

Lifestyle Factors Associated with Elevated Blood Pressure Among Young Adults

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ABSTRACT

Background: Elevated blood pressure among young adults has become an emerging public health concern due to unhealthy lifestyle changes and low awareness of cardiovascular risk factors. Lifestyle factors such as physical activity, smoking habits, dietary habits, and sleep quality may be associated with blood pressure levels in young adults. This study aimed to analyze the associations between lifestyle factors and elevated blood pressure among young adults.

Subjects and Method: This was an analytic observational study with a cross-sectional design conducted among students of Universitas Sebelas Maret, Surakarta, Central Java. A total of 200 respondents were selected using proportional random sampling. The dependent variable was elevated blood pressure, while the independent variables included physical activity, smoking habits, dietary habits, and sleep quality. Blood pressure was measured using a digital sphygmomanometer, while the other variables were assessed using questionnaires. Data were analyzed using simple and multiple logistic regression and presented as odds ratio (OR) and adjusted odds ratio (aOR) with 95% confidence interval (CI).

Results: Poor sleep quality was associated with higher odds of elevated blood pressure (aOR= 9.15; 95% CI= 3.42 to 24.53; $p<0.001$). Higher dietary habits were also associated with higher odds of elevated blood pressure (aOR= 1.27; 95% CI= 1.12 to 1.44; $p<0.001$), indicating that poorer dietary habits were related to increased odds of elevated blood pressure. In contrast, high physical activity was associated with lower odds of elevated blood pressure (aOR= 0.10; 95% CI= 0.01 to 0.79; $p=0.029$). Smoking habits were not significantly associated with elevated blood pressure.

Conclusion: Elevated blood pressure among young adults was associated with lifestyle factors. These findings highlight the importance of promoting healthy lifestyle behaviors as part of hypertension prevention efforts among university students.

Keywords: blood pressure, hypertension, prehypertension, lifestyle, young adults

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BACKGROUND

Hypertension is one of the leading public health problems worldwide and an important risk factor for various cardiovascular diseases, including coronary heart disease, stroke, kidney failure, and premature mortality. The World Health Organization (WHO) reported that more than 1.28 billion adults are living with hypertension, and nearly half of them are unaware of their condition because hypertension often develops without specific symptoms (World Health Organization, 2023). Consequently, hypertension is widely recognized as a silent killer and remains a major contributor to the global burden of non-communicable diseases.

In Indonesia, hypertension remains a significant public health challenge. Indonesian Health Survey 2023 reported that the prevalence of hypertension among adults reached 30.8%. Of greater concern, hypertension increasingly being identified among young adults. Data from Basic Health Research 2018 showed that the prevalence of hypertension among individuals aged 18–24 years was approximately 13%, yet only 0.85% had been diagnosed by healthcare professionals (Health Research and Development Agency, 2018). A similar pattern was observed in the 2023 Indonesian Health Survey, which reported a hypertension prevalence of 10.7% among individuals aged 18–24 years, while only 0.4% had ever received a diagnosis (Ministry of Health of the Republic of Indonesia, 2023). The gap between hypertension prevalence based on blood pressure measurements and the proportion of diagnosed cases indicates low levels of early detection and health awareness among young adults. These findings suggest that blood pressure abnormalities have emerged during young adulthood and may progress to hypertension and cardiovascular disease later in life if preventive

measures are not implemented at an early stage.

Lifestyle factors are important determinants that contribute to elevated blood pressure and hypertension. The World Health Organization has identified insufficient physical activity, smoking, unhealthy dietary habits, and poor sleep quality as major behavioral risk factors involved in the development of non-communicable diseases, including hypertension (World Health Organization, 2023). These factors are commonly observed among young adults, particularly university students, who are transitioning toward more independent lifestyles and often experience changes in daily habits due to academic and social demands.

