Ahmad Dahlan Medical Journal
VOL 6, No. 2, 150-159
http:// http://journal2.uad.ac.id/index.php/admj

Article

Association Between Obesity and the Incidence of Hypertension Among Adolescents in Ponorogo

[1]MH. Muflihatul Ulfa*, [2]Rachma Greta Perdana Putri, [3]Rais Fadhila
Email (Corresponding Author) : *muflihatul@med.uad.ac.id
[1,2]Faculty of Medicine, Universitas Ahmad Dahlan, Yogyakarta, Indonesia
[3]Faculty of Health Science, Universitas Muhammadiyah Surakarta, Surakarta, Indonesia

ARTICLE INFO

Article history
Received 26 Aug 25
Revised 19 Sep 25
Accepted 22 Sep 25

Keywords :
obesity,
hypertension,
adolescent

ABSTRACT

Obesity is characterized by excessive body fat accumulation resulting from an imbalance between energy intake and expenditure, where energy intake exceeds energy utilization. In adolescence, obesity is a multifactorial health problem influenced by genetic, behavioral, environmental, and social factors, and is a known risk factor for hypertension. The pathogenesis of hypertension in obese individuals involves abnormal adipose tissue activity in producing hormones and adipokines, although the mechanisms are not yet fully understood. Several studies have linked obesity to hypertension, but mostly in adult populations, where the indicators for obesity differ from those for adolescents and children. In younger populations, overweight or obesity assessment should be based on BMI-for-age charts adjusted for sex, yet studies in adolescents often still use adult criteria. This study aimed to determine the association between obesity and hypertension among adolescents in Ponorogo. An observational analytic study with a cross-sectional design was conducted using data from the 2024 PASHMINA (Pelayanan Kesehatan Remaja Milik NA) health screening program organized by Regional Board of Nasyiatul Aisyiyah of Ponorogo among senior high school students. A total of 179 respondents participated, with 65.9% female and 65.4% having normal nutritional status. The overall prevalence of hypertension was 22.3%, while obesity prevalence was 12.8%. Hypertension was more common in obese adolescents (43.5%) compared to non-obese adolescents (19.2%), with obesity increasing the risk of hypertension by 3.231 times ($p < 0.05$). These findings highlight the need for appropriate obesity assessment methods in adolescents and the importance of nutrition education, promotion of physical activity, early detection, and regular health monitoring to prevent hypertension from an early age.

This is an open access article under the CC–BY-SA license.

INTRODUCTION

Obesity is characterized by excessive body fat accumulation resulting from an imbalance between energy intake and expenditure, where energy intake exceeds energy utilization[1]. Adolescent obesity is a global health concern. Overweight in adolescence is an important risk factor for obesity in adulthood and the development of comorbidities[2]. Adolescent obesity has become a worldwide problem, particularly in developed countries. This condition can lead to

several diseases that contribute to increased morbidity and premature mortality[3].

A global analysis reported that the prevalence of obesity among children and adolescents was 8.5%. Overall, approximately 1 in 5 children and adolescents worldwide were affected by excess weight, with the prevalence of overweight at 14.8% and excess weight at 22.2% during the period 2000–2023[4]. In 2018, one in five school-aged children (20%, or 7.6 million), one in seven adolescents (14.8%, or 3.3 million), and one in three adults (35.5%, or 64.4 million) in Indonesia were living with overweight or obesity[5]. The causes of adolescent obesity include genetic, behavioral, environmental, and social factors. Obesity during adolescence can lead to various medical conditions, one of which is hypertension (high blood pressure)[3]. The pathogenesis of hypertension in obese individuals is complex and not yet fully understood; however, it is currently believed that increased abnormal adipose tissue activity in producing hormones and adipokines plays a significant role[6].

