THE EFFECT OF FASTING BLOOD GLUCOSE LEVELS ON LIPID PROFILES

Novendy[1], Silviana Tirtasari[2]

[1]Department and Residency Program in Family Medicine, Faculty of Medicine Universitas Pelita Harapan
[2]Department of Public Health Faculty of Medicine Universitas Tarumanagara
Correspondence: novendy.fk@uph.edu

ABSTRAK
Penyakit metabolik sudah menjadi satu masalah yang banyak dihadapi oleh masyarakat di Indonesia. Dua indikator yang menjadi pemantauan akan timbulnya penyakit metabolik adalah gula darah dan lipid darah. Gula darah memiliki hubungan fisiologis yang erat dengan metabolisme lipid darah, termasuk trigliserida, kolesterol total, LDL, dan HDL. Kelebihan gula darah yang tidak digunakan oleh sel akan dikonversi menjadi asam lemak melalui proses lipogenesis di hati, yang kemudian disimpan dalam bentuk trigliserida, sehingga meningkatkan kadar lipid darah yang dapat menimbulkan masalah penyakit metabolik pada manusia. Salah satu laboratorium klinik swasta di Kota Tangerang sudah banyak menerima pemeriksaan terkait gula darah dan lipid darah, namun belum pernah dilakukan analisis sehingga perlu dilakukan suatu penelitian. Penelitian ini menggunakan studi desain potong lintang. Total sebanyak 322 sampel yang memenuhi kriteria yang dianalisis dalam penelitian. Hasil penelitian ini menunjukkan bahwa terdapat hubungan yang signifikan antara gula darah puasa dengan kadar triglisedia (*p value* = 0,0001, PRR = 2,93) dan kadar HDL (*p value* = 0,01, PRR = 1,469). Namun tidak terdapat hubungan antara kadar gula darah puasa dengan kadar kolesterol total (*p value* = 0,209, PRR = 1,710) dan kadar LDL (*p value* = 0,977, PRR = 0,993). Temuan ini menegaskan pentingnya pengendalian gula darah untuk mencegah gangguan metabolisme lipid, meskipun tidak semua komponen profil lipid menunjukkan hubungan yang serupa.

Kata-kata kunci : gula darah, laboratorium, lipid, metabolik

ABSTRACT
Metabolic diseases have become a common health problem faced by many people in Indonesia. Two important indicators for monitoring the onset of metabolic diseases are blood glucose and blood lipids. Blood glucose has a strong physiological relationship with lipid metabolism, including triglycerides, total cholesterol, LDL, and HDL. Excess blood glucose that is not utilized by the cells is converted into fatty acids through the process of lipogenesis in the liver, which are then stored as triglycerides, leading to elevated blood lipid levels that may contribute to the development of metabolic diseases. One private clinical laboratory in Tangerang City has received numerous test requests related to blood glucose and blood lipids. However, no analysis has been conducted to date, highlighting the need for a research study. This study employed a cross-sectional design and analysed a total of 322 samples that met the inclusion criteria. The results showed a significant association between fasting blood glucose levels and triglyceride levels (p-value = 0.0001, PRR = 2.93), as well as HDL levels (p-value = 0.01, PRR = 1.469). However, no significant relationship was found between fasting blood glucose and total cholesterol (p-value = 0.209, PRR = 1.710) or LDL levels (p-value = 0.977, PRR = 0.993). These findings emphasize the importance of controlling blood glucose levels to prevent lipid metabolism disorders, even though not all lipid profile components showed a similar association.

Keywords : *blood sugar, laboratory, lipid, metabolic*

INTRODUCTION

Diabetes mellitus is a chronic metabolic disorder characterized by elevated blood glucose levels due to impaired insulin secretion, insulin action, or both[1,2]. Prolonged hyperglycemia can lead to serious complications, including microvascular disorders such as nephropathy, retinopathy, and neuropathy, as well as macrovascular complications such as coronary heart disease and stroke[1,2]. Poor glycemic control is a major predisposing factor for these critical conditions[3].

