosed to have type 2DM when the fasting blood glucose was ≥ 7.0mmo/L or random blood glucose was ≥ 11.1mmol/L. In symptomatic patient, one abnormal glucose level was diagnostic. In asymptomatic patient, 2 abnormal glucose levels were required. Patients who were pregnant, weight more than 240kg and height more than 190cm were excluded from the study. Patients' height and weight were taken for body mass index (BMI) calculation. BMI was calculated as weight (kg) divided by height^2 (m^2).

Patients lied in supine position with head at the top of table and arms by their sides. Then, patients were scanned for measurement of central abdominal fat by Hologic dual energy X-ray absorptiometry (DEXA) scan. The machine scanned the whole body from head to toe. Region of interest was placed in between lower border of second lumbar vertebra and lower border of fourth vertebra. The results of visceral abdominal fats were automatically generated by QDR system software version 13.4.2. The reading of visceral abdominal fat was taken in gram (g) as shown in Figure 1.

Data analysis was performed by using SPSS software version 21 (Chicago,United States). Demographic characteristic of patients involved in this study were analyzed by descriptive analysis. Data were analysed by using Pearson correlation.

3.4. RESULTS

Demographic data

A total of 29 participants were consented to participate in the present study. The general demographic data of study participants are as shown in Table 1. Among 29 patients that participate 62.1% are female and 37.9% are male. 65.5% (n=19) are Malays with 34.5% (n=10) are Chinese. Mean age of patients is 56.8 of age. Mean weight is 64.4(kg), height is 159.3(cm), BMI is 25.5(kg/m^2) and Vat is 449.2(g). Histograms of the age, weight, height, BMI, and visceral adipose tissue (Vat) distributions among study participants are as shown in Figure 2 to 6. All histograms revealed normal distribution curves.

Correlation between visceral abdominal fat and BMI in type 2 diabetic patient

Figure 7 shows the scatter plot between the BMI and Vat in study participants. Significant moderate correlation (r=0.684, p<0.05) was shown between BMI and Vat values in study participant (Table 2). An increase of each BMI unit was associated with an increment of 28 unit visceral abdominal fat.

Correlation between visceral abdominal fat and BMI in type 2 diabetic patient according to gender

Demographic data of study participant according to gender is shown in Table 3. Figure 8 shows the scatter plot between the Vat and BMI in study participants according to gender. Significant moderate correlations were shown between Vat and BMI values in both genders (Table 4). For male, an increase of each BMI unit associated with an increment of 40.36 unit visceral abdominal fat, while for female, an increase of each BMI unit associated with an increment of 26.35 unit visceral abdominal fat.

Correlation between visceral abdominal fat and BMI in type 2 diabetic patient according to race

Demography data of study participant according to race is shown in Table 5. Figure 9 shows the scatter plot between the Vat and BMI in study participants according to race. Significant substantial correlations were shown between Vat and BMI values in both races (Table 4). For Malay, an increase of each BMI unit associated with an increment of 31.49 unit visceral abdominal fats, while for Chinese, an increase of each BMI unit associated with an increment of 54.58 unit visceral abdominal fat.

3.6. DISCUSSION

There are few studies found that obesity is a factor for hypertension and type 2 diabetes. Study by Choi et al(2015) (8) found that DEXA can be a reliable method for quantification of visceral fat as it is cost effective, less radiation and inexpensive and there is lesser discrepancy ratio between DEXA and CT scan. The average difference between DEXA and CT was 56 cm^3, which was small relative to the average of Vat observed in the subjects (~1 kg) (5). It was also shown that visceral fat is associated with DM (8). Visceral fat is associated with metabolic risk factors and all-cause mortality in men, and is therefore considered a pathogenic fat depot. Visceral obesity is an independent risk factor for metabolic syndrome and the quantity of the fat is a prognostic factor (4). Vat released different bioactive molecules and hormones such as adiponectin and leptin. Increased leptin is associated with the inflammatory process and possibly the entire increased morbidity of obesity (4). Individuals with leptin insensitivity and high levels of leptin have parallel comorbidities chronic inflammation, type II diabetes, hypertension, and myocardial injury. Whereas adiponectin is inversely correlated with Vat. Decreased adiponectin is associated with type 2 DM, elevated glucose level and hypertension (4).

