

# The Relationship between Sodium Intake, Stress Levels, and Physical Activity on Prehypertension among Adolescents

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## ARTICLE INFO

### Article history

Submitted: 16 Oktober 2025

Revised: 19 November 2025

Accepted: 05 December 2025

### Keywords:

Adolescent, Sodium Intake, Physical Activity, Prehypertension, Stress Level

## ABSTRACT

Prehypertension is posing a significant health concern as it has the potential to develop into full hypertension if not addressed. The city of Bandung is noted for having one of the highest hypertension prevalence rates in West Java, reaching 23.5%. Among adolescents, prehypertension may arise from poor lifestyle habits, such as imbalance dietary intake, excessive nutritional status, insufficient physical activity, genetic factors, and socioeconomic factors. The study aimed to examine the relationship between sodium intake, physical activity, and stress levels with prehypertension among adolescents at SMAN 17 Bandung. Employing a quantitative cross-sectional design, the research was conducted from October 2024 to April 2025 at SMAN 17 Bandung. A total of 60 respondents were selected using purposive sampling. Sodium intake was assessed through two 24-hour dietary recalls. The PAL (Physical Activity Level) questionnaire was used to evaluate physical activity, while the Depression Anxiety Stress Scales (DASS) questionnaire measured stress levels. The Chi-Square was used for bivariate data analysis. Findings revealed that 53.7% of the adolescent participants experienced prehypertension. Statistical analysis demonstrated significant correlations ( $p < 0.05$ ) between sodium intake ( $p = 0.000$ ), physical activity ( $p = 0.042$ ), and stress levels ( $p = 0.007$ ) with prehypertension among adolescents at SMAN 17 Bandung. There is an effect of sodium intake, physical activity, and stress levels with prehypertension among adolescents at SMAN 17 Bandung.



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## INTRODUCTION

Hypertension often begins with a prehypertension phase (Syarif, 2022). According to American Academy of Pediatrics (AAP) (2017), prehypertension is a condition in which blood pressure levels are elevated beyond the normal range (120–129 mmHg and 80–89 mmHg) (Blowey et al., 2017). Prehypertension is a condition in which blood pressure levels are elevated beyond the normal range but do not meet the criteria for hypertension. If not properly managed through healthy lifestyle practices, this stage may progress to hypertension over time (Moussouni et al., 2022). Unhealthy behaviors are among the leading contributors to prehypertension or hypertension among adolescents (Sabbu et al., 2024).

Adolescence represents a critical period for the development of cardiovascular risk factors, as behavioral patterns formed during this stage often persist into adulthood. Adolescents are one of the age groups most at risk of developing prehypertension due to unhealthy daily habits (Salsabila et al., 2023). Data from the CDC (2024) show that 4% of adolescents aged 12–19 years have hypertension and 10% have prehypertension. The Indonesian Health Survey reports that approximately 29.2% of people in Indonesia have hypertension, with West Java Province ranking fourth based on hypertension measurements among residents aged  $\geq 15$  years at 32.6% (SKI, 2023). The prevalence of hypertension in Bandung City is around 23.6%, while Babakan Ciparay

District ranks first among the 30 districts with the highest prevalence of hypertension in Bandung City at 5.5% (Dinkes Kota Bandung, 2022). These statistics highlight the growing burden of elevated blood pressure at both the national and local levels, underscoring the need to identify modifiable risk factors among adolescents.

The prevalence of prehypertension among adolescents is caused by several factors, including nutritional status, nutrient intake, and lifestyle (Diana and Hastono, 2023). Unhealthy behaviors like chronic stress and lack of exercise can also lead to prehypertension (Salsabila et al., 2023). Most adolescents with light physical activity experience hypertension compared to adolescents with heavy physical activity. This condition can arise because low physical activity slows down metabolism, causing fat buildup, which may then narrow blood vessels and increase blood pressure (Kusparlina, 2022). Moreover, stress-related issues in teens often stem from family matters, social interactions, or school problem (Gusti et al., 2023). Unmanaged stress can lead to severe stress, which can contribute to the development of prehypertension. Stress levels also influence adolescents' dietary pattern, often leading to a preference for salty, fatty, and processed foods (Wiciyuhelma et al., 2022).