In addition to glucose metabolism disturbances, patients with diabetes often present with other metabolic comorbidities, such as obesity, hypertension, elevated low-density lipoprotein (LDL) cholesterol, and reduced high-density lipoprotein (HDL) cholesterol[4]. This combination of conditions is referred to as metabolic syndrome, which further increases the risk of cardiovascular complications[5].

As one of the body's primary sources of energy, glucose has a close physiological relationship with lipid metabolism, including triglycerides, total cholesterol, LDL, and HDL[5-7]. Under conditions of chronic hyperglycemia, excess glucose that is not utilized by cells is converted into fatty acids through hepatic lipogenesis and stored as triglycerides, which in turn elevates blood lipid levels[8-10]. Consequently, there is a complex interaction between glucose and lipid metabolism, influencing energy homeostasis and overall metabolic health. Understanding this relationship is increasingly important, as appropriate management strategies may help control glucose levels while simultaneously reducing the risk of dyslipidemia and related complications.

Previous studies have demonstrated that dyslipidemia significantly contributes to both the onset and progression of diabetes mellitus[11-13]. Interestingly, treatment of dyslipidemia with lipid-lowering agents such as statins has been reported to increase blood glucose levels[14], suggesting a complex bidirectional relationship between glucose and lipid metabolism. Current perspectives indicate that insulin resistance triggered by lipotoxicity—caused by abnormal lipid accumulation in peripheral tissues—is one of the key mechanisms linking hyperlipidemia to hyperglycemia[15].

Recent studies further suggest that lipids not only contribute to glucose instability but also exacerbate insulin resistance, while fluctuations in blood glucose may worsen dyslipidemia through multiple metabolic and inflammatory pathways[16-17]. Therefore, a deeper understanding of the dynamic interaction between glucose and lipid metabolism is crucial for developing more effective therapeutic approaches and individualized management of patients with both diabetes mellitus and dyslipidemia.

Given the importance of monitoring blood glucose and lipid levels, laboratory testing is essential. One private clinical laboratory in Tangerang City has served many patients requiring both glucose and lipid testing. However, these data have never been analyzed in depth. Thus, this study was conducted to analyze existing laboratory data to determine whether fasting blood glucose levels are associated with lipid profiles. The findings are expected to provide preliminary evidence that can raise community awareness about the relationship between lipid profiles and blood glucose. Moreover, this study may offer valuable insights for nutritionists and clinicians in managing metabolic disorders through improved diet monitoring and therapeutic strategies. For individuals without metabolic disease, the results may serve as a useful reference for lifestyle modifications to prevent future metabolic disorders.

METHODS

The research design used in this study was a cross-sectional study by collecting data from the results of fasting blood glucose and lipid profile examinations from January – December 2024. The activity was carried out at a private clinical laboratory located in Tangerang City in May – June 2025.

The target population in this study was all people aged 20 – 60 years in Indonesia, while the accessible population was people aged 20 – 60 years in Tangerang City. The sample was people aged 20 – 60 years who underwent fasting blood glucose and lipid profile examinations at a private clinical laboratory in Tangerang City.

The required sample size was calculated using a formula for two independent proportions in a cross-sectional study design. The value of P_1 was set at 53%[18] with a clinical judgment of 20%, giving P_2 = 73%. With α = 5% and β = 20%, and allowing for an estimated 10% dropout, the minimum required samples size was 205 respondents. The sampling technique applied in this study was total population sampling.

The inclusion criteria in this study were respondents aged ≥ 20 years up to 60 years and having complete laboratory data on fasting blood glucose and lipid profile, consisting of fasting blood glucose, total cholesterol, LDL cholesterol, HDL cholesterol, and triglycerides. The data used in this study were secondary data obtained from respondents who underwent fasting blood glucose and lipid profile examinations from January to December 2024.

