Relationship between Body Mass Index and Low-Density Lipoprotein and Triglycerides in Type 2 Diabetes Mellitus Patients

Abstract

One of the measurements of obesity is using the Body Mass Index (BMI). The increase in obesity is in line with the increase in type 2 diabetes mellitus. Type 2 DM causes disturbances in lipid metabolism in the body, especially hypertriglyceridemia, decreased HDL, and increased small dense LDL. This situation causes patients to have a greater risk of cardiovascular disease. Therefore, researchers want to further investigate the relationship between BMI, LDL, and triglyceride levels. The method used was correlational analysis with a cross-sectional approach using the medical records of Type 2 DM patients at the Indonesian Christian University Hospital for the 2018-2021 period. The study's results obtained a sample of 60 patients with type 2 diabetes mellitus. It was more common in patients of the female sex, ages between 65-74 years, with excess BMI, housewife work, excess LDL levels, and triglyceride levels, which is normal. The correlation test between BMI and LDL was $p = 0.588$, with a chance ratio of 0.912. Between BMI and triglycerides was $p = 0.704$ with an odds ratio of 0.702. Spearman rank correlation analysis between BMI and LDL showed a $p = 0.895$ with $r = -0.017$. BMI and triglycerides showed a value of $p = 0.523$ and $r = -0.084$.

Keywords: Type 2 Diabetes Mellitus, BMI, Triglycerides, Low-Density Lipoprotein

Introduction

Obesity is the excessive accumulation of fat in the body due to an imbalance in energy consumption greater than the energy used in a person's body [1]. The factors that trigger this can happen because of the food consumed a lot and the habits of life that don't move much. It cannot be denied because, along with the progress of time, people's lifestyles have also changed. In the past, when electronic equipment had not yet been invented, people did a lot of physical activity to wash or clean dirty homes. Even now, when someone wants to meet their food needs, they don't have to bother going to cook or buy outside the home but can order it only with the device. This progress makes a person not forced to do physical activity; even by sitting and not moving much, one can fulfill what is needed. The wrong diet is one of the causes of obesity [2]. A variety of fast food that is cheap and delicious increases people's consumption power even though fast food is high in salt and fat. Genetic factors, social environment, and culture can also influence the incidence of obesity. [3]

One measure of obesity is the Body Mass Index (BMI). The body mass index calculates the ratio of height to body weight. If a person's body mass index exceeds 27 kg/m2, he is classified as obese [4]. The effect of obesity, especially central obesity, is type 2 diabetes mellitus. Diabetes mellitus (DM) is a disease caused by chronic metabolic disorders with various etiologies characterized by high blood glucose levels and disturbances in carbohydrate, lipid, and protein metabolism as a result of the efficient functioning of insulin (WHO, 1999). The higher a person's BMI, the higher a person's risk of developing diabetes [5].

According to WHO, 2021, the number of patients suffering from diabetes has increased from 108 million people in 1980 to 422 million people in 2014, which means

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that one person has diabetes out of eleven people in the world. Meanwhile, 2019 is considered to have occurred 1.5 million deaths due to diabetes. WHO estimates that the number of people with diabetes will increase by 50% within 25 years, from 150 million in 2000 to 300 million in 2025. The International Diabetes Federation (IDF) also states that 382 million people worldwide had diabetes in 2013, and this is expected to increase to 592 million cases in 2035. [6]

The IDF stated that Indonesia is ranked sixth for the country with the most people with diabetes worldwide, with 10.3 million cases, and in the future, it is expected to be ranked fifth for the number of people living with diabetes, with 13.7 million cases in 2030. According to the 2018 national RISKESDAS, the prevalence of DM in Indonesia, based on the results of blood tests, is 8.5% of the population over the age of 15 years. DKI Jakarta is one of the four areas with the most diabetes mellitus, with 3.4% of people diagnosed by a doctor as having diabetes. Research in five areas in DKI Jakarta reported that there were still many cases of DM that had not been diagnosed, three times the cases of diabetes mellitus detected [7].