Blood pressure in hypertension is measured using a sphygmomanometer, whereas obesity is assessed using body mass index (BMI) cut-off points. According to international consensus, the assessment of overweight in children and adolescents is determined using body mass index (BMI) charts that are adjusted for age and sex. At present, three main reference standards are commonly applied, they are CDC 2000 (Centers for Disease Control and Prevention)[7], IOTF (International Obesity Task Force)[8], and WHO 2007 (World Health Organization)[9]. In Indonesia, according to the Minister of Health Regulation (Peraturan Menteri Kesehatan) No. 2 of 2020 on Child Anthropometric Standards, the assessment of nutritional status for children aged 5 to 18 years refers to the WHO Growth Reference 2007. Based on these criteria, nutritional status classifications in this age group include severely thinness, thinness, normal, overweight, and obese, with obesity defined as a body mass index-for-age (BMI-for-age) greater than +2 standard deviations (SD)[10]. Several studies have linked obesity and hypertension but mainly in adult populations[11–13], in which obesity indicators differ from those in adolescents or children. Overweight or obesity in younger populations should be evaluated using BMI-for-age charts adjusted for sex. However, studies in adolescents often still use adult criteria to diagnose obesity[14–16].

Research on the association between obesity and hypertension has mostly been conducted in adults, while studies focusing on adolescents or children remain limited. Therefore, further research is needed regarding the association between obesity and hypertension in adolescents. Previous related studies have often applied obesity criteria designed for adults[14–16], which deviate from the national standards, as Indonesia adopts the WHO 2007 Growth Reference for children aged 5 to 18 years. This study will analyze the association between obesity and hypertension in

adolescents, using obesity criteria based on national standards, by BMI-for-age charts. This study aimed to determine the association between obesity and hypertension among adolescents in order to prevent the early development of non-communicable diseases among adolescents, who represent the next generation in the future.

METHODS

This study employed an observational analytic method with a cross-sectional design involving adolescents aged 13–15 years who were senior high school or equivalent students in Ponorogo Regency and participated in the 2024 PASHMINA (Pelayanan Remaja Sehat Milik NA) health screening. The sample was selected using purposive sampling with the following inclusion criteria: (a) adolescents aged 13–15 years, and (b) participation in the PASHMINA health screening. The exclusion criteria were: (a) adolescents with a history of secondary hypertension, (b) adolescents with specific medical conditions such as chronic kidney disease, diabetes mellitus, or hyperthyroidism, and (c) incomplete data. All adolescents meeting the inclusion and exclusion criteria during the 2024 PASHMINA screening were included in the study, yielding a total of 179 subjects. Accordingly, the study sample represented the accessible population of adolescents in Ponorogo who participated in the PASHMINA program, rather than all adolescents in the region.

Obesity status was determined using body mass index (BMI) calculated as weight (kg) divided by height squared (m^2) and classified according national standards using the WHO 2007 Growth Reference for children aged 5 to 18 years, with obesity defined as a body mass index-for-age (BMI-for-age) greater than +2 standard deviations (SD)[10]. Hypertension in children was defined based on the Decree of the Minister of Health of the Republic of Indonesia (KMK) (No. HK.01.07/MENKES/4613/2021), with the classification for adolescents aged >13 years referring to the 2017 American Academy of Pediatrics (AAP) guideline, namely blood pressure ≥130/80 mmHg[17,18] . Data were obtained from the 2024 PASHMINA health screening, filtered according to inclusion and exclusion criteria, and compiled in Microsoft Excel. Data analysis was performed using SPSS for Windows version 24.0, with univariate analysis to describe the variables, followed by bivariate analysis between the independent and dependent variables using Chi-Square test.

RESULTS

We included 179 respondents in the study sample, of whom 65.9% were female and 34.1% were male (Table 1). Based on nutritional status according to WHO 2017 chart, the majority were classified as normo weight (65.4%), followed by overweight and obese, each accounting for 12.8%, and thinness at 8.4%. Only 0.6% were categorized as having severe thinness. Regarding hypertension status, most respondents (77.7%) were normotension, while 22,3% had hypertension. In terms of obesity status, 12.8% of respondents were categorized as obese, and

87.2% were non-obese. The mean height of respondents was 157.97 cm (SD ± 6.90 cm), with a mean body weight of 54.52 kg (SD ± 15.78 kg). The mean body mass index (BMI) was 21.72 kg/m^2 (SD ± 5.65 kg/m^2). The mean systolic blood pressure was 108.49 mmHg (SD ± 16.33), while the mean diastolic blood pressure was 69.57 mmHg (SD ± 10.28).