Physical activity plays an important role in maintaining cardiovascular function and blood pressure regulation. Individuals with low levels of physical activity are more likely to experience elevated blood pressure due to reduced cardiorespiratory fitness and increased peripheral vascular resistance (Hayes et al., 2022). Smoking may also contribute to elevated blood pressure through nicotine-induced sympathetic nervous system activation, resulting in increased heart rate, peripheral vasoconstriction, and acute increases in blood pressure (Hahad et al., 2023). In addition, dietary habits characterized by high sodium intake, excessive saturated fat consumption, frequent fast-food intake, and inadequate consumption of fruits and vegetables contribute to the development of hypertension (WHO, 2023). Poor sleep quality may also disrupt autonomic nervous system regulation and increase sympathetic nervous system activity, thereby contributing to elevated blood pressure (Saat et al., 2021).

Several studies have demonstrated associations between lifestyle factors and blood pressure among young adults. Low

physical activity and poor sleep quality have been associated with increased cardiovascular risk factors among university students (Saat et al., 2021). Other studies have shown that healthy lifestyle behaviors, including adequate physical activity, healthy dietary habits, non-smoking status, and optimal sleep, are associated with more favorable blood pressure profiles among young adults (Mao et al., 2024). Recent studies have also reported that smoking, unhealthy dietary habits, physical inactivity, and poor sleep quality are associated with elevated blood pressure and hypertension among university students and young adults (Abd Alsamad et al., 2025; Adetunji et al., 2025).

Although the relationship between lifestyle factors and blood pressure has been widely investigated, most studies have focused on hypertension as the primary outcome in the general adult population. In contrast, studies examining elevated blood pressure as an early stage in the development of hypertension among young adults remain relatively limited. Elevated blood pressure is an important predictor of future hypertension and cardiovascular disease (He et al., 2025). Therefore, further research is needed to examine lifestyle factors associated with elevated blood pressure among young adults. This study aimed to analyze the associations of physical activity, smoking habits, dietary habits, and sleep quality with elevated blood pressure among young adults.

SUBJECTS AND METHOD

1. Study Design

This was an analytic observational study with a cross-sectional design conducted at Universitas Sebelas Maret, Surakarta, Central Java, Indonesia, from February to March 2026.

2. Population and Sampel

The study population consisted of 25,173 active undergraduate students aged 18–24 years at Universitas Sebelas Maret. The sample size was determined based on the recommendation for multivariate analysis, which suggest including 15-20 subjects for each independent variable in the regression model (Murti, 2013). Since this study included 10 independent variables, a minimum sample size of 200 respondents was required. Accordingly, 200 respondents were selected using proportional random sampling, with participants from each faculty recruited proportionally to the size of the undergraduate student population.

3. Study Variables

The dependent variable was elevated blood pressure. The independent variables were physical activity, smoking habits, dietary habits, and sleep quality.

4. Operational Definition of Variables

Elevated blood pressure was defined as systolic blood pressure ≥ 120 mmHg and/or diastolic blood pressure ≥ 80 mmHg measured using a digital sphygmomanometer in accordance with the Indonesian Ministry of Health guidelines (Ministry of Health of the Republic of Indonesia, 2021). For analysis purposes, blood pressure was categorized into normal blood pressure and elevated blood pressure (prehypertension and hypertension).

Physical activity was defined as any bodily movement that requires energy expenditure during daily activities and was categorized into low, moderate, and high levels.

Sleep quality was defined as an individual's perception of sleep quality over the previous month, including sleep duration, sleep latency, sleep efficiency, sleep disturbances, use of sleep medication, daytime dysfunction, and categorized as good or poor.

Dietary habits were defined as of food consumption practiced by respondents in

their daily lives. Higher scores indicated poorer dietary habits.

Smoking habits were defined as smoking behavior and were categorized into non-smoker, low, moderate and high smoking intensity.

5. Study Instruments

Blood pressure was measured using a calibrated digital sphygmomanometer following standard measurement procedures. Physical activity was assessed using the International Physical Activity Questionnaire (IPAQ). Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI). Smoking habits were assessed using the Heaviness of Smoking Index (HSI). Dietary habits were assessed using a 13-item questionnaire that met the validity criterion (corrected item-total correlation >0.30) and reliability criterion (Cronbach's $\alpha=0.831$).

