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# *Hubungan antara Lingkar Leher dan Persen Lemak Tubuh dengan Kadar Glukosa Darah Puasa pada Mahasiswi Obesitas*

# Association among Neck Circumference and Percent Body Fat with Fasting Blood Glucose in Obese Female College Students

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***ABSTRAK***

***Latar Belakang****: Pengukuran antropometri Lingkar leher dapat mendeskripsikan jaringan adiposa subkutan tubuh bagian atas dan memiliki korelasi dengan obesitas serta diabetes melitus.*
***Tujuan:*** *Mengetahui hubungan persen lemak tubuh dan lingkar leher dengan kadar glukosa darah puasa pada mahasiswi obesitas.*
***Metode:*** *Penelitian ini memakai design cross-sectional, dilaksanakan di Universitas Diponegoro pada bulan Juni-Agustus 2019. Sebanyak 119 orang subjek perempuan usia 17-21 tahun dipilih dengan menggunakan metode purposive sampling. Pengukuran lingkar pinggang digunakan sebagai indikator obesitas. Persen lemak tubuh diukur memakai Bioelectrical Impendance Analysis (BIA), dan lingkar leher diukur menggunakan metline. Kadar glukosa darah puasa diperiksa setelah subjek berpuasa 8-12 jam, jumlah darah yang diambil sebesar 5cc. Data dianalisis menggunakan uji Rank-Spearman.*
***Hasil:*** *Sebanyak 84% subjek mempunyai persen lemak berlebih. Median lingkar leher 32,5 cm. Median kadar glukosa darah puasa sebesar 87 mg/dL. Terdapat hubungan signifikan antara persen lemak tubuh dengan kadar glukosa darah puasa (r=0,231, p=0,012). Tidak terdapat korelasi antara lingkar leher dengan kadar glukosa darah puasa (r=0,137, p=0,137).*
***Kesimpulan:*** *Persen lemak tubuh memiliki hubungan signifikan dengan kadar glukosa darah puasa, dan semakin besar lingkar leher maka kadar glukosa darah puasa semakin meningkat.*

***Kata Kunci****: Obesitas, Lingkar Leher, Persen Lemak Tubuh, Kadar Glukosa Darah Puasa.*

**ABSTRACT**

**Background**: Neck circumference could describe upper-body subcutaneous fat, correlated with obesity and diabetes mellitus.
**Objective:** The purpose of this study was to determine the correlation between percent body fat and neck circumference with fasting blood glucose in obese female college students.
**Methods**: The study was cross-sectional, conducted at Diponegoro University in June-August 2019. 119 participants were female, aged 17-21 years selected using the purposive sampling method. Measurement of waist circumference was used as an indicator of obesity. Percent body fat was measured using Bioelectrical Impedance Analysis (BIA), and neck circumference was measured using a met line. Fasting blood glucose was examined after the subject fasted for 8-12 hours, the amount of blood taken was 5 cc. Data were analyzed with the Rank-Spearman correlation test.
**Results:** As many as 84% of subjects had excess percent body fat. The median neck circumference was 32.5 cm. The median fasting blood glucose was 87 mg / dL. There was a significant correlation between percent body fat with fasting blood glucose (r = 0.231) (p = 0.012). There was no correlation between neck circumference with fasting blood glucose (r = 0.137) (p = 0.137).
**Conclusion**: Percent of body fat had a significant relationship with fasting blood glucose, and the greater the circumference of the neck, the greater fasting blood glucose

**Keywords**: Obesity, Neck Circumference, Percent Body Fat, Fasting Blood Glucose

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## INTRODUCTION

Obesity is a major risk factor for type 2 diabetes mellitus, the increasing prevalence of obesity is accompanied by an increase in the prevalence of diabetes mellitus. The prevalence of diabetes mellitus began to increase in the young age group[1]. According to the 2018 Basic Health Research the prevalence of diabetes mellitus aged 15 years and over was 10.9%[2]. Central obesity or excess fat accumulation concentrated in the abdomen has a higher risk of metabolic disorders compared to ordinary obesity. The decrease of pancreatic β cells activity and the occurrence of insulin resistance in obese patients is due to the increase in non-esterified fatty acids (NEFAs)[3]. In Indonesia there is an increase in the prevalence of central obesity aged 15 years and over, in 2013 from 26.6% to 31% in 2018. women, the prevalence of central obesity is higher, namely 56.3%, while in men it is 43.7%[4]. The prevalence of central obesity aged 15-24 years in Central Java is 11.57%, with the prevalence of central obesity in women in the city Semarang as much as 43.75%[5]. Women have a higher risk of diabetes mellitus at a young age than men. This is because it is easier for women to gain weight so that the risk of being overweight and obese is also higher[6].

