THE RELATIONSHIP BETWEEN BODY MASS INDEX AND BLOOD GLUCOSE LEVELS IN ADOLESCENTS IN THE PILOLODAA HEALTH CENTER AREA, WEST KOTA DISTRICT, GORONTALO CITY

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ABSTRACT

The body mass index is a simple weight and height index used to classify overweight and obesity. Adolescents' Body Mass Index that is above normal can increase the risk of rising total cholesterol, triglycerides, and blood sugar levels. This study aims to see the relationship between body mass index and blood sugar levels during adolescence in Pilolodaa Village, West Kota District, Gorontalo City. The method in this study uses a quantitative approach with the type of analytical observation research. The sample collection techniques used are *Purposive Sampling.* Data analysis using univariate and bivariate analysis using the SPSS application with a test *Pearson Product Moment Correlation Coefficient.* The results showed that the significance value (*2-tailed*) of 0.01 <α (0.05), which means that there is a significant relationship between body mass index (BMI) and blood glucose levels (GDS).

Keywords: *GDS, Body Mass Index, Adolescents*

INTRODUCTION

On February 1, 2023, the Indonesian Pediatricians Association (IDAI) reported that the number of cases of Diabetes Mellitus in children increased 70 times from 2010 to January 2023. Of the 1,645 pediatric patients affected by Diabetes Mellitus, 46.23% were aged 10–15 years, 31.05% were aged 5–9 years, 19% were aged 0–4 years, and 3% were over 15 years old (Setiawati and Yuliastuti, 2023).

Adolescence, around the age of 10-18, is a very vulnerable period in terms of nutrition because many factors influence. During this time, adolescents need good nutrition to support physical growth, but they are also often close to an unhealthy lifestyle. One of the impacts is being overweight. Excessive body weight compared to age or height can be a sign that someone feels overnourished, and this is more common in adolescent girls than adolescent boys. Obesity, which is the excessive accumulation of fat in the body, can lead to various health problems, including Diabetes Mellitus [42]

Obesity is one of the factors that can cause Diabetes Mellitus (DM). When fat in the body accumulates too much, the beta cells in charge of responding to blood sugar levels become less effective. In addition, the number of insulin receptors in the body's cells is reduced, so insulin cannot work properly. As a result, the body cannot use insulin to lower blood sugar levels. In overweight people, leptin levels (a substance that helps regulate body energy) will increase. However, this increase in leptin actually hinders the action of insulin in lowering blood sugar, so that blood sugar continues to rise [22]

Diabetes Mellitus is a long-term metabolic condition in which there is too much sugar in the blood (hyperglycemia) due to problems with insulin levels. If left untreated, Diabetes Mellitus can lead to

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serious complications and even death. This condition is caused by a lack of insulin production, insulin resistance (the body does not respond to insulin properly), or a combination of both, so that blood sugar remains high.

According to WHO data in 2022, around 422 million people worldwide suffer from Diabetes Mellitus. Diabetes is also predicted to be one of the top 10 causes of death in the world. Indonesia itself ranks seventh in the world with the most diabetes cases, after China, India, the United States, Pakistan, Brazil, and Mexico. The Ministry of Health of the Republic of Indonesia reported that in 2020 there were 10.7 million diabetics aged 20 to 79 years in Indonesia, with 1.5 million deaths due to this disease.

According to the opinion of the Ministry of Health (2020), the prevalence of Diabetes Mellitus in Indonesia is DKI Jakarta 3.4%, Yogyakarta and East Kalimantan 3.1%, North Sulawesi 3%, East Java 2.6%, Bangka Belitung Islands 2.5%, Aceh and Gorontalo 2.4%, Central Sulawesi and Banten 2.2%, Central Java 2.1%, North Sumatra 2%, Riau and West Papua 1.9%, South Sulawesi and South Kalimantan 1.8%, Bali, West Java 1.7%, West Sumatra, Central Kalimantan, West Nusa Tenggara, West Kalimantan 1.6%, North Maluku Province 1.5%, Southeast Sulawesi, Bengkulu, South Sumatra and West Sulawesi 1.3%.

