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Lifestyle interventions for blood pressure reduction and hypertension prevention in adolescents: A systematic review

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Abstract

Background: Hypertension in adolescents is an emerging public health concern, often linked to poor lifestyle habits formed early in life. Lifestyle interventions have been recommended as first-line, non-pharmacological strategies for blood pressure control and hypertension prevention.
Purpose: To evaluate the effectiveness of lifestyle interventions in reducing blood pressure and preventing hypertension among adolescents.
Method: A systematic literature review was conducted on June 30, 2025, using the PICO framework. Databases searched included PubMed, Sage Journals, ScienceDirect, and Google Scholar. Keywords included Lifestyle Interventions, Hypertension, and Adolescents. Inclusion criteria were original studies (RCTs, cohort, quasi-experimental) focusing on adolescents with lifestyle-based interventions. Articles in English or Indonesian were included if full-text was available and outcomes reported changes in blood pressure, BMI, or lifestyle practices.
Results: The reviewed studies consistently demonstrated that lifestyle interventions such as increased physical activity, dietary modification, and health education effectively reduced both systolic and diastolic blood pressure. Several interventions also resulted in improved BMI, physical fitness, and healthier lifestyle practices. Multicomponent and early interventions, particularly those implemented in schools and supported by family or community involvement, showed the most promising results. However, some adolescents with severe obesity or resistant hypertension may require complementary medical treatment.
Conclusion: Lifestyle interventions are effective, scalable, and evidence-based strategies for lowering blood pressure and preventing hypertension in adolescents. These findings support their integration into public health initiatives aimed at reducing long-term cardiovascular risk from an early age.

Keywords: Adolescents; Blood Pressure; Hypertension; Lifestyle Interventions.

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INTRODUCTION

Hypertension has now become a global health issue that affects not only adults but also adolescents. Based on a meta-analysis, the global prevalence of diagnosed hypertension among children and adolescents is 3.89%, while the prevalence of episodic hypertension reaches 11.85% (McCormick, 2025). These figures are concerning because hypertension at a young age often goes undetected and asymptomatic, yet it can increase the risk of cardiovascular complications in adulthood, such as coronary heart disease and stroke (Arivuselvan, Kumaravelu, & Priyatharicini, 2022; Baoum, Alamri, Bana, Alsulaim, Alzahrani, Aboqarn, Altamimi, Aljabri, Abubaker, Baflah, & Al Yahya, 2023).

A similar trend is evident in Indonesia. Data from the 2023 Indonesia Health Survey reported a hypertension prevalence of 10.7% among individuals aged 18–24 years, which increased to 17.4% in the 25-34 year age group (Ministry of Health of the Republic of Indonesia, 2024). This condition is concerning because hypertension is often referred to as a silent killer due to its lack of early symptoms. Hypertension has become a serious threat to the productive age group, potentially affecting the quality of Indonesia's human resources in the long term.

This situation necessitates comprehensive prevention strategies, one of which involves lifestyle interventions. These interventions include adopting healthy dietary patterns, increasing physical activity, reducing alcohol and tobacco consumption, and managing stress (Higuchi & Ohishi, 2025; Ojangba, Boamah, Miao, Guo, Fen, Agboyibor, & Dong, 2023). Implementing such interventions from adolescence is believed to help prevent the accumulation of cardiometabolic risk factors, thereby reducing the risk of hypertension in adulthood.