All patients who were diagnosed with type 2 DM were adviced for lifestyle modifications which include exercises and balanced diet (9). A study showed patient with type 2 DM who had exercise and diet modification showed improved level of peripheral insulin sensitivity, fasting glucose and free fatty acids (10).

The mean BMI for patients in this study was 25.5(kg/m^2). This shows that mean BMI of patients are under the category of pre obese (7). Mean visceral abdominal fat in this study is 449.2(g), lower as compared to similar study by Anjana et al (2004)(8) which was 1,547.7(g). This is probably because most of patients were aware of the benefits of reducing weight and the effectiveness of lifestyle modification as the baseline treatment of type 2 DM.

There was also showed significant correlation between BMI and visceral abdominal fat according to gender. Based on study done by Anjana et al (2004) (8), no significant difference between gender for central abdominal fat using DEXA scan. Men and women have different body composition. For a given BMI, men has higher lean mass and more visceral abdominal fat as compared to women who has increased general adipose tissue particularly subcutaneous fat [13]. Estrogen also plays a role in the gender differences. Estrogen has favourable effect on insulin, glucose homeostasis, adipose distribution and also pro-inflammatory markers (14).

Both Malay and Chinese shows significant correlation between BMI and visceral abdominal fat according to race. No significant difference between the races in correlation between BMI and visceral abdominal fat. There is no similar study among Malaysians. However, there was a study regarding fat distribution in different ethnicity (15). The study showed that the Hispanic men had higher central abdominal fat followed by Asian, Non Hispanic and African-American men. This was because of different anthropometry, metabolic and behavioural mechanism. A study by Stults-Kolehmainen et al (2013) (15) showed the mean BMI for Asian men was 23.9±3.4 (kg/m^2) as compared to our study which was 25.5±5.2 (kg/m^2). Another similar study by Nazare et l (2012) (16), showed that Southeast Asian men had BMI of 27.6±4.1 (kg/m^2) and women had BMI of 27.4±4.5 (kg/m^2). Despite lower levels of overall adiposity, East Asian men and women were characterized by a larger relative visceral fat accumulation than any other ethnic group, and this accumulation was even more pronounced at higher ranges of BMI (16).

Visceral abdominal fat can contribute in release of protein that promotes inflammation, hypertension and atherosclerosis. BMI can account for risk markers for cardiovascular disease and DM as effectively as DEXA scans (13). However, there is a study found that DEXA and anthropometry can be used to estimate visceral fat as a reliable alternatives to CT scan (17). BMI can account for variation in risk markers in white, predominantly middle-aged males as well as more sophisticated measures derived from DEXA scanning (13).

The main limitation of this study is the difficulty in recruiting expected sample size. A lot of patients were not interested to be enrolled as a subject as DEXA is not a routine screening. Even though the recruited sample is smaller than expected, this study still managed to produce significant outcomes from statistical analysis. A larger randomized study which includes more races and larger group of different BMI should be conducted in future for other parameters of the DEXA scan.

In conclusion, this study shows that DEXA and BMI can be a method in screening for visceral adipose tissue in type 2 DM patients. In the absent of DEXA scan, BMI also can be a tool for screening of visceral adipose tissue in type 2 DM.