Table 1. Demographic Profile of Respondents

Variable	***n***	***%***	***Mean ± SD***
Sex			
Male	61	34,1	-
Female	118	65,9	-
Nutritional Status			
Severe Thinness	1	0,6	-
Thinness	15	8,4	-
Normoweight	117	65,4	-
Overweight	23	12,8	-
Obese	23	12,8	-
Hypertension Status			
Normotension	139	77,7	-
Hypertension	40	22,3	-
Obesity Status			
Non-Obese	156	87,2	-
Obese	23	12,8	-
Height (cm)	-	-	157,97 ± 6,90
Weight (kg)	-	-	54,52 ± 15,78
Body Mass Index (kg/m^2)	-	-	21,72 ± 5,65
Systolic Blood Pressure (mmHg)	-	-	108,49 ± 16,33
Diastolic Blood Pressure (mmHg)	-	-	69,57 ± 10,28

Analysis of the distribution of hypertension status based on nutritional status categories revealed that the majority of respondents with severe thinness and thinness were normotension, accounting for 100% and 86.7% (13 out of 15). In the normoweight group, almost all were normotension, comprising 83.8% (98 out of 117), while 16.2% (19 out of 117) were hypertension (Table 2). In the overweight group, 34.8% (8 out of 23) of respondents had hypertension, while 65.2% (15 out of 23) were normotension. In the obese group, the proportion of hypertension increased to 43.5% (10 out of 23), with the remaining 56.5% (13 out of 23) being normotension. Of the total 179 respondents, 77.7% (139) were normotension and 22.3% (40) had hypertension. These data indicate a tendency for higher prevalence of hypertension in the overweight and obese groups compared to other nutritional status categories.

Table 2. Distribution of Nutritional Status by Hypertension Status

Nutritional Status	***Normotension n (%)***	***Hypertension n (%)***	***Total n (%)***
Severe Thinness	1 (100.0)	0 (0.0)	1 (0.6)
Thinness	13 (86.7)	2 (13.3)	15 (8.4)
Normoweight	98 (83.8)	19 (16.2)	117 (65.4)
Overweight	15 (65.2)	8 (34.8)	23 (12.8)
Obese	13 (56.5)	10 (43.5)	23 (12.8)

Total	139 (77.7)	40 (22.3)	179 (100)

Analysis of the association between nutritional status and the incidence of hypertension showed that in the non-obese group, only 19.2% of respondents had hypertension, while the remaining 80.8% were normotensive. Conversely, in the obese group, the prevalence of hypertension was much higher, at 43.5%, with 56.5% of respondents classified as normotensive (Figure 1). The odds ratio (OR) analysis indicated that individuals with obesity had a 3.231-fold higher risk of hypertension compared to non-obese individuals (OR = 3.231; 95% CI: 1.293–8.071), and this difference was statistically significant ($p < 0.05$) (Table 3). These findings indicate a statistically significant association between obesity and an increased risk of hypertension in the studied population.

