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A New Approach for Early Detection of Insulin Resistance in Correlation with Anthropometry of Non-Diabetic Obesity

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Obesity, Anthropometry, Metabolic Syndrome, Insulin Resistance

ABSTRACT:
Background: The prevalence of obesity has almost tripled since 1975. Obesity has a risk of developing diabetes by 44%, obesity will trigger the emergence of insulin resistance so that the absorption of glucose in body cells will be disrupted and cause body glucose levels to be above normal. Overweight or obesity can be determined through anthropometric examinations including Body Mass Index (BMI), Waist Circumference, Waist to Hip Ratio (WHR), and Waist to Height Ratio (WHtR). Objective: To determine the relationship between anthropometric measurements and insulin resistance in the non-diabetic obese population. Methods: This study is an analytical observational study with a cross-sectional method, analyzing 30 non-diabetic obese subjects selected through purposive sampling. The variables studied included subject characteristics, BMI, waist circumference, WHR, WHtR, and insulin resistance. Results: The results showed a weak positive significant correlation between insulin resistance and people with BMI over 25 and WHR values over 0.9 for men and 0.85 for women ($p<0.05$; $r<0.5$). In addition, those with a waist circumference of more than 90 cm for men and 85 cm for women, with a WHtR of more than 0.5, showed a significant positive correlation with insulin resistance ($p<0.05$; $r>0.5$). Waist circumference had the most significant correlation with insulin resistance, according to logistic regression analysis ($p=0.009$). Conclusion: There is a strong association between BMI, waist circumference, WHR, and WHtR, with insulin resistance. Waist circumference is the best measure to identify insulin resistance. The public will benefit from the findings of this study in terms of early detection of insulin resistance through the use of independent anthropometric measurements.

Introduction

According to the World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC), obesity is an abnormal condition in which body fat accumulates excessively, increasing the risk of health problems that can lead to complex and progressive chronic diseases, and have an impact on health. risks increase over time, including diabetes, dyslipidemia, heart disease, and others, and cause pathological conditions, namely insulin resistance, where blood glucose levels increase, and the body is unable to absorb glucose into the muscles, accompanied by increased glucose production by the liver resulting in hyperglycemia.[10] Obesity can increase health problems. One of them is type 2 diabetes mellitus, this is because obesity will trigger the emergence of insulin resistance so that the absorption of glucose in body cells will be disrupted and cause body glucose levels to be above normal.

There is an increase in the prevalence of obesity in various developed and developing countries, causing an increase in the obese population and causing various chronic degenerative diseases.[4] According to the Central Bureau of Statistics, the prevalence of obesity in individuals aged >18 years with BMI ≥25 has increased from 19.6% in 2013, to 24.0% in 2016 and 26.6% in 2018 for men. In women, the prevalence was 32.9% in 2016 and 26.6% in 2018.

In 2013, it increased to 41.6% in 2016, and reached 44.4% in 2018.5 Data from the Ministry of Health recorded the risk of obesity developing into diabetes at 44%, ischemic heart disease at 23%, and cancer. 7-

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41%.6 The 18-24 age range is the most vulnerable group for obesity, but the 35-54 age range is also at high risk due to difficulties in maintaining weight.[6]
Obesity related to body fat mass can be known through anthropometric examinations that assess overweight in a person.[8] several anthropometric indicators can determine obesity or overweight, including Body Mass Index (BMI), Waist Circumference, Waist to Hip. Among all the anthropometric measurements mentioned above, BMI is the most accurate for predicting obesity.[9] This statement is reinforced by a study conducted by Jonathan Purnell starting in 2018, which states that individuals who are overweight due to a predominant accumulation of abdominal fat will be considered at high risk of developing this condition despite not meeting the BMI criteria for obesity.
11 One commonly used method to assess insulin resistance in individuals is the Homeostasis Model Assessment of Insulin Resistance (HOMA- IR), which utilizes fasting glucose and insulin levels in its measurement.[13]
8 Masrul's research shows that anthropometric parameters such as BMI have a significant relationship with insulin resistance.[4] Based on Djap's statement, waist-height ratio has a significant relationship with the occurrence of diabetes, and this parameter is the only one that has a stronger relationship with diabetes compared to BMI and waist circumference.[14] Another important finding, mentioned by Septyaningrum, assessed the effectiveness of three anthropometric parameters BMI, waist circumference, and waist-hip ratio about a person's blood sugar level. The study found that waist circumference was the most effective parameter in determining blood sugar levels >125 mg/dl compared to the other two parameters.[15]
Various studies have been conducted, but further research is still needed regarding anthropometric parameters as an early detection tool to identify insulin resistance in individuals. Therefore, previous researchers have laid a foundation of optimism that various anthropometric parameters have a significant relationship with insulin resistance. However, what is even more important is to continue the research by measuring several anthropometric parameters simultaneously and determine which parameters are most effective in identifying insulin resistance. Therefore, the researcher had the idea to re-examine the relationship between various anthropometric parameters and insulin resistance in a non-diabetic obese population.
The new thing in this research is to look for the relationship between the four anthropometric parameters and insulin resistance and find out what anthropometric parameters are most effective in determining insulin resistance.

