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The Correlation between Body Mass Index and Total Fat Percentage with Random Blood Glucose Levels in Patients with Type 2 Diabetes Mellitus at Kotaagung Public Health Centre, 2024

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ABSTRACT

Background: The chronic metabolic condition known as type There is a positive correlation between the risk of developing type 2 diabetes mellitus and Body Mass Index (BMI) and body fat percentage. Signs of type 2 diabetes mellitus are hyperglycemia caused by insulin resistance or insulin deficiency. Pro-inflammatory adipokines are produced as adiposity increases, which interferes with insulin sensitivity, causing blood glucose to accumulate. As a result, the body has difficulty absorbing blood sugar. When blood sugar continues to rise, diabetes develops.
Objectives: This study aimed to determine the correlation between Body Mass Index (BMI), total body fat percentage, and random blood glucose levels in individuals with Type 2 Diabetes Mellitus.
Methods: This study used a cross-sectional approach, an analytical design, and quantitative methodology. The research was conducted at the Kotaagung Public Health Centre from October to December 2024 with a population of 87 and a research sample of 58 Diabetes Mellitus patients using the method of random sampling. A questionnaire was employed as the research tool, measuring body weight and body fat percentage with a Karada scan tool, measuring height using a microtome, and measuring blood sugar levels with a glucometer. Data analysis used the Pearson test.
Results: The respondent characteristics by gender showed 19 men (32.8%) and 39 women (67.2%). The mean Body Mass Index (BMI) was 22.23±3.25 kg/m² for men and 25.36±3.58 kg/m² for women. For total body fat percentage, the mean was 20.93±2.95% for men and 36.65±5.82% for women. The mean Random Blood Glucose (RBG) level was 211.00±67.4 mg/dL for men and 258.05±96.24 mg/dL for women.
Conclusion: In type 2 diabetes patients treated at Kotaagung Health Center, there was a correlation between random blood sugar levels with body mass index and body fat percentage, with a p-value=0.000.

Keywords*:* Body Mass Index, Healthy Lifestyle, Non-Communicable Diseases, Percent Total Fat, Random Blood Sugar

INTRODUCTION

Elevated blood glucose levels beyond normal limits are a key indicator of diabetes mellitus, a chronic metabolic disorder. The underlying causes of this condition form the basis for its classification into Type 1, Type 2, and Gestational Diabetes Mellitus (Kemenkes, 2025). The 2023 Indonesian Health Survey (SKI), an extension of the Basic Health Research (Riskesdas), reported a rising Indonesia experienced a rise in diabetes prevalence, growing from 10.9% in 2018 to 11.7% by 2023. Type 2 diabetes remains the most common, especially among adults. In Lampung Province, the prevalence of diabetes mellitus was 2.5% in 2023. At the local level, data from the Tanggamus Regency Health Office indicated that the Kotaagung Community Health Center recorded 87 cases of diabetes mellitus in July 2024, the highest among 26 community health centers, highlighting the urgency of addressing diabetes in this region. Body Mass Index (BMI), a standard tool used to assess

nutritional status, is widely recognized as a contributing factor to the development of type 2 diabetes. An elevated BMI is closely linked to a greater risk of insulin resistance, which impairs glucose uptake and leads to hyperglycemia (American Association Diabetes, 2022).

Obesity contributes to the mechanisms underlying metabolic disorders through various factors, including chronic inflammation, mitochondrial dysfunction, and hormonal imbalance. However, Body Mass Index (BMI) cannot distinguish between fat mass and muscle mass, making it less accurate in representing overall body composition. In contrast, body fat percentage provides a more representative measure of metabolic health and the risk of chronic diseases (Kawai et al., 2020; Manna & Jain, 2015). Lipid metabolism is also essential in maintaining glucose homeostasis. The process of lipolysis, the breakdown of triglycerides, produces glycerol and free fatty acids, which can be utilized for gluconeogenesis and energy supply. However, an excess of free fatty acids may lead to complications such as insulin resistance and oxidative stress (Zatterale et al., 2019).