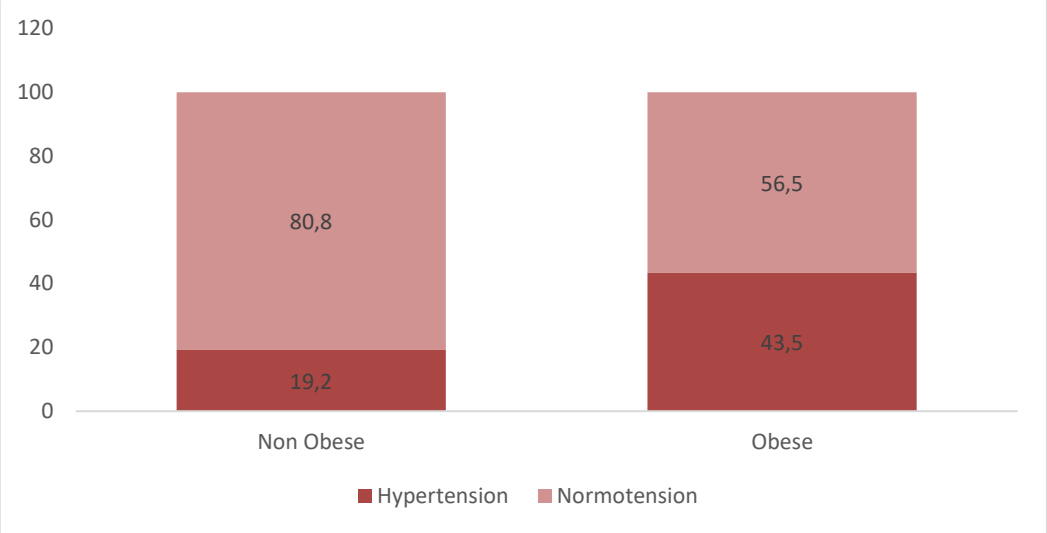

Figure 1. Distribution of Hypertension Status by Obesity Status

Table 3. Association Between Obesity Status and Hypertension Status

Nutritional Status	***Hypertension n (%)***	***Normotension n (%)***	***Total n (%)***	***OR (95% CI)***	***p-value***
Non-Obese	30 (19.2)	126 (80.8)	156 (100)	Ref	
Obese	10 (43.5)	13 (56.5)	23 (100)	3.231 (1.293–8.071)	0.009
Total	40 (22.3)	139 (77.7)	179 (100)		

DISCUSSION

Demographic Profile and Nutritional Status of Adolescents

Based on nutritional status according to WHO 2017, most respondents were in the normoweight category (65.4%), while the overweight and obesity groups accounted for 12.8% each. The proportion of respondents with undernutrition status, such as thinness and severe thinness, was relatively small at 8.4% and 0.6%, respectively. These findings are consistent with the double burden of malnutrition trend observed in Southeast Asia, where the prevalence of

undernutrition is declining, while overweight and obesity show a significant increase [19]. A systematic review conducted in Pakistan by Khan et al. [20] with a sample of more than 62,000 children aged 5–15 years also reported a similar phenomenon. However, in the study by Khan et al. [20], the prevalence of undernutrition was relatively high, with underweight at 25.1%, stunting 23%, wasting 24%, and thinness 12.5%, while overweight and obesity reached 11.4% and 6.9%. The dietary patterns of these children tended to be high in carbohydrates, sweetened beverages, and other sugary foods, but low in protein, fruit, and vegetable intake compared to daily recommendations. This reinforces the indication of a double burden of malnutrition along with suboptimal dietary patterns among school-aged children and early adolescents[20].

In Indonesia, the 2018 Riskesdas data also illustrate the double burden of malnutrition among adolescents. As many as 25.7% of adolescents aged 13–15 years and 26.9% of those aged 16–18 years experienced short and very short stature. In addition, the prevalence of thinness and severe thinness was 8.7% among adolescents aged 13–15 years and 8.1% among those aged 16–18 years. On the other hand, the prevalence of overweight and obesity was also relatively high, at 16.0% in adolescents aged 13–15 years and 13.5% in those aged 16–18 years [21]. Differences in nutritional status are also influenced by sex, with boys being more vulnerable to undernutrition due to biological and social factors [22,23].

Prevalence of Hypertension in Adolescents

The prevalence of hypertension among adolescents in this study showed considerable variation, with the majority of respondents (77.7%) classified as normotension and 22.3% experiencing hypertension. This finding is consistent with the results of Islam et al. [24], who reported that the prevalence of adolescent hypertension in Asia varies, ranging from 2.6% in Indonesia to 24.5% in Malaysia, with lifestyle and environmental factors playing significant roles. Other studies have also demonstrated varying rates of hypertension in Indonesia, such as a national prevalence of 5.3% based on the 2013 Riskesdas data and higher rates in certain urban areas, for example, 15.5% in Jakarta and 42.4% in Depok [25].

Hypertension in adolescents is a complex and multifactorial health issue influenced by the interaction of lifestyle and environmental factors. Studies indicate that psychosocial stress is one of the strongest risk factors for hypertension in this age group, as stress can trigger unhealthy coping behaviors, including disrupted sleep patterns, consumption of foods high in salt, sugar, and saturated fat, as well as smoking and alcohol use [26]. Additionally, obesity during childhood and adolescence has been consistently shown to increase the risk of hypertension, with evidence demonstrating that higher body mass index (BMI) is positively associated with elevated blood pressure from an early age. Diets high in sodium and excessive caloric intake further exacerbate

this condition, whereas diets rich in potassium, vegetables, fruits, and low-fat dairy products have protective effects on blood pressure [27]. Regular physical activity also contributes to significant reductions in blood pressure, while sleep disturbances, including obstructive sleep apnea, are associated with blood pressure dysregulation and hypertension in adolescents [27].