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3.8. TABLES AND FIGURES

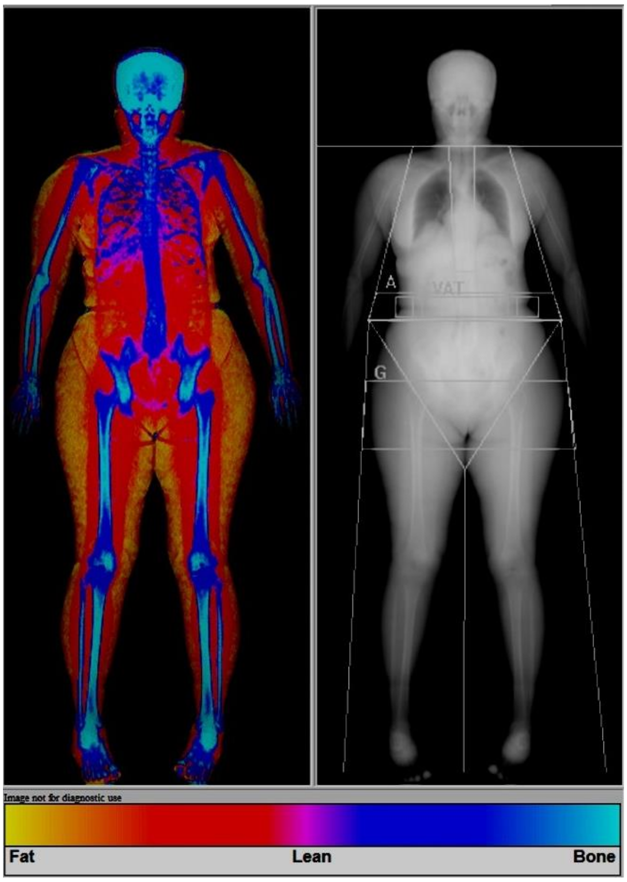

Figure 1 DEXA scan of whole body scan with visceral abdominal fat calculation.

Measure	Result	T-score	Z-score
Total Body % Fat	**45.3**	**1.2**	**0.4**
Fat Mass/Height^2 (kg/m^2)	12.6	0.8	0.1
Android/Gynoid Ratio	0.92		
% Fat Trunk/% Fat Legs	0.83	0.3	-0.5
Trunk/Limb Fat Mass Ratio	0.89	0.4	-0.5
Est. VAT Mass (g)	544		
Est. VAT Volume (cm^3)	589		
Est. VAT Area (cm^2)	113		

Figure 1: DEXA scan of whole body scan with visceral abdominal fat calculation.

The image on right side showed area of android fat (A) and gynoid fat (G). The android region was the region for measurement of visceral abdominal fat. Estimated Vat mass is the parameter that been used in this study.

Table 1 Demographic data of study participants (n=29)

Variable	Mean (SD)	n (%)
Age, year	56.8 (9.1)	
Gender		
Male		11 (37.9)
Female		18 (62.1)
Race		
Malay		19 (65.5)
Chinese		10 (34.5)
Weight, kg	64.4 (12.4)	
Height, cm	159.3 (8.1)	
BMI, kg/m²	25.5 (5.2)	
Vat, g	449.2 (212.32)	

Figure 2 Histogram of age distribution among study participants.

