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Correlation Study of Body Mass Index with Blood Pressure, Blood Uric Acid Levels, and Blood Sugar Levels

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ABSTRACT

The increase in the number of people who have an excess body mass index has an important impact on health problems and reduced quality of life. Excessive body mass index has been identified as a trigger factor for hypertension, hyperuria, type 2 diabetes mellitus, and several other types of diseases. The research design used was analytical with a cross sectional approach. The sample in this study was 181 respondents who were selected using purposive sampling. The variables in this study are body mass index, blood pressure, uric acid levels in the blood and blood sugar levels. The data collection instrument used in this research was an observation sheet. The data analysis test was carried out using the Spearman rho rank test. From the results of data analysis using the Spearman Rho rank correlation test, it was found that there was a correlation between body mass index and blood pressure (p value: 0.014 and r: 0.183), there was a correlation between body mass index and uric acid levels in the blood (p value: 0.028 and r: 0.164), and there is a correlation between body mass index and blood sugar levels (p value: 0.005 and r: 0.209). An increase in body mass index experienced by a person will trigger an increase in blood pressure, uric acid levels in the blood and blood sugar levels. Implementing a healthy lifestyle by doing regular physical activity, limiting eating patterns and consuming healthy foods, managing stress and avoiding various factors that trigger an increase in body mass index will help a person to avoid several types of chronic diseases.

Keywords: Body Mass Index; Blood presure; Uric Acid Levels; Blood Sugar Levels

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INTRODUCTION

The national development program in Indonesia adopted from SDGs 2030 is a sustainable development program where the underlying principle is no left behind.[1] This principle of health development firmly states that every community in Indonesia will be involved, either directly or indirectly, and feel the impact of health development. Some of the impacts of the development carried out in Indonesia are the ease of using technology, the use of transportation access and the ease of accessing various types of food.[2] However, on the other hand, the convenience obtained by the community has resulted in Indonesian people being reluctant to do physical activity and preferring to consume fast food, which has resulted in the emergence of a new problem, namely the increase in the incidence of obesity in Indonesia.[3] Obesity is characterized by an increase in body mass index, especially in the abdomen or better known as central obesity. Obesity is a problem in various parts of the world where its prevalence is increasing rapidly, both in developed and developing countries. The increase in obesity throughout the world has an important impact on health problems and reduced quality of life.[4] Obesity has an important contribution to the incidence of hypertension, hyperuricemia, type 2 diabetes mellitus, cancer, osteoarthritis and sleep apnea throughout the world.[5]

The World Health Organization reports that as many as 650 million adults, 340 million teenagers and 39 million children worldwide are obese. The World Health Organization estimates that by 2025, around 167 million adults and children will be unhealthy because of obesity.[6] The 2023 Indonesian Health Survey (SKI), which involved 599,528 residents throughout Indonesia, reported that the number of sufferers of central obesity (abdominal obesity) in Indonesia reached 36.8% of the total number of people involved in survey activities (95% CI 36.6-37.1). For the East Java region, the reported incidence of central obesity was 38.2% of the 94,457 people involved in survey activities (95% CI 37.5-39.0).[7] Obesity is a problem that requires serious attention considering that obesity experienced by a person will trigger various other health problems such as diabetes mellitus, hypertension and hyperuricemia.[8]

The results of a preliminary study conducted by researchers on 15 people in Gayaman Village, Mojokerto Regency, from the results of body mass index measurements, it was found that 4 people had a body mass index above the normal limit / had central obesity, and 11 people had a normal body mass index. From the results of blood pressure measurements, it was found that 2 people had stage 2 hypertension, 3 people had stage 1 hypertension, 4 people had high normal blood pressure, and 6 people had normal blood pressure. From the results of measuring uric acid levels in the blood, it was found that 2 people had hyperuricemia and 13 people had uric acid levels in the normal category. From the results of measuring blood sugar levels (temporary blood sugar levels), it was found that 1 person had diabetes mellitus (blood sugar levels ≥ 200 mg/dL), 5 people had pre-diabetes mellitus (blood sugar levels 140-

199 mg/dL), and 9 people had sugar levels in the normal category.