Lifestyle changes are increasingly important given the growing prevalence of unhealthy habits among adolescents. High consumption of fast food rich in salt, sugar, and saturated fats, coupled with reduced physical activity due to sedentary lifestyles, significantly contributes to rising blood pressure (Mahmood, Shah, Khan, Nawaz, Rashid, Baqar, & Kamran, 2019; Siregar & Emy, 2023). Intervention studies have shown that dietary and exercise education at school and community levels can lower blood pressure and increase adolescents' awareness of the importance of heart health (Amoah, Okai, Manu, Laar, Akamah, & Torpey, 2020; Vendrame, Adekeye, & Klimis-Zacas, 2022). Dietary Approaches to Stop Hypertension (DASH diet) is one strategy proven effective. This eating pattern emphasizes the consumption of fruits, vegetables, whole grains, and low-fat products and has been shown to reduce blood pressure in both adults and adolescents (Amborkar, Kasulkar, & Gupta, 2024; Baoum et al., 2023). However, adapting this dietary pattern to the sociocultural context of Indonesian adolescents, who tend to be more familiar with fast food and sugary drinks, is the greatest challenge. Beyond diet, the success of lifestyle interventions is highly influenced by adolescents' knowledge, attitudes, and behaviors. Studies show that adolescents with sufficient knowledge about hypertension are more likely to adhere to healthy lifestyle recommendations (Rakesh, Chavan, & Dongare, 2023; Vendrame et al., 2022). Therefore, continuous health education is an essential element in supporting interventions' success.

Along with technological developments, digital-based interventions are increasingly being used to enhance the effectiveness of hypertensive prevention programs. Health applications on smartphones can help adolescents monitor blood pressure, manage diets, and receive reminders for physical activities (Bozorgi, Hosseini, Eftekhar, Majdzadeh, Yoonessi, Ramezankhani, & Ashoorkhani, 2021; Martin, Damiati, Nurbaeti, & Mardiyanti, 2023). This technology has been proven to improve self-management in adult patients with hypertension and holds great potential if integrated into adolescent health programs. However, the implementation of lifestyle interventions cannot be separated from social, economic, and cultural factors. Race, ethnicity, and income levels can affect access to information and health services (Lobo, Karmakar, Abdelrazek, Abawajy, Chow, Zhang, & Islam, 2023; Mahmood et al., 2019). Therefore, interventions must be tailored to the local context to be more inclusive and acceptable to adolescents from diverse backgrounds.

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Although numerous studies have demonstrated the effectiveness of lifestyle interventions in managing blood pressure, most of the existing research remains concentrated on adults, individuals already diagnosed with hypertension, or specific clinical settings. Systematic evidence addressing the effectiveness of lifestyle interventions among adolescents remains limited, particularly in the context of early prevention. Furthermore, research in Indonesia that evaluates school-, family-, or community-based interventions aimed at reducing the prevalence of adolescent hypertension is still scarce.

This systematic literature review specifically aims to compile and analyze scientific evidence regarding the effectiveness of lifestyle interventions in reducing blood pressure and preventing hypertension among adolescents. This approach is expected to make a significant contribution by filling existing knowledge gaps while supporting the development of preventive policies grounded in empirical evidence. The synthesis of effective interventions may be adapted into school health programs, primary care services, and digital innovations that align with the lifestyles of adolescents. In this way, early prevention of hypertension can reduce the long-term disease burden at both national and global levels, while fostering a healthier and more productive young generation in the future outline the goals of the project and present a suitable context, while refraining from an extensive review of the literature or a recap of the findings.

RESEARCH METHOD

The review process was conducted in accordance with the PRISMA guidelines to ensure transparency, methodological rigor, and reproducibility. The protocol defined the study objectives, search procedures, eligibility criteria, and approaches for data extraction and analysis.

The search strategy encompassed both published and unpublished studies. Guided by the PICO framework, the research questions and search terms were structured as follows: *Population* (P): Adolescents; *Intervention* (I): Lifestyle interventions such as dietary modification, physical activity, health education, and school/community-based programs; *Comparison* (C): Standard care or no intervention; *Outcomes* (O): Reduction in systolic/diastolic blood pressure and prevention of hypertension through healthy BMI and lifestyle practices.

Systematic searches were performed on PubMed, Sage Journals, ScienceDirect, and Google Scholar on June 30, 2025. Articles in English and Indonesian were considered, using a combination of keywords, MeSH terms, and free-text phrases (e.g., “hypertension,” “adolescents,” “lifestyle intervention,” “blood pressure reduction in youth”).