Type 2 DM is caused by impaired insulin secretion and resistance, especially in the muscles and liver. The insulin hormone produced by the pancreas gland acts as a key for glucose to enter the body's cells and be converted into energy. Type 2 DM is more common in adults than children. The typical symptoms of diabetes mellitus are excessive thirst (polydipsia), excessive urine production (polyuria), and feeling hungry quickly (polyphagia).

In type 2 DM, the insulin hormone cannot be used properly, causing glucose in the blood to increase (hyperglycemia). Initially, insulin secretion compensates for insulin resistance, but the insulin-producing glands can become tired and damaged if this continues. In addition, because the body does not detect glucose that can be used, the body will stimulate the formation of glucose from adipose tissue (lipolysis) and increase free fatty acids. It causes glucotoxicity and lipotoxicity in the body [8].

If this cannot be detected early or the treatment of diabetes mellitus patients is irregular, it will lead to chronic complications of diabetes mellitus. It is this complication that causes the condition of patients with diabetes mellitus to worsen because the complications can affect various organs in the body. Diabetes influences chronic complications due to changes in the vascular system, both microvascular and macrovascular. Microvascularly it can cause retinopathy, nephropathy, and neuropathy; macrovascularlyit can cause cardiovascular disease, coronary heart disease, and disorders of the blood vessels of the lower limbs.

The main cause of death in diabetes mellitus is heart disease. Coronary heart disease develops due to early atherosclerosis, which can attack vital organs (heart and brain) [9]. Atherosclerosis is caused by multifactor, namely oxidative stress, hyperlipidemia, hyperglycemia, hyperinsulinemia, hyperproinsulinemia, premature aging, and changes in coagulation and fibrinolysis processes. Dyslipidemia occurs due to disturbances in lipoprotein metabolism which functions to transport lipids throughout the body, including increased concentrations of triglycerides, Very Low-Density Lipoprotein (VLDL), and small dense Low-Density Lipoprotein (sLDL), which are atherogenic and decreased concentrations of High-Density Lipoprotein (HDL) which are atherogenic, antiatherogenic, antioxidant and anti-inflammatory [10]. Therefore, monitoring body weight and total cholesterol in patients with diabetes mellitus is very necessary to prevent chronic complications of diabetes mellitus.

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Due to the very high increase in cases and diabetes complications, which have a very bad impact on the patient's condition, therefore the authors would like to further examine the relationship between Body Mass Index and LDL and triglycerides in type 2 diabetes mellitus patients. Early detection of type 2 diabetes mellitus and its complications. The formulation of the problem in this study is "Is there a relationship between body mass index and LDL and triglycerides in type 2 diabetes mellitus patients at UKI General Hospital in 2018-2021? The research objective was to determine the correlation between body mass index and LDL and triglycerides in type 2 diabetes mellitus patients at UKI General Hospital in 2018-2021.

Literature Review

Body mass index (BMI) is a simple weight index for height used to classify overweight and obesity levels in adults [11]. Measurements are made using the formula for body weight (Kg) divided by the square of height (m2) to determine a person's BMI. Lipids are a heterogeneous group of compounds, including fats, oils, steroids, waxes, and related compounds. Lipids are generally insoluble in water and soluble in nonpolar solvents such as ether and chloroform [12].

Lipids are classified into simple and complex lipids. Simple lipids are esters of fatty acids with various alcohols. [13] Simple lipids include: a) Fats, namely esters of fatty acids and glycerol. The liquid fat is known as oil; b) Waxes, namely esters of fatty acids and monohydrate alcohols with high molecular weight; and c) Complex lipids are esters of fatty acids, not always having alcohol and one or more fatty acids. Lipid derivatives are derivatives formed from the hydrolysis of simple and complex lipids. Examples include fatty acids, glycerol, steroids, alcohols, fatty aldehydes, ketone bodies, hydrocarbons, fat-soluble vitamins, micronutrients, and hormones. Neutral lipids are uncharged lipids such as acylglycerols (glycerides), cholesterol, and cholesterol esters. Triacylglycerol is the most abundant type of lipid in the body of mammals.

