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SODIUM ADEQUACY, FIBER, AND NUTRITIONAL STATUS IN RELATION TO BLOOD PRESSURE OF STUDENTS AT SMPN 13 BANDUNG

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Abstract

Hypertension is a growing health concern that can begin in adolescence and persist into adulthood. Nutritional factors such as nutritional status, sodium intake, and fiber intake play a key role in influencing blood pressure. This study aims to examine the relationship between nutritional status, sodium adequacy, and fiber adequacy with the incidence of hypertension among junior high school students. This research employed a cross-sectional design with a total of 64 students selected through purposive sampling. Nutritional status was assessed using Body Mass Index-for-Age (BMI/A), while sodium and fiber adequacy were measured using a Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ). Blood pressure was measured using a digital sphygmomanometer. Data were analyzed using the Spearman correlation test. The findings showed a significant relationship between nutritional status, sodium adequacy, and fiber adequacy with both systolic and diastolic blood pressure ($p < 0.05$). Nutritional status had a positive correlation with blood pressure, while sodium intake and fiber intake showed a negative correlation. There is a significant association between nutritional status, sodium adequacy, and fiber adequacy with blood pressure in adolescents. Promoting balanced nutrition from an early age is important to prevent the onset of hypertension.

Keywords: Adolescents, Fiber Intake, Hypertension, Nutritional Status, Sodium Intake

Introduction

Cardiovascular diseases, particularly hypertension, remain one of the leading causes of morbidity and mortality in Indonesia and require comprehensive management (Reski *et al*., 2023). According to the World Health Organization (WHO) report, hypertension is categorized as a serious health threat to the global population. Approximately 95% of hypertension cases are influenced by the interaction between genetic and environmental factors. Additionally, hypertension is known as a silent killer because it often does not exhibit characteristic clinical symptoms and can only be detected through regular blood pressure checks (Nuradina *et al*., 2023). Although the prevalence of hypertension is generally higher in the elderly, this condition has now begun to be found in adolescents. Hypertension in adolescence needs to be a concern because it has the potential to persist into adulthood, ultimately increasing the risk of cardiovascular diseases and other health complications. Several studies have shown that hypertension can develop as early as adolescence, and its prevalence tends to increase over time (Saputri & Pitaloka, 2018).

A study from The Brazilian Study of Cardiovascular Risk in Adolescents (ERICA) reported that the prevalence of hypertension in adolescents aged 12–17 years reached 9.6%, while in Indonesia, the incidence of hypertension in children and adolescents ranges from 3.11% to 4.6% (Saing, 2016). This condition is closely related to various risk factors, including nutritional status, obesity, and physical

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activity. According to the 2018 Basic Health Research (Riskesdas), the prevalence of overweight status in adolescents aged 13–15 years in West Java Province, particularly in Bandung City, was 12.38%, while the prevalence of obesity was 5.44% (Kemenkes, 2018). Dietary factors also play a significant role in influencing blood pressure. Several causes of hypertension related to eating patterns include high salt (sodium) intake, excessive caffeine consumption, and the use of additives such as monosodium glutamate (MSG), which is commonly found in processed products such as soy sauce, seasoning, and instant seasonings (Purwono *et al*., 2020). Adolescents who do not follow a healthy diet are reported to have a 1.54 times higher risk of developing hypertension compared to those with a good diet. An unbalanced consumption pattern, such as high fat intake and low fiber intake from vegetables and fruits, is also known to significantly increase blood pressure (Kurnianingsih *et al*., 2019). According to the Bandung City Health Office (2023), a total of 6,110 adolescents were recorded as overweight, with the highest number found in the working area of the Cijagra Lama Public Health Center, totaling 609 cases. This area includes SMP Negeri 13 Bandung, which is the largest contributor to the cases. Junior high schools are a strategic setting for health interventions, as students are in an active growth phase and the stage of forming long-term lifestyle habits. Based on these conditions, this study aims to analyze the relationship between nutrient intake patterns, nutritional status, and physical activity with blood pressure among students of SMP Negeri 13 Bandung.