6. Data Analysis

Univariate analysis was performed to describe the characteristics of the study participants. Bivariate analysis was conducted using simple logistic regression to estimate the odds ratio (OR) between lifestyle factors and elevated blood pressure. Multivariate analysis was performed using multiple logistic regression to identify

lifestyle factors independently associated with elevated blood pressure. The results were presented as adjusted odds ratios (aOR) with 95% confidence interval (CI). Statistical significance was set at $p<0.05$. All analyses were conducted using Stata version 16.

7. Research Ethics

Ethical approval for this study was obtained from the Research Ethics Committee of the Faculty of Medicine, Universitas Sebelas No. 35/UN27.06.11/KEP/EC/2026.

RESULTS

1. Sample Characteristics

A total of 200 students participated in this study. Table 1 presents the characteristics of the respondents according to sex, physical activity, smoking habits, dietary habits, sleep quality, and blood pressure categories. Most respondents were female (52.50%), had moderate physical activity levels (45.00%), were non-smokers (59.50%), and reported poor sleep quality (56.50%). Based on blood pressure categories, the majority of respondents were classified as prehypertensive (43.00%), followed by normal blood pressure (34.50%) and hypertension (22.50%).

Table 1. Sample Characteristics (Categorical Variables)

Variables	Frequency (n)	Percentage (%)
Sex		
Male	95	47.50
Female	105	52.50
Physical Activity		
Low	30	15.00
Moderate	90	45.00
High	80	40.00
Smoking Habits		
Non-smoker	119	59.50
Low	38	19.00
Moderate	32	16.00
High	11	5.50
Sleep Quality		
Good	87	43.50

Variables	Frequency (n)	Percentage (%)
Blood Pressure		
Poor	113	56.50
Normal	69	34.50
Prehypertension	86	43.00
Hypertension	45	22.50

Table 2 presents the continuous variables included in this study. The mean age of the respondents was 19.68 years (SD=1.56). In

addition, the mean dietary habit score was 36.27 (SD=6.66).

Table 2. Univariate Analysis of Continuous Variables

Variables	n	Mean	SD	Minimum	Maximum
Age (years)	200	19.68	1.56	18	24
Dietary habit score	200	36.27	6.66	20	56

2. Bivariate Analysis

Table 3 presents the results of the bivariate analysis of lifestyle factors associated with elevated blood pressure. Moderate physical activity was associated with lower odds of elevated blood pressure (OR= 0.46; 95% CI= 0.10 to 2.21; p= 0.334), although the association was not statistically significant. High physical activity was associated with lower odds of elevated blood pressure (OR= 0.03; 95% CI= 0.01 to 0.15; p<0.001). These findings suggest that higher levels of physical activity were associated with a lower likelihood of elevated blood pressure.

Low smoking intensity (OR= 3.57; 95% CI= 1.51 to 8.42; p= 0.004), moderate smoking intensity (OR= 14.26; 95% CI= 3.26 to 62.39; p<0.001), and high smoking intensity (OR= 9.51; 95% CI= 1.18 to 76.63; p= 0.034) increased elevated blood pressure compared to non-smoker.

Poor sleep quality (OR= 21.70; 95% CI= 9.85 to 47.81; p<0.001), and poor dietary habit (OR= 1.38; 95% CI= 1.25 to 1.53; p<0.001) increased elevated blood pressure.