Adolescents tend to choose fast food because of its quick preparation, convenience, tasty flavor, and ease of access, making it a popular option to meet dietary needs (Nurkhofifah & Putriningtyas, 2023). Frequent consumption of fast food by adolescents can increase the incidence of prehypertension due to high sodium content (Amrynia & Prameswari, 2022). High-sodium foods are not only found in fast food but also in snacks, both traditional and packaged. Snacks consumed by teenagers are mostly high in calories, sodium, and low in nutrients (Kaluku et al., 2023). Adolescents who have the habit of consuming high-sodium foods are 3.95 times more likely to develop prehypertension (Maziyah et al., 2023). Despite evidence linking sodium intake, physical activity, and stress to blood pressure, few studies have examined these factors concurrently among Indonesian adolescents, particularly in Bandung. Therefore, this study aims to examine the relationship between sodium intake, stress levels, and physical activity with prehypertension among adolescents at SMAN 17 Bandung.

## **METHOD**

The study employed a cross-sectional design and was implemented at SMAN 17 Bandung, situated in Babakan Ciparay District, Bandung City, West Java. The study period spanned from October 2024 to April 2025. The required sample size was determined using the Lemeshow formula, with a 5% margin of error and an anticipated attrition rate of 10%, yielding a minimum of 60 eligible respondents. Respondents were selected through purposive sampling, with consideration for both inclusion and exclusion criteria. Inclusion criteria were students willing to participate as respondents and adolescents aged 15–18 years. Exclusion criteria included adolescents who were absent during the study and those who were unwilling to participate as respondents.

The independent variables in this study are sodium intake, physical activity, and stress levels, while the dependent variable was prehypertension. Prehypertension was determined based on systolic and diastolic blood pressure thresholds ( $\geq 120$ – $129$  mmHg systolic or  $80$ – $89$  mmHg diastolic), measured using a digital sphygmomanometer validated for adolescent populations. Measurements were taken twice at 5-minute intervals, and the average value was used for classification.

Data were collected primarily through questionnaires and interviews, supported by a team of seven enumerators. Sodium intake was assessed using two 24-hour food recalls, including both weekday and weekend intake, and sodium content was calculated using the Indonesian Food Composition Table. Physical activity was measured using the PAL (Physical Activity Level) questionnaire, with categorization based on daily energy expenditure levels (light and high).

Stress levels were assessed using the stress subscale of the DASS-42 (Depression Anxiety Stress Scales), which has been validated in Indonesian adolescents (Cronbach's  $\alpha = 0,9$ ).

The data were analyzed using both univariate and bivariate techniques. Univariate analysis focused on examining individual variables one at time. Univariate analysis explored the distribution of respondents' characteristics as well as the independent variables (sodium-intake, physical activity, and stress levels), and dependent variables (prehypertension). Bivariate analysis used the Chi-Square test to assess the relationships among the independent variables (sodium intake, physical activity, and stress levels) and the dependent variable (prehypertension). The research ethics was submitted to the Non-Medical Health Research Ethics Committee of the University of Muhammadiyah Prof. Dr. Hamka with letter number KEPK-NK/02/02/2025/03223.

## RESULTS

The description of respondents' characteristics consisted of gender, age, pocket money, family history of hypertension, blood pressure, incidence of prehypertension, sodium intake, physical activity, and stress level.

**Table 1. Characteristics of respondents among adolescents**

| Variable                       | f  | %    |
|--------------------------------|----|------|
| <b>Gender</b>                  |    |      |
| Male                           | 28 | 46,7 |
| Female                         | 32 | 53,3 |
| <b>Age</b>                     |    |      |
| 15-16                          | 25 | 41,7 |
| 17-18                          | 35 | 58,3 |
| <b>Pocket Money (in a day)</b> |    |      |
| High ( $\geq$ Rp20,000)        | 35 | 58,3 |
| Low ( $<$ Rp20,000)            | 25 | 41,7 |

According to Table 1, the data indicated that majority of the respondents (53,3%) were female, with the most of respondents aged 17-18 years. More than half of the respondents (58,3%) have a high standard of living per day ( $\geq$ Rp20,000).

