



## RELATIONSHIP BETWEEN FASTING BLOOD GLUCOSE LEVELS AND LIPID PROFILES IN TYPE 2 DIABETES MELLITUS PATIENTS WITH HYPERTENSION

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### ABSTRACT

**Background:** Diabetes Mellitus (DM) is a global health emergency that experiences an increasing trend every year. Diabetes mellitus can cause complications if not treated properly. One of the complications that arises is hypertension. Type 2 DM patients with hypertension may have a higher risk of complications than type 2 DM patients without hypertension. **Aim:** To prove the relationship between Fasting Blood Glucose (FBG) levels and lipid profile levels in type 2 DM patients with hypertension. **Methods:** This research is an analytical observational study using a cross-sectional approach. This study used secondary data from type 2 DM patients with hypertension medical records at Diponegoro National Hospital, with as many as 38 respondents from 2021 to 2023. **Results:** Spearman Rank's analysis showed that in type 2 DM patients with hypertension, the correlation between GDP levels and total cholesterol levels was  $p = 0.073$  and  $r = 0.295$ , HDL cholesterol  $p = 0.232$  and  $r = 0.199$ , LDL cholesterol  $p = 0.048$  and  $r = 0.323$ , and triglyceride  $p = 0.371$  and  $r = 0.149$ . **Conclusion:** There was a significant positive correlation between GDP levels and LDL cholesterol levels in type 2 DM patients with hypertension.

**Keywords:** Diabetes Mellitus, Fasting Blood Glucose, Lipid Profile

### BACKGROUND

Diabetes Mellitus (DM) is a global health emergency that experiences an increasing trend every year. DM is characterized by metabolic disorders that cause increased blood glucose levels due to the body being unable to produce the insulin hormone or use the insulin hormone effectively. The International Diabetes Federation (IDF) projects there will be 783 million in 2045.<sup>1</sup> Indonesia is ranked in the top 6 countries with the highest number of DM cases in the world, reaching 10.3 million sufferers in 2019.<sup>2</sup> According to the Central Java Provincial Health Service, the number of DM patients is estimated to reach 652,822 individuals in Central Java. There are 50-75% of cases of hypertension that appear as a concomitant of type 2 DM in the world.<sup>3</sup>

Type 2 DM patients with hypertension can cause accelerated microvascular and macrovascular complications. Cardiovascular mortality in type 2 DM patients with hypertension is 2 - 3 times higher than normotension. Stroke, death, and myocardial infarction can also occur with a 2 - 4 times greater risk in type 2 DM patients with hypertension compared to normotension.<sup>4</sup> The World Health Organization (WHO) recommends checking blood glucose levels to diagnose DM. Fasting blood glucose (GDP) is a condition with no calorie intake for at least

8 hours.<sup>5</sup> Research conducted by Parameswari, *et al.*, 2023 explains that there is a relationship between GDP levels and hypertension in type 2 DM patients.<sup>6</sup>

Screening for complications can also be carried out in type 2 DM patients with hypertension by examining lipid profiles, namely total cholesterol, Low-Density Lipoprotein (LDL) cholesterol, High-Density Lipoprotein (HDL) cholesterol, and triglycerides.<sup>7</sup> The incidence of insulin resistance/deficiency in type 2 DM patients will increase in other risk factors, such as lipid metabolism disorders. Dyslipidemia occurs due to disorders of lipoprotein metabolism, causing oxidative stress, which is generally characterized by an increase in total cholesterol levels, a decrease in HDL cholesterol levels, an increase in LDL cholesterol levels, and an increase in triglyceride levels.<sup>8,9</sup> Research conducted by Haba, *et al.*, 2019 revealed that DM Type 2 patient showing a significant increase of total cholesterol and HDL cholesterol levels.<sup>10</sup> In contrast to this research, Sumertayasa, *et al.*, 2020 revealed that in type 2 DM patients, total cholesterol levels and triglycerides have increased compared to HDL cholesterol and LDL cholesterol levels.<sup>11</sup>

Lipid profiles are related to type 2 DM patients with hypertension, and the incidence of hypertension



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in these patients can influence the lipid profile results. Currently, research on the correlation between GDP levels and lipid profiles generally focuses on one population only: the population with type 2 DM, not the population with type 2 DM with hypertension. Therefore, further research needs to be carried out to determine whether there is a relationship between GDP levels and lipid profiles in type 2 DM patients with hypertension.