Table 3. Results of Simple Logistic Regression Analysis of Lifestyle Factors Associated with Elevated Blood Pressure

Independent Variables	OR	95% CI		p
		Lower limit	Upper limit	
Physical Activity				
Low	Ref			
Moderate	0.46	0.10	2.21	0.334
High	0.03	0.01	0.15	<0.001
Smoking Habits				
Non-smoker	Ref			
Low	3.57	1.51	8.42	0.004
Moderate	14.26	3.26	62.39	<0.001
High	9.51	1.18	76.63	0.034
Sleep Quality				
Good	Ref			
Poor	21.70	9.85	47.81	<0.001
Dietary Habits				
	1.38	1.25	1.53	<0.001

3. Multivariate Analysis

Table 4 presents that high physical activity was associated with lower odds of elevated blood pressure compared with low physical activity (aOR= 0.10; 95% CI= 0.01–0.79; p= 0.029). In contrast, respondents with poor sleep quality had higher odds of elevated

blood pressure than those with good sleep quality (aOR= 9.15; 95% CI= 3.42–24.53; p<0.001). Dietary habit score remained significantly associated with elevated blood pressure after adjustment for other lifestyle factors (aOR= 1.27; 95% CI= 1.12–1.44; p<0.001).

Table 4. Results of Multiple Logistic Regression Analysis of Lifestyle Factors Associated with Elevated Blood Pressure

Independent Variables	aOR	95% CI		p
		Lower limit	Upper limit	
Physical Activity				
Low	Ref.			
Moderate	0.68	0.08	5.53	0.714
High	0.10	0.01	0.79	0.029
Smoking Habits				
Non-smoker	Ref.			
Low	1.83	0.45	7.46	0.398
Moderate	2.82	0.46	17.43	0.264
High	3.69	0.23	57.95	0.353
Sleep Quality				
Good	Ref.			
Poor	9.15	3.42	24.53	<0.001
Dietary Habits	1.27	1.12	1.44	<0.001
N observation=200				
Pseudo R ² = 55.7%				
P value <0.001				

DISCUSSION

1. Association between physical activity and elevated blood pressure

This study found that high physical activity was significantly associated with lower odds of elevated blood pressure among young adults. In contrast, moderate physical activity was not significantly associated with elevated blood pressure after adjustment for other lifestyle factors. These findings suggest that higher intensity physical activity may be associated with more favorable blood pressure levels among young adults.

The findings are consistent with those reported by Guan et al. (2024) who found an inverse association between physical activity and blood pressure. Similarly, Zhou et al. (2022) reported that greater intensity, frequency, and volume of physical activity

were associated with a significantly lower risk of hypertension. An Indonesian study by Kusumaningtyas and Handari (2021) also reported that regular physical exercise significantly improved cardiorespiratory endurance among university students, highlighting the beneficial role of physical activity in promoting cardiovascular health. Although that study evaluated cardiorespiratory endurance rather than blood pressure, improved cardiovascular fitness may partly explain the lower odds of elevated blood pressure observed among physically active young adults. In contrast, Williamson et al. (2022) did not find a significant association among young adults. These differences may be explained by physiological compensatory mechanisms in younger individuals that help maintain

blood pressure within the normal range despite suboptimal physical activity levels.

The protective effect of physical activity may be explained by several physiological mechanisms. Regular moderate to vigorous physical activity enhances endothelial nitric oxide production, leading to improved vasodilation and reduced arterial stiffness. It also decreases sympathetic nervous system activity while improving parasympathetic tone, thereby reducing resting heart rate and peripheral vascular resistance. Furthermore, physical activity improves insulin sensitivity, helps maintain a healthy body weight, and reduces systemic inflammation all of which contribute to better blood pressure regulation (Hayes et al., 2022). These physiological adaptations may explain why participants with high physical activity had lower odds of elevated blood pressure in the present study, whereas moderate activity may not have been sufficient to produce measurable cardiovascular benefits after adjustment for other lifestyle factors.

2. Association between sleep quality and elevated blood pressure

This study found that poor sleep quality was significantly associated with elevated blood pressure among young adults. These findings suggest that sleep quality is an important lifestyle factor associated with blood pressure regulation, even among young adults.

The findings are consistent with those of Bigalke et al. (2024) who reported that sleep disturbances contribute to elevated blood pressure through cumulative physiological mechanisms. Physiologically, poor sleep quality may increase sympathetic nervous system activity, disrupt the normal nocturnal dipping process, and elevate the secretion of stress hormones such as cortisol. These conditions may lead to vasoconstriction, increased heart rate, and

endothelial dysfunction, ultimately contributing to elevated blood pressure (Asraf et al., 2023).