The collected data were then processed using statistical analysis software. Univariate data was presented in tabular form, with categorical data shown as percentages and numerical data shown as mean or median. Numerical data were tested for normality using Skewness or the Kolmogorov–Smirnov test. The statistical test used in this study was the chi-square test, and if the chi-square assumptions were not met, the data were analyzed using Fisher's Exact Test. Epidemiological association in this study was measured using the Prevalence Risk Ratio (PRR).

RESULTS AND DISCUSSION

A total of 512 fasting blood glucose (FBG) tests were collected between January and December 2024. Of these, 190 records did not meet the inclusion criteria, leaving 322 eligible results for analysis.

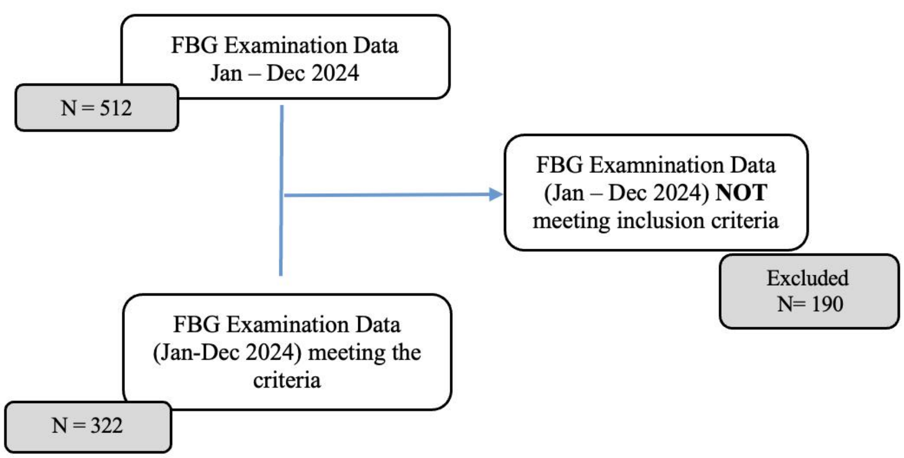

Figure 1. Flow of research sample selection

Based on the January – December 2024 records, the gender distribution was balanced: 162 (50,3%) males and 160 (49,7%) females. The mean age was 42,96 ± 10.50 years, with the largest proportion of participants in the 31-40 years age group (32,6%). Full demographics data are presented in Table 1.

Table 1. Demographic characteristic of Fasting Blood Glucose and lipid profile results in a private laboratory, Tangerang City

Variable	Proportion N = 322 (%)	Mean±SD	Median (Min – Maks)
Gender			
Male	162 (50,3)		
Female	160 (49,7)		
Age (years)		42,96±10,50	42,00 (22 – 60)
20-30	41 (12,7)		
31-40	105 (32,6)		
41-50	76 (23,6)		
51-60	100 (31,1)		

Only 20 respondents (6,2%) had fasting blood glucose ≥ 126 mg/dL, with a mean FBG value of 96,37 mg/dL. Compared to the 2023 Indonesian Health Survey (SKI), which reported a diabetes prevalence of 11,7% in individuals ≥ 15 years[19], this result was lower—likely due to differences in the age range of participants (this study: 20–60 years; SKI: ≥ 15 years up to > 75 years) and differences in diagnostic criteria. In addition, this difference can also be due to different determinations between the research results and the 2023 SKI results. The prevalence of diabetes mellitus in the 2023 SKI results was determined if the fasting blood glucose level was ≥126 mg/dL; or 2-hour post-load blood glucose level was ≥ 200 mg/dL[19]. Meanwhile, this study did not determine the prevalence of diabetes mellitus, but only looked at whether the fasting blood glucose value was ≥ 126 mg/dL or not.

The examination results with total cholesterol levels above or equal to 240 mg/dL were 49 (15,2%) with an average of 198,03 mg/dL. The examination results with triglyceride levels above or equal to 150 mg/dL were 80 (24,8%) with an average of 120,38 mg/dL. Meanwhile, the examination results with HDL cholesterol levels below 60 mg/dL were 203 (63,0%) with an average HDL cholesterol level of 56,24 mg/dL. And the examination results with cholesterol levels above or equal to 130 mg/dL were 163 (50,3%) with an average LDL cholesterol level of 132,11 mg/dL.

