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Associated between hypertension and body mass index, cholesterol, and blood sugar levels in elderly women

Hubungan antara hipertensi dan indeks masa tubuh, kolestrol, dan tingkat gula darah pada perempuan lansia

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Abstract

Hypertension is a major public health problem in Indonesia, with the highest number of elderly female patients. This study aimed to assess the relationship between BMI, cholesterol, and blood sugar levels, and systolic and diastolic blood pressure in elderly women. An observational study was conducted using a cross-sectional design, in which 330 women in West Aceh District aged 60 years or older were included. Data were analyzed using simple linear regression and multiple linear regression tests to determine the relationship between independent variables (systolic and diastolic blood pressure) and dependent variables (BMI, cholesterol, and blood sugar levels). The results showed that the correlation between BMI, cholesterol, and blood sugar levels and systolic blood pressure was weak ($r \leq 0.25$). The BMI with diastolic blood pressure was moderate (r=0.272). Conversely, the correlation between cholesterol and blood sugar levels and diastolic blood pressure was weak ($r \leq 0.25$). Multivariate analysis showed that BMI ($p<0.001$), cholesterol ($p<0.001$), and blood sugar levels ($p \leq 0.013$) were significantly associated with systolic blood pressure. Furthermore, diastolic blood pressure was significantly associated with BMI ($p <0.001$). In conclusion, BMI is associated with systolic and diastolic blood pressure, while cholesterol and blood sugar levels only contribute to systolic blood pressure but not diastolic blood pressure.

Keywords: Elderly, blood pressure, blood glucose, BMI, cholesterol

Abstrak

Hipertensi merupakan masalah utama kesehatan masyarakat, termasuk di Indonesia, dengan penderita tertinggi pada kelompok wanita lansia. Penelitian bertujuan untuk menilai hubungan antara IMT, kolesterol dan kadar gula darah dengan tekanan darah sistolik dan diastolik pada lansia wanita. Penelitian observasional telah dilakukan menggunakan rancangan potong lintang, dimana 330 wanita di Kabupaten Aceh Barat yang usia 60 tahun atau lebih dilibatkan sebagai sampel. Analisis data menggunakan uji regresi linier sederhana dan regresi linier berganda untuk mengetahui hubungan antara variabel bebas (tekanan darah sistolik dan diastolik) dengan variabel terikat (IMT, kolesterol, dan kadar gula darah). Hasil menunjukkan korelasi IMT, kolesterol, dan kadar gula darah dengan tekanan darah sistolik bersifat lemah yang ditunjukkan dengan nilai r di bawah 0,25. Sedangkan IMT dengan tekanan darah diastolik adalah sedang (r=0,272). Sebaliknya korelasi kadar kolesterol dan gula darah dengan tekanan darah diastolik lemah (r= <0,25). Hasil analisis multivariate diketahui bahwa IMT (p<0,001), kolesterol (p<0,001) dan kadar gula darah (p<=0,013) berhubungan secara signifikan dengan tekanan darah sistolik. Selanjutnya, tekanan darah diastolik hanya berkaitan secara signifikan dengan IMT (p<0,001).

Kesimpulan, IMT memiliki hubungan terhadap tekanan darah sistolk dan diastolik, sedangkan kolesterol dan kadar gula darah hanya berkontribusi terhadap tekanan darah sistolik, namun tidak dengan tekanan darah diastolik.

Kata Kunci: Lansia, gula darah, IMT, kolestrol, tekanan darah

Introduction

Hypertension remains a significant public health problem worldwide, including Indonesia (Debora et al., 2023). It is dubbed a silent killer, and this expression is quite reasonable since it is estimated that approximately 46% of adults with hypertension are unaware of their condition. Hypertension affects many adults and older adults (WHO 2023). Furthermore, the World Health Organization (WHO) adds that approximately 1.28 billion hypertensive patients are aged 30-79 years old worldwide. Two-thirds live in low and middle-income countries (WHO, 2023).

In Indonesia, the Basic Health Research (Riskesdas) in 2018 showed that the prevalence of hypertension was 19,30% in the age group 55-65, 24,53% in the age group 65-74, and 25,26% in the 75 years and older age group. Furthermore, the prevalence of hypertension is higher in female (11,57%) than in male (6,07%) (Badan Penelitian and Pengembangan Kesehatan, 2019). These results indicate that the older a person, the higher the risk of developing hypertension. Based on sex differences, women have a greater potential to develop hypertension than men (Hanif et al., 2021).