**Table 2. Incidence of prehypertension among adolescents**

| Variable                              | f  | %    |
|---------------------------------------|----|------|
| <b>Family history of hypertension</b> |    |      |
| Yes                                   | 14 | 23,3 |
| No                                    | 25 | 41,7 |
| Don't know                            | 21 | 35   |
| <b>Blood pressure</b>                 |    |      |
| <b>Systole</b>                        |    |      |
| $>120$ mmHg                           | 32 | 53,3 |
| $\leq 120$ mmHg                       | 28 | 46,7 |
| <b>Diastole</b>                       |    |      |
| $>80$ mmHg                            | 13 | 21,7 |
| $\leq 80$ mmHg                        | 47 | 78,3 |
| <b>Incidence of Prehypertension</b>   |    |      |
| Prehypertension ( $>120/80$ mmHg)     | 32 | 53,3 |
| Normal ( $<120/80$ mmHg)              | 28 | 46,7 |

As presented in Table 2, approximately 41,7% of respondents reported no family history of hypertension. More than half of the respondents (53,3%) had systolic blood pressure >120 mmHg, while most respondents (78,3%) had diastolic blood pressure ≤ 80 mmHg. Meanwhile, more than half of the respondents (53,3%) experienced an incidence of prehypertension (>120/80).

**Table 3. Sodium intake among adolescents**

| Variable                  | f  | %  |
|---------------------------|----|----|
| <b>Sodium Intake (mg)</b> |    |    |
| ≤1500 mg                  | 30 | 50 |
| >1500 mg                  | 30 | 50 |
| <b>Sodium Intake (%)</b>  |    |    |
| Over (>110%)              | 18 | 30 |
| Adequate (≤110%)          | 42 | 70 |

Based on Table 3. shows that the proportion of sodium consumption ≤1500 mg and >1500 mg is equal (50%). A small proportion of respondents (70%) have sodium intake in the adequate category.

**Table 4. Physical activity and stress level among adolescents**

| Variable                          | f  | %  |
|-----------------------------------|----|----|
| <b>Physical Activity (kcal/h)</b> |    |    |
| Light (≤1,7 kcal/h)               | 51 | 85 |
| High (>1,7 kcal/h)                | 9  | 15 |
| <b>Stress Level (Score)</b>       |    |    |
| Stress (>14)                      | 42 | 70 |
| Normal (≤14)                      | 18 | 30 |

As presented in Table 4, most respondents (85%) had high physical activity. More than half of the respondents (70%) had a stress.

**Table 5. Effect of sodium intake, physical activity, and stress levels on prehypertension among adolescents**

| Variable                 | Incidence of Prehypertension |      |        |      |       |    | OR    | p-value |
|--------------------------|------------------------------|------|--------|------|-------|----|-------|---------|
|                          | Prehypertension              |      | Normal |      | Total |    |       |         |
|                          | f                            | %    | f      | %    | f     | %  |       |         |
| <b>Sodium Intake</b>     |                              |      |        |      |       |    |       |         |
| Over (>110%)             | 16                           | 26,7 | 2      | 3,3  | 18    | 30 | 13,00 | 0,000*  |
| Adequate (≤110%)         | 16                           | 26,7 | 26     | 43,3 | 42    | 70 |       |         |
| <b>Physical Activity</b> |                              |      |        |      |       |    |       |         |
| Light (≤1,7 kcal/h)      | 30                           | 50   | 21     | 35   | 51    | 85 | 5,00  | 0,042*  |
| High (>1,7 kcal/h)       | 2                            | 3,3  | 7      | 11,7 | 9     | 15 |       |         |
| <b>Stress Level</b>      |                              |      |        |      |       |    |       |         |
| Stress (>14)             | 27                           | 45   | 15     | 25   | 42    | 70 | 4,68  | 0,009*  |
| Normal (≤14)             | 5                            | 8,3  | 13     | 21,7 | 18    | 30 |       |         |

\*Test Chi-Square with p-value < 0,05

According to the findings from the Chi-Square analysis in Table 2, sodium intake, physical activity, and stress levels are all significantly associated with prehypertension (p<0,05). Adolescents with excessive sodium intake (>110%) had 13 times higher odds of developing prehypertension compared to those with adequate intake. Likewise, those with light physical activity had five times the odds of prehypertension compared to those engaging in high activity. High stress levels were also associated with an approximately 4,68 times increase in the likelihood

of prehypertension. These findings suggest that high sodium intake, low physical activity, and elevated stress levels contribute significantly to the risk of prehypertension in adolescents.

## **DISCUSSION**

Most participants in this research were female, which aligns with the fact that the proportion of female students at SMAN 17 Bandung exceeds that of male students. This aligns with the findings of Tania et al (2024), which found that 127 female students (56.2%) and 99 male students (43.8%) were involved. This figure suggests a greater presence of female students than male students, resulting in a higher proportion of female respondents in the study. Regarding age, the respondents ranged from 15 to 18 years old, which falls within the late adolescent age range. Adolescence is categorized into two stages: early adolescence (ages 10–14) and late adolescence (ages 15–19) (PAHO, 2018).