[22] showed that there is a relationship between body weight index (BMI) and fasting blood sugar levels. Insulin resistance causes the supply of glucose to the body's cells to decrease, so the cells β the pancreas have to produce and excrete more insulin. These high insulin levels can regulate blood sugar well for several months. However, if it is excessive, the productivity of pancreatic cells will decrease due to overwork, and eventually insulin production will decrease or even stop. This leads to a high buildup of glucose in the blood.

[23] research on obese adolescents also found a relationship between blood sugar levels and body weight index (BMI) using the chi-square test with a significance level of p=0.009. This indicates that there is a variation in blood sugar levels. The results showed OR = 6,600, which means that obese adolescents are 6.6 times more likely to have high blood sugar levels. The higher the level of obesity, the more likely it is that blood sugar will increase; Conversely, the lower the level of obesity, the lower the blood sugar level.

The research of [40] focuses on adolescents in secondary school. From this research, most of the respondents had a healthy body weight index (BMI), which was 29 people (53.7%), while the least number of respondents had an obese BMI, namely 25 people (46.3%). This is due to a more efficient metabolic process in adolescents, in contrast to adults who are at higher risk of developing metabolic syndrome as they age, leading to a decrease in muscle mass and body fat gain.

Factors that can increase blood sugar levels include food and drink consumption, disease, hormonal imbalances, genetic factors, body weight, gender, stress, certain medications, physical activity, alcohol consumption, staying up late, and irregular eating schedules [41] The increase in cases of Diabetes Mellitus is strongly related to obesity. Obese people often feel an increase in blood sugar levels due to an uncontrolled diet. High blood sugar can cause the body to not be able to store glucose properly, resulting in a buildup of glucose in the blood because insulin fails to regulate excess glucose [1]

Cases of Diabetes Mellitus in Gorontalo Province were identified through screening of risk factors for Non-Communicable Diseases (NCDs) carried out by all Health Centers in Gorontalo in the activities of the

Integrated Development Post for Non-Communicable Diseases (Posbindu PTM). From the screening of PTM in Gorontalo Province, there are 374,899 participants involved. Diabetes Mellitus cases ranked second most in NCD screening participants with a total of 15,573 people or around 0.42 percent of all participants [8]

The Gorontalo Provincial Health Office (2022) reported that the level of Diabetes Mellitus in Gorontalo Province varies in each district/city, with prevalence ranging from 6% in Boalemo to 148% in Bone Bolango. Gorontalo City has a prevalence of 103%, North Gorontalo 55%, Pohuwato 8%, and Gorontalo Regency 19%. [7]

In 2020, the Pilolodaa Health Center in West Kota District, Gorontalo City, had 87 patients with Diabetes Mellitus. This number increased to 151 patients in 2021, 30 patients in 2022, and again rose to 167 patients in 2023 [8]

Body weight index (BMI) is a basic measurement of body weight and height used to categorize overweight and obesity in adults. BMI is used as a tool to evaluate body fat levels and identify weight-related health problems. According to the*National Institutes of Health*, an increase in BMI can increase the risk of heart disease, hypertension, type 2 diabetes, gallstones, respiratory infections, and cancer [33] An increase in BMI in adolescents can also increase the risk of high levels of total cholesterol, triglycerides, and blood sugar. Adolescence is a period where it is easy to be tempted to consume fatty and sweet foods, especially fast food, which can lead to an increase in blood sugar levels [20]

Researchers conducted a survey and found that many adolescents in Pilolodaa Village, West Kota District, felt obese, so they chose this location for research in Gorontalo City. Therefore, the researcher decided to use the title of this research: "The Relationship between Body Mass Index and Blood Sugar Levels During Adolescents in the Pilolodaa Village area, West Kota District, Gorontalo City".

RESEARCH METHODS

The method used in this research is a quantitative method. Based on the view of [38] quantitative data is a research approach rooted in positivism, where data is presented in the form of numbers and analyzed using statistical tests. This method aims to measure certain variables and find relationships between variables through numerical analysis.

