Journal of Medicine and Health (JMH) **e-ISSN: 2442-5257**
Vol. 7 No. 2 August 2025 **https://doi.org/10.28932/jmh.v7i2.11930**

Research Article

The Correlation of Body Composition with Random Blood Glucose in Young Adult Medical Students at Pelita Harapan University

Korelasi Komposisi Tubuh dengan Gula Darah Sewaktu pada Mahasiswa Usia Dewasa Muda di Fakultas Kedokteran Universitas Pelita Harapan

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Received: June 24, 2025
Accepted: July 16, 2025

Abstract

Body composition refers to the arrangement of fat, water, bone, muscle, skin, and other lean tissues that constitute the body. A shift in composition of the body, increased fat storage and reduced muscle mass lead to metabolic imbalance and elevate the likelihood of type 2 diabetes. Although the previous studies have shown the alterations in body composition related to their age, the correlation of body composition to random blood glucose of young adults has not yet been explored clearly. Therefore, our goal is to establish the relationship between body fat, muscle mass, and random blood glucose levels in young adults. In this cross-sectional study, 296 medical students aged 19-24 years old were included and examined for their body composition with Bioelectrical Impedance Analysis and measured random blood glucose with a glucometer. Using Spearman's correlation ($p<0.05$), we found significant positive correlations for body fat ($r=0.133$, $p=0.022$) and fat-to-muscle ratio ($r=0.131$, $p=0.024$), whereas muscle mass exhibited an inverse relationship ($r=-0.130$, $p=0.026$). Based on gender, the correlation for body composition and random blood glucose were significant in males but not for females. Higher body fat and lower muscle mass are associated with elevated random blood glucose levels in young adults, particularly in males.

Keywords*: body composition; random blood glucose; correlation; young adult; medical students*

How to Cite:
Atmodjo WL, Siregar RUP, Wijaya A, Kartono WS, Fernhandho V, Christy GA. The correlation of body composition with random blood glucose in young adult medical students at Pelita Harapan University. Journal of Medicine and Health. 2025; 7(2): 154-62. DOI: https://doi.org/10.28932/jmh.v7i2.11930

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Abstrak

Komposisi tubuh merupakan distribusi dari lemak, air, tulang, otot, kulit, dan jaringan tanpa lemak lain yang menyusun tubuh manusia. Pergeseran komposisi tubuh dengan adanya peningkatan lemak dan penurunan massa otot berkontribusi terhadap disregulasi metabolisme sehingga meningkatkan risiko diabetes melitus tipe 2. Walaupun beberapa penelitian sebelumnya melaporkan adanya perubahan pada komposisi tubuh sesuai dengan usianya, korelasi antara lemak tubuh dan massa otot terhadap kadar gula darah sewaktu pada usia dewasa muda belum diungkapkan dengan jelas. Penelitian ini bertujuan untuk mengetahui hubungan antara lemak tubuh dan massa otot terhadap kadar gula darah sewaktu pada populasi dewasa muda. Pada studi potong lintang ini, 296 mahasiswa kedokteran berusia 19–24 tahun diukur *body fat* dan massa otot dengan alat *Bioelectrical Impedance Analysis* sedangkan kadar gula darah sewaktu diukur dengan glukometer. Hasil analisis korelasi Spearman ($p<0,05$) menunjukkan hubungan positif yang signifikan antara lemak tubuh ($r=0,133$, $p=0,022$) dan rasio lemak terhadap otot ($r=0,131$, $p=0,024$), sementara massa otot menunjukkan hubungan negatif ($r=–0,130$, $p=0,026$) terhadap gula darah sewaktu. Berdasarkan jenis kelamin, terdapat hubungan korelasi yang signifikan pada laki-laki, tetapi tidak pada perempuan. Tingkat lemak tubuh yang tinggi dan massa otot yang rendah berhubungan dengan gula darah sewaktu pada usia dewasa muda terutama pada pria.

Kata kunci: komposisi tubuh; gula darah sewaktu; korelasi; dewasa muda; mahasiswa kedokteran

Introduction

Body composition refers to the arrangement of fat, water, bone, muscle, skin, and other lean tissues that constitute the body. This concept is typically represented as the percentage of total body weight composed of fat and/or lean mass, which is associated with an increased risk of certain chronic diseases and health issues.[1] Body composition is essential for hormone production, insulation, and various important bodily functions. The human body is made up of stored fat and non-fat mass, which includes bones, liver, kidneys, intestines, muscles, and other organs. Numerous health risks are associated with the balance between fat mass and non-fat mass. Individuals with a greater proportion of non-fat mass usually exhibit a leaner physique with increased muscle and lower susceptibility to various diseases.[2] Having high levels of body fat, particularly visceral fat, elevates the risk factors for several health problems, such as insulin resistance and type 2 diabetes, hyperlipidemia, high blood pressure, uncontrolled blood sugar, and heart disease.[3,4] People with body fat percentages above 25.2% in men and 30.3% in women face a considerably greater risk of developing type 2 diabetes mellitus.[5]