The research reveals that most respondents' pocket money is categorized as high which may be attributed to the absence of meals brought from home and the reliance on purchasing food from the school canteen. The habit of bringing food from home influences students' snack consumption. Students who did not bring food from home tend to purchase snacks more frequently, which encourages parents to provide a higher amount of pocket money to accommodate these purchasing habits (Tukiman et al., 2023). Additionally, the amount of pocket money can be influenced by peers. Peers play a significant role in students' decision-making when spending pocket money (Damayanti et al., 2025). This pressure can push teenagers toward a more consumptive lifestyle, thereby influencing parents' decisions to provide higher amounts of pocket money (Hartina et al., 2024).

A large population of respondents was reported to have a family background of hypertension. Respondents with such a family history are at a higher risk of developing hypertension. In addition, nearly all respondents experienced prehypertension (Widyasari, 2021). This is due to insufficient sleep, with respondents averaging only 6-7 hours of sleep per day. The CDC (2020) states that adolescents aged 13-18 years should sleep 8-10 hours per day. Nailufar et al. (2022) found that insufficient sleep duration can negatively affect health and increase the risk of high blood pressure.

Based on two 24-hour dietary recalls, nearly all respondents had low sodium intake. Despite the low sodium intake, respondents frequently consumed high-sodium foods such as instant noodles, seblak, snacks, processed meat products, and other foods. A study by Mardianti et al (2022) found that adolescents at SMK Lingga Kencana Depok consumed high-sodium foods, including bread, soy sauce, flavor enhancers, and sauces. Respondents with poor dietary intake were influenced by accessibility factors within the school environment. Easy access to food at school canteens or stalls can indirectly affect adolescents' eating patterns, as the food options/variety tend to lack balanced nutritional content (Lestari, 2021). Based on observations, respondents tend to choose unhealthy foods because the school canteen lacks healthy snacks, leading many vendors to sell high-sodium options. Amin & Sulaiman (2025) state that if the school environment provides unhealthy foods that are easily accessible, students will choose to consume unhealthy food. Conversely, when healthier foods are available in the school canteen, students are more inclined to select nutritious options.

Research shows that most respondents engage primarily in light physical activity. This is due to a sedentary lifestyle among adolescents, including sitting while using mobile phones and a lack of physical activity in daily life. This study is supported by research conducted by Aprilia et al. (2024), which found that most adolescents spend more time using gadgets, resulting in minimal physical activity. In addition, another factor influencing the low level of physical activity among respondents is that they only engage in light physical activity or exercise during physical education lessons. Fajar et al. (2023) state that many students only exercise during physical

education classes, resulting in low levels of physical fitness. However, some respondents engage in light exercise outside of physical education classes, such as sit-ups, push-ups, pull-ups, and others, with a very limited duration of approximately 18 minutes per week.

Based on research, shows that more than half of the respondents have mild stress levels. Stress arises from academic pressure, as most respondents are 12th-grade students preparing for college entrance exams. Research conducted by Christina et al. (2023) found that stress among 12th-grade students is caused by demands from school and outside school, such as choosing further education, additional assignments, and tutoring. Additionally, the majority of respondents with high gadget usage and low physical activity levels can experience stress. Uncontrolled phone usage and minimal physical activity may contribute to psychological disorders and disrupt stress hormone function, leading to stress (Christina et al., 2023; Kamaruddin et al., 2023). Additional factors associated with increase stress in adolescents include emotional development, internet addiction, living conditions, and parenting styles (Trifonia & Israfil, 2022).

The research findings indicate a correlation between sodium intake with prehypertension. High sodium consumption is significantly associated with elevated blood pressure in adolescence (Mantuges et al., 2021). Interview conducted using two 24-hour food recall assessments revealed that respondents consumed processed meat products, instant noodles, and high-sodium foods such as seblak, cireng, cimol, batagor, cuanki, fried meatballs, and chips. These type of food may trigger inflammation of the arterial walls responsible for transporting oxygenated blood, which can reduce vessel diameter and lead to increased blood pressure (Octarini et al., 2023).

Adolescents' consumption of high-sodium foods was influenced by factors such as accessibility and taste, including the availability of eating places in the school environment. Easy access to high-sodium foods in school canteens may contribute to unhealthy eating patterns that negatively affect health (Kaluku et al., 2023). Frequent intake of salty foods is related to higher blood pressure (Fajarwati et al., 2022). The palatable salty taste produced by sodium is generally perceived as appealing and enhances the flavor of foods, making such items more desirable for adolescents (Eryanti, 2023).