This type of observational analysis study involves examining the relationship or influence between two variables. The research was carried out by analyzing data from observations made in the laboratory and observing the analytical process that occurred [43]

The research will be carried out from July 15 to 25, 2024. The research was carried out at the Pilolodaa Health Center, West Kota District, Gorontalo City. The data results used are quantitative data. Quantitative data consists of numerical information, which is specifically related to blood sugar levels.

According to [14] population is the totality of each element to be studied that has the same characteristics, can be people from a group, event, or something being studied. The population in this research is all 38 adolescents in Pilolodaa Village. [38]) stated that the sample represents the number and characteristics of the population. Samples taken from the population need to accurately reflect or be a fair representation of the population being studied. In this research, the sample consisted of 27 teenagers who were selected based on a predetermined formula.

Scales were used to measure participants' body weight, meters were used to assess body height and calculate body weight index, and glucose test kits

were used to evaluate their blood sugar levels.

RESEARCH RESULTS

The research conducted at the Pilolodaa Health Center (PKM) aims to determine the relationship between body weight index and blood sugar levels in adolescents in the Pilolodaa Health Center area, West Kota District, Gorontalo City. The researcher selected 27 people from the Pilolodaa Village area using purposive sampling to determine the sample size.

1. Analis Univariat

The descriptive analyst used in this research is a univariate analyst to describe each variable in the research. The researchers provided variables that were the results of measuring the body weight index (BMI) and blood glucose levels (GDS) of the participants.

a. Description of Respondents' Body Mass Index (BMI) Results

1) Results of Respondents' Body Weight Index (BMI) Measurement

Table 4.1. Characteristics of Adolescents in the Pilolodaa Health Center Area. West City of Gorontalo City based on the results of BMI measurement.

BMI Measurement Results	Frequency	Percentage (%)
Thin	8	29.6
Usual	11	40.7
Excess Body Weight	1	3.7
Obesity	6	22.2
Obesity II	1	3.7
Sum	**27**	**100**

(Source: Primary Research Data, 2024).

Table 4.1 shows that based on the results of BMI measurement in adolescents in the Pilolodaa Health Center area, West Kota District, Gorontalo City, in this study, most of them are in the normal category, namely 11 people (40.7%). Then the thin category was 8 people (29.6%), the overweight category was 6 people (22.2%), while the overweight and overweight II categories were only 1 person (3.7%).

b. Description of Respondent's Blood Glucose Test Results (GDS)

Table 4.2. Glucose Level Test Results Blood During (GDS) On Adolescents in the Pilolodaa Health Center area. West City of Gorontalo City.

Up to GDS	Frequency	Percentage (%)
Low	2	7.4
Normal	13	48.1
Tall	12	44.4
Sum	**27**	**100**

(Source: Primary Research Data, 2024).

Based on table 4.2 above, it can be explained that from 27 respondents who were examined for blood glucose levels (GDS) at any time, the majority of GDS levels were within normal limits , namely 13 samples (48.1%), 12 samples (44.4%) had high GDS levels, and 2 samples (7.4%) had low GDS levels.

2. Analis Bivariat

Bivariate analyst is a method to evaluate the relationship between two variables, especially respondents' BMI and GDS blood glucose levels. This research uses parametric statistical analysis with a Person product moment correlation test, followed by a normality test to ensure normal data distribution with a confidence interval of 95% (α=0.05).

a. Normality Test

The purpose of the normality test is to determine whether the samples collected come from the same population or are normally distributed. In this study, the normality of body weight index (BMI) and momentary blood glucose levels (GDS) data was tested using the Shapiro-Wilk method.

1) Research Variable Normality Test

Table 4.3. Results of the Body Mass Index (BMI) and Current Blood Glucose Levels (GDS) Test Results.

	Shapiro-Wilk		
	Statistic	*Df*	*Mr*
IMT	0.950	27	0.216
Level GDS	0.931	27	0.074

(Source: Primary Data of Processed Research, 2024).