Body mass index above the normal limit or better known as obesity, is a complex disorder of appetite regulation and energy metabolism which is controlled by specific biological factors. Genetic factors are very influential in the development of this disease. Physiologically, obesity is defined as a condition with abnormal or excessive accumulation of fat in adipose tissue so that it can disrupt health. Obesity is known to be the main factor in various diseases such as coronary heart disease (CHD), ischemic stroke, hypertension, hyperuricemia and type 2 diabetes mellitus (DMT2) which occur in both developed and developing countries.[4] Mechanisms linking obesity and hypertension include dietary factors, metabolic factors, endothelial and vascular dysfunction, sodium retention, glomerular hyperfiltration, proteinuria, maladaptive immune and inflammatory responses. Visceral fat tissue causes resistance to insulin and leptin, and is also a site for changes in the secretion of molecules and hormones such as adiponectin, leptin, resistin, TNF and IL-6, which ultimately results in cardiovascular disease. Gut microbes also play a role in modulating the above mechanisms. Apart from that, uric acid, changes in incretin activity and DP-4 (dipeptidyl peptidase-4) also play a role in the occurrence of hypertension in obesity.[9] In the early phase of obesity, sodium retention occurs as a result of increased renal tubular reabsorption. Extracellular fluid volume increases so that the renal fluid apparatus resets the level of hypertension, consistent with the model of hypertension resulting from excess fluid volume. Plasma renin activity, angiotensionogen, angiotensin II and plasma aldosterone values increase significantly with obesity. Insulin resistance and inflammation alter the profile of vascular function with the consequence of hypertension. Leptin and other neuropeptidases are thought to be the link between obesity and hypertension.[10]

Obesity experienced by a person will also trigger an increase in uric acid levels in the blood or what is known as hyperuricemia. Obesity causes hyperuricemia through increased uric acid production and decreased renal clearance which causes decreased urate excretion by the kidneys with insulin resistance. Various studies have revealed that insulin resistance is inversely proportional to 24-hour urinary uric acid clearance. Therefore, a decrease in uric acid excretion in the kidneys can explain that in humans, the insulin hormone produced by the body can increase renal tubular reabsorption of uric acid.[11]

Apart from hypertension and hyperuricemia, a body mass index above the normal limit also has the potential to trigger an increase in blood sugar levels or better known as diabetes mellitus. In obese sufferers, the diabetes mellitus that is often experienced is type 2 diabetes mellitus. Someone who has a body mass index above the normal limit / obesity, causes the body to experience difficulty in using the insulin produced by the body. Insulin itself is a polypeptide hormone produced in the β cells of the

pancreatic Langerhaens gland. Insulin plays an important role in regulating blood sugar levels (blood sugar levels are maintained at 3.5-8.0 mmol/liter). The insulin hormone produced by the body is also known as endogenous insulin.[12] Obesity is also influenced by physical activity which can control blood sugar levels. Glucose will be converted into energy during physical activity, causing insulin to increase so that blood sugar levels will decrease. Wrong diet, not consuming enough fruit and vegetables, will also trigger obesity. [12]

The condition of excess body mass index with the occurrence of hypertension, hyperuricemia and type 2 diabetes mellitus, is an event that is still frequently encountered.[5] The prevalence of obesity sufferers accompanied by hypertension, hyperuricemia and type 2 diabetes mellitus also continues to increase. According to several studies, obesity and the occurrence of hypertension, hyperuricemia and type 2 diabetes mellitus have a significant relationship. From Jullaman's research explained that if a sufferer has a BMI in the obese category, they will have a 1.64 times risk of suffering from hypertension compared to a normal BMI. Reducing body mass index or losing weight is an effort that can be done by sufferers of hypertension, hyperuricemia and type 2 diabetes mellitus in an effort to control blood pressure, uric acid levels in the blood and blood sugar levels so that they remain in optimal condition and at the same time reduce the risk of occurrence of other diseases.[13] The key to preventing obesity is to act early, ideally before the baby is even conceived. For obesity sufferers, adopting a healthy lifestyle, diligently doing physical activity, and limiting the amount of food consumed are the main keys to preventing weight gain.

METHOD

This research is an analytical observational study with a cross sectional approach. The population in this study was the entire community of Gayaman Village, Mojoanyar District, Mojokerto Regency, totaling 332 residents. The sample in this study was 181 respondents. The sampling technique in this research uses a non-probability sampling method with a purposive sampling approach. The variables in this study are body mass index, blood pressure, uric acid levels in the blood and blood sugar levels. The data collection instrument used in this research was an observation sheet. Data collection is carried out by enumerators. Data analysis was carried out using the Spearman rho rank correlation test with significance α (0.05). If the p value obtained is < significance α (0.05), then the research hypothesis is accepted, which means there is a relationship between body mass index and blood pressure, uric acid levels in the blood, and blood sugar levels in the people of Gayaman Village, Mojoanyar District, Mojokerto Regency. To reduce errors in data analysis, in this study the data was analyzed using the SPSS for Windows application. After the data is analyzed, the research results are presented as a form

of research results using a frequency table. Furthermore, the results of data analysis can be presented in the form of percentages.