## **METHODS**

This research uses an analytical observational method with a cross-sectional approach. This study used a purposive sampling technique based on medical record data of type 2 DM patients with hypertension in 2021 - 2023 at the Diponegoro National Hospital Medical Records Installation who met the inclusion and exclusion criteria. The inclusion criteria in this study were patients aged 35 – 65 years, women because the prevalence of type 2 DM with hypertension was higher in this gender group, there were medical records of laboratory examination results with GDP levels  $\geq 126$  mg/dL, Systolic Blood Pressure (BP)  $\geq 140$  mmHg and/or Diastolic Blood Pressure (BBP)  $\geq 90$  mmHg with a minimum of 2 examinations, as well as medical records of laboratory examination results for lipid profiles. Meanwhile, the exclusion criteria for this study were patients diagnosed with Type 1 DM and smokers.

This research used a correlative test and the minimum sample required was 38 type 2 DM patients with hypertension. The independent variable is GDP levels and the dependent variable is lipid profile levels (total cholesterol levels, HDL cholesterol levels, LDL cholesterol levels, and triglyceride levels).

The statistical analysis of this research is univariate, including age and degree of hypertension, and bivariate including the correlation between GDP levels and lipid profile levels.

This research has obtained ethical permission from the Health Research Ethics Committee, Faculty of Medicine, Diponegoro University with certificate number No. 305/EC/KEPK/FK-UNDIP/VI/2023.

## **RESULTS**

### **Research Overview**

Data required for the research was collected in September 2023. The sample obtained was 38 medical records of respondents suffering from type 2 DM with hypertension in 2021-2023. Apart from the variables to be tested, researchers also collected data on the characteristics of respondents in this study, such as age and degree of hypertension.

### **Characteristics of Respondent**

The results of the univariate analysis showed that most of the respondents in this study were  $\geq 45$  years old (92.1%). Based on the degree of hypertension, it was found that the majority of respondents in this study had isolated systolic hypertension (55.3%). Based on lipid profile data, the majority of respondents in this study had normal total cholesterol levels (50%), normal HDL cholesterol (44.7%), near-optimal LDL cholesterol (31.6%), and normal triglycerides (55.3%).

The average age of respondents was 56 years old. The average BSP in this population was 157.32 mmHg with the lowest BDP being 121 mmHg and the highest being 220 mmHg. The average diastolic blood pressure of the respondent was 86.76 mmHg with the lowest value being 55 mmHg and the highest being 154 mmHg. Based on GDP, the average GDP level was 216.79 mg/dL, with the highest level being 542 mg/dL. The average total cholesterol level was 220.71 mg/dL with the lowest value being 120 mg/dL and the highest being 544 mg/dL. The mean HDL level was 46.89 mg/dL with the lowest value being 22 mg/dL and the highest being 88 mg/dL. The average LDL level was 126 mg/dL with the lowest value being 59 mg/dL and the highest 233 mg/dL. Lastly, triglyceride levels averaged 250.29 mg/dL with the lowest value of 72 mg/dL and the highest of 1,268 mg/dL.

Based on the results of the Spearman-Rank correlation test, GDP levels only significantly correlated with LDL cholesterol levels, which showed a weak correlation strength. Meanwhile, GDP levels did not have a significant correlation with total cholesterol, HDL cholesterol, and triglyceride levels (Table 2)



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**Table 1.** Characteristic of Respondent

Characteristic	n	(%)
<b>Age (Years)</b>		
<45	3	7,9
≥45	35	92,1
<b>Degree of Hypertension (mmHg)</b>		
Degree 1	8	21,1
Degree 2	7	18,4
Degree 3	2	5,3
Isolation Systolic	21	55,3
<b>Total Cholesterol (mg/dL)</b>		
Normal <200	19	50
Borderline 200-239	9	23,7
High ≥240	10	26,3
<b>HDL Cholesterol (mg/dL)</b>		
Low <40	14	36,8
Normal 40-60	17	44,7
High ≥60	7	18,4
<b>LDL Cholesterol (mg/dL)</b>		
Very Good (<100)	11	28,9
Good (100-129)	12	31,6
Borderline (130-159)	7	18,4
High (160-189)	4	10,5
Very High (≥190)	4	10,5
<b>Triglyceride (mg/dL)</b>		
Normal (<150)	21	55,3
Borderline (150-199)	6	15,8
High (200-499)	8	21,1
Very High (≥500)	3	7,9