Monitoring body composition is an effective tool to maintain muscle mass and body fat then may reduce the risk factors of health problems.[6, 7] Assessing body composition enables the estimation of body tissues, organs, and their distributions in living individuals without causing harm. The ways to measure body composition vary i.e. skinfold assessment, DEXA scan, abdominal waist circumference, hydrostatic weighing, anthropometric measurements include body mass index (BMI), and bioimpedance analysis (BIA). Certain methods for measuring body

composition may be more user-friendly but can lack precision, while others, despite being more challenging to utilize, provide enhanced accuracy. Skinfold measurements, for instance, require the use of a specialized caliper designed to assess the thickness of skin folds. This technique involves carefully pinching the skin along with the subcutaneous fat at multiple anatomical sites.[8] A bioimpedance analysis (BIA) is another indirect method used to assess fat mass, muscle mass, and water mass that are painless and low-energy electrical current.[9]

To assess if the ratio of fat to lean mass is linked to glucose metabolic disorders, a study showed a strong association that influence the disparity between fat and muscle mass might exert a combined effect on the likelihood of experiencing glucose metabolic disorders.[10] The ratio of muscle mass to visceral fat is a significant predictor of metabolic syndrome in college students was reported.[11] Therefore, the body composition of all people needs to be observed for their increase of fat accumulation and decreased of lean muscle mass that increases the likelihood of developing type 2 diabetes.[12] The ever-increasing trend of diabetes mellitus poses as a major health treat globally. Over the past 50 years, these numbers have steadily increased and have now reached an epidemic level. Recent literature showed differences in the body composition suggesting that it might be a risk factor of the development of diabetes. A shift in body composition, with increased fat accumulation and decreased lean muscle mass known as sarcopenic obesity, contributes to metabolic dysregulation, and raises the risk of type 2 diabetes. [13,14] Excess body fat and elevated blood glucose levels are associated with increased inflammation and a higher risk of age-related diseases.[15]

According to the International Diabetes Federation (IDF), it is estimated that 1 in 11 adults aged 20-79 years old are diagnosed with diabetes mellitus and keep on increasing up to a staggering 578 million by 2030, and 783.2 million by 2045.[16] It was reported that the percentage of body fat is for the risk of abnormal blood glucose in adult population.[17] Diabetes type 2 is characterized by hyperglycemia demonstrating high blood sugar either fasting or at random.

The World Health Organization (WHO) has proposed a standardized classification for the average age structure of the global population. This classification includes the following age groups: adolescents, defined as individuals aged 10 to 18 years; young adults, encompassing those aged 19 to 24 years; adults, categorized as individuals aged 25 to 59 years; and older adults, comprising those aged 60 to 90 years.[18] Moreover, as individuals age, they experience various biological, immunological, and developmental changes throughout their lifespan, which significantly impact both mental and physical abilities.

The ratio of muscle mass to visceral fat serves as a significant predictor of metabolic syndrome, as indicated by findings from research conducted on college students. [19] This research

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seeks to examine the relationship between body fat, muscle mass, and random blood glucose levels among medical students aged 19 to 24 years. This demographic is particularly relevant as they often experience reduced physical activity levels due to the demands of their academic responsibilities and the need to prioritize their studies.

Methods

This study protocol was approved by the Ethics Committee of the Faculty of Medicine, Universitas Pelita Harapan, on 13 May 2025 with protocol number 197/K- LKJ/ETIK/V/202.

A cross-sectional study was conducted to observe the correlation between random blood glucose levels and body composition parameters in young adults. A cross-sectional methodology is used in this study to evaluate the relationship between body fat percentage, and muscle mass with random blood glucose in young adults of medical students aged 19 to 24 years old.

Participants will be recruited using a convenience sampling technique depending on their readiness and interest to take part. The formula used is the sample size calculation for estimating a population mean showed the final sample size is 296 participants with inclusion criteria is medical students aged 17-24 years old who provide informed consent.

All participants provided informed consent before data collection began. Demographic data, such as age and gender, were obtained through interviews. The independent variables are body composition parameters such as body fat percentage (%) and muscle mass percentage (%), were measured using a bioimpedance analyzer (BIA), and the fat-to-muscle ratio was subsequently calculated from these primary measurements. The dependent variable for this study was blood glucose level (mg/dL) taken two hours after meal, which was determined from a capillary blood sample obtained from the fingertip using a digital glucometer.

