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LOW SUN EXPOSURE AS A DOMINANT RISK FACTOR OF HYPERTENSION AMONG ADOLESCENTS IN SMPN 21 SOUTH TANGERANG

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ABSTRACT

Hypertension is a global health problem that can occur in adolescents. According to Riskesdas 2018, the national prevalence of hypertension is 34.1%. In Banten Province, it stands at 29.4%, and in South Tangerang City, it's 27.5%. This study was aimed to determine the association between age, sex, vitamin D intake, fat intake, and sun exposure with the incidence of hypertension among adolescents at SMPN 21 South Tangerang and the dominant factor among these variables that is a risk factor of hypertension. This study used a cross-sectional design with a sample of 102 respondents taken using a stratified random sampling technique. Data were collected through blood pressure measurements, the Sun Exposure Questionnaire (SEQ), and the Semi Quantitative Food Frequency Questionnaire (SQ-FFQ). Association analysis was conducted using the chi-square test and Fisher's exact test, showing that there was an association between sun exposure (<0.05; OR = 7.902) with the incidence of hypertension, and there were no association between age (p = 0.556), sex (p = 0.386), vitamin D intake (p = 0.760), and fat intake (p = 1.000) with the incidence of hypertension among adolescents at SMPN 21 South Tangerang. The result of multivariate analysis using the regression logistic test showed that sun exposure was the most correlated factor of hypertension among adolescents at SMPN 21 South Tangerang (p = <0.05; OR = 7.949). Respondents should have more sun exposure to prevent hypertension.

Keywords: adolescents, fat intake, hypertension, sun exposure, vitamin D intake

Introduction

Hypertension is a global health problem with an increasing prevalence. It is often referred to as the "silent killer" because it can lead to death without any noticeable symptoms.[1] If left uncontrolled over the long term, hypertension can trigger cardiovascular disease.[2] According to Riskesdas data, the prevalence of hypertension in individuals aged over 18 increased from 25.8% in 2013 to 34.11% in2018.[3,4] In 2018, the prevalence of hypertension among people aged over 18 in Banten Province was 29.47%, and in South Tangerang City was 27.5%.[5]

While hypertension is typically associated with the elderly, it can also affect adolescents. Adolescent hypertension is characterized by blood pressure readings ≥130/≥80 mmHg.[6] Teenagers with hypertension can experience both short-term and long-term effects, including symptoms like headaches, dizziness, and potential organ damage affecting the eyes, brain, heart, kidneys, and blood vessels.[7] This condition in adolescents can be attributed to changes in their dietary and behavioral habits.[8] This is indicated by the increase in the incidence of hypertension in adolescents in recent years, rising from 9% in 2007 to 10.7% in 2013.[9] A 2017 study by the Centers for Disease Control and Prevention (CDC) reported approximately 1.3 million adolescents aged 12-19 years, or 1 in 25 adolescents, have high blood pressure.[10] Research conducted on 71 high school students in South Tangerang revealed that 16.9% of adolescents suffered from hypertension.[11] Out of 220 teenagers in South Tangerang, 10.5% have prehypertension.[2]

The incidence of hypertension in Indonesian adolescents is influenced by various factors, including age, sex, nutritional status, family history, stress, physical activity, nutrient intake, and lifestyle.[8] A study conducted on children in Cameroon found an association between age and hypertension, particularly among those aged >10 years.[12] According to a study conducted in Pangkalpinang, there was a positive association between sex and the risk of hypertension, with men having higher blood pressure levels than women.[13]

Nutrient intake plays a significant role in affecting blood pressure, with low vitamin D and high fat intakes being dominant factors. Vitamin D can be obtained through oral consumption or synthesized through sunlight exposure. A study involving pregnant women indicated a significant association between vitamin D intake and systolic blood pressure.[14] Research conducted on women of childbearing age stated a decrease in SBP (9.1%) and DBP (7.5%) after a 12-week intervention involving exposure to sunlight for 30 minutes.[15] According to a study conducted on young women, there was a significant association between fat intake and the incidence of hypertension.[16]