Lipids have an important role in the body, including as the body's main energy source, acting as an electrical insulator that allows signals to travel along myelinated nerves. Lipids bound to proteins (lipoproteins) form cell membranes and mitochondria and transport lipids in the blood. Lipids around the subcutaneous tissue and certain organs act as heat insulators for the body and protectors for the organs. [14] To circulate in the blood, lipids need a means of transportation, namely lipoproteins, because lipids cannot dissolve in water. The four main lipids present in lipoproteins are triacylglycerols (16%), phospholipids (30%), cholesterol (14%), cholesterol esters (36%), and free fatty acids (4%) [15]. Four main lipoproteins play an important role in physiology and clinical diagnosis: chylomicrons, very low-density lipoproteins, low-density lipoproteins, and high-density lipoproteins. [14] There are three lipid metabolism pathways in the body: the exogenous pathway, an endogenous pathway that metabolizes low-density lipoprotein, and the reverse cholesterol transport pathway, which metabolizes high-density lipoprotein.

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Table 1. Normal Serum Lipid Levels in Humans

Classification of plasma lipid levels	
Total Cholesterol (mg/dl)	
• Wanted	< 200
• Slightly high (borderline)	200-239
• High	≥ 240
LDL Cholesterol(mg/dl)	
• Optimum	< 100
• Close to optimal	100-129
• Slightly high (borderline)	130-159
• High	160-189
• Very high	≥ 190
HDL cholesterol (mg/dl)	
• Low	<40
• High	≥ 60
Triglycerides (mg/dl)	
• Normal	<150
• Slightly high (borderline)	150-199
• High	200-499
• Very high	≥ 500

Source: *National Cholesterol Education Program Adult Panel III* (NCEP-ATP III), 2019

Diabetes Mellitus is a group of metabolic diseases characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both. [16] Types of diabetes according to the American Diabetes Association, 2019 recommended by the Indonesian Endocrinology Association (Perkeni), namely Type 1 DM, Type 2 DM, Gestational Diabetes / Diabetes Mellitus (DMG), and certain types of diabetes (neonatal diabetes and maturity-onset diabetes at a young age) [17].

The risk factors for Type 2 Diabetes Mellitus are [18]: a) Family history of diabetes (parents or siblings with type 2 diabetes); b) Obesity (BMI 25 kg/m2); c) Low physical activity habits, high sitting time and television viewing duration; d) Certain races/ethnicities (African Americans, Latinos, Native Americans, Asian Americans, Pacific Islanders); e) history of impaired glucose tolerance or impaired fasting glucose; f) History of gestational diabetes or giving birth to a baby > 4 kg; g) Hypertension (blood pressure 140/90 mmHg); h) HDL cholesterol level <35 mg/dL and/or triglyceride level >250 mg/dl; i) PCOS or acanthosis nigricans; j) History of vascular disease; k) Increased biomarkers (uric acid, CRP, levels of adiponectin, vitamin D, alanine ami-notransferase (ALT), gamma-glutamyl transferase); l) Unhealthy diet patterns (increased consumption of meat, sweetened beverages, decreased fiber-containing foods); and m) Smoking.

Impaired glucose metabolism is caused by two main factors, namely inadequate insulin secretion (insulin deficiency) and insensitivity of body tissues to insulin (insulin resistance), and is supported by environmental factors (environment) [19]. The body needs glucose as the main ingredient in the formation of energy. This energy need is met by the intake of food and drinks consumed by humans. When food and drink enter the body, there will be a process of digestion of food in the form of carbohydrates,

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proteins, and fats into glucose. Glucose will then enter the blood. Increased blood glucose levels will stimulate pancreatic beta cells to secrete insulin. In the body's physiological state, insulin is secreted in two phases. The first phase of secretion (Acute Insulin Secretion Response = AIR) is insulin secretion, which takes place quickly after the stimulation of beta cells and ends quickly. The peak of this first-phase secretion is usually relatively high in anticipation of a significant rise in blood glucose after a meal. The first phase of secretion is very important because it affects the performance of the second phase.