Free fatty acids can serve as an alternative energy source, but their excess can lead to ketoacidosis in type 1 diabetes (Bakker *et al*., 2018). Hyperglycemia can further stimulate lipogenesis, creating a feedback loop that worsens diabetic conditions (Griffin *et al*., 2017). An imbalanced cycle between glucose and fat can exacerbate diabetes and lead to complications. Body fat percentage measures the proportion of fat in the body compared to total body mass. Body fat percentage provides more detailed information regarding body composition and metabolic health compared to BMI, because BMI does not differentiate between muscle and fat.

Despite the implementation of the Non-Communicable Disease (NCD) Prevention and Control Program at the Kotaagung Community Health Center, which includes education, routine screening, and lifestyle interventions, the prevalence of diabetes remains significant. The two leading NCDs recorded are hypertension and diabetes mellitus. Hypertension affects 25.3% of the at-risk population, followed by diabetes at 15.8% Azizah *et al*. (2023), which reported an increasing trend of 5% annually for hypertension cases over the past three years. Meanwhile, diabetes mellitus follows in second place with a prevalence of 15.8%, according to a study by Rahmawati (2023), which noted an annual increase of 4.2%. Both NCDs demonstrate a continuous upward trend, influenced by a less active community lifestyle, unhealthy diets, and high stress levels. This increase in prevalence indicates an urgency for the Kotaagung Community Health Center to strengthen its promotive and preventive programs, especially in health education, to reduce the incidence of NCDs in the future. This is influenced by several factors, one of which is the low adherence of the community to recommended lifestyle changes.

Based on a preliminary study conducted by the researchers on 10 respondents at the Kotaagung Community Health Center, measurements using a Karada Scan and Glucometer yielded the following average results: BMI 27.39 kg/m², Random Blood Sugar (GDS) level 233 mg/dL, Body Fat Percentage 32.9%, Visceral Fat 10.9. Additionally, all 10 respondents had a history of diabetes mellitus and were taking medication regularly. This study was conducted due to the high prevalence of Type 2 Diabetes Mellitus, which ranks among the top ten most common diseases recorded at the Kotaagung Public Health Center. This study will focus on the connection between total body fat and Body Mass Index (BMI), percentage with random blood sugar levels, considering that Insulin resistance and the onset of diabetes mellitus are frequently linked to fat. From the aforementioned explanation, the authors are interested in conducting research titled "The Relationship Between Body Mass Index (BMI) and Total Body Fat Percentage with Random Blood Sugar (GDS) Levels in Patients with Diabetes Mellitus at the Kotaagung Community Health Center."

METHODS

Data collection for this study was done after getting research permission from the Kotaagung Health Center. The process of identifying potential respondents undergoing examination or treatment at the Kotaagung Public Health Center was carried out. Respondent selection was based on the data required for this research, which included information on name, age, gender, as well as the results of height and weight measurements. Additionally, measurements of total body fat percentage and random blood glucose levels were performed on patients who met the study criteria. This study was conducted from October to December 2024, covering the stages of preparation, research permit acquisition, data analysis, and final presentation. The field data collection was specifically carried out on November 25th and 26th, 2024, at the Kotaagung Public Health Center. The data collection process began with the preparation and administrative procedures, including obtaining research permits, in October 2024. Identification and selection of eligible respondents were carried out in early November. The actual field data collection, including anthropometric measurements and biochemical tests, was conducted over two days, on November 25th and 26th, 2024, at the Kotaagung Public Health Center. The final stages, including data processing and analysis, took place in December 2024. The exclusion criteria for respondents were those who traveled long distances

or out of town during the study period and those who withdrew from the study.

To ensure that every member of the population has an equal opportunity to be sampled, this study uses a simple random sampling method to select as respondent. The Lemeshow formula was applied to calculate the sample size (1997). In addition, 10% of the total sample was added to anticipate possible dropouts. Prior to the measurement process, respondents were required to complete a registration form as an administrative requirement for receiving treatment at the Health of the Community. After the registration process was completed, Anthropometric measurements carried out included height, weight, and total body fat percentage using the Omron Karada Scan device HBF-375. Subsequently, respondents underwent random blood glucose level testing performed by healthcare professionals, and the results were recorded as part of the research data. The measurement was conducted using a blood glucose meter, YASEE brand, Model GLM-77. In this study, random blood glucose refers to glucose levels in the blood measured at random times throughout the day, regardless of the participant's last meal. The measurement was conducted using a capillary blood sample obtained via finger prick, analyzed with a digital glucometer. This method was chosen for its practicality and suitability for field data collection. This research has undergone ethical review and was deemed ethical with ethical approval number 429/UAP.OT/KEP/EC/2024 approved on November 9, 2024 from the Health Research Ethics Committee at the Faculty of Public Health, Aisyah University, Pringsewu. The data were analyzed using the Pearson correlation test with a significance value of 0.000. The analysis was performed using the IBM SPSS Statistics 23 application.