Compared to the results of the 2023 Indonesian Health Survey (SKI), the results of this study also differ from those of the survey. The SKI results showed a prevalence of high total cholesterol of 11,7%; high and very high triglyceride levels of 23,9%; low HDL cholesterol levels of 87% and high and very high LDL cholesterol levels of 8,5[19]. The difference between the 2023 SKI results and the research results is due to different category divisions. In this study, total cholesterol, triglycerides, HDL cholesterol, and LDL cholesterol were only divided into 2 groups, while in the SKI, blood lipids were divided into several categories. In addition, the difference in results is also due to the different ages of the respondents taken in this study and the 2023 SKI results.

Table 2. Fasting blood glucose and lipid profile results in a private laboratory, Tangerang City

Variable	Proportion N = 322 (%)	Mean±SD	Median (Min – Maks)
Fasting Blood Glucose (md/dL)		96,37±35,48	89,00 (70 – 407)
≥ 126	20 (6,2)		
< 126	302 (93,8)		
Total Cholesterol (mg/dL)		198,03±43,75	195 (104 – 417)
≥ 240	49 (15,2)		
< 240	273 (84,8)		
Triglycerides (mg/dL)		120,38±63,22	102,50 (43 – 538)
≥ 150	80 (24,8)		
< 150	242 (75,2)		
HDL (mg/dL)		56,24±15,10	54 (26 – 115)
< 60	203 (63,0)		
≥ 60	119 (37,0)		
LDL (mg/dL)		132,11±40,11	130 (41 – 351)
≥ 130	162 (50,3)		
< 130	160 (49,7)		

The results of this study in table 3 show that 25% of those with fasting blood glucose examination results ≥ 126 mg/dL had total cholesterol levels ≥ 240 mg/dL. A total of 65% of fasting blood glucose examination results ≥ 126 mg/dL had triglyceride levels ≥ 150 mg/dL. In addition, this study also found that 90% of fasting blood glucose results ≥ 126 mg/dL had HDL cholesterol levels < 60 mg/dL and 50% of fasting blood glucose results ≥ 126 mg/dL had LDL cholesterol levels ≥ 130 mg/dL. Compared to the results of research conducted by Rahayu et al. in 2020 from laboratory examination results at the Regional General Hospital (RSUD) in Mojokerto, these results differ from those obtained in this study. In the study by Rahayu et al., 35% of respondents with above-normal fasting blood glucose levels had above-normal total cholesterol levels[18]. A total of 47% of respondents with above-normal blood glucose had high triglyceride levels[18]. In addition, 65% of respondents with above-normal fasting blood glucose levels had low HDL cholesterol levels, and 24% of respondents with above-normal fasting blood glucose levels had high LDL cholesterol levels[18]. These differences are due to different research data collected, where in the study by Rahayu et al., laboratory examination data came from respondents with diabetes mellitus, while in this study, the history of diseases owned by the respondents was not precisely known, and most respondents were likely healthy respondents.

This study found no significant relationship between fasting blood glucose levels and total cholesterol levels (p-value = 0,209) and LDL cholesterol levels (p-value = 0,997). However, the prevalence risk ratio (PRR) calculation showed that people with fasting blood glucose levels ≥ 126 mg/dL had a 1,7 times risk of having total cholesterol levels ≥ 240 mg/dL, while it did not affect LDL cholesterol levels. This result is similar to the research by Lestari et al. in 2023 on type 2 diabetic patients with hypertension, which found no significant relationship between fasting blood glucose levels and total cholesterol levels (p-value = 0,073)[20]. However, the study by Lestari et al. found a relationship between fasting blood glucose levels and LDL cholesterol levels (p-value = 0,048)[20].