The period of change from adolescence to adulthood occurs at the age of 18-25 years, especially for female students in college, there are lifestyle changes such as sedentary life style, consumption of foods high in energy and fat so that it can cause nutritional problems such as obesity[7,8,9]. Diet and habits during adolescence can affect the condition of the body and health in adulthood and the elderly. Obesity in adolescence can continue into adulthood and the elderly [10].

Obesity is not only associated with the amount of fat stored in the body but also its distribution, differences in fat distribution are associated with the risk of different metabolic disorders[11]. Upper body subcutaneous adipose is one of the contributors to the presence of free fatty acids (FFA) which can cause various risks [12,13]. Every addition of 50 cm3 thickness of upper body subcutaneous fat is associated with an increase in body mass index of 2.65 - 3.23 kg / m2 and an increase in fasting blood glucose levels of 1.66 - 2.53 mmg / dL[12].

Anthropometric measurement methods that were often used to determine obesity were body mass index (BMI) and waist circumference (LP). However, BMI cannot be used to determine the composition and distribution of body fat[14]. Measurement of waist circumference is closely related to BMI. Waist circumference predicts central obesity better than BMI, but cannot be used to differentiate the distribution between subcutaneous and visceral adipose tissue.

Measurement of body fat percent is another method used to measure obesity, this method can describe the body fat mass and non-fat mass. Measurement of body fat ideally uses Dual Energy X-ray Absorptiometry (DEXA) and Magnetic Resonance Imaging (MRI), but measurements using these methods were considered impractical, difficult to do in large populations and quite expensive. (BIA) is a method that is often used to measure percent body fat, this method is considered easier, cheaper and has a good relationship with measurements using DEXA and MRI[15].

Neck circumference measurement is used as a new method to determine obesity and differences in fat distribution, especially upper subcutaneous fat [16,17,18]. The advantage of using neck circumference measurement is that it is not affected by breathing movements, abdominal fullness, and is easy to measure and did not change throughout the day [19,20]. Neck circumference measurements have a significant relationship with other anthropometric measurements for obesity such as BMI and waist circumference (LP)[16,21,22,23]. Several studies suggest a correlation between neck circumference and fasting blood glucose levels and diabetes mellitus[17,24,25,26]. The accumulation of excess fat in the neck causes the high release of free fatty acids into the plasma, thereby activating protein kinases, which interfere with insulin signaling and affect blood glucose levels [27,28]. The Framingham Heart Study in Brazil showed a positive correlation only in female subjects, [29] whereas in the Ben-Noun and Laor study changes in neck circumference did not contribute to changes in blood glucose levels [30]. The relationship between measurements of neck circumference and percent body fat with fasting blood glucose levels in one population may have different results with other populations. In addition, data on neck circumference in obese women in early adulthood is still limited in Indonesia. This study aims to determine the relationship between neck circumference and percent body fat with fasting blood glucose levels in obese female students.

## METHODS

This study used a cross-sectional design which was conducted from June to August 2019 at Diponegoro University Semarang. This research received permission from the Health Research Ethics Committee with Number 373 / EC / KEPK / FK UNDIP / VII / 2019.

The study was started by screening 1260 subjects, found 215 subjects who met the inclusion criteria, then using the purposive sampling method 119 subjects were selected. The inclusion criteria in this study were Diponegoro University students aged 17-21 years, had a waist circumference> 80 cm, had no family history of diabetes mellitus, did not consume drugs that could affect blood glucose levels, were not experiencing abnormalities in the neck. resulting in enlargement of the neck, not being pregnant, not consuming alcohol, not being sick or being under a doctor's care.

The data collected in the form of subject identity, anthropometric measurements (weight, height, waist circumference and neck circumference), percent body fat and fasting blood glucose levels. Anthropometric measurements were carried out by trained enumerators. Body weight was measured using digital scales with an accuracy of 0.1 kg. Height was measured using a microtoise with an accuracy of 0.1 cm. The independent variables in this study were neck circumference and percent body fat. Measurement of neck circumference


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using a 1 mm scale metline tape, with the subject standing upright, face straight facing forward, shoulders relaxed and not slouching. Measurements were made in the cricoid cartilage, mid-length of the neck, between the mid-cervical and mid anterior vertebrae of the neck. Measurement of body fat percentage using Bioelectrical Impedance Analysis (BIA). Percent body fat aged 18-39 years in Asia was categorized as normal 21% -34%, overweight 35% -39%, and obesity ≥ 40% [31].