References were managed in Mendeley to eliminate duplicates. Titles and abstracts were screened manually, with full texts reviewed when relevance was uncertain. Inclusion criteria covered original research (RCTs, cohort, quasi-experimental) involving children or adolescents, lifestyle interventions, and full-text availability in English or Indonesian. Exclusion criteria applied to adult-only studies, animal or in vitro research, and articles lacking outcome data.

The methodological quality of eligible studies was assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Tools (Barker et al., 2024). Five studies were evaluated independently by two reviewers: three using the Quasi-Experimental Checklist and two using the Cohort Checklist. Data extracted from each study included author, year, country, objectives, methodology, sample size, demographics, setting, intervention type, and key findings.

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RESEARCH RESULTS

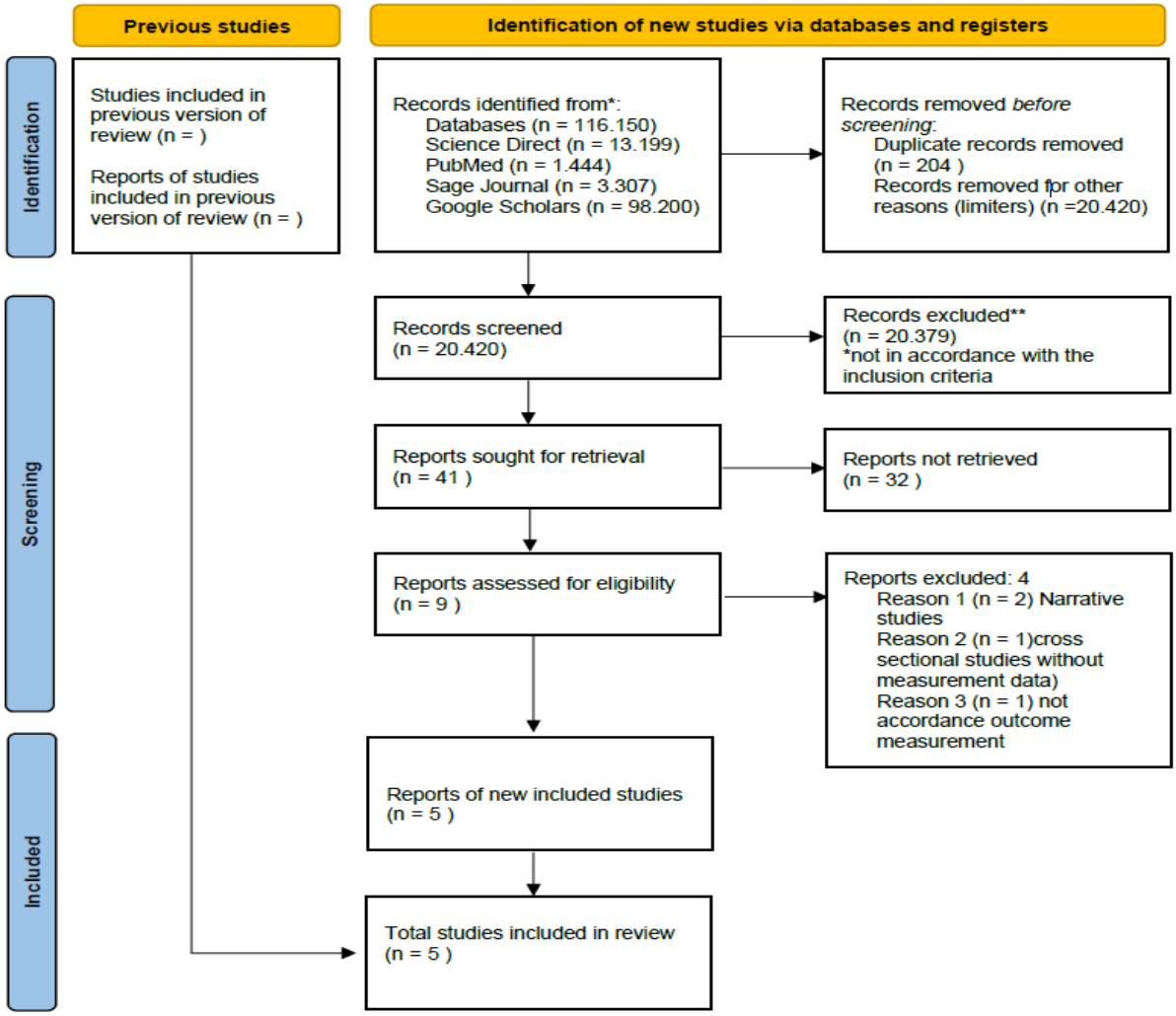


Figure PRISMA Flowchart

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Table Characteristics of the Included Articles