Vitamin D is a fat-soluble vitamin with a steroid molecular structure. It exists in two: vitamin D2 (ergocalciferol), found in plants, and vitamin D3 (cholecalciferol), found in animals. In addition to oral consumption, vitamin D can also be synthesized in the skin through sunlight exposure.[17] The synthesis of vitamin D in the skin is influenced by factors, such as the time, duration, and frequency of sunlight exposure. Moreover, a lack of outdoor activities, wearing

clothing made from materials that do not readily absorb sunlight, and the use of sunscreen can hinder the synthesis of vitamin D in the skin.[18]

Both orally obtained vitamin D and sunlight synthesis can impact blood pressure by inhibiting the activation of the Renin Angiotensin Aldosterone System (RAAS). This inhibited RAAS activation can increase blood pressure through two mechanisms: suppressing renin production and inhibiting the expression of the enzyme Cyclooxygenase-2 (COX-2). The suppression of renin production involves inhibiting the transcription process of the renin gene, while suppressing COX-2 expression prevents the conversion of prostaglandins from arachidonic acid, thereby preventing the activation of the RAAS.[19]

Fat is the body's primary source of energy and can be found in various foods.[20] Types of fat present in food include triglycerides, saturated fatty acids, unsaturated fatty acids, phospholipids, and cholesterol.[21] Excessive consumption of saturated fat can lead to an increase in blood cholesterol levels, especially LDL (Low-Density Lipoprotein). This increase can lead to the formation of plaque, which can obstruct blood flow and cause the heart to work harder, resulting in elevated blood pressure.[22,23]

This research was conducted at SMPN 21 South Tangerang. The choice of this location was based on the fact that the prevalence of hypertension in South Tangerang City has increased by 5.1% compared to the previous year, with 10.5% of adolescents suffering from hypertension.[2] Previous research has not explored the connection between vitamin D intake and sun exposure about the incidence of hypertension among adolescents. The selection of this educational institution was made because no similar research has ever been conducted. Given this information, researchers are interested in researching the association between age, sex, vitamin D intake, fat intake, and sun exposure with the incidence of hypertension among adolescents at SMPN 21 South Tangerang. This study aims to determine the dominant risk factor of adolescents' hypertension between age, sex, vitamin D intake, fat intake, and sun exposure at SMPN 21 South Tangerang.

Methods

This was an observational study employing a cross-sectional design conducted in May 2023 at SMPN 21 South Tangerang. The research population consisted of Class VIII students, totaling 350 students. The minimal sample size was 42 respondents, but we examined 102 students as the study participants. The study participants were selected using the stratified random sampling method to ensure representation from all nine classes. Inclusion criteria for respondents were as follows: students registered in Class VIII, aged 13-15 years, willing to participate as research respondents by signing the informed consent form, and physically and mentally healthy. Exclusion criteria included students who withdrew from the study and did not participate fully in the research.

In this study, the dependent variable was the incidence of hypertension, while the independent variables were age, sex, vitamin D intake, fat intake, and sun exposure. The data collected were the respondent's characteristics, which consist of age, sex, use of clothing material, body protection against sun exposure, vitamin D and fat intake, sun exposure, and blood pressure. Blood pressure readings were classified from 4 categories into 2 groups: normal and prehypertension to normal/prehypertension (<130/<80 mmHg) and hypertension 1 and 2 into hypertension (≥130/≥80 mmHg).[6] Blood pressure was recorded once in a seated position using a Digital Sphygmomanometer and was measured by two Nursing Students.

Age and sex were collected through a questionnaire by recording the date of birth and the respondent's self-reported sex. Vitamin D and fat intake were assessed using the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) through interviews conducted by Nutrition Students. The SQ-FFQ included a list of foods containing vitamin D and fat, along with information on the frequency and quantity of consumption over the past 3 months. Respondents' vitamin D intake was classified into two categories: low if <70% AKG (<10.5 µg) and adequate if ≥70% AKG (≥10.5 µg).[24] According to AKG 2019, the recommended intake for individuals aged 13-15 years is 15 µg.[25] Similarly, respondents' fat intake was categorized as adequate if <110% AKG (<88 grams for boys and <77 grams for girls) and high if ≥110% AKG (≥88 grams for boys and ≥77 grams for girls).[24] According to AKG 2019, the recommended intake for individuals aged 13-15 years is 80 grams for boys and 70 grams for girls.[25]

Sun exposure was assessed using the Sun Exposure Questionnaire (SEQ) and categorized as low, moderate, and high based on the scores obtained. Specifically, exposure levels were categorized as low if the score was 0-33, moderate if the score was 34-44, and high if the score was 45-56. These sun exposure scores were calculated by adding up the results of multiplying the Total Time Exposed by Sunlight (TTES) by the Total Body Areas Exposed by Sunlight (TBAES) for a period of 7 days.[26]