Fasting blood glucose level was the dependent variable in this study. Before taking blood, the subjects were required to fast for 8-12 hours. The amount of blood drawn in this study was 5 cc. Fasting blood glucose levels were categorized as normal <100 mg / dL, prediabetes 100-125 mg / dL, and diabetes ≥ 126 mg / dL [32].

Data analysis using statistical software. Univariate analysis was used to describe the characteristics of the subject by describing each variable including age, weight, neck circumference, percent body fat and the subject's fasting blood glucose levels. Normality test using Kormogorov-Smirnov. Bivariate analysis to determine the relationship between the independent variable and the dependent variable using the Spearman Rank correlation test with a significance of p <0.05.

## RESULTS AND DISCUSSION

### Subject Characteristics

Table 1 shows the age ranges for the subjects of 18-21 years with a mean of 19 years. The median neck circumference was 32.5 cm. The maximum value of body fat percent was 55.5% with a median of 39.10. The minimum value of fasting blood glucose levels was 68 mg / dL while the maximum value was 206 mg / dL.

**Table 1.** Subject Characteristics

| Subject Characteristics | At a minimum | Maximum | Median |
|---|---|---|---|
| Age (years) | 18 | 21 | 19 |
| Weight (kg) | 47.8 | 107.4 | 66.7 |
| Height (cm) | 141.2 | 171.4 | 157.5 |
| Neck Circumference (cm) | 29 | 39 | 32.5 |
| Percent Body Fat (%) | 28.5 | 55.5 | 39.1 |
| Fasting Blood Glucose Levels (mg / dL) | 68 | 206 | 87 |
| Waist (cm) | 80.5 | 94 | 85.75 |

Table 2 explains that as many as 84% of the subjects had excess body fat percent with 39% being overweight and 45% in the obese category. As many as 94% of subjects had normal fasting blood glucose levels.

**Table 2**. Overview of Fat Percentage, and Fasting Blood Glucose Levels

| Characteristics | n (119) | (%) |
|---|---|---|
| Fat Percent 31 | | |
| Normal | 19 | 16 |
| Overweight | 47 | 39 |
| Obesity | 53 | 45 |
| Fasting Blood Glucose Levels 32 | | |
| Normal | 112 | 94 |
| Prediabetes | 6 | 5 |
| Diabetes | 1 | 1 |

**Table 3.** Relationship between Neck Circumference, Fat Percent, and Fasting Blood Glucose Levels

| Variable | Fasting Blood Glucose Levels | |
|---|---|---|
| | R | p |
| Neck Circumference (cm) | 0.137 | 0.137 |
| Fat Percent (%) | 0.231 | 0.012 |

The results of the analysis showed that there was a relationship between percent body fat and fasting blood glucose levels, had a correlation coefficient of (r = 0.231) with a meaningful value (p <0.05), it could be concluded that there was a significant relationship between body fat percent and fasting blood glucose levels. The results obtained (r = 0.137) with a significance value (p> 0.05) on the correlation between neck circumference and fasting blood glucose levels, this indicates a positive correlation so that the greater the neck circumference, the higher the fasting blood glucose levels, but statistically there was no significant correlation. There was a strong and significant correlation between percent body fat and neck circumference (r = 0.682) (p <0.01).

The median neck circumference in this study was 32.5 cm, this result was in accordance with a study in India on adult subjects who stated that the cut off point


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of neck circumference in women for obesity was 32.5 cm [33]. Research on obese female students in Arabic obtained an average result. The average neck circumference was 31.28 ± 2.40 cm [34]. Research on students in Bosnia states that neck circumference ≥37.45 cm in males and ≥32.75 cm in females was a cut off point for identifying obese individuals.21 Research In students aged 18-20 years in Pakistan, the cut off point for neck circumference was ≥ 35.5 cm for men and ≥ 32 cm for women [35].

Neck circumference was associated with obesity because in obese people there were deposits of subcutaneous fat in the neck area which makes the neck circumference larger. Adipose tissue in the neck area was a tissue that has high lipolytic activity so that it can increase levels of free fatty acids, oxidative stress and insulin resistance [13,20,28].