(Authors, Year) (Country)	Purpose	Method	Sample Size, Gender & Age	Settings	Intervention	Key Findings
(Seo et al., 2019) (South Korea)	To evaluate multidisciplinary lifestyle interventions program with and without exercise.	Quasi-experiment	103 participants (63 boys & 40 girls). Children and adolescents aged 6 to 16 years with a BMI ≥85th percentile. Most participants (80.6%) had a BMI ≥97th percentile, indicating moderate to severe obesity.	The program was conducted within a hospital, Korea.	Lifestyle Interventions (Medical consultation, nutrition counseling, activity monitoring + structured exercise 3×/week) during 16 weeks.	BMI z-score decreased significantly by 0.05 after 16 weeks (p=0.02), mainly in the exercise group (0.1; p=0.03), but no between-group difference was found after adjustment (p>0.05). Body Composition: % Body Fat decreased significantly in the exercise group (mean Δ 1.6%, p < 0.01). Lean Body Mass increased significantly only in the exercise group (p < 0.05). Blood Pressure: Diastolic BP decreased significantly in the exercise group (-2.9 mmHg, p < 0.05). Inflammation marker (hs-CRP): Significant reduction in the exercise group (p < 0.05). Physical Fitness: Significant improvements in lower extremity strength (wall sit test (β = 50.74).
(Semou et al., 2025) (India)	To establish the effectiveness of a hypertension knowledge education intervention to foster lifestyle changes aimed at preventing hypertension among Indian adolescents.	Quasi-experiment (pre–post, repeated measures)	423 participants (195 boys & 228 girls). School students from grades 6 to 10, aged 11 to 16 years, from schools in Nagaland, India	Three schools in Kohima and Dimapur, Nagaland, India.	A 30-minute educational video delivered by a healthcare professional addressed hypertension prevalence, risks, symptoms, management, and lifestyle changes. Instruments included the Hypertension Knowledge Test (HKT) to assess knowledge and the Healthy Lifestyle Practice Scale for Children and Adolescents (HELIPSCA) to measure daily lifestyle behaviors.	Hypertension knowledge increased significantly across all domains (p<0.001), with sustained retention up to 90 days post-intervention. Healthy lifestyle practices improved significantly after education (p<0.01), with a greater effect among early adolescents (10–14 years) than late adolescents (15–17 years). Early adolescents showed a mean increase from 78.39 to 79.69.