The majority of respondents in the high daily allowance category tend to choose high-sodium foods such as those seasoned with salt or flavored with MSG (monosodium glutamate), which are available in canteens at affordable prices (Rp5,000–Rp10,000 per portion). Students with daily allowances of around Rp22,018 usually spend it on high-sodium and fast food due to easy access and affordable prices (Salsabilah et al., 2024). Adolescents' pocket money plays an important role in decision-making regarding food purchases, which can influence the consumption patterns (Andriani et al., 2024). Continuous high-sodium consumption, facilitated by easy access, can contribute to increased blood pressure (Lubis et al., 2024).

Research conducted by Qurbo (2024) found a significant relationship between physical activity with hypertension risk among adolescents. Based on the research results, respondents typically engage in physical activity only during physical education classes, which occur once a week for 60–90 minutes—an amount that does not meet the WHO recommendation of at least 150 minutes per week. Mulyasari & Srimati (2020) added that low physical activity levels are a key contributor to the rise in prehypertension rates. Adolescents who are less active tend to have weaker heart function, leading the heart to work harder when pumping, which puts additional strain on the arteries and raises blood pressure. Outside of physical education class hours, respondents spend more time in sedentary activities, such as sitting for long periods, using phones, and engaging in little physical activity. Sedentary behavior reduces nitric oxide production, thereby decreasing blood vessel elasticity and increasing vascular resistance (Swihasnika et al., 2021).

Physical activity and sleep duration play an important role in blood pressure regulation. Sleep duration of less than 8 hours may influence blood pressure through the activation of physiological systems such as the sympathetic nervous system and the renin-angiotensin-aldosterone system, both of which contribute to increased blood pressure (Ernawati et al., 2023).

The fewer hours of sleep, the higher the risk for elevated blood pressure (Gosal et al., 2022). Short sleep duration and insufficient physical activity are two interrelated factors that can increase blood pressure. Low physical activity not only directly affects blood vessels but also worsens sleep quality, thereby increasing the incidence of prehypertension in adolescents (Heriady et al., 2023).

The research findings show that there was a relationship between stress levels with prehypertension among adolescents. The study aligns with Salsabila et al (2023), who found a significant association between stress with hypertension among adolescents. Stress is more commonly experienced by 12th-grade respondents due to upcoming school exams and university admissions. 12th-grade students face significant emotional and psychological pressure caused by educational and other factors (Deantri & Sawitri, 2020). This pressure can lead to habits such as staying up late or sleeping less than 8 hours per day. Insufficient sleep can increase levels of norepinephrine and epinephrine hormones, which are stress-related hormones may contribute to increase blood pressure (Hayeeteh et al., 2023). Low physical activity can reduce endorphin production, which influences stress levels. Prolonged stress can increase the incidence of prehypertension (Navia, 2024). Chronic stress may also disrupt the endocrine functions of the thyroid and adrenal glands, disturbing hormone production. This hormonal imbalance can impair the body's internal regulation system, leading to increased heart rate and elevated blood pressure (Trista et al., 2024).

## **CONCLUSION**

According to the results of the study, it also revealed that the prevalence of prehypertension among adolescents at SMAN 17 Bandung was 53.7%, and 23.3% of the respondents had a family history of hypertension. The research was also identified a significant correlation between sodium intake, physical activity, and stress levels with prehypertension among adolescents. These findings highlight the importance of promoting healthy dietary habits, encouraging regular physical activity, and managing stress among adolescents to prevent the early onset of hypertension in the future.

## **AUTHOR'S DECLARATION**

### **Authors' contributions and responsibilities**

RD: Formal Analysis, Writing Original Draft, Conceptualization.

WA: Supporting Draft,

HMI: Data Collection, Review, and Editing.

AF: Review, and Editing.

### **Funding**

Personal expenses

### **Availability of data and materials**

All data and supporting materials for this study are available and can be requested directly from the corresponding author.

### **Competing interests**

The authors declare no competing interests.

## ACKNOWLEDGEMENT

The author would like to express gratitude to all the parties involved who have provided assistance, facilities, support, constructive criticism, and suggestions throughout the entire research process.

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Jurnal Kesehatan Metro Sai Wawai, Vol 18(2) No 2, December 2025, 1-11. E-ISSN 2657-1390 I P-SSN 19779-469X

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