RESULTS AND DISCUSSION

According to the research results, anthropometric measurements such as height, weight, and body fat percentage were included in the data collection process, using the Omron Karada Scan device. Additionally, random blood glucose level testing was performed by healthcare professionals to obtain an overview of the respondents' metabolic status. Each respondent underwent the procedure according to the predetermined stages, starting from registration, anthropometric measurements, to blood glucose level testing. The data obtained from each stage was used as the basis for analyzing the respondents' health conditions and their relationship with other research variables. The following table presents the respondent gender characteristics:

Table 1. Respondent Gender Characteristics

Gender	Age (Mean)	Frequency	Percent
Male	43.74	19	32.8
Female	44.26	39	67.2
Total		58	100.0

"Source: Primary Data Processed, 2024"

The gender characteristics of the respondents are shown in Table 1. The data reveal that the average age of male participants was 43.74 years, whereas female participants had a mean age of 44.26 years. In terms of frequency, there were 19 male respondents, representing 32.8% of the total sample. The study included 39 female respondents, who constituted 67.2% of the overall respondent group. The differences between male and female respondents in this study indicated that females had higher values in all three key measured variables. However, these differences remain descriptive and have not yet been tested statistically to determine whether they are significant or merely observational. Therefore, further analyses, such as comparative tests or multivariate analysis, are necessary to confirm whether gender has a true effect on the metabolic parameters, taking into account potential confounding variables such as age and lifestyle.

Table 2. Univariate Examination of Blood Glucose, Body Mass Index, and Total Body Fat Percentage

Variable	Male		Female	
	Mean	±SD	Mean	±SD
Body Mass Index (kg/m^2)	22.23	3.25	25.36	3.58
Total Body Fat Percentage (%)	20.93	2.95	30.65	5.82
Blood Glucose (mg/dl)	211.00	67.40	258.05	96.24

"Source: Primary Data Processed, 2024"

The results of the univariate analysis showed that women had higher body mass index, total body fat percentage, and random blood glucose levels compared to men. The 39 female respondents had a mean body mass index of 25.36 mg/dL and a mean total body fat percentage of 30.65%, while the 19

male respondents had a mean body mass index of 22.23 mg/dL and a mean total body fat percentage of 20.93%. Random blood glucose levels were also higher in females, with a mean of 258.05 mg/dL, compared to males with a mean random blood glucose level of 211.00 mg/dL.

Increased adiposity in women, influenced by the hormone estrogen, can trigger the production of pro-inflammatory adipokines. These adipokines can impair cellular sensitivity to insulin, causing insulin resistance, a condition that prevents the body from absorbing glucose from the blood, resulting in increased blood sugar levels and raising the risk of developing type 2 diabetes. In addition to triggering the production of pro-inflammatory adipokines, the hormone estrogen plays a significant role in the regulation of glucose metabolism in women. Fluctuations in estrogen levels during the menstrual cycle can affect insulin sensitivity and glucose tolerance. During certain phases of the menstrual cycle, particularly before menstruation, insulin resistance tends to increase. This may lead to a heightened risk of developing type 2 diabetes mellitus in women (Lee *et al*., 2023).