The analysis consisted of univariate, bivariate, and multivariate analyses conducted using the IBM SPSS Statistics 24 application. Univariate analysis was performed on all respondents to examine the distribution and frequency of both dependent and independent variables, as well as the respondents' characteristics. Bivariate analysis was conducted to investigate associations between variables using the Chi-Square Test and Fisher's Exact Test. Multivariate analysis aimed to determine which independent variable had a stronger association with the dependent variable, using the Logistic Regression Test. This study has received ethical approval from the Research Ethics Committee of the University of Pembangunan Nasional "Veteran" Jakarta, with the approval number: 149/V/2023/KEPK.

Results

This research involved 102 students in Class VIII of SMPN 21 South Tangerang. Table 1 presents the characteristics of the respondents in this study, including their sex, age, frequently used clothing materials, and sun protection practices.

Table 1. Sociodemographics and Sun Exposure-Related Characteristics of Respondents

Characteristics of Respondents	Frequency (n)	Percentage (%)
Sex		
Male	42	41.2
Female	60	58.8
Age (Year)		
13	21	20.6
14	68	66.7
15	13	12.7
Clothing Material		
Polyester	4	3.9
Cotton	60	58.8
Denim/jeans	5	4.9
Others	33	32.4
Use of Umbrellas		
Sometimes	61	59.8
No	41	40.2
Use of Hats		
Yes	12	11.8
Sometimes	55	53.9
No	35	34.3
Use of Sunscreen/Sunblock		
Yes	36	35.3
Sometimes	18	17.6
No	48	47.1
SPF		
SPF <30	37	68.5
SPF >30	17	31.5

Based on Table 1, the univariate analysis of respondents' characteristics revealed that the majority were female (58.8%) and aged 14 years (66,7%). The most commonly used clothing material among respondents was cotton (58.8%). Regarding sun protection practices, the majority of respondents reported sometimes using umbrellas (59.8%), sometimes using hats (53.9%), and did not use sunscreen/sunblock (47.1%). Among the respondents who used sunscreen/sunblock (54 in total), the majority used products with SPF <30, comprising 37 respondents (68.5%).

Table 2 displays the distribution of blood pressure among adolescents at SMPN 21 South Tangerang, with hypertension being the predominant category (53.9%). Table 2 also shows that the majority of respondents have a low intake of vitamin D (55.9%). The average consumption of respondents' vitamin D intake was 13.24±13.09 µg (equivalent to 88.3% of the 2019 AKG) with a minimum value of 0.2 µg and a maximum value of 73.8 µg. In terms of fat intake, 50% of respondents fell into the categories of either adequate or high fat intake. The average consumption

of respondents' fat intake was 106.78±86.82 grams, with a minimum value of 13.9 grams and a maximum of 485 grams.

Table 2. Univariate Analysis of Blood Pressure, Vitamin D Intake, Fat Intake, and Sun Exposure

Variables	Frequency (n)	Percentage (%)
Blood Pressure		
Normal/prehypertension	47	46.1
Hypertension	55	53.9
Vitamin D Intake (µg)		
Low	57	55.9
Adequate	45	44.1
Fat Intake (g)		
Adequate	51	50.0
High	51	50.0
Sun Exposure		
Low	95	93.1
Moderate	7	6.9

Based on Table 2, the data indicates that the majority of respondents had low sun exposure (93.1%). None of the respondents had a high exposure score in this study. The average sun exposure score for respondents was 17.32+9.23, with a minimum score of 0 and a maximum of 42. Furthermore, the data reveals that the average TTES among respondents was 9.16±3.18, ranging from a minimum of 0 to a maximum of 14, while the average TBAES among respondents was 13.20±4.76, with a minimum of 5 and a maximum of 21.

According to Table 3, the results indicated that 32 respondents (56.1%) had low vitamin D intake and hypertension, while 23 respondents (51.1%) had adequate vitamin D intake and hypertension. The results of the bivariate analysis showed a p-value of 0.760 (p-value > 0.05). Based on these findings, it can be concluded that there is no association between vitamin D intake and the incidence of hypertension among adolescents at SMPN 21 South Tangerang.