After the first phase of secretion ends, it is followed by the second phase of secretion (latent phase). The second phase of secretion is different from the first phase. The second phase of secretion increases slowly and lasts a relatively long time. The peak of phase 2 secretion depends on how high the blood glucose level is at the end of phase 2. If in phase one, the secretion is inadequate, and then compensation occurs in phase two secretion. It is done in order to maintain a normoglycemic state. If this continues, the compensation will not be adequate to create a normoglycemic state, and decompensation will occur. There is an increase in postprandial blood glucose levels, and the patient will experience a prediabetic state when the condition is not treated, a state of chronic hyperglycemia, there will be damage to pancreatic beta cells and insulin resistance, which brings the patient into a state of diabetes.

When insulin is released into the blood, insulin must bind to the insulin receptor substrate (IRS). The insulin receptor substrate (IRS) binds. The insulin and receptor bonds will provide signals that are useful for the process of glucose metabolism in muscle and fat cells. This bond will trigger the synthesis and translocation of glucose transporter 4 (GLUT-4). This transporter will work to enter glucose from extracellular to intracellular. In addition to the need for sufficient insulin secretion, sensitivity (action) of tissues to insulin is needed. When insulin resistance occurs, insulin cannot be used and causes glucose levels in the blood to increase, known as insulin resistance. [19]

When the glucose level in the blood increases, glucose will be excreted through the urine. Glucose absorbs water so that when a lot of glucose is wasted, fluids in the body are also wasted (osmotic diuresis). The classic symptom of polyuria characterizes it. When too much fluid is removed, the body will become dehydrated and cause excessive thirst in patients or polydipsia. When insulin resistance occurs, there is no inhibitory effect on nerve cells that produce neuropeptide Y, which increases appetite; therefore, patients always feel hungry or polyphagi [20]. DM patients also show classic symptoms of weight loss, and this occurs due to gluconeogenesis resulting in increased breakdown of protein and fat in the body [21].

Diagnosis can be made by examining blood glucose and venous blood glucose. However, whole blood, vein, or capillary can also be used. Diagnostic is done if there are signs of DM. The typical symptoms of DM are polyuria, polydipsia, polyphagia, and unexplained weight loss. If there are typical symptoms, only one abnormal blood glucose test is needed, but if the patient does not have the typical symptoms of DM, then two abnormal blood glucose tests are needed.

Increasing BMI per kg/m2 will increase the risk of developing type 2 DM by 18%. The increase in BMI will align with lipid levels in the blood. According to the lipid overflow hypothesis, this excess lipid will trigger ectopic storage of lipids in organs that metabolize glucose, including the pancreas, muscles, and liver. The increase in fatty acids in the above organs causes lipotoxicity. This lipotoxicity can interfere with

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insulin sensitivity, receptors, and glucose transporters (GLUT 4). It makes the body fall into a hyperglycemic state and, in the long run, can cause type 2 diabetes mellitus. The higher the BMI, the higher the incidence of diabetes mellitus. It is evidenced by increased total cholesterol, LDL cholesterol, triglycerides, and decreased HDL cholesterol [22]. Under these conditions, patients with diabetes mellitus have a higher risk of developing cardiovascular disease because the lipid profile picture above shows highly atherogenic diabetic dyslipidemia. The most common diabetic dyslipidemia is increased triglycerides, increased small-dense LDL, and decreased HDL. However, the most common finding is increased triglycerides (hypertriglyceridemia) [23].