**Table 2.** Spearman Correlation Test

Lipid Profile	Kadar GDP	
	p	r
Total Cholesterol (mg/dL)	0,073	0,295
HDL Cholesterol (mg/dL)	0,232	0,199
LDL Cholesterol (mg/dL)	0,048*	0,323
Triglyceride (mg/dL)	0,371	0,149

\*p-value significant

## DISCUSSION

### Characteristics of Research Subjects

Respondents in this study were female patients with type 2 DM hypertension. Women have a higher risk of developing type 2 DM with hypertension is

caused by differences in physical activity and daily lifestyle patterns between women and men. In addition, women generally have higher cholesterol levels than men. Fat in women is 20 – 25% of body weight, while in men it is 15 – 20%.<sup>15</sup>

The age distribution of respondents in this study was only 3 respondents under 45 years old. Meanwhile, the majority of respondents were ≥45 years old. Age is one of the risk factors for Type 2 DM. The risk of developing type 2 diabetes increases with age.<sup>7</sup> This study's results align with a previous study by Susilawati, 2021. This study had 132 research subjects as type 2 DM patients and 127 (62.3%) aged >45 years. Patients aged ≥ 45 years have an increased risk of type 2 DM with higher hypertension due to degenerative factors, namely decreased body function for glucose metabolism.<sup>12</sup>

Based on the classification of hypertension, the majority of research subjects suffered from isolated systolic hypertension, namely 21 patients (55.3%). Isolated systolic hypertension is a condition that is generally suffered by patients aged >50 years due to stiffness in the arterial walls which causes an increase in SBP (Systolic Blood Pressure) which is triggered by high atrium levels in the body, increased renin enzyme activity, and the hormone aldosterone in the body. This hypertension is characterized by SBP ≥140 mmHg and DBP (Diastolic Blood Pressure) <90 mmHg. Research conducted by Afriansyah, 2023 found that isolated systolic hypertension can also be caused by smoking habits, namely smoking >5 packs in 1 year can increase the risk by 30%, alcohol consumption >100 grams/day, and salt >6 grams/day increases the risk by 7%, physical activity for 21 minutes/day can reduce blood pressure by 4-9 mmHg, and excessive BMI can cause cholesterol plaques so that blood pressure increases.<sup>13</sup>

The mean blood pressure of type 2 DM patients with hypertension in this study was SBP (157.32 mmHg) and DBP (86.76 mmHg). Research carried out by Akalu, 2020 showed that the average SBP was 134.6 mmHg and TDD 86.4 mmHg. The average TDD results of this study are similar to research that has been carried out. Hypertension in hyperglycemic conditions can occur due to complex processes. The hormone insulin has an important role in the development of hypertension. Type 2 DM patients with hypertension generally have disorders in the form of increased serum glucose transport and the



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pancreas is stimulated to produce insulin. This increase in insulin can result in an increase in blood pressure through sympathetic activation or by stimulating hypertrophy of vascular smooth muscle cells which results in increased vascular resistance.<sup>14</sup>

Percentage of GDP levels in this study was 216.79 mg/dL. This shows a poor glycemic control respondent in this study. This study's findings align with research carried out by Rahayu in 2020 showing that the average GDP level of patients was 206 mg/dL which indicates poor glycemic control. Poor glycemic control is influenced by age, physical activity, food consumption, and also a history of obesity.<sup>6,15</sup>

Based on lipid profile level data, the majority of type 2 DM patients with hypertension have normal total cholesterol levels, normal HDL cholesterol, near-optimal LDL cholesterol, and normal triglycerides. Rahayu, 2020 showed similar results in this study. Namely, in 34 type 2 DM patients with ischemic stroke and females, the mean total cholesterol lipid profile level was 193.9 mg/dL which was categorized as normal and LDL cholesterol levels were 120.4 mg/dL which is categorized as close to optimal. Meanwhile, there were differences in the results of the mean HDL cholesterol levels in this study, namely 37.5 mg/dL which was categorized as low, and triglyceride levels of 191.1 mg/dL which were categorized as slightly high. This can occur due to differences in the characteristics of the subject population taken.<sup>15</sup>