Table 3 also showed that 27 respondents (52.9%) had high fat intake and hypertension, while 28 respondents (54.9%) had adequate fat intake and hypertension. The results of the bivariate analysis showed a p-value of 1.000 (p-value > 0.05). From these results, it can be inferred that there is no association between fat intake and the incidence of hypertension among adolescents at SMPN 21 South Tangerang.

Table 3. Bivariate Analysis Result of Association Between Age, Sex, Vitamin D Intake, Fat Intake, and Sun Exposure with Blood Pressure among Adolescents

Variables	Blood Pressure				Total		P-value	POR (95% CI)
	Hypertension		Normal/Pre-hypertension					
	n	%	n	%	n	%		
Age								
13	12	57.1	9	42.9	21	100.0		1
14	35	51.5	33	48.5	68	100.0	0.757	0.833 (0.203 – 3.422)
15	8	61.5	5	38.5	13	100.0		0.663 (0.197 – 2.233)
Sex								
Male	20	47.6	22	52.4	42	100.0	0.386	1.540 (0.696 – 3.406)
Female	35	58.3	25	41.7	60	100.0		
Vitamin D Intake								
Low	32	56.1	25	43.9	57	100.0	0.760	1.224 (0.559 – 2.683)
Adequate	23	51.1	22	48.9	45	100.0		
Fat Intake								
High	27	52.9	24	47.1	51	100.0	1.000	0.924 (0.424 – 2.014)
Adequate	28	54.9	23	45.1	51	100.0		
Sun Exposure								
Low	54	56.8	41	43.2	95	100.0	0.046	7.902 (0.915 – 68.221)
Moderate	1	14.3	6	85.7	7	100.0		

For the bivariate analysis involving sun exposure and the incidence of hypertension, Fisher's exact test was utilized as an alternative to the chi-square test due to the presence of 2 cells with expected counts less than 5. As shown in Table 3, the results indicated that 6 respondents (85.7%) had moderate sun exposure and normal/prehypertension blood pressure, while 54 respondents (56.8%) had low sun exposure and hypertension. The results of the bivariate test showed a p-value of 0.046 (p-value <0.05). Consequently, it can be concluded that there is a significant association between sun exposure and the incidence of hypertension among adolescents at SMPN 21 South Tangerang. Respondents with low sun exposure had a 7.9 times (OR 7.902) greater risk of experiencing an increase in blood pressure compared to respondents with moderate sun exposure.

Table 4. Analysis Result of Determinant Variables of Hypertension

Determinants Variables	Crude Analysis		Adjusted Analysis	
	P-value	POR (95% CI)	P-value	POR (95% CI)
Age				
13	0.470	1		
14		0.833 (0.203 – 3.422)		
15		0.663 (0.197 – 2.233)		
Sex	0.146	1.559 (0.684 – 3.552)		
Vitamin D Intake	0.349	1.216 (0.453 – 3.263)	0.318	1.267 (0.477 – 3.368)
Fat Intake	0.352	1.210 (0.453 – 3.233)	0.377	1.169 (0.442 – 3.095)
Sun Exposure	0.030	8.162 (0.927 – 71.889)	0.030	7.949 (5.989 – 9.909)

After being adjusted by age, sex, vitamin D intake, and fat intake, it was found that the most strongly correlated factor with hypertension among adolescents was sun exposure, with a p-value of 0.03 (p-value <0.05). The risk of hypertension among the group with low sun exposure was 7.9 times higher than the group that had moderate sun exposure. The confounding variables in the last model were vitamin D intake and fat intake. Age and sex were excluded from the last model because, after being excluded, there was no instance of Exp(B) exceeding 10%.

Discussion

This study found no association between vitamin D intake with the incidence of hypertension among adolescents at SMPN 21 South Tangerang. Despite the lack of association, it is noteworthy that respondents with hypertension tended to have lower vitamin D intake compared to those with adequate vitamin D intake (Table 3). This aligns with the theory that low vitamin D can contribute to elevated blood pressure. Low vitamin D may lead to increased renin production, ultimately stimulating the RAAS to become active, resulting in higher blood pressure.[27]

The study's findings indicate that a food source of vitamin D that is overlooked is fish oil, which contains 250µg/100 gr of vitamin D.[28] This could be attributed to the relatively high cost of fish oil, limiting access to individuals from diverse economic backgrounds.[29] The data also showed that the average vitamin D intake among respondents was 13.2 µg, whereas the recommended intake for adolescents aged 13-15 years is 15 µg.[25] This indicates that the average vitamin D intake among respondents falls below the government's recommended intake.