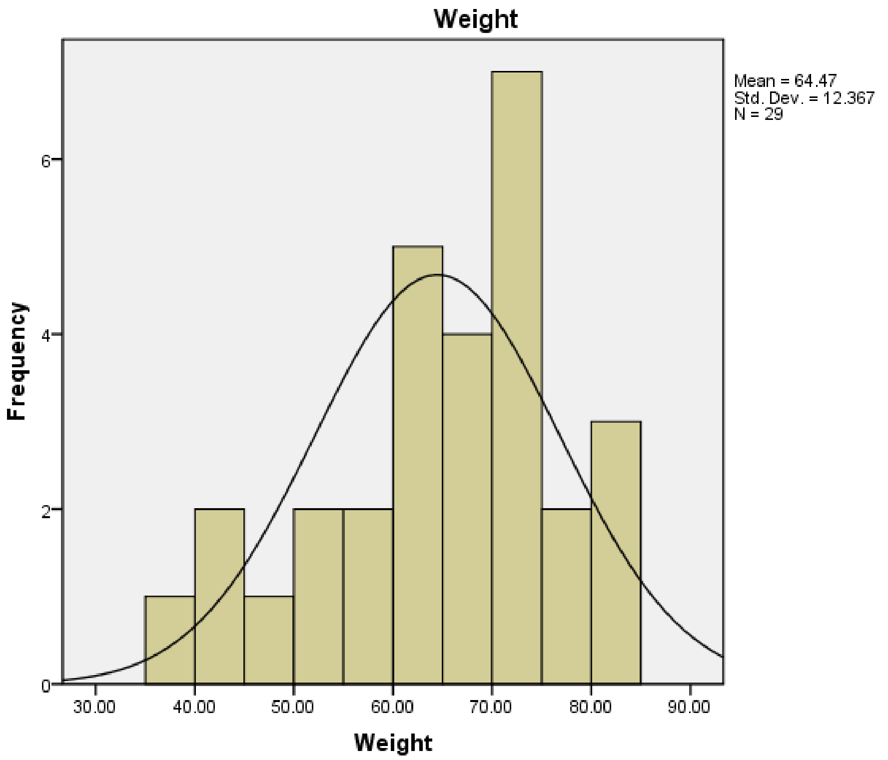

Figure 3 Histogram of weight distribution among study participants.

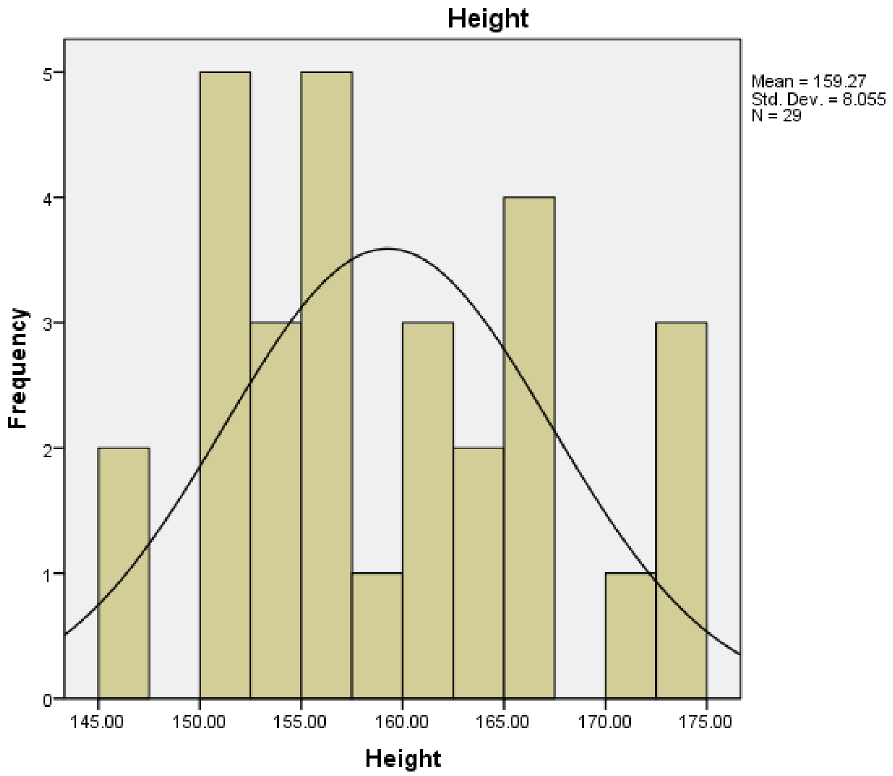

Figure 4 Histogram of height distribution among study participants.