In the present study, sleep quality demonstrated the strongest association among all lifestyle factors examined. The multivariate analysis showed that respondents with poor sleep quality had 9.15 times higher odds of elevated blood pressure than those with good sleep quality. This finding suggests that sleep quality may be the lifestyle factor most strongly associated with elevated blood pressure among university students. This association may be influenced by academic demands, nighttime use of electronic devices, and irregular sleep patterns, all of which are common among young adults.

However, some studies have reported different findings. Laxmi & Udaya (2024) found that sleep disturbances were not always significantly associated with hypertension unless accompanied by short sleep duration. Similarly, Sajjadih et al. (2020) suggested that the cardiovascular system of young adults may still possess sufficient compensatory capacity, preventing immediate increases in blood pressure. Nevertheless, recurrent and prolonged sleep disturbances may exceed this compensatory capacity and contribute to elevated blood pressure.

Among university students, poor sleep quality may be influenced by late-night activities, excessive use of digital devices, caffeine consumption and irregular sleep schedules, all of which are common in university settings and may disrupt normal sleep patterns (Kumar et al., 2025). Beyond these behavioral factors, chronic sleep disruption may activate the hypothalamic pituitary adrenal axis and increase oxidative stress and systemic inflammation, which can impair endothelial function and reduce vascular compliance. Over time, these

physiological changes may contribute to persistent elevations in blood pressure. Therefore, the strong association observed in this study suggests that maintaining good sleep may represent an important strategy for preventing elevated blood pressure among young adults.

3. Association between dietary habits and elevated blood pressure

This study found that higher dietary habits were significantly associated with elevated blood pressure among young adults. Because higher scores represented poorer dietary habits, these findings indicate that less healthy dietary patterns were associated with increased odds of elevated blood pressure. Dietary habits therefore represent an important lifestyle factor associated with blood pressure regulation.

The findings are consistent with those reported by Andrianto et al. (2023), who found significant associations between dietary patterns, particularly the consumption of salty foods, sugar-sweetened beverages, and inadequate fruit and vegetable intake, and the prevalence of hypertension. Their multivariate analysis further demonstrated a significant association between daily salty food consumption and hypertension prevalence. Unhealthy dietary habits often interact with other lifestyle factors, thereby increasing the likelihood of cardiovascular disorders (Fatima et al., 2024).

Physiologically, excessive sodium intake may lead to fluid retention and increased blood volume, while excessive fat consumption may increase vascular resistance, both of which contribute to elevated blood pressure (Relyta, 2023). Although some studies have reported inconsistent findings among young adults (Azizah et al., 2025; Fernández-Galván et al., 2025), the present study suggests that unhealthy dietary habits remain associated with

elevated blood pressure among university students.

Beyond excessive sodium and fat intake, unhealthy dietary patterns may also promote oxidative stress and impair endothelial function by reducing nitric oxide bioavailability, increasing endothelial cell stiffness, and damaging the endothelial glycocalyx, thereby reducing vascular relaxation and increasing arterial stiffness (Patik et al., 2021). In addition, inadequate consumption of fruits and vegetables may reduce dietary potassium intake, which plays an important role in maintaining endothelial function and counteracting the adverse vascular effects of high sodium intake. These physiological mechanisms may explain the higher odds of elevated blood pressure observed among students with poorer dietary habits in the present study, highlighting the importance of promoting healthy eating behaviors as part of blood pressure prevention strategies.

4. Association between smoking habits and elevated blood pressure

This study found that smoking habits were not significantly associated with elevated blood pressure after adjustment for other lifestyle factors. This finding differs from the bivariate analysis, which showed a significant association between smoking habits and elevated blood pressure. The attenuation of the association in the multivariate model suggests that the relationship between smoking and elevated blood pressure may be influenced by other lifestyle factors included in the analysis.