A study conducted in Surakarta with adolescent participants found no significant association between vitamin D intake and the incidence of prehypertension (p = 0.235).[30] Another study involving elderly subjects reported no association between vitamin D intake and the incidence of hypertension (p = 1,000).[31] A systematic review study, examining eight studies, indicated no evidence that vitamin D supplementation could reduce both SBP and DBP in children and adolescents. This could be attributed to other influential factors in vitamin D metabolism, such as ethnic and genetic variations.[32]

Vitamin D intake typically provides less than 10% of the body's vitamin D requirements when compared to exposure to sunlight.[14] This theory underscores the challenge of meeting daily vitamin D needs solely through dietary intake, except for fatty fish consumption.[33] Another theory states that blood vitamin D levels cannot be accurately described solely by oral intake of vitamin D.[34] This is supported by research findings that suggest no significant effect of vitamin D intake on daily vitamin D requirements and blood levels of vitamin D.[30,35] Given this explanation, it can be concluded that the study's results were not statistically significant, as vitamin D intake contributed only 10% to the body's vitamin D needs. Consequently, there must be other factors beyond vitamin D intake that influence blood pressure.

This study also revealed that fat intake had no association with the incidence of hypertension among adolescents at SMPN 21 South Tangerang. Although the result was statistically insignificant, it is worth noting that there were more respondents with higher fat intake in the hypertension category compared to those with higher fat intake but normal/prehypertension blood pressure (Table 3). The analysis also revealed that the most frequently consumed source of dietary fat was milk, a type of saturated fat. These findings align with the theory that excessive fat consumption can lead to increased cardiac workload, subsequently raising blood pressure.

Excessive consumption of dietary fat, particularly saturated fat, has been linked to elevated LDL levels. Elevated LDL tends to adhere to vessel walls, forming plaque that can harden and obstruct blood flow. This arterial blockage places greater strain on the heart, resulting in increased blood pressure.[22,23]

Meanwhile, high intakes of saturated fat can also elevate blood pressure by activating the RAAS. Increased saturated fat consumption stimulates the release of renin, which subsequently leads to the production of Angiotensin II and Aldosterone. Angiotensin II acts as a vasoconstrictor, narrowing blood vessels and resulting in an increase in blood pressure. On the other hand, Aldosterone enhances sodium and water reabsorption while increasing potassium excretion, further contributing to elevated blood pressure and blood.[36,37]

Research involving adolescents at the Lingga Kencana Vocational School Depok found no significant association between fat intake and blood pressure ($p = 0.204$).[38] Similarly, a study conducted with adolescents at Sejahtera 1 High School obtained similar results, indicating no significant association between fat intake and blood pressure ($p = 0.526$).[39] Another study involving adolescents in Semarang reported findings that were in line ($p = 0.803$). This study presented an OR value of 1.133, suggesting that excessive fat intake is not a risk factor for hypertension. This outcome can be attributed to the limited fat intake among the respondents.[40] Research on adolescents in Mexico also demonstrated similar results, revealing no significant association between total fat intake and blood pressure, with a p-value of 0.48.[41]

This study showed a significant result between sun exposure and the incidence of hypertension among adolescents at SMPN 21 South Tangerang. These findings align with the theory that low sun exposure can lead to increased blood pressure. This result can be explained by the fact that polyester, the most commonly used material of clothing (Table 1), provides limited sun protection, allowing UV radiation to penetrate the skin more easily compared to denim or jeans, which offer greater sun protection. Additionally, the use of body protection, such as umbrellas, hats, and sunscreen, can further reduce skin exposure to sunlight. Sunscreen inhibits sunlight synthesis of vitamin D in the skin by blocking the absorption of the sun's UVB spectrum.[18] The effectiveness of sunscreen in hindering vitamin D production varies depending on its SPF content, with SPF 15 reducing production by 93%, SPF 30 by 97%, and SPF 50 by 98%.[42]

Based on the data collected, it was observed that, on average, respondents were exposed to sunlight during two main time intervals: 07.00-08.59 and 11.00-13.59. The exposure during 07.00-08.59 had a lower intensity, equivalent to 0.1-0.4 MED/hour or 25-200 µg of vitamin D intake, while exposure during 11.00-13.59 had more substantial intensity, corresponding to 2 MED/hour or 500-1000 µg of vitamin D intake.[18] It was also obtained that, on average, respondents spent less than 5 minutes in direct sunlight, with the primary areas of exposure being the face, hands, and arms. The limited exposure to sunlight among respondents was largely due to spending time indoors for studying and other activities.