Method

This study employed a quantitative analytic method with a cross-sectional design to determine the correlation between nutritional status, sodium intake adequacy, and fiber intake adequacy with the incidence of hypertension among adolescents. The cross-sectional design was chosen to assess the relationship between the independent and dependent variables at a single point in time. The independent variables in this research were nutritional status, sodium adequacy, and fiber adequacy, while the dependent variable was hypertension status measured through systolic and diastolic blood pressure. The research was conducted at SMP Negeri 13 Bandung in February 2025. The study population consisted of students aged 13 to 15 years, with a total sample of 64 students selected using purposive sampling based on inclusion and exclusion criteria. Nutritional status was assessed through anthropometric measurements using Body Mass Index for Age (BMI-for-age), categorized based on CDC 2000 growth chart percentiles. Sodium and fiber adequacy were measured using Semi-Quantitative Food Frequency Questionnaires (SQ-FFQ), which were compared to the recommended dietary allowances for adolescents aged 13–15 years according to the 2019 Recommended Dietary Allowances (AKG). Data analysis included descriptive statistics for univariate analysis and Spearman correlation tests for bivariate analysis.

Results

Subject characteristics included age, gender, allowance, grade level, disease history, father's occupation, and mother's occupation, obtained from 64 students of SMP Negeri 13 Bandung through the completion of a questionnaire form. The distribution of subject characteristics is presented in Table 1.

Table 1. Data Distribution Of Subject Characteristics

Indicator	n	%
Gender		
Male	31	48.4
Female	33	51.6
Age		
13 years	28	43.8
14 years	17	26.6
15 years	19	29.7
Mean ± SD		13,9 ± 0,86
Min - Max		13 – 15
Class		
VII	20	31,3
VIII	22	34,4
IX	22	34,4
Pocket money		
<20.000	26	40.6
≥20.000	38	59.4
Mean ± SD		19, 984± 0,49
Min - Max		0 – 40.000

Table 1 illustrates that the distribution of gender among the subjects was nearly balanced between male and female students, with the average age being 13 years. Regarding pocket money, the mean daily allowance among participants was IDR 19,984. In terms of parental occupation, the majority of fathers were employed in the private sector, while most mothers were housewives. Nutritional status was assessed based on anthropometric measurements, specifically body weight and height, whereas health status was determined through blood pressure measurements. The detailed distribution of nutritional and health status is presented in Table 2.

Table 1. Distribution Of Nutritional Status And Health Status Data

Indicator	n	%
Nutritional Status (%)		
Underweight (<5%)	7	10,9
Normal (≥5 - <85%)	43	67,2
Overweight (≥85 - <95%)	4	6,3
Obesity (≥95%)	10	15,6
Mean ± SD		51,4 ± 34,1
Minimum – Maximum		0 – 98
Systolic Blood Pressure		
Normal (<120 mmHg)	46	71,9
Pre Hypertension (≥120 - <129 mmHg)	10	15,6
Stage 1 Hypertension (≥130 - <139 mmHg)	6	9,4
Stage 2 Hypertension (≥140 mmHg)	2	3,1
Mean ± SD		109,2 ± 17,2
Min - Max		71 – 147
Diastolic Blood Pressure		
Normal (<80 mmHg)	54	84,4
Hipertensi Tahap I (≥80 - <89 mmHg)	6	9,4
Hipertensi Tahap II (≥90 mmHg)	4	6,3

Indicator	n	%
Mean ± SD		68,8 ± 11,4
Min - Max		42 – 103

Table 2 indicates that the majority of students had a normal nutritional status. Furthermore, the results of systolic blood pressure measurements showed that the average student's blood pressure fell within the normal range. A similar pattern was observed for diastolic blood pressure, where most students were also within the normal category. Dietary intake patterns of the students were evaluated using the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ), and the distribution of dietary intake data is presented in Table 3.