The data was analyzed using SPSS Statistics for Windows, Version 27. The Kolmogorov-Smirnov test was used to determine the normal distribution of continuous variables. The correlation between the dependent variable, i.e. random blood glucose level and the independent variables such as percentage of body fat, percentage of muscle mass, and fat-to-muscle ratio was investigated using Spearman's rank correlation coefficient. All tests were declared statistically significant with a p-value less than 0.05.

Results

A total of 296 young adults participated in the study. The median age of the participants was 19.00 years (IQR: 19.00–20.00). Most participants were female (n = 211, 71.28%), with males constituting 28.72% (n = 85). The median body fat percentage was 31.00% (IQR: 25.70–

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35.90), median muscle mass percentage was 64.10% (IQR: 59.40–69.00), and the median fat-to-muscle ratio was 0.48 (IQR: 0.37–0.61). The median random blood glucose level was 107.50 mg/dL (IQR: 95.00–120.00), with 92.91% (n = 275) of participants classified as having normal glucose levels and 7.09% (n = 21) as prediabetic (Table 1).

Overall body fat percentage showed a weak, statistically significant positive correlation with random blood glucose levels (r = 0.133, p = 0.022) (Table 2). Muscle mass percentage demonstrated a weak, statistically significant negative correlation with random blood glucose levels (r = -0.130, p = 0.026). Similarly, the fat-to-muscle ratio exhibited a weak, statistically significant positive correlation with random blood glucose levels (r = 0.131, p = 0.024).

Significant differences in body composition between male and female participants were observed (Table 3). Males had a significantly lower median body fat percentage (24.50% vs. 33.00%, p < 0.001), significantly higher median muscle mass percentage (70.30% vs. 62.30%, p < 0.001), and a significantly lower median fat-to-muscle ratio (0.35 vs. 0.53, p < 0.001) compared to females. There were no statistically significant differences in median age (p = 0.412), median random blood glucose levels (p = 0.145), or the proportion of individuals with prediabetes (4.7% in males vs. 8.1% in females, p = 0.444) between the two sexes.

Table 1 Baseline Characteristics (n = 296)

Characteristics	Median (IQR) n (%)
Age (year)	19.00 (19.00 - 20.00)
Gender	
Male	85 (28.72)
Female	211 (71.28)
Body fat (%)	31.00 (25.70 - 35.90)
Muscle mass (%)	64.10 (59.40 - 69.00)
Fat to muscle Ratio	0.48 (0.37 - 0.61)
Random blood glucose (mg/dL)	107.50 (95.00 - 120.00)
Normal	275 (92.91)
Prediabetes	21 (7.09)

IQR = Interquartile range

Table 2 Correlation Between Body Composition to Random Blood Glucose (n = 296)

Body composition	r	p-value
Body fat (%)	0.133	0.022
Muscle mass (%)	-0.130	0.026
Fat to muscle Ratio	0.131	0.024

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In males (n = 85), body fat percentage demonstrated a significant positive correlation with random blood glucose level (r = 0.227, p = 0.036), muscle mass percentage showed a significant negative correlation (r = -0.228, p = 0.036), and the fat-to-muscle ratio also demonstrated a significant positive correlation (r = 0.230, p = 0.035) (Table 4). In contrast, no significant correlations were found between any of the body composition variables (body fat percentage, muscle mass percentage, or fat-to-muscle ratio) and random blood glucose levels (all p > 0.300) in females (n = 211). These findings showed that the relationship between body composition and random blood glucose levels is more evident in males than in females within this young adult cohort.

Table 3 Characteristics of Sample Based on Gender (n = 296)

Characteristic	Male (n = 85)	Female (n = 211)	p-value
	Median (IQR) or n (%)	Median (IQR) or n (%)	
Age (year)	19. 00 (18.50 - 20.00)	19.00 (19.00 - 20.00)	0.412
Body fat (%)	24.50 (18.65 - 30.90)	33.00 (27.80 - 38.10)	< 0.001
Muscle mass (%)	70.30 (64.30 - 75.95)	62.30 (57.20 - 67.00)	< 0.001
Fat to muscle Ratio	0.35 (0.25 - 0.48)	0.53 (0.42 - 0.67)	< 0.001
Random blood glucose (mg/dL)	104.00 (95.00 - 115.00)	108.00 (95.00 - 122.00)	0.145
Normal	81 (95.3)	194 (91.9)	0.444
Prediabetes	4 (4.7)	17 (8.1)	

IQR = Interquartile range

Table 4 Correlation Between Body Composition and Random Blood Glucose Based on Gender (n = 296)