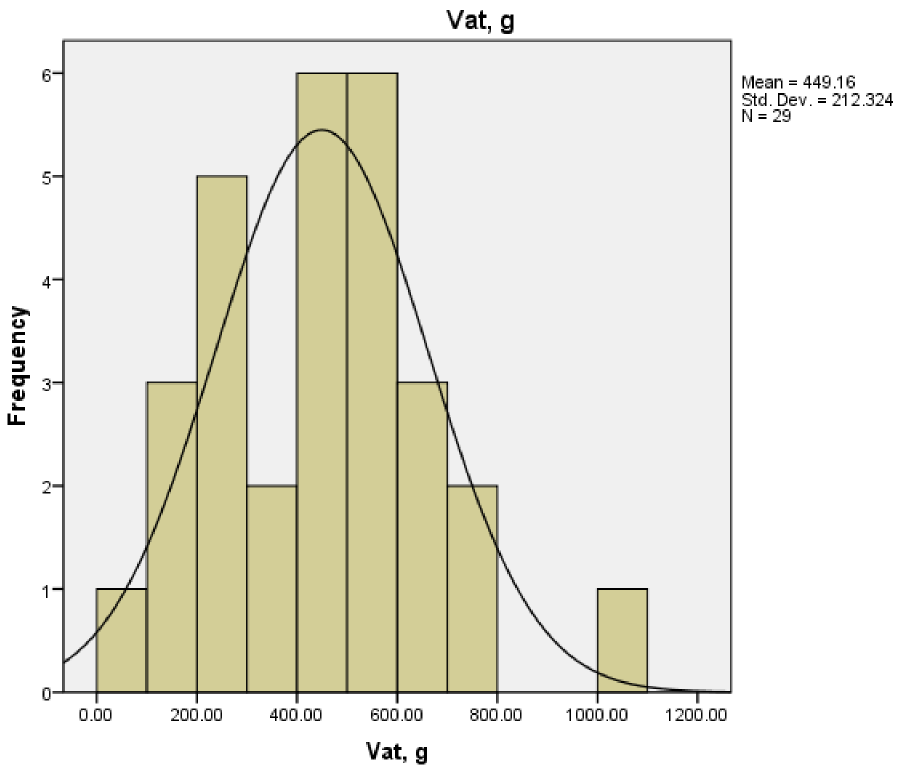

Figure 5 Histogram of Vat distribution among study participants.

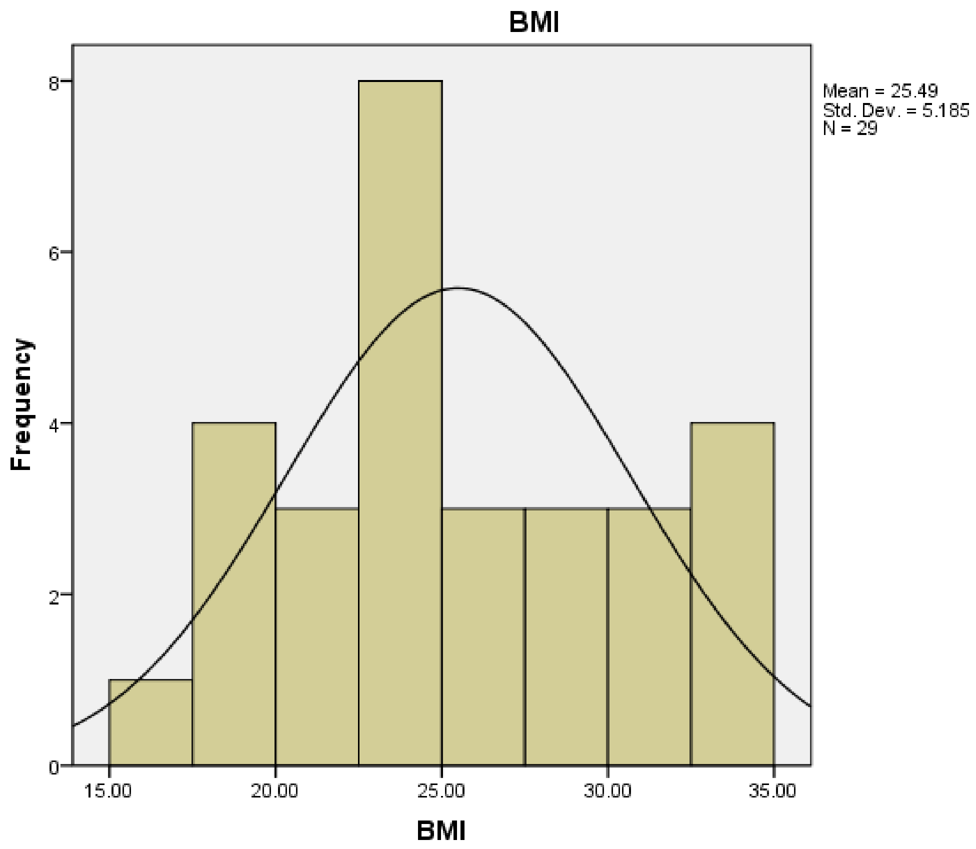

Figure 6 Histogram of BMI distribution among study participants.