#### **Relationship between GDP levels and total cholesterol levels**

The significance of GDP levels with total cholesterol levels in type 2 DM patients with hypertension was found to be  $p = 0.073$ . This result shows that there is no significant relationship between GDP levels and total cholesterol levels in type 2 DM patients with hypertension. The research results carried out in Haiti, in 2023 are in line with this study. Analysis correlation of blood glucose levels and total cholesterol level was  $p = 0.646$  showing no significant relationship between blood glucose levels and total cholesterol levels in this study.<sup>16</sup> Research conducted carried out by Wang in China also showed similar results, namely that there was no significant relationship between GDP levels and total cholesterol levels with  $p = 0.42$ .<sup>17</sup> This is different from a study by Sumampouw in 2019 which found that there was a

significant relationship with a weak correlation between levels GDP with total cholesterol levels with  $p\text{-value} = 0.02$  and  $r\text{ value} = 0.19$ .<sup>18</sup>

The majority of the subjects in this study had normal total cholesterol levels so insignificant results could occur in type 2 DM patients with hypertension. Research carried out by Anggraini, 2018 on type 2 DM patients found that GDP levels would increase in the group with abnormal cholesterol levels compared to the group with normal cholesterol levels. Total cholesterol levels in the blood are associated with type 2 DM and hypertension. This condition was associated with lipid metabolism disorders due to insulin resistance which affects enzymes and pathways in lipid metabolism. The worse glycemic control in patients can increase the risk of dyslipidemia. Pathological conditions that generally occur in type 2 DM patients with hypertension are low cholesterol absorption and increased cholesterol synthesis. Body weight is also associated with cholesterol metabolism, namely a decrease in cholesterol absorption can occur along with an increase in body weight.<sup>19</sup>

#### **Relationship between GDP levels and HDL cholesterol levels**

The correlation test of GDP levels and HDL cholesterol levels in this study was  $p = 0.232$ , showing that there is no significant relationship between GDP levels and HDL cholesterol levels in type 2 DM patients with hypertension. Research conducted by Sumampouw, 2019, shows that the values  $p=0.42$  and  $r=-0.02$  in the correlation analysis between GDP levels and HDL cholesterol levels also illustrate that there is no significant positive relationship between the two variables. These findings support this study's results that there is no significant positive relationship between GDP levels and HDL cholesterol levels in type 2 DM patients with hypertension. This is different from the findings by Purwanti, 2016 which showed  $p\text{ value} = 0.03$  which means there is a significant negative relationship. Between GDP levels and HDL cholesterol levels in type 2 DM patients at Sanglah General Hospital. Previous studies concluded that higher GDP levels will cause a decrease in HDL cholesterol levels.<sup>9</sup>

Abnormalities in lipoprotein metabolism can occur in type 2 DM with hypertension. Abnormalities in insulin function cause an increase in the sensitive





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lipase hormone, resulting in lipolysis which causes the release of fatty acids and glycerol into the blood circulation. This can increase free fatty acids which, if excessive, will be metabolized in the liver to be converted into phospholipids, cholesterol, and triglycerides, increasing cholesterol and triglyceride levels. LDL and HDL lipoproteins will then be transported to the circulation. This study showed that the majority of respondents in this study had normal levels of total cholesterol, HDL cholesterol, and triglycerides, resulting in an insignificant relationship with GDP levels in type 2 DM patients with hypertension. This shows that HDL cholesterol levels in type 2 DM patients with hypertension are not only influenced by high GDP levels, but are also influenced by many other factors such as physical activity patterns, diet, drug consumption, and genetic factors.<sup>9,20</sup>

### **Relationship between GDP levels and LDL cholesterol levels**

The significance of GDP levels with LDL cholesterol levels in this study was  $p=0.048$  and a correlation coefficient value of 0.323. This result shows that there is a significant positive relationship between GDP levels and LDL with a weak strength of correlation. The results of this study are in line with previous study that was carried out on 1,747 type 2 DM patients carried out by Wang, 2022. Wang found that there was a positive significant correlation between GDP levels and LDL cholesterol levels with a  $p$ -value  $<0.05$ .<sup>19</sup> Similar results were also found in Reddy, 2014. He found that from 490 type 2 DM patients in India, there was a positive significant correlation between GDP levels and LDL cholesterol levels with a  $p$ -value  $<0.00$  in 490 type 2 DM patients.<sup>21</sup>

A study conducted by Sumampouw in 2019, explains the findings of the correlation analysis between GDP levels and LDL levels with  $p=0.42$  and  $r=0.02$  showing that there is no significant relationship between GDP levels and LDL levels in the type 2 DM patient population.<sup>18</sup> These findings are not in line with the results of this study. Research carried out by Pradana in 2022 in type 2 DM patients who had normal blood pressure (BDP: 90 – 120 mmHg/ TDD: 60 – 80 mmHg) found that there was no significant relationship between GDP levels and LDL cholesterol levels.  $P$ -value = 0.119 and  $r = 0.250$

in normotensive type 2 DM patients that are not in line with this study.