Hypertension is considered one of the leading causes of premature death worldwide (WHO, 2023). In America, it is estimated that more than 692,095 deaths in 2021 will be due to hypertension. The most feared aspect of hypertension is its potential impact on the three principal organs of the human body: heart, brain, and kidney. Other health problems attributed to hypertension include stroke, dementia, and cardiovascular disease (Bosu et al., 2019). Guyton explained that increased cardiac output in hypertension is recognized as a cause of heart diseases, such as heart failure and coronary heart disease. Hypertension can also cause the blood vessels in the brain to burst, leading to stroke. It can also cause damage to blood vessels in the kidneys, leading to kidney failure (Ohishi et al., 2023).

Several studies have reported an association between hypertension and its various contributing factors. Anwar et al. (2019) found a relationship between hypertension and spirituality, physical activity, and sleep duration. Previous studies have also shown a relationship between hypertension, BMI, and blood sugar levels (Ferrannini & Cushman, 2012; Kuwabara et al., 2019).

The number of hypertension cases in West Aceh is quite high every year. Based on the Profil Kesehatan Kabupaten Aceh Barat, the number of hypertension sufferers in 2021 is 53,704 people and in 2022 it is 38,971 people (Dinas Kesehatan Kabupaten Aceh Barat, 2024). There may have been a spike in the incidence of hypertension.

Research on the correlation between hypertension (systolic and diastolic blood pressure) and body mass index, cholesterol, and blood sugar levels in older individuals is important because it is related to diet patterns and physical activity. The influence of the dependent variable on the risk of hypertension was determined. This is based on a previous finding of a higher prevalence of hypertension in elderly women, as reported by Riskesdas. Therefore, this study aimed to assess the relationship between BMI, cholesterol, and blood sugar levels as well as systolic and diastolic blood pressure in elderly women.

Methods

This was an observational study using a cross-sectional design, in which both independent and dependent variables were measured simultaneously for each study subject. All procedures involving Humans as Research Subjects were performed with the approval of the Aisyiyah University Bandung Research Committee, Bandung, Indonesia (Approval Number. 621/KEP.01/UNISA-BANDUNG/VII/2023).

The study population and sample comprised of women aged 60 years. The inclusion criteria were good communication skills, hearing ability, and willingness to participate. The exclusion criteria were those receiving healthcare services, those who were critically ill, and those who

requested to stop participating in the data collection process. The sample size was calculated using the following formula:

$$n = \frac{Z^2 p (1-p)}{d^2}$$

Based on the results of Riskesdas (2018), the prevalence of hypertension in Indonesian women was 11,6% (p = 0,116). The margin of error is 0,035. The calculation results showed that the minimum required sample size was 322 women, and the sample size taken in the study was 330 women. The subject area of this study encompasses the assessment of hypertension prevalence among women in Aceh Barat, with a focus on understanding the relationship between systolic and diastolic blood pressure, body mass index (BMI), cholesterol levels, and blood sugar levels. This study aimed to investigate the prevalence of hypertension in this demographic and to explore the association between blood pressure and other cardiovascular risk factors. This study sought to provide insights into the epidemiology and risk factors of hypertension among women in Aceh Barat by utilizing digital blood pressure monitors and measuring instruments for body mass index (BMI), cholesterol, and blood sugar levels.

This study assessed two independent variables (systolic and diastolic blood pressure) and three dependent variables (BMI, cholesterol level, and blood sugar level). Systolic and diastolic blood pressure were measured as independent variables using a digital blood pressure monitor (OMRON HEM-8712). Blood pressure was measured twice with a 1-2 minute interval on the left arm while sitting. A third measurement was taken if there was a difference of >10 mm Hg between the first and second measurements. The third blood pressure measurement was performed after resting for 10 minutes and removing the cuff from the arm (Kemenkes, 2019[a]). Blood pressure was classified as normal (systolic <120 mmHg and diastolic <80 mmHg) or pre-hypertensive (systolic 120-139 mmHg and diastolic 80-89). Next, hypertension stage 1 (systolic 140-159 mmHg and diastolic 90-100 mmHg) and hypertension stage 2 (systolic ≥160 mmHg and diastolic >100 mmHg) were considered.