This condition of diabetic dyslipidemia is primarily caused by oxidative stress, increasing Microsomal Triglyceride Transfer Protein (MTP). This protein regulates the content of cholesterol and triglycerides in VLDL and chylomicrons. The higher the MTP, the higher the proatherogenic potential. In addition, this causes a decrease in triglyceride chylomicron clearance and makes LpL decrease its function. Ultimately chylomicrons, triglycerides, VLDL, and VLDL-Apo B increase and cause hypertriglyceridemia. Oxidative stress also causes HDL function and levels to decrease. When HDL decreases, the function of cholesterol clearance, antioxidants, and anti-atherogenic also decreases; this causes the formation of LDL to become small and dense and easily oxidized on the walls of arterial blood vessels or what is often called small dense LDL (sLDL). Conditions like this put diabetic patients at 30 percent risk of cardiovascular disease [23].

Research Method

This study used a correlational analysis method with a cross-sectional approach to determine the relationship between BMI and the Lipid Profile of Type 2 DM Patients at UKI General Hospital 2018-2021. This research was carried out at the medical records section of the Indonesian Christian University Hospital and was carried out from November 2021 to January 2022. This study used secondary data as a research instrument. Secondary data were obtained from medical records on patients with type 2 diabetes mellitus at UKI General Hospital in 2018-2021. The population was all type 2 diabetes mellitus patients at UKI General Hospital for 2018-2021. Using all samples that match the inclusion criteria and exclusion criteria. It follows the total sampling method. Data collection and collection used secondary data from the medical records of patients with type 2 DM at the UKI General Hospital for the 2018-2021 period, which researchers will conduct. After all the data has been collected, the data is selected according to predetermined inclusion and exclusion criteria. The data obtained will be used in this study, and then the data will be copied into the database. The data collected will then be analyzed using the SPSS ver.28 (Statistical Package for the Social Science) program uses data processing procedures starting from editing, coding, entry, and tabulation. The first is descriptive analysis (univariate) to calculate the mean, mode, and median of the dependent and independent variables. Then a bivariate test was performed using the chi-square test. Bivariate analysis of the relationship is significant if $p < 0.05$ and meaningless if $p > 0.05$ between the two variables and considers the odds ratio. After the bivariate test, a multivariate test will be carried out using the Spearman rank. To assess the significance between the two independent variables.

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Result and Discussion

Based on data obtained from the medical records of Type 2 DM patients for the 2018-2021 period at UKI General Hospital. Obtained research samples following the inclusion criteria, namely 60 patients. The results of this study will be described using univariate, bivariate, and multivariate analysis. Univariate analysis was used to determine the frequency distribution characteristics of diabetes mellitus patients based on sex, age, body mass index, occupation, and low-density lipoprotein and triglyceride profiles.

Table 2. Distribution of Type 2 Diabetes Mellitus Patients Based on Gender

Gender	Frequency	Percentage
Female	32	53.5
Male	28	46.7
Total	**60**	**100.0**

Table 2 describes the characteristics of type 2 DM patients at UKI General Hospital for the 2018-2021 period based on the gender of type 2 DM patients, and more are female. There were 32 patients (53.5%) compared to 28 male patients (46.7%).

Table 3. Distribution of Type 2 Diabetes Mellitus Patients Based on Age

Age	Frequency	Percentage
35 – 44	5	8.3
45 – 54	16	26.7
55 – 64	16	26.7
65 – 74	23	38.3
Total	**60**	**100.0**

Table 3 describes the characteristics of type 2 DM patients at UKI General Hospital for the 2018-2021 period according to age. It was found that type 2 DM patients were dominated between the ages of 65 and 74, with 23 patients (38.3%). Then in second place with 16 patients between 45-54 years and 55-64 years (26.7%). Third place with five patients aged 35-44 (8.3%).

Table 4. Distribution of Type 2 Diabetes Mellitus Patients Based on Body Mass Index

IMT	Frequency	Percentage
Normal	21	35.0
Abnormal	39	65.0
Total	**60**	**100.0**

Based on Table 4, it can be seen that the frequency of BMI in type 2 DM patients is normal weight in 21 patients (35%) and abnormal weight in 39 patients (65%).