Table 3. Bivariate Analysis: Body Mass Index, Total Body Fat Percentage, and Blood Glucose

Variable	Blood Glucose (p-value)
Body Mass Index (kg/m^2)	0.000
Total Body Fat Percentage (%)	0.000

Source: Primary Data Procesed, 2024
Note: Pearson Test

The results of the study are shown in Table 3, which shows the correlation between body mass index and random blood sugar levels in type 2 DM patients at the Kotaagung Public Health Center (p-value=0.000). The Pearson correlation coefficients were as follows: Body Mass Index (r=1.000), Random Blood Glucose (r=0.447), and Percent Body Fat (r=0.815). This finding is in line with research conducted by Riaz et al. (2024), which identified a significant association between body mass index and blood glucose levels among type 2 diabetes mellitus patients at Telaga Dewa Health Center. At the Telaga Dewa Health Center, Bengkulu City, most participants showed an abnormal body mass index. The body can produce fat as a result of an unbalanced diet and excessive food consumption. This can cause the body mass index to become abnormal or increase. It is important to acknowledge that although Body Mass Index (BMI) is commonly used as an indicator of nutritional status, it has limitations, as it does not differentiate between fat mass and muscle mass. Therefore, interpretations of BMI should be made with caution, particularly when distinguishing excess weight due to fat from that due to muscle.

The study by Fatria et al. (2022), which showed a connection between body mass index and diabetes mellitus, also supports these research findings. This is brought on by insulin resistance, which decreases cells' absorption of glucose and increases the production and secretion of insulin produced by pancreatic beta cells. Blood sugar can be managed for several months with high insulin levels. However, because of the overabundance of activity, this may result in a reduction of pancreatic cell formation. Hypertension will result from the accumulation of glucose in the blood. Masruroh (2018). Obesity is the leading contributor to the onset of diabetes mellitus, as it can cause cells to become resistant to insulin. Insulin facilitates glucose absorption in various cells and thereby contributes to the regulation of carbohydrate metabolism. Consequently, insulin resistance at the cellular level may lead to impaired blood glucose control (Hartono & Fitriani, 2019).

The investigation carried out by Sovia (2023) provides further evidence for these research findings. Obesity is a major contributing factor to the development of diabetes mellitus, as it may lead to cellular insulin resistance. Insulin facilitates glucose absorption in numerous cells and thereby regulates carbohydrate metabolism. Consequently, when cells develop insulin resistance, the regulation of blood glucose levels may become impaired(Rahmatunisa *et al*., 2021). The body's metabolic processes are highly dependent on the availability of glucose as the primary energy source. After food is digested, glucose is absorbed by the intestines and enters the bloodstream. The hormone made insulin, secreted by the pancreas, regulates blood glucose levels by promoting glucose uptake into cells (Harahap *et al*., 2020). Under normal conditions, insulin binds to receptors on the cell surface, opening the door for glucose to enter and be used as energy. However, in conditions of obesity, this process is disrupted. As a result, glucose has difficulty entering cells and accumulates in the blood, causing blood sugar levels to rise. Furthermore, the increase in free fatty acids associated with obesity can stimulate the production of the LITAF protein, which triggers an inflammatory response through the initiation of multiple signaling cascades, such as the NF-κB pathway, thereby impairing insulin sensitivity (Gheflati *et al*., 2019).

Based on the findings of Rosyida *et al*. (2019), obesity leads to conditions such as diabetes, dyslipidemia, inflammation, hypertension, and a procoagulant state, which can develop into cardiovascular disease in an individual. Obesity occurs when nutrient intake exceeds the calories needed. Excess energy intake is stored as

triglycerides in adipose tissue, which, in the context of obesity, leads to adipose tissue dysfunction. This dysfunction is characterized by macrophage infiltration into adipose tissue, reduced lipid-buffering capacity, adipocyte hypertrophy, and increased production of proinflammatory cytokines, all of which are closely associated with insulin resistance (Cavalcante-Silva et al., 2015; Li et al., 2023). Lipid abnormalities in individuals with obesity are generally marked by elevated levels of VLDL, apolipoprotein B, and triglycerides. In addition, LDL levels are also increased, particularly small dense LDL particles, which are more prone to becoming trapped in the arterial walls and are considered highly atherogenic (Chandrasekaran & Weiskirchen, 2024).

Table 3 shows the relationship between total body fat percentage and random blood sugar levels in type 2 diabetes patients at Kotaagung Health Center, with a p-value=0.000. This is in accordance with the research findings. of Zanzabil et al. (2023), which indicated that a higher body fat percentage can lead to excessive fat accumulation, potentially causing obesity and impairing an individual's health. This is because body composition, which influences body weight, includes not only body fat but also water content, bone mass, muscle mass, and other tissues. Body mass index alone cannot determine body fat distribution as effectively as measurements from skinfold thickness (Aune *et al*., 2018). Maintaining a normal body fat percentage is crucial, as total body fat is related to fat levels, and excess fat leads to central obesity, which carries a very high risk of various dangerous diseases. Furthermore, obesity plays a significant role in the high incidence of cardiovascular diseases such as coronary heart disease at the Darul Imarah Community Health Center in Aceh Besar (Arnisam & Wagustina, 2019).