Environmental and behavioral factors also play a significant role in the development of hypertension during adolescence. Exposure to air pollution and chemical compounds such as phthalates can affect endocrine function and increase the risk of abnormal blood pressure [27]. Smoking habits among adolescents, influenced by family, peers, and media, also have been shown to be significantly associated with hypertension [28].

Association of Obesity with Hypertension

The results of the study showed that the prevalence of hypertension increased among children with overweight (34.8%) and obesity (43.5%), while the majority of those in the normoweight and undernutrition groups were normotensive. This finding is consistent with studies that identify obesity, particularly visceral fat, as a major cause of primary hypertension [29]. Obesity induces hypertension through multiple interconnected and complex physiological mechanisms. One of the main mechanisms is the excessive activation of the sympathetic nervous system, which increases heart rate and sodium reabsorption in the kidneys, thereby elevating blood volume and blood pressure [30]. The accumulation of visceral fat around the kidneys also exerts physical pressure that can activate the renin-angiotensin-aldosterone system (RAAS), triggering vasoconstriction as well as sodium and water retention, which further aggravates hypertension [31]. In addition, visceral adipose tissue produces pro-inflammatory adipokines such as leptin, TNF-alpha, and interleukins, which cause endothelial dysfunction and vascular inflammation, thereby impairing vascular tone regulation [32].

Insulin resistance, which frequently occurs in obesity, also contributes to increased sympathetic nervous system and RAAS activity, as well as enhanced sodium reabsorption through tubular transporters in the kidneys [30,31]. Obesity raises the risk of obstructive sleep apnea, which, through recurrent hypoxia, activates the sympathetic nervous system and RAAS and triggers chronic inflammation, thereby worsening hypertension [31]. The leptin-melanocortin pathway, which links fat storage signals to sympathetic nervous system centers, also enhances sodium retention and blood volume expansion, contributing to elevated blood pressure [32].

Excessive free fatty acid metabolism generates oxidative stress via reactive oxygen species production, which damages vascular endothelial function and exacerbates hypertension [31]. Genetic and epigenetic factors also influence individual susceptibility to obesity-related hypertension [32]. Overall, hypertension in obesity results from the complex interplay of neurohumoral dysregulation, inflammation, renal dysfunction, and metabolic disturbances,

requiring a multidisciplinary management approach that includes weight control, appropriate pharmacological therapy, and precision medicine [30–32].

Risk of Obesity for Hypertension

The analysis showed a hypertension prevalence of 19.2% in non-obese and 43.5% in obese, with a 3.231-fold higher risk of hypertension in obesity (OR = 3.231; $p < 0.05$). This finding is consistent with Das [33], who reported a 1.6-fold higher risk of hypertension in overweight individuals and 2.3-fold in obese individuals, as well as the meta-analysis by Zaen et al. [34], which found a 2.4-fold and 4.5-fold higher risk in overweight and obese adolescents, respectively. Therefore, early detection and prevention of obesity are crucial to reducing the risk of hypertension in children and adolescents.

CONCLUSION

The findings of this study demonstrate that obesity significantly increases the risk of hypertension among adolescents, with obese adolescents being more likely to experience hypertension compared to their non-obese peers. The overall prevalence of hypertension (22.3%) and obesity (12.8%) in this study indicates that early preventive efforts are essential. Appropriate obesity assessment methods, nutrition education, promotion of physical activity, early detection, and regular health monitoring should be prioritized to reduce the risk of hypertension from an early age.