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(Authors, Year) (Country)	Purpose	Method	Sample Size, Gender & Age	Settings	Intervention	Key Findings
(Hagman et al., 2019) (Sweden)	To observe subjects undergoing behavioral lifestyle modifications, including diet, physical activity, and lifestyle changes aimed at reducing body weight	Prospective cohort study.	5,279 subjects (2707 boys & 2572 girls). Children and adolescents between 5 and 18 years of age with an obesity diagnosis according to the International Obesity Task Force criteria.	The study used data from the Swedish national registry for the treatment of childhood obesity (BORIS).	Lifestyle interventions, which included diet, and lifestyle modification	Both systolic and diastolic BP SDS decreased when a lower BMI SDS was achieved. Systolic BP SDS decreased by 0.41 (99% CI: 0.33-0.49) and diastolic BP SDS decreased by 0.26 (99% CI: 0.20-0.32) per unit of BMI SDS reduction. This impact was greater in subjects with hypertensive BP 1627evel sat the start of treatment. A one-unit decrease in BMI SDS resulted in a systolic BP SDS reduction of 0.66 (99% CI: 0.41-0.92; p<0.001) in this group.
(Paulsamy et al., 2021) (India)	To identify the prevalence of overweight and hypertension in adolescent populations while analyzing how the Exercise and Lifestyle Motivation Intervention (SEAL-MI) affects cardiovascular risk factors and educational achievement	An experimental study with a before-and-after control group design.	520 in the study and 485 in the control group (235 boys and 285 girls in the study group, and 204 boys and 281 girls in the control group). Adolescents aged 13-14 years with overweight (BMI ≥ 85th percentile) and prehypertension (BP ≥ 90th percentile).	High schools in the Tiruvallur district, Tamilnadu, India.	The study group received the SEAL-MI for six months, which included : Exercise (Rope jumping exercise for 45 minutes per day, 5 days a week). Lifestyle Interventions (a motivation intervention related to healthy dietary habits, physical activity, and sleep quality).	Intervention Effects: After 6 months, 81% of the study group adolescents became normal weight, and 69.4% became normotensive, with these results being statistically significant (p=0.001). Correlations: A significant positive correlation was found between BMI and SBP (p=0.001), proving that an increase in BMI is strongly correlated with an increase in blood pressure. A significant negative correlation was found between BMI and academic performance (p=0.003) in the post-test 2. Predictive Factors: Regression analysis revealed that gender (B: 0.47), age (B: 0.39), family income (B: 0.2), residence (B: 0.19), and type of family (B: 0.25) had the strongest correlations with adolescent BMI. Mother's education (B: 0.35) had the strongest correlation with SBP.

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(Authors, Year) (Country)	Purpose	Method	Sample Size, Gender & Age	Settings	Intervention	Key Findings
(Genovesi et al., 2018) (Italy)	To assess the effect of a non pharmacological, multidisciplinary intervention based on lifestyle modifications on body weight and blood pressure (BP) in a population of children and adolescents.	Prospective cohort study.	273 children and adolescents (150 boys & 123 girls). Children and adolescents aged 4–18 years who were referred to a Cardiovascular Risk Prevention Clinic due to elevated BP and/or excess weight.	A Cardiovascular Risk Assessment Unit in Italy.	Multidisciplinary non-pharmacological interventions that include lifestyle modifications. Recommended interventions include structured physical activity for at least 2–3 hours per week, reducing screen time to no more than 1 hour per day, and a healthy and balanced diet. Specific and personalized nutritional recommendations are provided based on the child's pathological condition).	Among 273 children with follow-up, 61% were overweight only, 7% had high BP only, and 32% had both. The probability of reaching clinical targets rose from 19% at 1 year to 38% at 3 years. SBP z-score decreased from 0.99 to 0.52 and BMI z-score from 1.77 to 1.47 ($p<0.0001$). Significant reductions were seen across groups, particularly in children with high BP only ($\Delta=0.91$; $p=0.0157$). Children with a single condition were more likely to achieve targets, with the highest success in the high BP–only group (rate ratio=13.9).

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DISCUSSION

The impact of lifestyle interventions on adolescent blood pressure has been consistently demonstrated across multiple studies. A multidisciplinary approach including structured physical activity for 2-3 hours per week, limiting screen time to ≤1 hour per day, and maintaining a healthy, balanced diet reduced the BMI z-score from 1.77 to 1.47 and the systolic BP z-score from 0.99 to 0.52 within one year ($p < 0.001$). The probability of achieving clinical targets increased from 19% in the first year to 38% in the third year (Genovesi et al., 2018). Each one-unit reduction in BMI-SDS was associated with decreases in SBP-SDS by 0.41 and DBP-SDS by 0.26 (99% CI) (Hagman et al., 2019). Stronger effects were observed in adolescents with baseline hypertension, where a one-unit reduction in BMI-SDS corresponded to a 0.66 decrease in SBP-SDS ($p < 0.001$). The combination of education, physical activity, and behavioral approaches is the most effective strategy for managing obesity and hypertension in children and adolescents (Salam, Padhani, Das, Shaikh, Hoodbhoy, Jeelani, & Bhutta, 2020).