This study found a significant relationship between fasting blood glucose levels and triglyceride levels (p-value = 0,0001) and HDL cholesterol levels (p-value = 0,01). In addition, the prevalence risk ratio (PRR) analysis showed that people with fasting blood glucose results ≥ 126 mg/dL had almost 3 times the risk (PRR = 2,93) of having triglyceride levels ≥ 150 mg/dL and almost 1,5 times the risk (PRR = 1,469) of having HDL levels < 60 mg/dL. The study results differ from the results of Lestari et al.'s study, which found no relationship between fasting blood glucose levels and increased triglyceride levels (p-value = 0,371) and increased HDL cholesterol levels (p-value = 0,232)[20].

Sugar is the main energy source for the human body. After carbohydrate consumption, sugar is absorbed into the bloodstream and stimulates the release of insulin from the pancreas[21]. Insulin allows sugar to enter cells to be used as energy or stored as glycogen in the liver and muscles[21]. If there is excess sugar intake, the excess will be converted into fatty acids and triglycerides through the process of lipogenesis, which occurs in the liver and adipose tissue[21].

Cholesterol is an important lipid used to form cell membranes, steroid hormones, and bile acids[22]. About 70–80% of cholesterol in the body is synthesized by the liver through the mevalonate pathway, which starts from acetyl-CoA[22]. Cholesterol is then transported in the blood by lipoproteins in the form of LDL cholesterol, which transports cholesterol from the liver to body tissues, and HDL cholesterol, which takes cholesterol from body tissues and carries it back to the liver[22].

Acetyl-CoA, the end product of sugar metabolism, is a major precursor in cholesterol synthesis[21,22]. When sugar is in excess, some will be converted into acetyl-CoA and then synthesized into cholesterol and triglycerides[21,22]. This process is influenced by insulin, which stimulates cholesterol synthesis and inhibits fat breakdown[21,22]. In conditions of insulin resistance, such as in type 2 diabetes, the body does not respond well to insulin[21,22]. This causes blood sugar levels to remain high, which triggers the liver to continue producing sugar and lipids, including cholesterol and triglycerides[21,22]. As a result, there is an increase in LDL cholesterol and triglycerides and a decrease in HDL cholesterol[21,22]. This disturbance in sugar and cholesterol metabolism can lead to metabolic syndrome.

Table 3. Association between fasting blood glucose and lipid profiles in a private laboratory, Tangerang City

Variable	Total Cholesterol		Mean±SD	PRR	95% CI	P value
	≥ 240 N = 49	< 240 N = 273				
FBG (mg/dL)						
≥ 126	5 (25,0)	15 (75,0)	202,35±54,82	1,716	0,77 – 3,85	0,209*
< 126	44 (14,6)	258 (85,4)	197,74±43,01	1,000		
	Triglycerides					
	≥ 150 N = 80	< 150 N = 242				
FBG (mg/dL)						
≥ 126	13 (65,0)	7 (35,0)	204,25±121,68	2,930	1,99 – 4,31	0,0001*
< 126	67 (22,2)	235 (77,8)	114,83±53,19	1,000		
	HDL					
	< 60 N = 203	≥ 60 N = 119				
FBG (mg/dL)						
≥ 126	18 (90,0)	2 (10,0)	49,45±14,82	1,469	1,24 – 1,74	0,01
< 126	185 (61,3)	117 (38,7)	56,69±15,04	1,000		
	LDL					
	≥ 130 N = 162	< 130 N = 160				
FBG (mg/dL)						
≥ 126	10 (50,0)	10 (50,0)	133,80±48,60	0,993	0,63 – 1,56	0,977
< 126	152 (50,3)	150 (49,7)	132,00±39,57	1,000		

*Analyze with *Fishers' Exact Test*

CONCLUSION

The results showed a significant relationship between fasting blood glucose levels and triglyceride levels as well as HDL levels. This indicates that an increase in fasting blood glucose levels can affect the lipid profile, specifically by increasing triglyceride levels and decreasing HDL. However, no significant relationship was found between fasting blood glucose levels and total cholesterol or LDL levels. These findings emphasize the importance of controlling blood glucose levels to prevent lipid metabolism disorders, even though not all lipid profile components showed a similar association.

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