Table 2. Data Distribution Of Sodium And Fiber Adequacy Patterns

Indicator	n	%
Sodium Sufficiency		
Less (<77%)	19	29,7
Simply (≥77%)	45	70,3
Mean ± SD		111,5 ± 53,2
Min-max		26 - 292
Fiber Sufficiency		
Less (<89%)	30	46,9
Simply (90 - <119%)	17	26,6
Excess (≥120%)	17	26,6
Mean ± SD		97,2 ± 59,3
Min-max		15 - 300

Table 3 shows that the majority of students had sodium adequacy levels classified as sufficient. In contrast, most students were categorized as having inadequate fiber intake.

Table 3. Relationship Between Nutritional Status And Blood Pressure

Indikator	r	p value
Systolic		
Nutritional Status	0.484	0.000*
Diastolic		
Nutritional Status	0.404	0.001*

**Significant p<0,05*

Table 4 demonstrates a significant relationship between nutritional status and both systolic and diastolic blood pressure. Moreover, the positive correlation coefficient indicates a direct relationship between the two variables, suggesting that an increase in nutritional status tends to be followed by an increase in both systolic and diastolic blood pressure.

Table 4. Relationship Between Sodium & Fiber Adequacy Level And Blood Pressure

Indicator	r	p value
Systolic		
Sodium Sufficiency	-0.323	0.009*
Fiber Sufficiency	-0.362	0.003*
Diastolic		
Sodium Sufficiency	-0.252	0.045*
Fiber Sufficiency	-0.313	0.012*

**Significant p<0,05*

Table 5 shows that all variables related to the frequency of nutrient adequacy have a significant relationship with blood pressure. Furthermore, the negative correlation coefficients indicate an inverse

relationship between the variables, meaning that lower levels of sodium and fiber adequacy tend to be associated with increased systolic and diastolic blood pressure.

Discussion

The Relationship between Nutritional Status and Blood Pressure

Based on Table 2, the majority of respondents have a normal nutritional status, although some are classified as obese. The analysis results in Table 4 show that nutritional status has a significant relationship with systolic and diastolic blood pressure, with a positive correlation. This means that the higher the nutritional status, the higher the respondents' blood pressure. These findings are in line with the study by Ainiyah *et al*. (2020), which found a correlation between BMI and systolic blood pressure in adolescents, and are supported by the results of Saputri *et al*. (2021). Adolescents with a BMI above normal have a 5.57 times higher risk of elevated blood pressure compared to those with a normal BMI. An increase in BMI during adolescence leads to a greater blood volume required to supply oxygen and nutrients to body tissues. The increase in body tissue mass causes an increase in cardiac output, as the heart must work harder to pump a larger volume of blood. This process raises the pressure on the walls of blood vessels (arteries), ultimately resulting in an overall increase in blood pressure. Excess body fat also contributes to insulin resistance and the activation of the sympathetic nervous system and the renin-angiotensin-aldosterone system (RAAS), both of which play roles in increasing blood pressure (Isfaizah & Widyaningsih, 2021). Additionally, increased body mass is directly proportional to the volume of circulating blood, which in turn raises the pressure on arterial walls. These findings reinforce the notion that obesity is one of the major factors contributing to the development of hypertension during adolescence.

The Relationship between Sodium Adequacy Level and Blood Pressure

The results of the study showed a significant relationship between sodium adequacy levels and both systolic and diastolic blood pressure. The majority of the subjects in this study were categorized as having adequate sodium intake. This aligns with the SQ-FFQ interview results, which indicated that most subjects regularly consumed high-sodium foods such as instant noodles, packaged snacks like "chiki," "seblak," and various types of fried snacks available both at school and at home. These findings are supported by studies conducted by Putri et al. (2023) and Sabila & Sari (2023), which also demonstrated a significant relationship between sodium intake and blood pressure. This suggests that excessive sodium intake is a significant risk factor for elevated blood pressure. However, the direction of the correlation found in this study was negative. This means that the lower the sodium adequacy level, the higher the blood pressure tended to be. This correlation appears to contradict the general understanding that excessive sodium intake increases blood pressure. The negative correlation may be interpreted as a physiological response of the body to sodium deficiency, rather than a direct effect of low sodium intake on blood pressure. When sodium levels drop significantly, the body responds by activating the Renin-Angiotensin-Aldosterone System (RAAS) to maintain sodium levels in circulation. Activation of this system promotes increased sodium and water reabsorption in the kidneys and causes vasoconstriction or narrowing of the blood vessels. This condition increases blood volume and vascular resistance, ultimately leading to an increase in blood pressure, particularly systolic pressure (Judge & O'Donnell, 2021). On the other hand, excessive sodium intake can trigger a narrowing of arterial diameter. This condition may lead to increased vascular resistance and force the heart to work harder to pump blood through the constricted vessels. As a result, blood pressure rises, leading to the onset of hypertension (Darmawan *et al*., 2018). However, not all studies have shown consistent results. This needs to be taken into account in interpretation, especially considering that the