RESULTS

1. Age

Table 1. Characteristics of research respondents based on age in Gayaman Village, Mojoanyar District, Mojokerto Regency

Characteristics	Amount (frequency)	Percentage (%)
21-30 years	69	38,1
31-40 years	48	26,5
41-50 years	48	26,5
>50 years	16	8,8
Total	181	100

Source: Research data, 2024

From the research results, it was found that almost half of the research respondents were aged 21-30 years, namely 69 respondents (38.1%) and a small proportion of respondents were >50 years old, namely 16 respondents (8.8%).

2. Gender of respondent

Table 2. Characteristics of research respondents based on gender in Gayaman Village, Mojoanyar District, Mojokerto Regency

Characteristics	Amount (frequency)	Percentage (%)
Man	95	52,5
Women	86	47,5
Total	181	100

Source: Research data, 2024

From the research results, it was found that more than half of the research respondents were men, namely 95 respondents (52.5%), and less than half of the research respondents were women, namely 86 respondents (47.5%).

3. Educational background

Table 3. Characteristics of research respondents based on educational background in Gayaman Village, Mojoanyar District, Mojokerto Regency

Characteristics	Amount (frequency)	Percentage (%)
Graduated from middle school	51	28,2
Graduated from high school	123	68,0
Diploma / Bachelor's degree	7	3,9
Total	181	100

Source: Research data, 2024

From the research results, it was found that the majority of respondents had a high school graduate educational background, namely 123 respondents (68.0%), and a small number of respondents had a diploma/bachelor's educational background, namely 7 respondents (3.9%).

4. Work activities

Table 4. Characteristics of research respondents based on work activities in Gayaman Village, Mojoanyar District, Mojokerto Regency

Characteristics	Amount (frequency)	Percentage (%)
Not working / housewife	38	21,0
Actively working	143	79,0
Total	181	100

Source: Research data, 2024

From the research results, it was found that the majority of respondents were actively working, namely 143 respondents (79.0%), and a small proportion of respondents in the study did not work / were housewives, namely 38 respondents (21.0%).

5. Marital status

Table 5. Characteristics of research respondents based on marital status in Gayaman Village, Mojoanyar District, Mojokerto Regency

Characteristics	Amount (frequency)	Percentage (%)
Marry	172	95,0
Life/death divorce	9	5,0
Total	181	100

Source: Research data, 2024

From the research results, it was found that almost all respondents had a marital status in the married category, namely 172 respondents (95.0%), and a small number of respondents in this study had a marital status in the divorced/dead category, namely 9 respondents (5.0%)

6. Body mass index

Table 6. Body mass index of research respondents in Gayaman Village, Mojoanyar District, Mojokerto Regency

Characteristics	Amount (frequency)	Percentage (%)
Severe overweight (obesity)	46	25,4
Mild excess weight (overweight)	65	35,9
Normal weight	70	38,7
Total	181	100

Source: Research data, 2024

From the research results, it was found that almost half of the research respondents had a body mass index in the normal weight category, namely 65 respondents (38.7%), and a small proportion of research respondents had a body mass index in the severe overweight category, namely 46 respondents (25.4%).

7. Blood pressure

Table 7. Blood pressure of research respondents in Gayaman Village, Mojoanyar District, Mojokerto Regency

Characteristics	Amount (frequency)	Percentage (%)
Grade 2 hypertension	8	4,4
Grade 1 hypertension	34	18,8
Pre-hypertension	68	37,6
Normal	71	39,2
Total	181	100

Source: Research data, 2024

From the research results, it was found that almost half of the research respondents had MAP (mean arterial pressure) blood pressure conditions in the normal category, namely 71 respondents (39.2%), and a small number of research respondents had MAP (mean arterial pressure) blood pressure conditions in the hypertension category. level 2 (mild hypertension), namely 8 respondents (4.4%).

8. Uric acid levels in the blood

Table 8. Uric acid levels in the blood of research respondents in Gayaman Village, Mojoanyar District, Mojokerto Regency

Characteristics	Amount (frequency)	Percentage (%)
Hyperuricemia	27	14,9
Normal	154	85,1
Total	181	100

Source: Research data, 2024

From the research results, it was found that the majority of research respondents had uric acid levels in the blood in the normal category, namely 154 respondents (85.1%), and a small number of respondents in the study had uric acid levels in the blood in the hyperuricemia category, namely 27 respondents (85,1%)

9. Blood sugar levels

Table 9. Blood sugar levels in research respondents in Gayaman Village, Mojoanyar District, Mojokerto Regency