REFERENCES

1. Ainun N, Simbolon D. Macronutrient Intake and Obesity in Adolescents: A Meta-Analysis Study. *Media Gizi Indonesia*. 2024;19(1SP):29-35. doi:10.20473/mgi.v19i1SP.29-35
2. Fiamenghi VI, Mello ED de. Vitamin D deficiency in children and adolescents with obesity: a meta-analysis. *J Pediatr (Rio J)*. 2021;97(3):273-279. doi:10.1016/J.JPED.2020.08.006
3. Smith JD, Fu E, Kobayashi MA. Prevention and Management of Childhood Obesity and Its Psychological and Health Comorbidities. *Annual Review of Clinical Psychology Downloaded from www.annualreviews.org Guest*. 2025;45:21. doi:10.1146/annurev-clinpsy-100219
4. Zhang X, Liu J, Ni Y, et al. Global Prevalence of Overweight and Obesity in Children and Adolescents: A Systematic Review and Meta-Analysis. *JAMA Pediatr*. 2024;178(8):800-813. doi:10.1001/jamapediatrics.2024.1576
5. UNICEF Indonesia. *Analisis Lanskap Kelebihan Berat Badan Dan Obesitas Di Indonesia*.; 2022. Accessed September 22, 2025. https://www.unicef.org/indonesia/id/gizi/laporan/analisis-lanskap-kelebihan-berat-badan-dan-obesitas-di-indonesia
6. Drozdz D, Alvarez-Pitti J, Wójcik M, et al. Obesity and cardiometabolic risk factors: From childhood to adulthood. *Nutrients.MDPI*. 2021;13(11). doi:10.3390/nu13114176
7. CDC. *CDC Growth Charts*. Public Health Service, Centers for Disease Control and Prevention, National Center for Health Statistics; 2024. Accessed September 22, 2025. https://www.cdc.gov/growthcharts/cdc-growth-charts.htm
8. Llorca-Colomer F, Murillo-Llorente MT, Palau-Ferré A, Pérez-Bermejo M, Legidos-García ME. Differences in Classification Standards For the Prevalence of Overweight and Obesity in Children. A Systematic Review and Meta-Analysis. *Clin Epidemiol*. 2022;14. doi:10.2147/CLEP.S375981