In addition, this research aligns with the findings of Albert et al. (2020), who found that a correlation exists between BMI and body fat percentage in diabetic patients. Low body mass index is associated with low body fat levels, while excessive body fat levels can lead to higher insulin resistance. The risk of diabetes increases with a high percentage of body fat. The production of pro-inflammatory cytokines such as TNF-α and IL-6 increases when a person is obese. This causes a long-lasting inflammatory response. These cytokines interfere with insulin signaling through various mechanisms, such as insulin receptor desensitization and impaired intracellular signal transduction. As a result, body cells cannot absorb insulin, resulting in hyperglycemia. Free fatty acids released from adipose tissue also disrupt mitochondria and oxidative stress, which aids insulin resistance. There may be a role for body fat in increasing blood sugar levels, as shown by the glycemic index of type 2 diabetic patients who have a higher percentage of body fat than others (Lisnawati et al., 2023).

Figure 1. Documentation of Activities

In the data collection process, an advantage identified was the use of the Omron Karada Scan device, which allowed for practical and accurate measurement of body fat percentage. Furthermore, random blood glucose level testing was conducted directly by healthcare professionals, making the results more reliable and in accordance with applicable medical procedures. Measurements were taken systematically after respondents completed the registration process, which facilitated smooth data collection and ensured regularity in recording research findings. However, several challenges were encountered during the measurement process, such as some respondents feeling uncomfortable or anxious during blood glucose level testing due to the blood sampling procedure. Before the research began, the researcher introduced themselves and explained the research process, followed by the signing of the informed consent form. Additionally, the crowded environment and time constraints during examinations caused some respondents to wait longer before measurements were taken. The limited number of devices also posed a challenge, as they had to be used alternately, thus slowing down the overall data collection process. To mitigate these limitations, during the informed consent and personal data collection, the researchers provided assistance to respondents in completing the necessary forms. Furthermore, all measurements utilizing the Karada Scan HBF-375 were meticulously performed by the researchers.

This study has several limitations. First, the sample size was relatively small (58 respondents) and the research was conducted at a single site, namely UPTD Puskesmas Kotaagung, which reduces the extent to which the results can be applied to a wider population. Second, due to its cross-sectional design, the study is unable to determine causal links between variables. Future research is recommended to employ a longitudinal design and include a larger and more diverse population to obtain more representative and generalizable results.

CONCLUSION

The research results show that among individuals suffering from Type 2 Diabetes Mellitus at Kotaagung Health Center there is a significant correlation between Body Mass Index (BMI) and Casual Blood There is a significant value of p-value=0.000 for Random Blood Sugar (GDS) and there is a significant value of p-value=0.000 for the correlation between total body fat percentage and Random Blood Sugar (GDS). It is recommended that subsequent researchers include additional variables, such as the type of antidiabetic medication and levels of physical activity, to obtain a deeper insight into the subject of the research topic. This study's outcomes underscore the importance of regularly monitoring body mass index, body fat percentage, and blood glucose levels as part of public health screening programs, particularly among populations at elevated risk for type 2 diabetes. These results provide a valuable foundation for the development of targeted health promotion initiatives focused on early detection, lifestyle modification, and metabolic health education, with the aim of preventing diabetes and its associated complications. Future studies are encouraged to adopt longitudinal research designs to evaluate temporal changes in anthropometric and metabolic parameters and their long-term effects on health outcomes. Furthermore, intervention-based research such as structured dietary and physical activity programs should be conducted to assess the effectiveness of preventive strategies in reducing body fat and improving glycemic control.

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None.

Contributions of the Authors

Conceptualization, investigation, methodology, supervision, writing-review & editing, writing-review & editing, writing-review & editing, methodology, formal analysis, writing-original draft, formal analysis, resources, writing-review & editing, writing-review & editing.

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