Characteristics	Amount (frequency)	Percentage (%)
Diabetes mellitus (> 200 mg/dL)	32	17,7
Normal (≤ 200 mg/dL)	149	82,3
Total	181	100

Source: Research data, 2024

From the research results, it was found that the majority of research respondents had blood sugar levels in the normal category (≤ 200 mg/dL), namely 149 respondents (82.3%), and a small

number of research respondents had blood sugar levels in the diabetes mellitus category (> 200 mg/dL) namely 32 respondents (17.7%)

10. The relationship between body mass index and blood pressure

Table 10. The relationship between body mass index and blood pressure in Gayaman Village, Mojoanyar District, Mojokerto Regency

Body mass index	Blood pressure				Total
	Grade 2 hypertension	Grade 1 hypertension	Pre-hypertension	Normal	
Severe overweight (obesity)	5 (2,8%)	14 (30,4%)	16 (34,8%)	11 (23,9%)	46 (100%)
Mild excess weight (overweight)	3 (4,6%)	5 (7,7%)	28 (43,1%)	29 (44,6%)	65 (100%)
Normal weight	0 (0,0%)	15 (21,4%)	24 (34,3%)	31 (44,3%)	70 (100%)
Total	8 (4,4%)	34 (18,8%)	68 (37,6%)	71 (39,2%)	181 (100%)
Correlation coefficient			0,183		
Sig (2-tailed)			0,014		

Source: Research data, 2024

From the results of data analysis, it was found that for research respondents who had a body mass index in the severe overweight (obesity) category, almost half of them had blood pressure in the pre-hypertension category, namely 16 respondents (34.8%), for research respondents who had an index body mass in the mildly overweight category, almost half had blood pressure in the normal category, namely 29 respondents (44.6%), and for research respondents who had a body mass index in the appropriate weight category, almost half had blood pressure blood in the normal category, namely 31 respondents (44.3%).

From the results of data analysis using the Spearman Rho rank correlation test, the correlation coefficient value was 0.183 and the p value was 0.014. Because the p value obtained is < significance α (0.05), it can be concluded that there is a correlation between body mass index and blood pressure.

11. The relationship between body mass index and uric acid levels in the blood

Table 11. The relationship between body mass index and uric acid levels in the blood in Gayaman Village, Mojoanyar District, Mojokerto Regency

Body mass index	Uric acid levels in the blood		Total
	Hiperurisemia	Normal	
Severe overweight (obesity)	12 (26,1%)	34 (73,9%)	46 (100%)
Mild excess weight (overweight)	8 (12,3%)	57 (87,7%)	65 (100%)
Normal weight	7 (10,0%)	63 (90,0%)	70 (100%)
Total	27 (14,9%)	154 (85,1%)	181 (100%)
Correlation coefficient	0,164		
Sig (2-tailed)	0,028		

Source: Research data, 2024

From the results of data analysis, it was found that for research respondents who had a body mass index in the severe overweight category (obesity), the majority had uric acid levels in the blood in the normal category, namely 34 respondents (73.9%), for research respondents who had a body mass index in the mildly overweight category, the majority had uric acid levels in the blood in the normal category, namely 57 respondents (87.7%), and for research respondents who had a body mass index in the appropriate weight category , the majority had uric acid levels in the blood in the normal category, namely 63 respondents (90.0%).

From the results of data analysis using the Spearman Rho rank correlation test, the correlation coefficient value was 0.164 and the p value was 0.028. Because the p value obtained is < significance α (0.05), it can be concluded that there is a correlation between body mass index and uric acid levels in the blood.

12. The relationship between body mass index and blood sugar level

Table 12. The relationship between body mass index and blood sugar levels in Gayaman Village, Mojoanyar District, Mojokerto Regency

Body mass index	Blood sugar level		Total
	Diabetes mellitus	Normal	
Severe overweight (obesity)	18 (39,1)	28 (60,9%)	46 (100%)
Mild excess weight (overweight)	4 (6,2%)	61 (93,8%)	65 (100%)
Normal weight	10 (14,3%)	60 (85,7%)	70 (100%)
Total	32 (17,7%)	149 (82,3%)	181 (100%)
Correlation coefficient	0,209		
Sig (2-tailed)	0,005		

Source: Research data, 2024

From the results of data analysis, it was found that for research respondents who had a body mass index in the severe overweight category (obesity), the majority had blood sugar levels in the normal category, namely 28 respondents (60.9%), for research respondents who had body mass index in the mildly overweight category, almost all of them had blood sugar levels in the normal category, namely 61 respondents (93.8%), and for research respondents who had a body mass index in the appropriate weight category, some The majority had blood sugar levels in the normal category, namely 60 respondents (85.7%).