Table 1 Correlation between BMI and Vat in study participants (n=29)

	B (95% CI ß)	**t statistics**	**r**	**r^2**	**P value**
BMI, kgm^{-2}	28.01 (16.22, 39.81)	4.87	0.684	0.468	<0.001

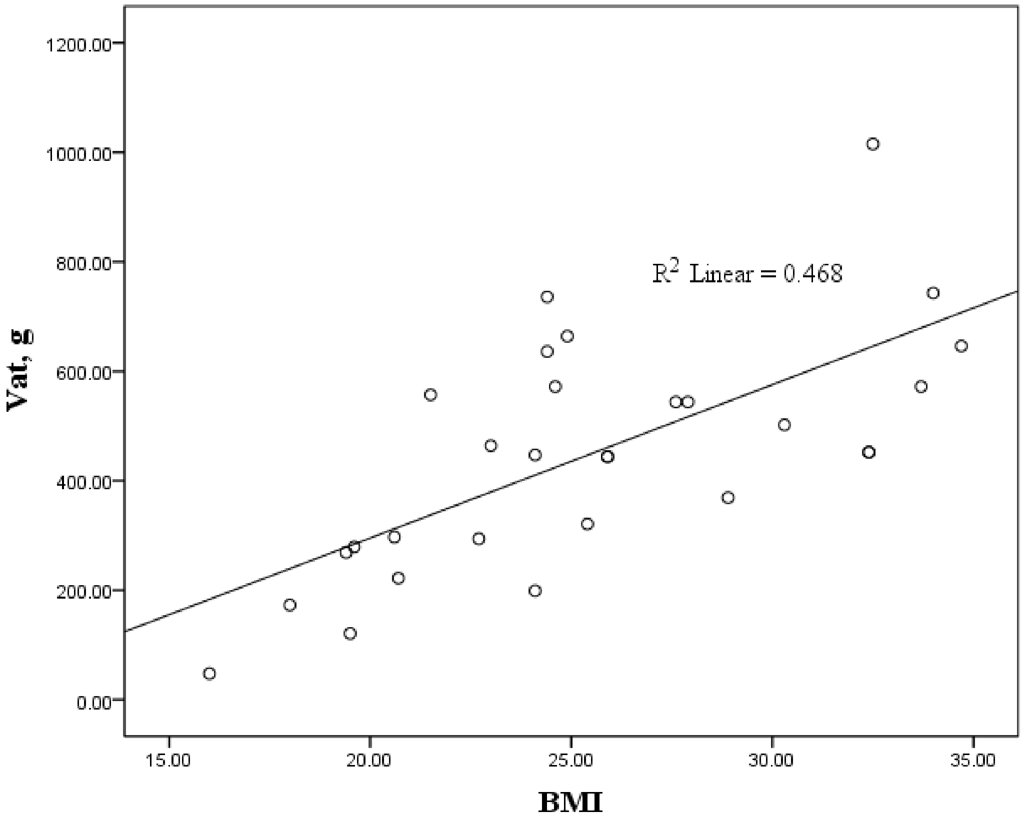

Figure 7 Scattergram of Vat versus BMI in study participants

Table 3 Demographic data of study participant according to gender

	Gender	N	Mean	Std. Deviation	P value
Age	Male	11	51.45	10.28	0.011*
	Female	18	60.00	6.66	
Weight	Male	11	65.5091	10.33	0.729
	Female	18	63.8278	13.71	
Height	Male	11	166.1182	6.91	0.000*
	Female	18	155.0833	5.47	
BMI	Male	11	23.5727	2.41	0.122
	Female	18	26.6556	6.09	
Vat, g	Male	11	385.8182	157.59	0.215
	Female	18	487.8722	235.50	