9. World Health Organization. BMI-for-age (5-19 years). 2007. Accessed August 18, 2025. https://www.who.int/tools/growth-reference-data-for-5to19-years/indicators/bmi-for-age
10. Kementerian Kesehatan Republik Indonesia. *Peraturan Menteri Kesehatan Republik Indonesia Nomor 2 Tahun 2020 Tentang Standar Antropometri Anak*.; 2020.
11. Zhang Y, Hou LS, Tang WW, et al. High prevalence of obesity-related hypertension among adults aged 40 to 79 years in Southwest China. *Sci Rep*. 2019;9(1). doi:10.1038/s41598-019-52132-6
12. Angelin Te C, Karjadidjaja I. *Hubungan Overweight Dan Obesitas Terhadap Hipertensi Pada Pengemudi Bus Antar Kota PT GM Jakarta*. Vol 2.; 2020.
13. Alfalah NJ, Hasni D, Febrianto BY, Warlem N. Hubungan Obesitas dengan Kejadian Hipertensi pada Perempuan Minangkabau. *Poltekita : Jurnal Ilmu Kesehatan*. 2022;15(4):360-364. doi:10.33860/jik.v15i4.823
14. Kisno Saputri R, Al-Bari A, Indah R, Pitaloka K. Hubungan Status Gizi dan Aktivitas Fisik dengan Kejadian Hipertensi Remaja. *Jurnal Gizi*. 10(2):2021.
15. Rosdiana E, Elizar. Hubungan Obesitas, Asupan Makanan Sumber Natrium Dan Aktivitas Fisik Dengan Kejadian Hipertensi Pada Remaja Di UPTD Puskesmas Muara Batu Kabupaten Aceh Utara Tahun 2022. *Journal of Healtcare Technology and Medicine*. 2022;8(2):2615-109.
16. Fiamenghi VI, Mello ED de. Vitamin D deficiency in children and adolescents with obesity: a meta-analysis. *J Pediatr (Rio J).Elsevier Editora Ltda*. 2021;97(3):273-279. doi:10.1016/j.jped.2020.08.006
17. Flynn JT, Kaelber DC, Baker-Smith CM. *Clinical Practice Guideline for Screening and Management of High Blood Pressure in Children and Adolescents*. Vol 140.; 2017. http://publications.aap.org/pediatrics/article-pdf/140/3/e20171904/1104403/peds_20171904.pdf
18. Kementerian Kesehatan Republik Indonesia. Pedoman Nasional Pelayanan Kedokteran Tata Laksana Hipertensi pada Anak Tata Laksana Hipertensi Anak. *Kementerian Kesehatan Republik Indonesia*. Published online 2021.
19. Rahman MM, De Silva A, Sassa M, Islam MR, Aktar S, Akter S. *A Systematic Analysis and Future Projections of the Nutritional Status and Interpretation of Its Drivers among School-Aged Children in South-East Asian Countries*.; 2023. www.thelancet.com
20. Khan DSA, Das JK, Zareen S, et al. Nutritional Status and Dietary Intake of School-Age Children and Early Adolescents: Systematic Review in a Developing Country and Lessons for the Global Perspective. *Front Nutr*. 2022;8. doi:10.3389/fnut.2021.739447
21. Kementerian Kesehatan Republik Indonesia. Gizi Saat Remaja Tentukan Kualitas Keturunan. 2020. Accessed September 19, 2025. https://kemkes.go.id/id/gizi-saat-remaja-tentukan-kualitas-keturunan
22. Thurstans S, Opondo C, Seal A, et al. Boys are more likely to be undernourished than girls: A systematic review and meta-analysis of sex differences in undernutrition. *BMJ Glob Health*. 2020;5(12). doi:10.1136/bmjgh-2020-004030
23. Thurstans S, Opondo C, Seal A, et al. Understanding Sex Differences in Childhood Undernutrition: A Narrative Review. *Nutrients*. 2022;14(5). doi:10.3390/nu14050948
24. Islam B, Ibrahim TI, Tingting W, Wu M, Jiabi Q. Current status of elevated blood pressure and hypertension among adolescents in Asia: a systematic review. *J Glob Health.University of Edinburgh*. 2025;15. doi:10.7189/JOGH.15.04115
25. Shaumi NRF, Achmad EK. Kajian Literatur: Faktor Risiko Hipertensi pada Remaja di Indonesia. *Media Penelitian dan Pengembangan Kesehatan*. 2019;29(2):115-122. doi:10.22435/mpk.v29i2.1106
26. Kurnianto A, Kurniadi Sunjaya D, Ruluwedrata Rinawan F, Hilmanto D. Prevalence of Hypertension and Its Associated Factors among Indonesian Adolescents. *Int J Hypertens*. 2020;2020. doi:10.1155/2020/4262034
27. Falkner B, Gidding SS, Baker-Smith CM, et al. Pediatric Primary Hypertension: An Underrecognized Condition: A Scientific Statement from the American Heart Association. *Hypertension*. 2023;80(6). doi:10.1161/HYP.0000000000000228
28. Berliana N, Listiawaty R. Behavioral Risk Factors in Prevention of Hypertension Among Adolescent. *Journal of Global Research in Public Health ISSN*. 2020;5(2).
29. Shariq OA, Mckenzie TJ. Obesity-related hypertension: A review of pathophysiology, management, and the role of metabolic surgery. *Gland Surg*. 2020;9(1). doi:10.21037/gs.2019.12.03

30. Jia G, Sowers JR, Whaley-Connell AT. Obesity in Hypertension: The Role of the Expanding Waistline Over the Years and Insights Into the Future. *Hypertension*. 2024;81(4). doi:10.1161/HYPERTENSIONAHA.123.21719
31. El Meouchy P, Wahoud M, Allam S, Chedid R, Karam W, Karam S. Hypertension Related to Obesity: Pathogenesis, Characteristics and Factors for Control. *Int J Mol Sci*. 2022;23(20). doi:10.3390/ijms232012305
32. Parvanova A, Reseghetti E, Abbate M, Ruggenenti P. Mechanisms and treatment of obesity-related hypertension—Part 1: Mechanisms. *Clin Kidney J*. 2024;17(1). doi:10.1093/ckj/sfad282
33. Das S. Association of hypertension with overweight and obesity among adults in Rangpur region of Bangladesh: A cross-sectional study. *Human Nutrition and Metabolism*. 2024;37. doi:10.1016/j.hnm.2024.200273
34. Zaen NA, Tamtomo D, Ichsan B. Effects of Overweight and Obesity on Hypertension in Adolescents: A Meta-Analysis. *Journal of Epidemiology and Public Health*. 2023;8(1). doi:10.26911/jepublichealth.2023.08.01.10