From the results of data analysis using the Spearman Rho rank correlation test, the correlation coefficient value was 0.209 and the p value was 0.005. Because the p value obtained is < significance α (0.05), it can be concluded that there is a correlation between body mass index and blood sugar levels.

DISCUSSION

1. The relationship between body mass index and blood pressure

From the results of data analysis, it was found that for research respondents who had a body mass index in the severe overweight (obesity) category, almost half of them had blood pressure in the pre-hypertension category, namely 16 respondents (34.8%), for research respondents who had an index body mass in the mildly overweight category, almost half had blood pressure in the normal category, namely 29 respondents (44.6%), and for research respondents who had a body mass index in the appropriate weight category, almost half had blood pressure blood in the normal category, namely 31 respondents (44.3%). From the results of data analysis using the Spearman Rho rank correlation test, the correlation coefficient value was 0.183 and the p value was 0.014. Because the p value obtained is < significance α (0.05), it can be concluded that there is a correlation between body mass index and blood pressure.

The results of this study are similar to research conducted by Yhuwono where the results of the research conducted show that there is a positive correlation between body mass index and blood pressure with a significance value obtained of 0.029 with a correlation coefficient of 0.154.[14] The results of this research are also supported by research conducted Abineno & Malinti where from the results of research conducted between body mass index and the incidence of hypertension, a significance value of 0.039 was obtained with a correlation coefficient of 0.197, so it can be concluded that there is a positive relationship between body mass index and the incidence of hypertension in adults.[15]

Excessive body mass index can be a contributing factor to various diseases, one of which is hypertension. The Framingham Study found a 15% increase in body weight could result in an 18% increase in systolic pressure. People who are overweight in the overweight category with a 20% increase in body weight have an eight-fold greater risk of developing hypertension.[16] According to Susanto, body mass index has a major impact on the incidence of hypertension, and excessive body mass index is associated with higher risk factors for hypertension compared to body mass index in the normal range.[17] According to the American Society of Hypertension (ASH), normal blood pressure is systolic blood pressure < 120 mmHg and diastolic blood pressure < 80 mmHg.[18] According to Anggraini, hypertension is an important risk factor for non-communicable diseases that can cause death if not treated properly, and one third of the world's population has this disease.[19]

In individuals who have an excess body mass index, there will be an increase in the heart's work to pump blood. The greater the body mass, the more blood supply is needed to supply oxygen and nutrients to body tissues. This causes the volume of blood circulating through the blood vessels to increase, so that the pressure on the artery walls becomes greater. The role of body mass index level in high blood pressure is also due to the stimulation of the activity of the sympathetic nervous system and the Renin Angiotensin Aldosterone System (RAAS) by mediators such as hormones, adipokines, cytokines, etc. One of them is the hormone aldosterone which is closely related to water and sodium retention so that blood volume increases. An increase in blood volume that is not balanced by the elasticity of blood vessels due to various factors, one of which is the aging process, makes a person more susceptible to hypertension.

Excessive accumulation of fat in the body can trigger heart disease and hypertension. The mechanism by which excess body mass index can result in hypertension is associated with hyperinsulinemia and damage to blood vessel structures. In obese sufferers (body mass index above the normal limit), the fat in the body as a result of the accumulation of calories that are not absorbed optimally, will gather in the form of visceral fat which accumulates in several parts of the body such as the abdomen. If the amount of visceral fat is excessive and there is a decrease in leptin sensitivity, as well as the presence of cytokines that infiltrate fat tissue, there will be an increase in intracellular free fatty acids which can lead to hyperinsulinemia and insulin resistance. When insulin resistance occurs, there is a decrease in nitric oxide, resulting in vascular vasodilation, decreased salt sensitivity, and an increase in plasma volume which together will result in increased blood pressure or hypertension.

Excessive fat intake will cause an increase in free fatty acids in the body. An increase in free fatty acids can increase blood levels of Low Density Lipoprotein (LDL), which can trigger

atherosclerosis which can cause blockages in blood vessels and cause hypertension. Indonesian Ministry of Health states that consuming excessive amounts of food sources of fat can increase the risk of hypertension, this shows that moderate consumption of fat can help reduce the risk of hypertension. Reducing the amount of fat consumed, or reducing the amount of calorie intake that enters the body can help reduce an individual's blood pressure.[20]

Implementing a healthy lifestyle such as consuming healthy food according to the diet that fills my plate, getting enough rest, managing stress, actively exercising and avoiding fizzy drinks are forms of efforts to control body weight. When the body has an ideal body weight, individuals will be able to carry out various positive activities that can support their lives and at the same time be able to enjoy life without having to be confused by the emergence of various health problems.