Body mass index (BMI) was measured by comparing the height and weight of the participants. The Instrument used to measure height was a meter that measured the size of the participants in an upright standing position with their backs against the wall.

Weight was assessed using a Bioimpedance Analysis (BIA) Karada Scan Body Composition Monitor (HBF-375 OMRON, Japan). BMI classification refers to the values recommended by the WHO, including underweight (<18,5), normal weight (18,5-22,9), overweight (23,0-24,9), obesity 1 (25,0-29,9), and obesity 2 (≥30) (Kemenkes, 2018).

Cholesterol and blood sugar levels were measured using an Easy Touch GCU 3-in-1. Assessment was performed by collecting blood from the middle or index finger using a strike. The time required to obtain cholesterol results was 30 s, whereas that for blood sugar levels was 10 s. Cholesterol results were categorized into three classes: average (<200 mg/dL), slightly high (200-239 mg/dL), and high (>240 mg/dL) (Kemenkes, 2019[b]). Blood sugar levels were classified into two groups: average (<200 mg/dL) and above-normal (≥ 200 mg/dL) (Kemenkes, 2020).

Correlation and simple linear regression tests were performed to determine the relationships between the two variables. Multivariate analysis was performed using multiple linear regression.

Result and Discussion

The presentation of demographic characteristics (Table 1) shows that the average age of respondents was 69,28± 8,608 years, and based on categorization, the majority of respondents fell in the 60-69 age group (58,5%). More respondents were educated (59,0%), unemployed (72,4%), and had no income (49,7%). The average BMI of the respondents was 23,60±4,79%, and based on categorization, more respondents had a normal BMI (49,7%). The intermediate cholesterol level was 228,50±49,62, and more respondents had above-normal cholesterol levels (74,9%). The blood glucose level score was 143,86±81,42, and more respondents had a standard blood glucose level score (87,6%).

Meanwhile, the moderate systolic blood pressure was 145,50 (SD= 20,65), and most of the respondents had stage I hypertension (34,23%). For diastolic blood pressure, the average pressure was 84,55 (SD= 11,39), and

more respondents had normal and prehypertensive blood pressure (34,8%).

Table 1. Demographic characteristics, BMI, body fat, cholesterol, blood sugar levels, and systolic blood pressure (n=330).

Characteristic	n	%	Mean	SD
Age			69,28	8,608
60-69 years old	193	58,5		
≥ 70 years old	137	41,5		
Education				
Non school	162	49,1		
School	186	59,0		
Job				
Not working	239	72,4		
Working	91	27,6		
Income		334030,3		629710,5
No income	164	49,7		
IDR <1,000,000,-	120	36,4		
IDR 1,000,000,- s,d <2,000,000,-	35	10,6		
IDR ≥2,000,000,-	11	3,3		
BMI		23,60		4,79
Underweight	46	13,9		
Normal	106	32,1		
Overweight	55	16,7		
Obesity I	96	29,1		
Obesity II	27	8,2		
Cholesterol		228,50		49,62
Normal	83	25,1		
Slightly high	118	35,8		
High	129	39,1		
Blood sugar level		143,86		81,42
Normal	289	87,6		
High	41	12,4		
Systolic blood pressure		145,50		20,65
Normal	26	7,6		
Pre Hipertension	111	33,6		
Hipertension I	113	34,2		
Hipertension II	80	24,2		
Diastolic blood pressure		84,55		11,93
Normal	115	34,8		
Pre Hipertension	115	34,8		
Hipertension I	66	20,0		
Hipertension II	34	10,3		

Table 2. Correlation and simple regression analyses.

	Systolic Blood Pressure			Diastolic Blood Pressure		
Variables	R	R^2	p-value	R	R^2	p-value
BMI	0,212	0,045	<0,001*	0,272	0,074	<0,001*
Cholesterol	0,234	0,055	<0,001*	0,109	0,012	0,048
Blood sugar level	0,176	0,031	0,001*	0,143	0,020	0,010

Abbreviations: R^2= R square, * = significant p-value

The results of the simple correlation and regression tests (Table 2) showed that BMI, cholesterol, and blood sugar levels were related to systolic blood pressure (p<0,001; p<0,001;

p=0,001). The relationships between BMI, cholesterol, blood sugar levels, and systolic blood pressure were weak, as indicated by r values of < 0,25. Bivariate test results also showed a relationship between BMI, cholesterol, and blood sugar levels, and diastolic blood pressure (p<0,001, p=0,048, and p=0,010, respectively). Based on this, it is known that the relationship between BMI and diastolic blood pressure is moderate (r=0,272), in contrast, the relationships between cholesterol and blood sugar levels and diastolic blood pressure are weak, with r values < 0,25.