METHOD

This study received ethical approval from the Health Research Ethics Commission (KEPK) of the Faculty of Medicine, Diponegoro University with reference number EC No. 395/EC/KEPK/FK-UNDIP/VIII/2023 valid until August 1, 2024. The identity of the research subjects and all data obtained in this study will be kept confidential and only used for research purposes.
The research method used was analytic observation with a cross-sectional design. This study used purposive sampling to collect data from non-diabetic obese subjects at Ngesti Waluyo cck Parakan Christian Hospital. The study was conducted during August 2023. This study was conducted using questionnaire methods, anthropometric measurements, and venous blood collection. This study involved a total of 30 subjects who were categorized as obese, but did not have diabetes, as indicated by fasting blood sugar examination below 125 mg/dl. The study inclusion criteria were subjects aged 25-60 years, normal body temperature, absence of diabetes symptoms, and willingness to participate in the study by giving informed consent. The exclusion criteria included subjects with a family history of diabetes, pregnant individuals, active smokers, people with dyslipidemia, individuals taking steroid drugs, and those who had a history of diabetes living a sedentary lifestyle for more than 5 hours per day.
Research was initiated by identifying subjects who exhibited obesity within Ngesti Waluyo Christian Hospital Parakan. Next, the researcher contacted each subject through social media to briefly explain the upcoming research. Once the subject agreed to participate, the researcher submitted a consent form for the subject to fill out and conducted an on-site questionnaire session. Subjects were required to fast for 8 hours prior to the scheduled blood draw date. Body weight and height were measured using a digital scale and height meter, respectively. Waist circumference was measured using a measuring tape with an accuracy of 0.1 cm. After obtaining the necessary data, anthropometric parameters (BMI, waist circumference, WHR, WHtR) were calculated as obesity screening. Blood samples were then collected using SST vacuum tubes and Greiner NaF

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anticoagulant tubes for fasting blood sugar (FBS) and insulin assessment. Subjects were asked to consume 75 grams of glucose solution for a 2-hour postprandial blood sugar test, which indicates the results of an oral glucose tolerance test (OGTT). Blood glucose was tested using Roche's Cobas C111 based on the hexokinase method, while insulin levels were tested using Abbott's Architect based on the chemiluminescent immune method.

The data obtained were statistically analyzed using SPSS. Initially the analysis Univariate analysis was conducted to determine the distribution, frequency, and percentage of each characteristic and variable in this study. Further testing includes bivariate analysis using the correlation test to test the research hypothesis. Data on subject characteristics had a nominal scale, so Chi Square and Fisher's Exact tests were used. Data from ratio-scale independent and dependent variables were tested using Pearson and Spearman correlation tests, which assessed the normality of data distribution. All associations with p values <0.25 were retested in multivariate analysis using logistic regression to identify the most dominant variables affecting insulin resistance.

RESULTS

This study involved 34 subjects, the inclusion criteria amounted to 30 subjects, while the remaining 4 subjects were excluded due to the diagnosis of diabetes mellitus. Each subject has specific characteristics that can affect insulin resistance, including gender, age, family history of diabetes, smoking, lack of exercise, eating habits with high sugar content, and dyslipidemia. The correlation between subject characteristics and insulin resistance is in table 1.