2. The relationship between body mass index and uric acid levels in the blood

From the results of data analysis, it was found that for research respondents who had a body mass index in the severe overweight category (obesity), the majority had uric acid levels in the blood in the normal category, namely 34 respondents (73.9%), for research respondents who had a body mass index in the mildly overweight category, the majority had uric acid levels in the blood in the normal category, namely 57 respondents (87.7%), and for research respondents who had a body mass index in the appropriate weight category , the majority had uric acid levels in the blood in the normal category, namely 63 respondents (90.0%). From the results of data analysis using the Spearman Rho rank correlation test, the correlation coefficient value was 0.164 and the p value was 0.028. Because the p value obtained is < significance α (0.05), it can be concluded that there is a correlation between body mass index and uric acid levels in the blood.

The results of this study are similar to research conducted by Leokuna & Malinti.[21] The results of the analysis carried out on data on body mass index and uric acid levels obtained a p value of 0.001 and a correlation coefficient of 0.398, where these results explain that body mass index has an influence on uric acid levels in the blood, where the higher the body mass index value, the higher the level of uric acid. Uric acid will also increase. Research conducted by Mao et alto test the relationship between body mass index and uric acid levels, it showed that there was a positive correlation between body mass index and uric acid levels in the blood (β = 0.06, 95% CI: 0.05, 0.06). When the body mass index increases, the urate levels in the blood also increase significantly with a positive correlation.[22]

Pathophysiologically, individuals with a body mass index above the normal limit (obesity) indicate an imbalance between calorie intake and energy expenditure. This condition results in excessive accumulation of abdominal and visceral fat. This increased adiposity contributes to an

overall increase in nucleic acid metabolism, which in turn promotes uric acid synthesis via purine metabolism. In addition, a body mass index above the normal limit (obesity) can cause glomerular hemodynamic abnormalities and trigger excessive activation of the renin-angiotensin-aldosterone system, which has the potential to cause obesity-related nephropathy. Prolonged exposure to these effects can cause glomerular atherosclerosis, which ultimately reduces renal excretion of uric acid. Insulin resistance, which is a common consequence of having a body mass index above the normal limit (obesity), will further complicate the metabolism of uric acid in the blood by affecting the excretion of uric acid in the blood through the kidneys. Additionally, certain adipocytokines associated with obesity, such as adiponectin and leptin, have been reported to correlate with the development of hyperuricemia.

Uric acid is the end product of purine catabolism. Uric acid is synthesized primarily in the liver, in a reaction catalyzed by the enzyme Xanthine oxidase. Humans do not have the peroxisome enzyme uricase (urate oxidase), which plays a role in breaking down uric acid into allantoin, so that the uric acid formed will be excreted through the urinary tract in the form of urine. An increase in uric acid levels beyond normal levels is called hyperuricemia. Hyperuricemia can cause the accumulation of uric acid crystals. If accumulation occurs in the kidneys, uric acid can cause damage to the kidneys. In the early stages of kidney disease it does not cause any symptoms. However, as hyperuricemia continues to occur, further kidney damage will occur.

An increase in uric acid levels can be caused by decreased renal excretion, increased formation, and increased intake of uric acid. Kidney disease can affect uric acid excretion, while certain enzyme disorders can cause increased uric acid levels. Apart from abnormalities in metabolic processes in the body, lifestyle factors including high purine consumption, alcohol consumption and obesity are associated with gout which is characterized by hyperuricemia. One expert stated that obesity may be an inflammatory condition. The spread of fatty tissue leads to increased production of proinflammatory molecules and results in low-grade inflammation. Studies in mice and humans prove that nutrient ingestion can acutely trigger an inflammatory response; So, it is thought that the initial signal of inflammation is excessive food consumption and the pathway begins in fat tissue, liver and muscle, until it finally triggers an inflammatory response. Fat tissue produces pro-inflammatory cytokines, called adipocytokines, which irreversibly convert endothelial Xanthine dehydrogenase to its active form, xanthine oxidase. Xanthine oxidase ultimately converts xanthine into uric acid.