Body composition	male (n = 85)		female (n = 211)	
	r	p-value	r	p-value
Body fat (%)	0.227	0.036	0.061	0.376
Muscle mass (%)	-0.228	0.036	-0.056	0.417
Fat to muscle Ratio	0.230	0.035	0.058	0.405

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Discussion

The demographic characteristics of a total of 296 young adults participated in the study showed that most participants were female (71.28%), with aged between 19 and 20 years. The median body fat percentage was 31.00%, median muscle mass was 64.10% and the median fat-to-muscle ratio was 0.48. The random blood glucose of participants classified as having normal glucose was 92.91% and 7.09% diagnosed as prediabetic. In this study, random blood glucose levels were categorized as normal ranging from 70–140 mg/dL, prediabetes ranging from 140–200 mg/dL, and diabetes is above 200 mg/dL.[20]

In the correlation between body composition to random blood glucose analysis revealed that body fat and fat-to-muscle ratio percentage showed significant positive correlation, while muscle mass percentage demonstrated statistically significant negative correlation. Although statistically significant, the strength of these associations was low. These findings are consistent with a meta-analysis conducted by Chen *et al.*[21] which reported a relationship between body fat percentage and blood glucose levels in children and adolescents.[22] The meta-analysis, which included 20 studies, concluded that individuals with higher body fat percentages tended to have elevated blood glucose levels. Similarly, a study by Claudia *et al.* reported comparable results. Their research found a weak positive correlation between total body fat and diabetes indicators, a weak negative correlation between muscle mass and diabetes indicators, and a strong positive correlation between the fat-to-muscle ratio and diabetes indicators. [10] The correlations observed in this study was significant, along with findings from previous research, indicate a clear relationship between body composition and blood glucose levels. This correlation may be explained by the fact that individuals with higher body fat levels are more likely to be obese, which is associated with increased blood glucose levels. An imbalanced fat-to-muscle ratio is linked to inflammatory responses in the body, which can impair insulin secretion and result in elevated blood glucose compared to individuals with a balanced fat-to-muscle ratio. Muscle mass is negatively correlated with blood glucose because skeletal muscle is a highly effective site for glucose uptake, approximately 80% of glucose entering the body after a meal is absorbed by muscle tissue to support its activity.[21] Therefore, individuals with greater muscle mass have an enhanced capacity for glucose uptake, contributing to better blood glucose regulation.

The analysis of the sample reveals notable gender-based differences in body composition metrics, including fat percentage, muscle mass, and the fat-to-muscle ratio among male and female participants. Specifically, males exhibited reduced body fat, increased muscle mass, and a lower fat-to-muscle ratio in comparison to their female counterparts. Statistically significant results further substantiate these observations. These results are similar with the result of Srinkanthan *et*

al., who examined the relationship between sex and body composition. Their study reported a significant association between sex and body composition, with 58.4% of males exhibiting lower body fat and higher muscle mass compared to 41.6% of females, with a p-value < 0.001.[23] Based on these findings, supported by previous research, there appears to be a relationship between sex and body composition. This relationship can be explained by differences in lipid metabolism between males and females.[24] The hormones estrogen and testosterone play crucial roles in regulating body fat distribution. Males typically have higher circulating testosterone levels, whereas females have higher levels of estrogen and progesterone. These hormonal differences lead to distinct fat storage patterns: males tend to accumulate fat predominantly in the abdominal region, while females preferentially store fat in areas such as the hips, thighs, and buttocks**.**[25] This variation in fat distribution contributes to sex-specific differences in lipid and muscle metabolism, with male body fat being more readily mobilized during physical activity compared to females.

In the correlation between body composition to random blood glucose based on the subjects' sex revealed a statistically significant positive correlation between body fat and the fat-to-muscle ratio with random blood glucose levels in male subjects, as well as a significant negative correlation between muscle mass and random blood glucose levels in males. All these correlations were statistically significant. In contrast, female subjects did not exhibit any statistically significant correlations. These findings correspond to the study conducted by Wu et al., which investigated the relationship between body fat, body composition, and random blood glucose. Their research demonstrated a specific association between body fat and blood glucose in male subjects that was not observed in female subjects.[26]

This study represents a novel investigation as it examines the correlation between body composition and random blood glucose levels among medical students at Pelita Harapan University. However, this study has several limitations, including an unequal proportion of male and female participants, the absence of an assessment of participants' physical activity levels, and the use of self-reflection for reporting participants' mealtimes.

Conclusion

We found significant weak positive correlations for body fat and fat-to-muscle ratio, while for muscle mass showed a negative correlation. Based on gender, the correlation for body composition and random blood glucose were significant in males but not for females. It suggested that significant different correlation between gender were influenced by hormonal and lipid metabolism.

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