A study in West Java produced consistent results, demonstrating that sun exposure can reduce both SBP (p-value = 0.004) and DBP (p-value = 0.011). After 30 minutes of sunlight exposure over 12 weeks, the subjects experienced an average decrease of 9.1% (11.2 mmHg) in SBP and 7.5% (6 mmHg) in DBP.[15] Another study conducted in Ponorogo with similar findings indicated that sun exposure significantly reduces SBP and DBP (p-values 0.001 and 0.001) in hypertensive patients. The results revealed that blood pressure levels were lower after just 30 minutes of sunlight exposure over two weeks. This reduction in blood pressure can be attributed to the production of vitamin D.[43] A study conducted in China also supported these findings, indicating a negative association between sun exposure and hypertension ($p < 0.001$).[44]

Sunlight exposure serves as an excellent source of vitamin D, with no reported cases of vitamin D intoxication resulting from excessive exposure. When the body is exposed to sunlight, UVB rays interact with 7-dehydrocholesterol or provitamin D3 present in the skin. This provitamin D3 is subsequently converted into previtamin D3 and vitamin D3 through a mild catalytic process. Vitamin D3 then undergoes further metabolism in the liver to 25(OH)D3 (Calcidiol) and later in the kidneys to become 1,25(OH)2D3 (Calcitriol). Calcitriol plays a role in suppressing the production of renin, an enzyme that is involved in the RAAS. Reduced renin production prevents the conversion of Angiotensinogen into Angiotensin II, a vasoconstrictor, and the hormone Aldosterone, which leads to sodium and water retention. The absence of Angiotensin II formation helps keep blood vessels dilated, thereby lowering blood pressure. Additionally, the absence of Aldosterone production helps maintain sodium and water balance, preventing an increase in extracellular fluid volume and further contributing to reduced blood pressure.[19,43,45]

A study conducted in Macau revealed that increased sun exposure may reduce the risk of hypertension, even after being adjusted for age, sex, and occupation (OR 0.03).[44] Another study involving Community-Dwelling Adults produced similar findings, demonstrating that after extensive adjustments for variables including serum 25(OH)D temperature, season, age, race, sex, region, physical activity, screen time, current use of anti-hypertensive drugs, BMI, calcium, phosphate, PTH, and fibroblast GF-23, low sun exposure was associated with the elevated SBP (p-value = 0.010).[46] A study conducted as part of the Reasons for Geographic And Racial Differences

in Stroke (REGARDS) research reported a significant association between low sun exposure and high SBP (p-value = 0.0012) after being adjusted for temperature, age, race, region, sex, education, income, vitamin D intake, alcohol use, smoking, body mass index, and antihypertensive medication use.[47]

This research has certain limitations. Firstly, the blood pressure measurements were conducted only once due to time constraints, which might have impacted the data's accuracy. Moreover, the definition of hypertension used may not precisely align with a physician-diagnosed condition. Secondly, the measurements of vitamin D intake and fat intake collected over the past three months which rely on the respondents' memories, introduce the possibility of inaccuracies due to potential exaggeration or omissions in their responses. Lastly, sun exposure was assessed through a questionnaire, which is subjective and dependent on respondents' opinions.

Conclusion

There was an association between sun exposure and the incidence of hypertension among adolescents at SMPN 21 South Tangerang. Low sun exposure emerged as the most dominant risk factor for hypertension among adolescents at SMPN 21 South Tangerang after being controlled by age, sex, vitamin D intake, and fat intake in relation to the incidence of hypertension. It is recommended that respondents ensure adequate vitamin D intake, choose healthy fats such as polyunsaturated fats, and maintain sufficient sun exposure to prevent an increase in blood pressure. For further research, it is advisable to minimize SQ-FFQ bias through enumerator training in probing techniques, conduct blood pressure measurements twice, consider socio-cultural factors, and explore alternative analytical research designs.

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