Table 1

Correlation between subject characteristics and insulin resistance

Characteristics	**Insulin Resistance**		
	≥ 2,5	**< 2,5**	**p**
Gender			
Male	7 (58,3%)	5 (41,7%)	0,104
Female	4 (22,2%)	14 (77,8%)	
Age			
≤30	2 (50%)	2 (50%)	
31-40	3 (23,1%)	10 (76,9%)	0,575
41-50	4 (44,4%)	5 (55,6%)	
>50	2 (50%)	2 (50%)	
Family history of diabetes			
Yes			
No	5 (62,5%)	3 (37,5%)	0,18
	6 (27,3%)	16 (72,7%)	
Smoking			
Yes	3 (50%)	3 (50%)	0,776
No	8 (33,3%)	16 (66,7%)	
Infrequent exercise			
Yes			
No	8 (36,4%)	14 (63,6%)	0,637
	3 (37,5%)	5 (62,5%)	
Dietary habits with high sugae content			
Yes			
No			
	8 (36,4%)	14 (63,6%)	0,637
	3 (37,5%)	5 (62,5%)	
Dyslipidemia			
Yes	1 (100%)	0 (0%)	0,778
No	10 (34,5%)	19 (65,5%)	

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The correlation between gender and insulin resistance resulted in a p-value of 0.104 which indicates that there is no significant relationship between gender and insulin resistance. The correlation between age and insulin resulted in a p-value of 0.575 indicating no significant correlation between age and insulin resistance.

The correlation between family history of diabetes and insulin resistance resulted in a p- value of 0.18, indicating no significant relationship between the two. The correlation between smoking and insulin resistance obtained a p-value of 0.776 which means there is no significant relationship between smoking and insulin resistance. The impact of infrequent exercise on the occurrence if insulin resistance obtained a p-value of 0.637 so it is concluded that there is no significant relationship between smoking and insulin resistance. There is a significant relationship between the two. The effect of high sugar diet on the occurrence of insulin resistance resulted in a p- value of 0.637, meaning there is no correlation between the two. The correlation between dyslipidemia and insulin resistance resulted in a p-value of 0.778 which means there is no significant correlation between dyslipidemia and insulin resistance. This study focused on a target population categorized as obese based on anthropometric parameters and not diagnosed with diabetes mellitus. Therefore, measurements using four anthropometric parameters and blood tests were conducted to determine the subjects' blood sugar levels.

Table 2 Correlation between anthropometric parameters and insulin resistance

Variable	**Insulin Resistance**	
	p	**r**
Body Mass Index **(BMI)**	0,014[a*]	0,442
Waist circumference	0,004[a*]	0,506
Waist-to-Hip Ratio (WHR)	0,019[b*]	0,426
Waist-to-Height Ratio (WHtR)	0,003[a*]	0,528

Table information:

[a] : Spearman Correlation

[b] : Pearson Correlation

[*] : Significant correlation (p<0,05)

Table 3 illustrates the correlation of anthropometric parameters, BMI, waist circumference, WHR, WHtR, and insulin resistance. Bivariate testing was performed using Pearson and Spearman correlation tests depending on the distribution of the data.

The correlation between BMI and insulin resistance tested by Spearman correlation yielded a p value of 0.014 and r = 0.442 indicating that both BMI and insulin resistance were correlated. These variables have a significant but weak positive correlation.

The correlation between waist circumference and insulin resistance assessed by the Spearman correlation test obtained a p- value of 0.004 and r = 0.506, indicating a significant and strong positive correlation between waist circumference and insulin resistance.

The relationship between WHR and insulin resistance tested with Pearson's correlation resulted in a p-value of 0.019 with r = 0.426 which indicates a significant but weak positive correlation between the two variables.

The relationship between WHtR and insulin resistance assessed using Spearman correlation yielded a p-value of 0.003 and r = 0.528 indicating a significant and strong positive correlation between the two variables.

The four independent variables were then tested for their effectiveness in predicting insulin resistance in multivariate logistic regression analysis. Data with p-value <0.25 included family history of diabetes, BMI, waist circumference, WHR, and WHtR.