Neck circumference was believed to be a good predictor of obesity because of the strong correlation between neck circumference and abdominal adiposity [36]. Ben-Noun's study states that neck circumference ≥37 cm for men and ≥34 cm for women was the cut off point for determining BMI subjects. ≥25.0 kg / m2. Meanwhile, neck circumference ≥39.5 cm for men and ≥36.5 cm for women was the cut off point for determining BMI subjects ≥30 kg / m2 [16].

As many as 84% of the subjects had excess body fat percent. In this study, it was also found that there was a significant relationship between the percent of body fat and neck circumference (r = 0.682) (p <0.01). These results were consistent with a study conducted on obese women at Zayed University, Saudi Arabia, which stated that there was a significant correlation between body fat percent and neck circumference (r = 0.478) (p <0.01) [34]. Research in India on young adults also showed a correlation. significant between neck circumference and percent body fat in male and female subjects (p <0.01) [37].

As many as 94% of subjects in this study had normal fasting blood glucose levels. There was 1 subject with fasting blood glucose levels categorized as diabetes mellitus, while 6 other people were categorized as prediabetes. Even though all subjects were categorized as central obesity, abnormalities in blood glucose levels may still occur in the early days where blood glucose homeostasis can still be maintained so that it has not affected fasting blood glucose levels even though there may have been changes in insulin secretion or sensitivity [38].

There was a significant correlation between body fat percent and fasting blood glucose levels in this study. This was in line with research conducted on students at Columbia University, which showed a significant positive correlation (p <0.05) between percent body fat and fasting blood glucose levels [39]. There was a significant correlation between percent body fat and fasting blood glucose levels in female subjects, but not in men[40]. Another study in Korea on adult subjects aged under 40 years showed a significant correlation between percent body fat and fasting blood glucose levels in women. Results were obtained in female subjects with a body fat percentage of ≥30% that for every 1% increase in fat percentage, blood glucose levels increased by 1,306 times [41]. A case control study conducted in Iraq showed that the risk of developing type 2 diabetes mellitus in subjects with a percentage of body fat excess showed a normal BMI of 2.7 times [42].

The relationship between excess fat accumulation in the body with the risk of metabolic diseases such as diabetes mellitus can start from a young age. Weight changes were more common in adolescence and early adulthood, during this period there was a transition between high school and university where there were changes in routine and habits. Habits that lead to weight gain and body fat have a long-term impact on health in adulthood [43]. Adipose tissue affects the body's metabolism by secreting various hormones, glycerol, and other substances as well as non esterified fatty acids (NEFAs). In obese people, secretion of NEFAs by adipose tissue was increased. Increasing levels of NEFAs in plasma will contribute to the loss of pancreatic β-cell function [14].

This study showed no relationship between neck circumference and fasting blood glucose levels in obese female students. These results were consistent with research in Egypt on obese child subjects, which showed that there was no significant relationship between neck circumference and fasting blood glucose levels [44]. This was in line with a study in Brazil on adult subjects which stated a positive correlation between neck circumference and fasting blood glucose levels [17]. Research in China states that neck circumference has a risk factor of 1.32 times in women and 1.26 times in men of increasing fasting blood glucose levels [26].

The neck was one of the upper subcutaneous fat adipose tissue sites. The subcutaneous fat tissue of the upper body was responsible for the release of more free fatty acids than visceral fat, especially in obese individuals. Excess release of free fatty acids will disrupt glucose homeostasis [45]. Fatty acids circulating in plasma will be distributed to the liver and oxidized to acetyl CoA. The increase in acetyl coA inactivates the pyruvate dehydrogenase enzyme, resulting in an increase in citric acid which inhibits the action of phospho-fructokinase and glucose-6 phosphate (G-6-P). This made hexokinase II activity inhibited, causing an increase in intracellular glucose levels and a decrease in muscle glucose uptake. Greater insulin levels were needed for glucose to enter the muscles, if this happens continuously will result in insulin resistance [46].

**CONCLUSION**

There is a positive correlation between percent body fat and fasting blood glucose levels, which means that the greater the percentage of body fat is associated with an increase in fasting blood glucose levels. There is no significant correlation between neck circumference and fasting blood glucose levels

Obese students need to pay attention to eating habits and physical activity in order to cause healthy weight loss to prevent or delay the progression of prediabetes and diabetes. As well as the need for further research with male and female subjects in order to


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differentiate the neck circumference image in the two groups, it is necessary to measure the presence of confounding factors that can affect fasting blood glucose levels.

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