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Table 5. Distribution of Type 2 Diabetes Mellitus Patients by Occupation

Job	Frequency	Percentage
Housewife	23	38.3
Private	13	21.7
Retired	11	18.3
Self-employed	5	8.3
Trader	1	1.7
Pastor	2	3.3
Teacher	1	1.7
Government employees	4	6.7
Total	**60**	**100.0**

Based on Table 5 above, the distribution of work in people with type 2 DM is mostly in housewives with 23 patients (38.3%), private 13 patients (21.7%), retirees with 11 patients (11%), self-employed five patients (8.3%), civil servants four patients (6.7%), priests two patients (3.3%), traders and teachers each one patient (1.7%).

Table 6. Distribution of Type 2 Diabetes Mellitus Patients Based on Low-Density Lipo-protein

LDL	Frequency	Percentage
Normal	12	20.0
Excess	48	80.0
Total	**60**	**100.0**

Table 6 shows the distribution of Low-Density Lipoprotein in type 2 DM patients, with normal values in 12 patients (12%) and excess in 48 patients (80%).

Table 7. Distribution of Type 2 Diabetes Mellitus Patients Based on Triglycerides

Triglycerides	Frequency	Percentage
Normal	32	53.3
Excess	28	46.7
Total	**60**	**100.0**

Table 7 shows the distribution of triglycerides in type 2 DM patients, with normal values in 32 patients (53.3%) and excess in 28 patients (46.7%). Bivariate analysis was used to determine whether there was a correlation between the dependent and independent variables using the chi-square statistical test and the Odds Ratio.

Table 8. Correlation between Body Mass Index and Low-Density Lipoprotein

IMT	*Low-Density Lipoprotein*				Total		*p-value*	OR (95 % CI)
	Normal		Excess					
	N	%	N	%	N	%		
Normal	4	19	17	81	21	100	0.588	0.912
Abnormal	8	20.5	31	79.5	39	100		0.239-3.475
Total	**12**	**20**	**48**	**80**	**60**	**100**		

The table above shows that the p-value >0.05. It shows no significant relationship between Body Mass Index and Low-Density Lipoprotein. Patients with a normal body

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mass index tend to have a normal LDL of 0.912 compared to patients with an abnormal BMI.

Table 9. Correlation between Body Mass Index and Triglycerides

IMT	Triglycerides				Total		*p-value*	OR (95 % CI)
	Normal		Excess					
	N	%	N	%	N	%		
Normal	10	47.6	11	52.4	21	100	0.704	0.702 0.242-2.038
Abnormal	22	56.4	17	43.6	39	100		
Total	**32**	**53.3**	**28**	**46.7**	**60**	**100**		

The table above shows an insignificant relationship between body mass index and triglycerides, with a p-value> 0.05, 0.704. From the odds ratio, it was found that type 2 DM patients with normal BMI tended to have normal triglycerides of 0.702 compared to patients who had abnormal BMI.

Table 10. Spearman Rank Correlation between BMI, LDL, and Triglycerides

Correlation				
		IMT	LDL	Triglycerides
IMT	Correlation Coefficient	1.000	-0.017	-0.084
	Sig. (2-tailed)		0.895	0.523
LDL	Correlation Coefficient	-0.017	1.000	0.217
	Sig. (2-tailed)	0.895		0.096
Triglycerides	Correlation Coefficient	-0.084	0.217	1.000
	Sig. (2-tailed)	0.523	0.096	

The table above shows the p-value between BMI and LDL is 0.895 (> 0.05). It indicates that there is no correlation between BMI and LDL. The correlation coefficient of -0.017 indicates a very weak relationship between BMI and LDL. P-value on BMI and triglycerides showed no correlation with a value of 0.523 (> 0.05). The correlation coefficient between BMI and triglycerides is -0.084, which explains the weak relationship between BMI and triglycerides.