Table 3. Results of Logistic Regression Test on Insulin Resistance

Variable	**Insulin Resistance**	
	B	**p**
BMI	0,19	0,676
Waist circumference	0,133	0,532
Waist-to-Hip Ratio (WHR)	7,387	0,715

Waist-to-Height Ratio (WHtR)	26,753	0,571
Family history of diabetes	-0,944	0,510
Constant	-43,001	0,041

Backward Likelihood Ratio Step 1 Method

Variable	**Insulin Resistance**	
	B	**p**
Waist circumference	0,295	0,009*
Constant	-30,178	0,008

Backward Likelihood Ratio Step 5 Method (last step)
Table information:
B: Regression coefficients
*: Significant correlation (p<0,05)

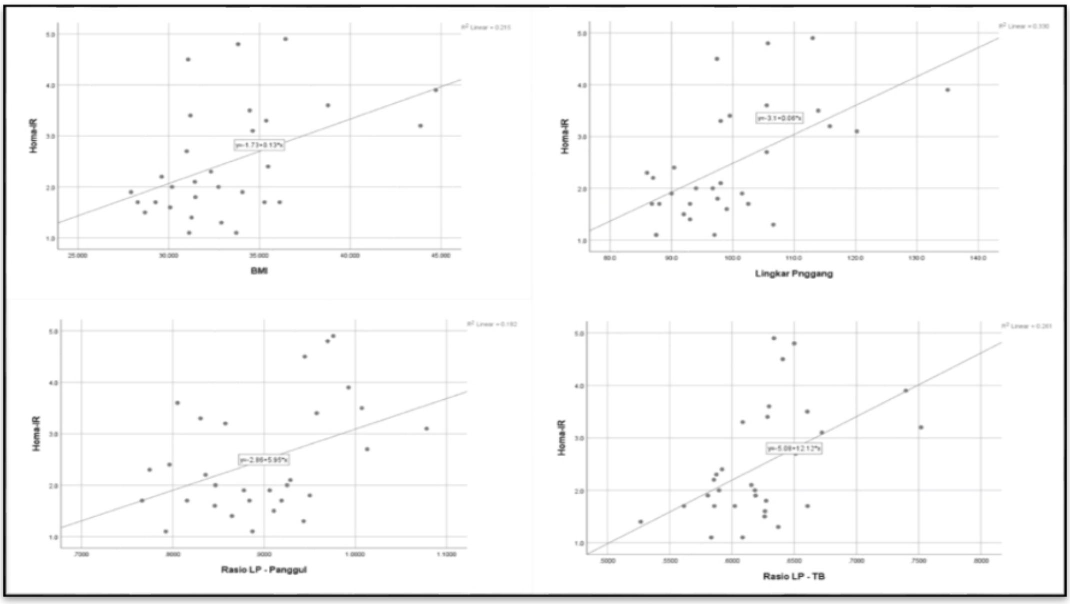

Figure 1. Correlation between BMI, waist circumference, WHR, and WHtR with Insulin Resistance

Table 4 presents the results of multivariate testing between the five variables and insulin resistance. After going through five stages of testing, the variable that survived and showed a significant correlation was waist circumference. This is evidenced by the p- value obtained in the final test of 0.009. The regression coefficient of 0.295 indicates that an increase in waist circumference by 1 unit will increase the value of insulin resistance by 0.295.

Figure 1 illustrates a positive linear correlation with an increasing trend of BMI, waist circumference, WHR, and WHtR towards insulin resistance. This shows that the greater the value of anthropometric parameters, the higher the likelihood of insulin resistance**.**

DISCUSSION

The results of this study indicate a significant relationship between Body Mass Index (BMI) and insulin resistance, obtained a p-value of 0.014 ($p < 0.05$) and an r-value of 0.442 which indicates a weak positive correlation strength. This indicates that as BMI increases, the likelihood of insulin resistance also increases. This finding is in line with the existing hypothesis and is supported by previous research conducted by Okura (2018), which states that there is a significant relationship between BMI and the occurrence of insulin resistance and diabetes. Research on the Japanese population states that BMI above 23 is a risk factor for insulin resistance.[16] BMI can have a significant impact because individuals with BMI scores High levels indicate the accumulation of large amounts of visceral fat, which is closely related to insulin resistance.[17]

A significant correlation was also found between waist circumference and insulin resistance. The bivariate test results obtained a p-value of 0.004 and an r-value of 0.506, indicating a significant relationship between the