Note: Independent t-test, statistically significant at $p<0.05$

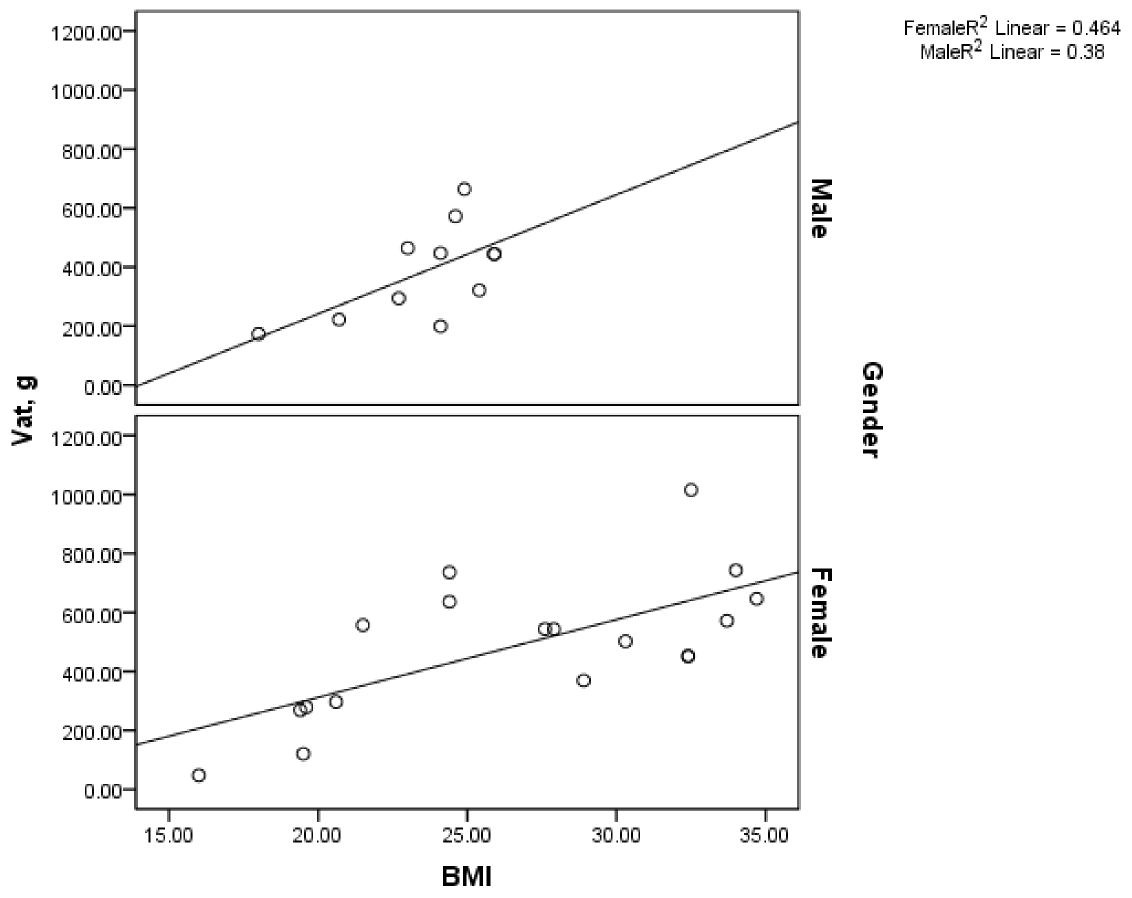

Figure 8 Scattergram of Vat versus BMI in study participants according to gender

Table 4 Correlation between BMI and Vat in study participants according to gender

	Vat, g	r	R^2	P value
BMI, kgm^{-2}	Male	0.616	0.380	0.043*
	Female	0.681	0.464	0.002*