Table 3. Results of multiple linear regression tests

	Systolic Blood Pressure					Diastolic Blood Pressure				
Variabel	R^2	B	SE	T	*P value*	R^2	B	SE	T	p-value
BMI		0,797	0,227	3,507	0,001*	0,074	0,676	0,132	5,112	<0,001*
Kolesterol	0,112	0,090	0,022	4,115	<0,001*		0,022	0,013	1,723	0,086
Blood sugar level		0,033	0,013	2,445	0,015*		0,014	0,008	1,806	0,076

Abbreviations: R^2= R square, B = Beta coefficient, SE = Standard Error, t=nilai t test, * = significant p-value.

Multiple linear regression showed that body mass index (p<0,001), cholesterol level (p<0,001), and blood glucose level (p=0,013) were significantly associated with systolic blood pressure. The R-squared value was 0,116, meaning the three independent variables could explain 11,6% of the systolic blood pressure variable. In addition, diastolic blood pressure was significantly associated with body mass index (p<0,001). After analyzing the variables of cholesterol and blood glucose levels removed (as they were not significant), an R-squared value of 0,074 was obtained, which means that BMI can explain 7,4% of diastolic blood pressure.

Systolic blood pressure is the force exerted on the arterial walls when the heart pumps blood, whereas diastolic pressure is exerted on the arterial walls when the heart is at rest or when it is filled with blood. Systolic pressure is higher than diastolic pressure, and both forms of blood pressure are used as indicators to assess whether a person's blood pressure is high. If one or both of these types of pressures are above normal (systolic ≥120 mmHg; diastolic ≥80 mmHg), then the blood pressure is considered higher (falling into one of the following categories: pre-hypertension, stage 1 hypertension, and stage 2 hypertension). Many factors contribute to blood pressure, including body mass index (BMI) and cholesterol and blood sugar levels.

Relationship BMI and Blood Pressure

BMI is recognized as an indicator that can determine a person's weight (underweight, normal, overweight, or obese), and is usually associated with a person's health. A higher BMI is often associated with a higher risk of health problems such as hypertension. Our study results showed that BMI was significantly associated with SBP and DBP (p < 0.001). Higher BMI was associated with higher systolic and diastolic blood pressures.

These results are supported by several previous studies, such as those conducted by Dua et al. (2014), who found a significant positive relationship between BMI and blood pressure (SBP and DBP)(Dua et al., 2014). Similarly, Landi et al. (2018) reported an increase in blood pressure (SBP and DBP) in individuals with higher BMI levels. Chen et al., (2018) involved 32,482 respondents in a study and found a positive correlation between BMI and average natural systolic blood pressure (ARVSBP) variability. They considered BMI as a risk factor for the increase in ARVSBP(Chen et al., 2018)

The heart rate in people who are overweight or obese is higher than that in people with lower or normal weight. It is a mechanism that distributes nutrients and oxygen through the blood to all the organs and tissues of the body. Gradually, this condition causes an increase in blood vessel pressure (Van Rensburg 2019). A study in rats showed a robust positive correlation between BMI and blood pressure (Yusni & Yusuf, 2022). Specifically, Shuger et al. (2008) explained that, although weight is within the normal BMI range, women with a higher BMI are more likely to develop hypertension.

Relationship Cholesterol and Blood Pressure

High cholesterol levels have been linked to hypertension (Sopiah et al., 2021) as a person's life journey often experiences higher blood pressure if they have high cholesterol levels. It was shown from our study that total cholesterol is significantly (p<0,001) associated with systolic blood pressure, but it is not associated with diastolic blood pressure, but it is not associated with diastolic blood pressure. This discrepancy may arise because of variations in the mechanism of the influence of total cholesterol on systolic and diastolic blood pressure. Additionally, it can be influenced by dietary patterns, physical activity, and genetic factors, resulting in differential effects on blood pressure. Furthermore, individual variability in the body's response to total cholesterol may also contribute to these divergent outcomes (Bosu et al., 2019)

Older women with higher cholesterol levels also have higher systolic pressure. High blood cholesterol can lead to plaque formation in blood vessels, where cholesterol accumulates. This leads to the narrowing of blood vessels, and blood cannot flow properly throughout the body, which can increase the heart rate to allow blood to flow properly throughout the body. An increased heart rate causes an increase in blood pressure.