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two with a strong positive correlation strength. The graph generated from this test also shows an increase, meaning that the higher the waist circumference, the higher the likelihood of insulin resistance. Based on a review by Ross (2020), it is stated that waist circumference is an important anthropometric parameter or measure to identify health problems experienced by a person, including diabetes mellitus.18 Waist circumference reflects the condition of visceral fat accumulation. High visceral fat has been shown to be more strongly associated with insulin resistance than fat in other parts of the body.[18]

This study also showed a significant correlation with other anthropometric parameters, namely Weight-to-Hip Ratio (WHR), where the bivariate test results between WHR and insulin resistance obtained a p-value of 0.019 and an r-value of 0.426. These results indicate a significant correlation between the two variables with a weak positive correlation strength. The graph also shows an increase, which indicates that the higher the WHR, the higher the insulin resistance the possibility of insulin resistance. Karimah's research (2018) which examined several anthropometric parameters to determine the strength of their relationship with increased blood sugar levels stated that the Waist-Hip Ratio is a parameter that has the strongest relationship with insulin resistance, especially in obese populations.[19] This result may occur because high body fat levels can affect corticosteroid and adrenaline hormone levels. Both hormones can affect the increase in blood glucose, causing insulin resistance.[19]

The results of testing the Waist to Height Ratio (WHtR) on insulin resistance also provide significant findings, with a p- value of 0.003 and an r-value of 0.528 which indicates a significant relationship with a strong positive correlation strength. The greater the WHtR value, the greater the likelihood of insulin resistance. These results are supported by previous research by Djap (2018) who said that WHtR is an anthropometric parameter that can predict prediabetes and type 2 diabetes in Indonesia. This study also showed that WHtR can provide better information in predicting insulin resistance than BMI or waist circumference alone.[14] Another study mentioned that WHtR has a strong correlation with metabolic risk factors, including insulin resistance, type 2 diabetes, pressure, and insulin resistance. high blood pressure, and type 2 diabetes. cholesterol levels, and cardiovascular disease.[20]

This study revealed a significant correlation between four anthropometric parameters and insulin resistance in non- diabetic obesity. However, this study also aimed to identify the anthropometric parameters that are most influential in predicting the occurrence of insulin resistance. After multivariate testing with logistic regression, it was found that waist circumference was the most effective parameter in predicting insulin resistance. These results are in line with the hypothesis described in the previous chapter, reviewing several previous studies, such as research conducted by Ross which states that waist circumference is an important measure for identifying metabolic diseases, such as type 2 diabetes. Blood sugar determination in the endocrine system is integrated with adiposity tissue, adipocytes also produce pro- inflammatory cytokines such as IL-6 and TNF- α, which increase inflammation and free fatty acid (FFA) levels, disrupt insulin signaling, and reduce adiponectin production.[12] As a result, cells become less responsive to insulin, increasing insulin resistance, type 2 diabetes, and metabolic syndrome. Central obesity can activate mitochondria and trigger a negative feedback loop that weakens mitochondrial function, thus affecting insulin-mediated glucose uptake.[11]

Genetic factors, fetal malnutrition, and increased visceral adiposity also contribute to insulin resistance. Increased NEFA levels worsen insulin resistance and body glucose control.[12] Insulin resistance in obese individuals develops due to the reduced ability of the body to take up glucose, which is caused by excess fat accumulation and lipolysis in adipocytes.[17] In addition, according to Septyaningrum (2014) who measured the effectiveness of three anthropometric parameters namely BMI, waist circumference, and WHR with a person's blood sugar level. The study concluded that waist circumference has the strongest relationship compared to the other two anthropometric parameters in determining blood sugar levels >125 mg/dl.[15]

There are limitations to this study due to several other factors that may affect the results of the study, such as genetic factors, the influence of the hormone adiponectin, and cytokines that were not analyzed in this study. In addition, the duration of obesity experienced by each subject is also different, so there is a possibility of influencing the appearance of insulin resistance.

CONCLUSIONS

There is a significant correlation between BMI, waist circumference, waist-to- hip ratio, height and insulin resistance in non- diabetic obesity. Waist circumference is the most effective anthropometric parameter in determining insulin resistance in non-diabetic obesity.

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