Obesity is associated with an increased risk of osteoarthritis and gout. This is thought to be due to increased leptin levels in obese sufferers. Leptin is a substance that functions to regulate the

concentration of uric acid in the blood so that increasing leptin levels will trigger hyperuricemia.[23] Hyperuricemia can be caused by increased consumption of foods high in purine and disturbances in uric acid excretion. One condition that can affect the uric acid excretion process is insulin resistance. Low physical activity and increased calorie consumption result in obesity, increased free fatty acids in plasma, insulin sensitivity and insulin resistance.[24] Obesity is associated with increased uric acid levels because renal excretion tends to be low. Obesity sufferers cause hyperuricemia through increased uric acid production and decreased renal clearance which causes a decrease in urate excretion by the kidneys with insulin resistance.[25] According to Niu et al, obese sufferers have insulin resistance which is characterized by hyperinsulinemia. Hyperinsulinemia causes tubular sodium-hydrogen exchange which results in decreased reabsorption of uric acid by the kidneys, resulting in hyperuricemia.[26]

Many factors can influence an increase in uric acid levels, one of which is a body mass index above the normal limit. However, this often cannot be explained scientifically because this condition does not apply to all ages and cultures and lifestyles. Consuming foods high in purine can be one of the causes of hyperuricemia in individuals with an excess body mass index. Someone who frequently consumes foods high in purine ≥ 3-4 times/week will often experience hyperuricemia. Likewise with gender. In women, hyperuricemia is often complained of as a health problem compared to men, especially when women have entered menopause. The variety of factors that influence uric acid levels in the blood means that individuals must actively pay attention to their diet and physical activity patterns. Controlling diet by implementing a healthy lifestyle will help individuals control uric acid levels in the blood. Apart from that, diligently carrying out physical activities such as regular exercise will help the body to secrete uric acid to form energy so that uric acid levels in the blood are always under control.

3. The relationship between body mass index and blood sugar levels

From the results of data analysis, it was found that for research respondents who had a body mass index in the severe overweight category (obesity), the majority had blood sugar levels in the normal category, namely 28 respondents (60.9%), for research respondents who had body mass index in the mildly overweight category, almost all of them had blood sugar levels in the normal category, namely 61 respondents (93.8%), and for research respondents who had a body mass index in the appropriate weight category, some The majority had blood sugar levels in the normal category, namely 60 respondents (85.7%). From the results of data analysis using the Spearman Rho rank correlation test, the correlation coefficient value was 0.209 and the p value was 0.005.

Because the p value obtained is < significance α (0.05), it can be concluded that there is a correlation between body mass index and blood sugar levels.

The results of this study are similar to research conducted by Pratiwi, regarding the relationship between body mass index (BMI) and fasting blood sugar levels in type II diabetes mellitus sufferers in the Regional Technical Services Unit (UPTD) Work Area of Community Health Center I, West Denpasar District Health Service. From the results of research data analysis, it was found that the p value was 0.000 < α (0.05), where this result shows that there is a relationship between body mass index (BMI) and fasting blood sugar levels in people with type II diabetes mellitus in the UPTD Puskesmas I Work Area of the Health Service West Denpasar District.[27] The results of the Spearman rank test also obtained a correlation coefficient value of 0.792, so it can be interpreted that there is a strong relationship between body mass index and fasting blood sugar levels. The correlation coefficient value, when squared, is 79.2, which means that BMI contributes 79.2% to fasting blood sugar levels in people with type II diabetes mellitus, while the rest is influenced by other factors that were not studied. The results of this research are also supported by research conducted by Harahap et al where from the results of data analysis it was found that the p value was 0.000 < α (0.05) and the correlation coefficient was 0.925. This research concludes that there is a significant relationship between body mass index and blood sugar levels. Excessive body mass index is a risk factor for increasing blood sugar levels.[28]

In the digestive tract, food is broken down into the basic ingredients of the food itself. Carbohydrates become glucose, proteins become amino acids, and fats become fatty acids. These three food substances will be absorbed by the intestines, then enter the blood vessels and circulate throughout the body to be used by the organs as fuel. In order to function as fuel, in cells food substances, especially glucose, must be metabolized first. In this metabolic process, the hormone insulin plays an important role, namely entering glucose into cells, where it can then be used as fuel. Under normal conditions, this means that insulin levels are sufficient and sensitive, insulin will be captured by the insulin receptors on the surface of the cells, then open the cell entrance, so that glucose can enter the cells and then be burned into energy. The amount of glucose used for metabolic processes will determine the final amount of glucose in the body. The higher the amount of glucose used for absorption of the food consumed, the final glucose level will decrease, the impact of which is a decrease in glucose levels in the body.