The effectiveness of exercise programs is equally evident. After a 12-week intervention, BMI z-score decreased by 0.1 ($p = 0.03$), DBP decreased by 5.24 mmHg, CRP decreased by 1.67 mg/L, and lean body mass increased ($\beta = 1.20$). Physical fitness also improved significantly, with a 50.74-point increase in the wall sit test (Seo et al., 2019). Structured aerobic programs lowered SBP by up to 7 mmHg in children with primary hypertension (Valenzuela, Carrera-Bastos, Gálvez, Ruiz-Hurtado, Ordovas, Ruilope, & Lucia, 2021).

School-based interventions further reinforce these outcomes. Through the SEAL-MI program, it was found that after six months, 81% of adolescents returned to normal weight and 69.4% became normotensive ($p = 0.000$). Average SBP decreased by 1.57 mmHg (SD 1.53) and DBP by 0.69 mmHg (SD 1.26) (Paulsamy et al., 2021). Similarly, a 30-minute hypertension education video significantly increased knowledge ($F = 527.15$, $p < 0.001$) and improved healthy lifestyle practices (77.90 - 78.85, $p < 0.01$), with stronger effects in early adolescents compared to older peers (Semou et al., 2025). In addition, community-based education can significantly reduce blood pressure among children and adolescents in developing countries (Jafar, Islam, Hatcher, Hashmi, Bux, Khan, & Chaturvedi, 2010).

Negative lifestyle factors are also strongly associated with hypertension risk. Excessive salt intake, sitting for more than three hours per day, and low physical activity were major contributors to elevated blood pressure (Arafa, Yasui, Kokubo, Kato, Matsumoto, Teramoto, & Kogirima, 2024). A study in Indonesia reported poor sleep quality increased hypertension risk 4.1-fold, high BMI 4.85-fold, and family history of hypertension 3.9-fold (Shaumi, & Achmad, 2019). It was found that 43.6% of adolescents with obesity had elevated uric acid levels, which are strongly linked to hypertension (Nicolucci & Maffeis, 2022).

Placed in a global context, these findings align with the multilevel meta-analysis which analyzed 37 school-based RCTs and found average reductions in BMI of -0.29 kg/m² and SBP of -1.64 mmHg in children and adolescents (Oosterhoff, Joore, & Ferreira, 2016). A nationwide school-based lifestyle program in China significantly reduced the prevalence of obesity and hypertension (Dong, Zou, Wang, Dong, Hu, Ma, & Ma, 2021). Together, the results of the five primary studies examined here can be interpreted as part of a consistent global trend.

However, the long-term effectiveness of lifestyle interventions remains limited. It was reported that 27% of adolescents with hypertension did not normalize their blood pressure despite intervention (Hagman et al., 2019). This highlights the need for additional strategies, such as pharmacotherapy (e.g., GLP-1 receptor agonists) (Nicolucci & Maffeis, 2022) or self-regulation-based approaches, such as acceptance-based therapy (Manasse, Moussaoui, Lampe, Brown, Zhang, Janicke, & Butryn, 2024)..

Overall, evidence from cohort studies, experimental trials, and meta-analyses strongly support that lifestyle interventions are effective in lowering blood pressure and preventing hypertension in adolescents. Comprehensive strategies integrating education, physical activity, healthy diet, sufficient sleep, and family and school support emerge as the most effective and sustainable approach for long-term hypertension prevention in youth.

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CONCLUSION

This review concludes that lifestyle interventions are effective in lowering blood pressure and preventing hypertension in adolescents. Interventions such as physical activity, dietary changes, and health education consistently led to significant improvements in blood pressure, BMI, and cardiovascular risk markers. Early, structured, and school-based programs showed the most promising results, especially when supported by families and delivered in a multidimensional format. Although not all cases respond equally, particularly in severe hypertension, lifestyle modification remains a key preventive strategy that is both practical and evidence-based. The conclusion section contains research findings in the form of answers to research questions or in the form of the essence of the results of the discussion. The conclusion is presented in the form of paragraphs.

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CONFLICT OF INTEREST

The authors report no conflicts of interest in the preparation of this systematic literature review.

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