Based on table 4.3, the results of the normality test using Shapiro-Wilk show that the asymp for BMI is 0.216 and for the GDS level is 0.074. Because these two values exceeded the level of α 0.05 (0.216 > 0.05 for BMI and 0.074 > 0.05 for GDS), it can be concluded that the BMI and GDS measurements in this study followed the normal distribution. Thus, the normality requirement of the regression model is achieved

b. Research Hypothesis Test

After confirming that the data is distributed normally, the next step for analysts is to test the correlation coefficient of Person Product Moment. The results of the correlation test are presented:.

Table 4.4. Results of the Correlation Coefficient Test *Person Product Moment* The relationship between BMI and GDS rates.

		IMT	Level GDS
IMT	Person Correlation	1	.649
	Sig. (2-tailed)		.000
	N	27	27
Level GDS	Person Correlation	.649	1
	Sig. (2-tailed)	<.001	
	N	27	27

Table 4.4 shows the results of 27 respondents who were measured by BMI and their GDS levels and then searched for relationships using the Persona correlation test *in the SPSS 27.0 application*. Based on the table, the results of the statistical test of the r calculation *value (person correlation)* of 0.649 with a Sig significance value were obtained. *(2-tailed)* by 0.01.

Based on these findings, it can be concluded that there is a significant relationship between body mass index and blood sugar levels in adolescents in Pilolodaa District, located in Kota Barat District, Gorontalo City.

A. Discussion of Research Results

1. BMI and GDS Levels in Adolescents in the Pilolodaa Health Center Area, West Kota District, Gorontalo City.

Based on the research that has been carried out and in accordance with the research results shown in table 4.1, about the prevalence of BMI category, the results were mostly in the normal category, namely 11 people (40.7%). Then the thin category is 8 people (29.6%), the overweight category is 6 people (22.2%), while the overweight and obesity II categories are only 1 person each (3.7%).

The results of the research in table 4.2 about the prevalence of blood glucose levels (GDS) in respondents, the majority of GDS levels were within the normal limit , namely 13 samples (48.1%), high GDS levels of 12 samples (44.4%), and low GDS levels of 2 samples (7.4%).

Based on the questionnaire distributed to the respondents, it was found that from 27 respondents, the majority did not do physical activity in the form of exercise <3 times a week, as many as 17 people (63%) and 10 people (37%) who did exercise 3 times a week. The respondents who often consumed sweet foods from 27 respondents were 17 people (63%) and 10

people (37%) who did not consume sweet foods.

Lack of physical activity is another risk factor that can cause an increase in blood sugar levels. Physical activity includes every movement performed by the skeletal muscles and their supporting systems that require an expenditure of energy. This includes all forms of physical activity, such as sports and exercise, both as a hobby and in daily life [34] The research of [5] cited in [12] shows that minimal physical activity is associated with a greater likelihood of feeling a weight gain of more than 5 kg and developing diabetes.

2. The Relationship Between Body Mass Index (BMI) and Current Blood Glucose Levels (GDS) in Adolescents in the Pilolodaa Health Center Area, West Kota District, Gorontalo City.

The results of the research shown in table 4.1, about the prevalence of the BMI category, obtained results mostly in the normal category, namely 11 people (40.7%). Then the thin category is 8 people (29.6%), the overweight category is 6 people (22.2%), while the overweight and obesity II categories are only 1 person each (3.7%).

The results of the research in table 4.2 about the prevalence of blood glucose levels (GDS) in respondents, the majority of GDS levels were within normal limits , namely 13 samples (48.1%), high GDS levels of 12 samples (44.4%), and low GDS levels of 2 samples (7.4%).

Table 4.4 displays the results of Person correlation analysis conducted using SPSS 27.0, showing a correlation coefficient between BMI and GDS levels of 0.649, with a significant 2-sided significance value of 0.01. These findings show clear significance: because of $0.01 < \alpha$ (0.05), the null hypothesis (H0) is rejected while the alternative hypothesis (Ha) is accepted. This indicates that there is a significant relationship between body weight index and blood sugar levels in adolescents in the Pilolodaa Health Center area, Gorontalo City.