This condition will be different in individuals who have an excess body mass index. In individuals with excess body mass index, there was an increase in Lipopolysaccharides (LPS)-induced TNF-α factor (LITAF) mRNA and protein levels along with an increase in body mass

index indicating a parallel relationship between LITAF (Lipopolysaccharide-induced tumor necrosis factor-alpha factor) and metabolic disorders. LITAF is activated in obese patients and plays a role in the development of obesity which induces inflammation and insulin resistance, based on the fact that LITAF plays a role in the inflammatory process in regulating the expression of TNF-α, IL-6 and MCP-1 which results in insulin resistance, and TLR4. One of the LITAF receptors on macrophages can also be stimulated by free fatty acids which can cause an inflammatory process in individuals who have an excess body mass index. LITAF is a transcriptional regulator of TNF-α which should play a role in the immune mechanism against infection. The LITAF gene is located at 16p13.13 which is significantly found in spleen, lymph nodes and peripheral blood leukocytes. TNF-α is a potent inducer of pro inflammatory adipocytokinins such as IL-6, MCP1, leptin and PAI-1. It is highly involved in the inflammatory process in individuals who have an excess body mass index. The increase in TNF-α observed in the fat tissue of obese patients shows a direct relationship to the emergence of insulin resistance in individuals who have an excess body mass index. The occurrence of insulin resistance causes glucose circulating in the blood to be unable to enter the cells, so that blood sugar levels become higher than normal.

Obesity, which is characterized by an excess body mass index, is a predisposing factor for increased blood sugar levels. This is because some of the beta cells of the islets of Langerhans become less sensitive to stimulation or due to increased sugar levels and excessive body mass index which will also suppress the number of insulin receptors on cells in the body. Fat metabolism depends on energy requirements and is regulated by food as well as nervous and hormonal signals. For example, a decrease in glucose levels when used as energy by tissues such as muscles, liver and kidneys. The shift in metabolism from carbohydrate-based to fat-based is caused by a reduction in insulin and an increase in several hormones such as epinephrine, growth hormone and corticosteroids. On the other hand, the post pradial influx of fatty acids into adipose and lipogenesis increases. Increased glucose and fat will result in fatty acid transport into adipose and increased lipogenesis. This increase is under the influence of insulin. Partial oxidation of fatty acids produces ketones which are an alternative fuel source for the brain and various organs. Currently, fat tissue is known not only as a storage place for energy reserves but as a dynamic tissue with various functions. Absence of fat tissue causes hyperlipidemia, insulin resistance, and type II diabetes mellitus. Excess fat tissue (obesity), a condition increasingly common in modern society, is also associated with insulin resistance and diabetes.[29]

Excessive body mass index often triggers insulin resistance, which is a condition when the ability of the insulin hormone to reduce blood glucose levels by suppressing hepatic glucose

production and stimulating glucose utilization in skeletal muscle and adipose tissue decreases, all of this makes the pancreas continuously produce insulin, which then results in injury. insulin, the body is unable to produce insulin as needed. This condition makes sugar production in the liver uncontrolled so that blood sugar levels increase. Christine & Elon suggests that an increase in fatty acids, an increase in the hormone resistin and a decrease in adiponectin due to fat accumulation in obese sufferers affects insulin work so that it can cause high blood glucose levels.[30] According to Bakri et al, insulin resistance causes decreased glucose uptake by muscle and fat tissue and the inability of the hormone to suppress hepatic gluconeogenesis. Obesity, especially, is directly related to insulin levels. Beta cell dysfunction in type II diabetes mellitus reflects the inability of these cells to adapt to the long-term demands of peripheral insulin resistance and increased insulin secretion.[29]

According to researchers, obesity is associated with increased blood sugar levels because fat accumulation in the stomach of people who suffer from central obesity causes insulin resistance, which is a condition where the ability of the insulin hormone to lower blood glucose levels by suppressing hepatic glucose production and stimulating glucose utilization in skeletal muscle and tissue. adipose decreases, this makes the pancreas continuously produce insulin, which then results in insulin injury, the body is unable to produce insulin as needed. This condition makes sugar production in the liver uncontrolled so that blood sugar levels rise. If not controlled, this can develop into diabetes mellitus.

Controlling blood sugar levels so that they remain in optimal condition is a real effort that individuals can make to maintain their health condition. Doing physical activities such as cleaning the house, walking or doing regular exercise will help to control blood sugar levels. Limiting the intake of food consumed, reducing consumption of sweet foods and drinks, especially ready-to-drink drinks, will help individuals control blood sugar levels. Excessive blood sugar levels will cause a person to experience prediabetes. If this condition is not treated seriously, prediabetes will develop into diabetes mellitus and in the end the individual will have to live side by side with diabetes mellitus for the rest of his life

CONCLUSION

From the results of data analysis using the Spearman Rho rank correlation test, the correlation coefficient value was 0.164 and the p value was 0.028, so it was concluded that there was a correlation between body mass index and uric acid levels in the blood.

From the results of data analysis using the Spearman Rho rank correlation test, the correlation coefficient value was 0.209 and the p value was 0.005, so it was concluded that there is a correlation between body mass index and blood sugar levels

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