The findings are consistent with those of Andrianto et al. (2023), who reported that smoking was not significantly associated with hypertension prevalence in multivariate analysis after considering other relevant risk factors. Similarly, the absence of a significant association in the present study may be partly related to the charac-

teristics of the study population, which consisted predominantly of young adults. Younger individuals may have relatively shorter durations and lower cumulative exposure to smoking. Therefore, its long-term cardiovascular effects on blood pressure may not yet be fully apparent.

Although smoking was not significantly associated with elevated blood pressure in this study, it remains an important risk factor for cardiovascular disease. Nicotine stimulates catecholamine release, leading to increased sympathetic nervous system activity, elevated heart rate, and peripheral vasoconstriction, which can acutely increase blood pressure. Chronic cigarette smoke exposure further promotes oxidative stress, inflammation, and endothelial dysfunction by reducing nitric oxide bioavailability and increasing vascular stiffness, thereby contributing to long term vascular damage and hypertension (Chang et al., 2021; Dimitriadis et al., 2022; Hahad et al., 2023). Therefore, the absence of a statistically significant association in the present study should not be interpreted as evidence that smoking has no adverse cardiovascular effects.

Overall, this study found that lifestyle factors were associated with elevated blood pressure among young adults. High physical activity was associated with lower odds of elevated blood pressure, whereas poor sleep quality and higher dietary habits scores were associated with higher odds of elevated blood pressure. Because higher dietary habits scores reflected poorer dietary habits, respondents with less healthy patterns were more likely to experience elevated blood pressure. Sleep quality demonstrated the strongest association among the lifestyle factors examined. In contrast, smoking habits were not significantly associated with elevated blood pressure after adjustment for other lifestyle factors in the multivariate

model. This study has several limitations. First, the cross-sectional design does not allow causal relationships between lifestyle factors and elevated blood pressure to be established. Second, most variables were assessed using self-reported questionnaires, which may have introduced information bias due to reporting errors. Third, the study was conducted among students from a single university, limiting the generalizability of the findings to broader young adult populations. Nevertheless, the findings highlight the importance of strengthening health promotion programs that focus on increasing physical activity, improving sleep quality, and encouraging healthy dietary habits as part of hypertension prevention efforts among university students and young adults.

AUTHOR CONTRIBUTIONS

FAI conceptualized the study, developed the research proposal, collected the data, performed the statistical analysis, interpreted the findings, and prepared the original manuscript. S and BW supervised the study, contributed to the study design and research methodology, critically reviewed and revised the manuscript. EBC and MPW provided critical feedback on the study, contributed to the interpretation of the findings, reviewed and refined the manuscript. All authors read and approved the final version of the manuscript.

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest related to this study or its publication.