The difference between the findings of this study and this study can be related to the condition of increased blood pressure (hypertension) because in this study the subjects taken had minimum criteria for  $BP \geq 140$  mmHg and/or  $BP \geq 90$  mmHg. This is supported by a previous study conducted by Siregar in 2019 which states that LDL cholesterol levels in type 2 DM patients have a significant positive relationship with the incidence of hypertension with  $p < 0.05$ . Hypertension is a condition associated with systemic vascular resistance caused by atherosclerosis. Atherosclerosis in type 2 DM and dyslipidemia can arise through lipoproteins undergoing oxidation so that an increase in lipoprotein peroxide occurs in the interstitial space or vasa walls, resulting in fat accumulation.<sup>22</sup>

Insulin resistance can increase LDL cholesterol levels in type 2 DM patients. Elevated LDL cholesterol levels will also get worse if there is a process of endothelial dysfunction caused by hypertension. Increased blood pressure causes the heart to pump harder to strengthen blood flow. This blood flow will then cause the elasticity of the blood vessels to become weak and trigger LDL to be oxidized and the accumulation of small dense LDL in the arterial endothelial walls. Therefore, it can be concluded that an increase in LDL cholesterol levels in type 2 DM patients with hypertension can occur.

### **Relationship between GDP levels and triglyceride levels**

Spearman correlation test between GDP and triglyceride levels shows that there was no significant correlation with  $p$ -value = 0.371. Research carried out by Winardo in 2020 also showed findings that were in line with the research results, namely that the analysis of the relationship between GDP levels and triglyceride levels showed  $p=0.662$ , which illustrates that there is no significant relationship between GDP levels and triglyceride levels.<sup>23</sup> Similar research was also carried out by Wang in China conducted on 5,822 patients who provided findings in line with the results of this study, namely a  $p$ -value of 0.532 which indicates that there is no significant relationship between GDP levels and triglyceride levels.<sup>27</sup>

In contrast to research conducted by Sumampouw which stated that there was a significant



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positive relationship between GDP levels and triglyceride levels, namely a p value of 0.01 and a correlation coefficient of 0.21.20 Triglyceride levels can be influenced by several factors such as the use of cholesterol-lowering drugs (simvastatin) as well as nutritional intake which has a significant impact on triglyceride levels. Consuming excess saturated fatty acids can increase triglyceride levels. Meanwhile, consuming excess unsaturated fatty acids can reduce triglyceride levels. Consuming foods with fiber or natural oxidants such as whole grains, fruit, vegetables, and nuts can reduce triglyceride levels. The different characteristics of drug therapy and nutritional intake in each type 2 DM patient with hypertension may result in insignificant results in this study.<sup>24</sup>

The differences obtained from each study are a result of the heterogeneity in the population, type of research, operational definitions, and confounding variables. There are also interference factors that can influence GDP levels and lipid profiles in type 2 DM patients with hypertension. These factors include physical activity, the length of time the patient has suffered from type 2 DM with hypertension, nutritional intake which can influence the five variables, and certain eating patterns which can also contribute to the relationship between GDP levels and lipid profile.

### **Research Limitations**

The limitation of this study is that there are interference factors in the form of drug therapy to treat dyslipidemia in this study which was not evaluated. Data on physical activity patterns and nutritional intake which can influence GDP levels and lipid profile levels are generally not available in medical record data so they cannot be evaluated. Suggestions that can be given for further research are expected to take into account other interfering factors, such as physical activity, the length of time the patient has suffered from type 2 DM with hypertension, nutritional intake, diet, and the patient's use of medication.

### **CONCLUSION**

Based on the results of the research and discussion, it can be concluded that there is no significant relationship between GDP levels and total cholesterol, HDL cholesterol, and triglyceride levels

and there is a significant positive relationship between GDP levels and LDL cholesterol levels in type 2 DM patients with hypertension.

### **CONFLICT OF INTEREST**

There is no conflict of interest in writing this publication.

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