The results of the data processing in this study are in line with the findings in the research shown in table 4.1 above the majority of adolescents' BMI in the normal category (40.7%), and the results shown in table 4.4 which also show the majority of GDS levels in adolescents within the normal limit (48.1%), in other words, the number of normal BMIs directly shows many normal GDS levels.

The findings are in line with the theory of [42] which states that obesity arises due to the accumulation of excess fat in the body's adipose tissue. [39] further explained that excess body fat can reduce the response of beta cells to blood glucose. In addition, target cells can develop resistance to insulin receptors and sense a decrease in their number, thus inhibiting the utilization of insulin in the bloodstream. In people who feel obese, leptin levels increase, which is an adipoline involved in regulating energy balance. Increased leptin levels can inhibit the phosphorylation of insulin receptor substrate 1, resulting in higher blood sugar levels and impaired glucose uptake.

Based on this theory, researchers found that adolescents' BMI and blood sugar levels are influenced by physiological and metabolic factors. This is consistent with [24] who stated that various physiological and metabolic processes can affect blood glucose levels and their relationship with BMI:

a. Insulin Resistance: one of the main mechanisms that link high BMI to blood sugar levels is insulin resistance. Adolescents with high BMI tend to have a higher amount of body fat, especially in the abdominal area. This visceral fat is known to play a role in increasing insulin resistance, where the body's cells become less sensitive to insulin. As a result, the

pancreas must produce more insulin to keep blood sugar levels normal, which can ultimately lead to increased blood sugar levels and the risk of developing type 2 diabetes.

b. Chronic Inflammation: Being overweight and being overweight are often associated with chronic, low-level inflammation. This inflammatory condition can affect the function of the pancreatic beta cells responsible for insulin production, as well as increase insulin resistance. These two factors contribute to impaired glucose metabolism, which ultimately increases blood sugar levels in adolescents with high BMI.

c. Adipositokina dysfunction: The body's fat tissue produces various adipositokines, which are hormones that affect glucose and lipid metabolism. In adolescents with obesity, the production of adipositocines such as leptin and adiponectin is impaired, which can lead to changes in blood sugar regulation, including an increase in blood glucose levels due to decreased insulin sensitivity.

The findings of this research are consistent with the findings of [23] who examined obese adolescents found a significant relationship between blood sugar levels and body weight index on the chi-square test (p = 0.009). This indicates blood sugar levels vary in BMI opinion. The analyst also revealed an odds ratio (OR) of 6,600, which shows teens who are overweight are 6.6 times more likely to experience increased blood sugar levels. This means that the higher the level of obesity is directly correlated with the increase in blood sugar levels, while the lower level of obesity is directly related to the decrease in blood sugar levels.

Similarly, this research establishes a normal BMI, indicating that glucose levels are also within the normal range. This is because metabolic function in adolescents is relatively efficient compared to adults. As we age, the risk of developing metabolic syndrome increases, leading to muscle loss and higher levels of body fat. In the research of [40] involving high school teenagers, 29 respondents (53.7%) had a normal BMI, with the majority (80.3%) maintaining normal glucose levels. On the other hand, 25 respondents (46,3%) had an obese BMI, and 19,7% showed abnormal glucose levels.

Conclusion

Here are the conclusions from the research:

1. The majority of adolescents' body weight index (BMI) at the Pilolodaa Health Center, West Kota District, Gorontalo City, is in the normal category (40.7%), with 29.6% being thin, 22.2% being obese, and 3.7% each for overweight and obesity II.
2. Adolescent blood glucose levels (GDS) in the same region showed 48.1% within the normal limit, 44.4% high, and 7.4% low.
3. There was a significant relationship between BMI and GDS, with a sig. (2-tailed) 0.01 < α (0.05), so the null hypothesis was rejected and the alternative hypothesis was accepted.

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