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RESULTS

- Abd-Alsamad YA, Jaffal BMS, Shuhait KRI, Alzaabi RKKK, Lataifeh SMM, Sadia TT, Hussein A, et al. (2025). High Prevalence of Elevated Blood Pressure (Prehypertension) and Hypertension among Undergraduate University Students in the UAE: a Serious Health Concern. *J Hum Hypertens*. 39(6): 442–447. Doi: 10.1038/s41371-025-01015-7.
- Adetunji A, Uche-Orji C, Ezebialu C, Adebayo PC, Sanusi F, Imo U, Adiat T, et al. (2025). The Prevalence and Risk Factors of Pre-Hypertension and Hypertension among Clinical Students at The University of Ibadan, Nigeria. *BMC Cardiovasc Disord*. 25: 393. Doi: 10.1186/s12872-025-04852-z.
- Andrianto, Bhisma MS, Triastuti F, Pikir BS & Trissatharra A. (2023). Association between dietary patterns of salty foods, sweet drinks, fruit and vegetables and the prevalence of hypertension in East Java: Multivariate analysis of Indonesian Basic Health Surveys Data 2018. *Media Gizi Indonesia*, 18(1), 1-7. Doi: 10.20473/mgi.v18i1.1-7.
- Asraf NO, Hasan MKA., Ahmad AM, Burayk AM, Sahl ZH, Mujir AS, Hassan SS, et al. (2023). Relationship between hypertension and sleep: an overview. *Int J Life Sci Pharma Res*. 13(1). Doi: 10.22-376/ijlpr.2023.13.1.SP2.L42-L56.
- Azizah HN, Ilmiyati L, Amalina BI. (2025). Tekanan darah pada usia produktif 20-59 tahun dan kaitannya dengan konsumsi zat gizi makro, sayur dan buah (Blood pressure among adults aged 20–59 years and its association with macronutrient, vegetable, and fruit intake). *J Pharm Nutr Res*, 1(1). Doi: 10.64689/jopanur.v1i01.3.
- Bigalke JA, Greenlund IM, Bigalke JR, & Carter JR. (2024). Actigraphy-based sleep and muscle sympathetic nerve activity in humans. *Am J Physiol Regul Integr Comp Physiol*. 327(2), R145–R151. Doi: 10.1152/ajpregu.00113.2024
- Chang JT, Anic GM, Rostron BL, Tanwar M, Chang CM. (2021). Cigarette smoking reduction and health risks: A systematic review and meta-analysis. *Nicotine Tob Res*. 23(4): 635-642. Doi: 10.1093/ntr/ntaa156.
- Dimitriadis K, Narkiewicz K, Leontsinis I, Konstantinidis D, Mihas C, Andrikou I, Thomopoulos C, et al. (2022). Acute effects of electronic and tobacco cigarette smoking on sympathetic nerve activity and blood pressure in humans. *Int J Environ Res Public Health*. 19(6): 3237. Doi:10.3390/ijerph19063237.
- Fatima H, Ahmad S, Fatima N, Ahmad H, Sheikh N. (2024). Prevalence and Risk Factors of Hypertension in Young Adults and Middle-Aged Individuals: A Cross-Sectional Study. *Albus Scientia*, 1–3. Doi: 10.56512/AS.2024.2.e24122-3.
- Fernández-Galván LM, Adelantado-Renau M, Beltran-Valls MR, Moliner-Urdiales D. (2025). Relationship between dietary patterns and blood pressure during adolescence: A longitudinal analysis from Dados study. *Am J Hum Biol*. 37(1): e24199. Doi: 10.1002-ajhb.24199
- Guan T, Cao M, Zheng C, Zhou H, Wang X, Chen Z, Zhang L, et al. (2024). Dose-response association between physical activity and blood pressure among