cross-sectional design of the study does not allow for the observation of long-term effects of sodium intake on blood pressure.

The Relationship between Fiber Adequacy Level and Blood Pressure

The data distribution results showed that the majority of school children had inadequate fiber intake. This condition was obtained from the SQ-FFQ interviews, which revealed that most subjects rarely consumed fruits and vegetables as their main sources of fiber. Some subjects even admitted to disliking certain vegetables and preferred low-fiber processed foods such as fast food, snacks, or instant meals. The lack of variety and frequency in consuming fruits and vegetables caused the total daily fiber intake to fall below the recommended nutritional adequacy levels. The analysis results indicated a significant relationship between fiber adequacy and both systolic and diastolic blood pressure. The correlation found was negative, meaning that the lower the fiber intake, the higher the blood pressure tended to be. This direction of the relationship suggests that fiber plays an important role in lowering or maintaining blood pressure within normal limits. These findings are consistent with the study by Yuriah et al. (2019), which also showed a significant relationship between fiber adequacy and blood pressure. When bile acids are not efficiently excreted, the body responds by increasing cholesterol production to ensure sufficient bile acid availability. This leads to elevated cholesterol levels in the blood, especially low-density lipoprotein (LDL). Excess cholesterol accumulates in the walls of blood vessels, forming atherosclerotic plaques that narrow the vessels and increase blood flow resistance. To compensate for this narrowing, the heart must pump blood with higher pressure, causing increased blood pressure (hypertension). Prolonged hypertension worsens atherosclerosis and poses risks for serious cardiovascular complications such as heart attack, stroke, or heart failure (Zhang *et al*., 2022). Adequate fiber intake serves as a protective factor against hypertension, but this effect is optimal when accompanied by a balanced diet, adequate physical activity, and good stress management (Wirayani *et al*., 2019). Therefore, these results strengthen the important role of fiber in maintaining healthy blood pressure and emphasize the need for education and habits encouraging adequate and varied consumption of fruits and vegetables among adolescents. The negative correlation between nutrient adequacy levels and blood pressure does not directly indicate that low nutrient adequacy causes increased blood pressure. This correlation may be interpreted as a protective effect, where nutrient adequacy within normal limits plays a role in maintaining blood pressure stability. However, prolonged nutrient deficiency can affect nutritional status and metabolic function, ultimately impacting blood pressure (Mphahlele *et al*., 2020). Interpretation of this relationship should be done cautiously, considering that the cross-sectional study design only allows data collection at a single point in time, thus unable to depict the long-term effects of nutrient adequacy on blood pressure. This represents a limitation of the study, especially in observing dynamic variables such as nutrient adequacy and blood pressure.

Conclusion

This study found a significant relationship between nutritional status, sodium adequacy, and fiber adequacy with the incidence of hypertension in adolescents. Sodium and fiber adequacy levels showed a negative correlation with blood pressure, meaning that the more balanced the intake of sodium and fiber, the lower the risk of developing hypertension. Therefore, blood pressure control in adolescence can be achieved through maintaining a normal nutritional status, restricting sodium intake according to daily needs, and increasing fiber consumption through a healthy and balanced diet. These preventive measures are important to implement early on to prevent future cardiovascular complications.

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