A study conducted in Bangladesh showed that the mean total serum cholesterol level was higher in patients with hypertension than in those with normal blood pressure. The results also showed a statistically significant association between total cholesterol levels and hypertension (Choudhury & Headey, 2018). Previous studies conducted in Indonesia reported similar results, in which total cholesterol was significantly correlated with systolic blood pressure (Pratama & Mariana, 2021).

Relationship Blood Sugar and Blood Pressure

Blood sugar or glucose is the primary type of sugar found in the blood and is used as an energy source by cells of the body (Dai et al., 2019; Yan et al., 2016). Higher blood sugar levels have also been linked to increased blood pressure (Yan et al., 2016). In individuals with higher blood sugar levels, the blood becomes thicker, which triggers increased blood pressure. Although unlike BMI, which contributes to both types of blood pressure (systolic and diastolic), this study shows that blood sugar levels are equivalent to total cholesterol, playing an essential role in systolic pressure with significant (p=0,013) results. This suggests that the higher the blood sugar level in older adults, the higher the systolic pressure. People who consume high-carbohydrate and sugary drinks are at risk of developing high blood pressure(Janse Van Rensburg, 2019). This is because both effects increase the amount of sugar in the blood. It is reinforced by. stated that individuals with type 2 diabetes mellitus generally experience high blood pressure, which is considered a result of insulin resistance (Ferrannini & Cushman, 2012), leading to an increase in glucose levels in the blood vessels. Individuals with diabetes are estimated to be twice as likely to experience higher blood pressure than those without diabetes (Dai et al., 2019; Ferrannini & Cushman, 2012). Furthermore, it has been found that high blood pressure can cause an increase in the strength of arteries, and if combined with high blood glucose levels, the increase in arterial strength becomes significant (Dai et al., 2019). It is acknowledged that an increase in artery strength can increase the risk of damage to other organs in the body (Scuteri et al., 2018) and has been proven to impact cardiovascular problems (Kuwabara et al., 2019; Shuger et al., 2008; Yusni & Yusuf, 2022)

Several previous studies have supported these findings, such as a study in West Java conducted by Dwi and Netra (2020) on individuals with hypertension, which found a close relationship between blood glucose levels and blood pressure. A retrospective cohort study in Japan showed that hypertension can develop in individuals with high fasting blood glucose levels. Hypertension can develop when fasting blood glucose levels exceed 100 mg/dl. Previous studies in China (Kuwabara et al., 2019) also found a significant relationship between higher fasting glucose levels and the risk of hypertension in older adults (Yan et al., 2016). Ahn et al. (2021) concluded that high blood glucose levels were an independent risk factor for developing blood pressure in Korea (Ahn et al., 2021).

Based on previous reviews, BMI, cholesterol, and blood sugar levels play a significant role in blood pressure. These three

conditions are often associated with behavior and lifestyles. A healthy lifestyle includes healthy eating patterns, regular physical activity, ability to respond to disease symptoms, giving time to rest, and avoiding smoking (Abbasi & Aghaamiri, 2020). Diet and physical activity have been shown to be associated with BMI (Duncan et al., 2022; Haerens et al., 2010). Healthy fat intake and physical activity have been associated with decreased cholesterol levels (Van Rensburg, 2019). Furthermore, lifestyle and dietary patterns contribute to blood sugar levels (Dwi, 2020). It is recommended that older adults maintain a healthy lifestyle by reducing the consumption of high-carbohydrate or glucose-rich foods, high-fat foods, and sweet drinks. Older adults need to consume more vegetables and fruits and regularly engage in physical activity.

Research related to other pathophysiological factors, such as the influence of sodium consumption, stress, and obesity on the risk of hypertension, also needs to be conducted. Thus, individuals can independently prevent a potential risk of developing hypertension.

Conclusion

Body mass index plays a vital role in systolic and diastolic blood pressure. Although cholesterol and blood sugar levels are not significantly associated with diastolic blood pressure, they do contribute to systolic blood pressure. The study results suggest that seniors should maintain a healthy lifestyle by maintaining a healthy diet and staying physically active to control their body mass index, cholesterol, and blood sugar levels.

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