- chinese adults: a nationwide cross-sectional study. *J Hypertension*, 42(2), 360–370. Doi: 10.1097/HJH.00000-00000003587.
- Hahad O, Kuntic M, Kuntic I, Daiber A, Münzel T. (2023). Tobacco smoking and vascular biology and function: evidence from human studies. *Pflugers Arch*, 475(6): 797–805. doi:10.1007/s00424-023-02805-z.
- Hayes P, Ferrara A, Keating A, McKnight K, O'Regan A. (2022). Physical activity and hypertension. *Rev Cardiovasc Med*. 23(9): 302. Doi: 10.31083/j.rcm230-9302.
- He C, Lu S, Yu H, Sun Y, Zhang X. (2025). Global, Regional, and National Disease Burden Attributable to High Systolic Blood Pressure in Youth and Young Adults: 2021 Global Burden of Disease Study analysis. *BMC Med*, 23(1). Doi: 10.1186/s12916-025-03918-1
- Health Research and Development Agency. (2018). National Report of the 2018 Basic Health Research (RISKESDAS). Jakarta: Publishing Agency of the Health Research and Development Agency.
- Kumar P, Sahani AK, Hafiz AB, Tyagi AD. (2025). The Impact of Sleep on Student Health: Exploring its Effects on Physical Well-being, Mental Health, and Academic Performance. *Int J Innov Res Technol*. 12(2): 2309–2313. <https://ijirt.org/article?manuscript=182405>
- Kusumaningtyas M, Handari HK. (2021). The effects of skipping rope exercise, brisk walking exercise, and weight training on cardiorespiratory endurance in physiotherapy students. *Indones J Med*, 6(4): 423-429. Doi: 10.26911/theijmed.2021.6.4.453
- Laxmi C, Udaya I. (2024). Sleep quality and its longitudinal effects on cardiovascular health in adults: an observational study. *Int J Pharm Clin Res*, 16(3): 1682–1687. <https://impactfactor.org/pdf/ijpcr/16/ijpcr,vol16,issue3,article280.pdf>.
- Mao B, Yang Y, Fan Z, Li Y, Xiang W, Dong B, Hu J. (2024). Association of a healthy lifestyle with ambulatory 24-hour blood pressure among Chinese Youths: A Cross-Sectional Study. *Am J Hypertens*. 37(9): 674–681. Doi: 10.1093/ajh/hpae074
- Ministry of Health of the Republic of Indonesia. (2021). National Guidelines for Medical Services (PNPK): Management of Hypertension in Adults. Jakarta: Ministry of Health of the Republic of Indonesia. Retrieved from <https://kemkes.go.id/id/pnpk-2021---tata-laksana-hipertensi-dewasa>.
- Ministry of Health of the Republic of Indonesia. (2023). Indonesian Health Survey (SKI) 2023 in Figures. Jakarta: Ministry of Health of the Republic of Indonesia. Retrieved from <https://www.badankebijakan.kemkes.go.id/ski-2023-dalam-angka/>.
- Murti B. (2013). Desain dan ukuran sampel untuk penelitian kuantitatif dan kualitatif di bidang kesehatan (Design and sample size for quantitative and qualitative health research). Yogyakarta: UGM Press.
- Patik JC, Lennon SL, Farquhar WB, Edwards DG. (2021). Mechanisms of dietary sodium-induced impairments in endothelial function and potential countermeasures. *Nutrients*. 13(1): 270. Doi:10.3390/nu13010270.
- Relyta AE. (2023). Systematic literature review: hubungan pola makan, faktor stres, dan asupan natrium terhadap tekanan darah pada penderita hipertensi. *Nautical: Jurnal Ilmiah Multi-disiplin*. 2(6): 421-426. <https://jurnal.->

- arkainstitute.co.id/index.php/nautical/article/view/950/760.
- Saat NZBM, Hanawi SA, Farah NMF, Amin HM, Hanafiah H, Selvaraj T. (2021). Associations of physical activity, sleep quality and cardiovascular risk factors in University Students. *Sustainability*, 13(21): 11806. Doi: 10.3390/su1321-11806.
- Sajjadih A, Shahsavari A, Safaei A, Penzel T, Schoebel C, Fietze I, Mozafarian N, et al. (2020). The association of sleep duration and quality with heart rate variability and blood pressure. *Tanaffos*, 19(2): 135–143. <https://pubmed.ncbi.nlm.nih.gov/33262801/>
- Williamson W, Lewandowski AJ, Huckstep OJ, Lapidaire W, Ooms A, Tan C, Mohamed A, et al. (2022). Effect of Moderate to High Intensity Aerobic Exercise on Blood Pressure in Young Adults: The TEPHRA Open, Two-Arm, Parallel Superiority Randomized Clinical Trial. *EClinicalMedicine*, 48: 1014-45. Doi: 10.1016/j.eclinm.2022.101445.
- WHO. (2023). WHO Global Report on Sodium Intake Reduction. World Health Organization.
- WHO. (2023). Hypertension. World Health Organization. <https://www.who.int/news-room/fact-sheets/detail/hypertension>.
- Zhou L, Feng W, Xiang N, Cheng Y, Ya X, Wang M, et al. (2022). Association Between Physical Activity Dimensions and The Risk of Hypertension among Middle and Older Adults: A Cross-sectional Study in China. *Front Public Health*. 10: 995755. Doi: 10.3389/fpubh.2022.995755.