In univariate analysis, type 2 DM patients were dominated by women, following the 2018 National RISKESDAS; there were more type 2 DM patients, with an average of 1,923 cases compared to 1,253 cases of men. The age of Type 2 DM patients at UKI General Hospital occurs mostly between the ages of 65-74 years; this is also in line with Perkeni 2015. The risk of developing type 2 diabetes is higher with age; this is due to a decrease in the function of insulin produced by the pancreas gland with age.

Abnormal body mass index is more common in type 2 DM patients than patients with normal body mass index; this is in line with Umrahwati's literature study regarding the description of body mass index in which type 2 DM patients are most obese (at risk, obesity 1 and obesity 2). Obesity is one of the risks of developing type 2 DM. A person with obesity has twice the risk of developing type 2 DM [24]. In obesity, there is an

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increase in lipids which can cause lipotoxicity. This lipotoxicity condition can interfere with the performance of the pancreas in producing insulin and cause the body to be in a hyperglycemic state in the long term; if left unchecked, it can cause type 26 DM.

Excess LDL levels in type 2 DM patients at UKI General Hospital occurred in 48 more patients than patients with normal LDL levels in 12 patients, while triglyceride levels in this study had more normal levels (32 patients) than those with excess (28 patients). It is in line with the research conducted at Hospital Prof. Dr. R. D. Kandou Manado where in the DM patients they found higher LDL levels than normal and fewer high triglyceride levels than normal [25]. It differs from research that states that the most common feature of dyslipidemia found in type 2 DM is increased triglycerides. [26] In the bivariate analysis of LDL with BMI and triglycerides with BMI, a p-value> 0.05 was obtained; this indicated that there was no significant relationship between LDL and BMI as well as triglycerides and BMI. It is in line with research at Hospital Prof. Dr. R. D. Kandou Manado and research in the coastal area of Kendari city prove that there is no significant relationship between LDL and triglycerides on BMI in type 2 DM patients, but there is a significant relationship between HDL and BMI. [27] This discrepancy could occur due to the neglect of using a lipid lower agent in Type 2 DM patients, thereby affecting the patient's LDL and triglycerides. It is evidenced by research on the independent practice of Hakikiyah doctors in Lampung by including the exclusion criteria of patients using lipid lower agents and finding a significant relationship between BMI and LDL levels. Patients with obesity have a 3,433 times greater risk of having high LDL [27]. Also, in research conducted at RSPAU, Dr. S. Hardjolukit Yogyakarta stated that there was a relationship between BMI and triglyceride levels [28].

Multivariate analysis found a weak relationship between BMI, LDL, and triglycerides. It aligns with research by Choi S and Tan E, which proved no relationship between BMI and the lipid profile of Type 2 DM patients [29]. Compared with waist and abdominal circumference measurements, the relationship between obesity and lipid profile is stronger. However, contrary to research conducted by Biadgo B. et al., where there is no significant relationship between BMI and triglycerides or low-density lipoprotein, there is a significant relationship between waist and hip ratio measurements to BMI [30]. There are limitations in this study due to the use of secondary data, namely medical records, in data collection. The medical records also do not fully record the treatment taken when the patient seeks treatment outside the UKI General Hospital and consumes other than a doctor's prescription. The number of samples used is also a limitation of this study.

Conclusion

Based on the results of a study of type 2 DM patients at UKI General Hospital for the 2018-2021 period, it can be concluded: a) In this study, a total sample of 60 patients with type 2 diabetes mellitus was obtained. Most cases occurred in patients of the female gender, ages between 65-74 years, housewife occupation; b) Body Mass Index Patients with Type 2 DM are mostly overweight (at risk, obesity 1 and obesity 2); c) Low-Density Lipoprotein in type 2 DM patients has more excess than normal; d) There are more triglycerides in type 2 DM patients that are normal than those that are excessive; and e) There is no significant relationship between body mass index and LDL cholesterol and triglyceride levels. Thus, it is hoped that the community can maintain health by not only maintaining body weight but also waist and hip

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circumference and carrying out periodic checks such as measurements, blood glucose, lipid profiles, and others so that the patient's quality of life can be maximized and complications can be prevented.

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