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Prevention Strategies of Prehypertension among Adolescents in Developing Countries: A Scoping Review

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ABSTRACT

Introduction: Adolescents in developing countries face a significant risk of prehypertension, with prevalence rates varying across different regions. In Indonesia, 16.8% of adolescents aged 15-19 have prehypertension. Several factors contribute to prehypertension in adolescents, including lifestyle choices, genetics, and environmental factors. Preventing prehypertension in adolescents is crucial for promoting their overall health and reducing the risk of future cardiovascular diseases. This study aims to determine the prevention strategies to reduce prehypertension among adolescents in developing countries.
Methods: This scoping review followed PRISMA-ScR guidelines. Articles were retrieved from PubMed, Science Direct, and ProQuest using predefined keywords. The search, conducted between March and June 2024, focused on studies published in the last five years (2019–2024).
Results: The search yielded 2,425 articles (712 from PubMed, 1,597 from Science Direct, and 116 from ProQuest). After screening and eligibility assessment, 10 relevant studies were selected. These studies identified key prevention strategies, including health education, dietary modifications (DASH diet), physical activity, and stress management.
Conclusion: A multifaceted approach is crucial for preventing prehypertension among adolescents. School-based interventions are the most evidence-based and feasible in resource-limited settings, offering broad coverage and lower costs. Clinicians should support blood pressure screening and nutrition education, while educators should integrate health topics into curricula and encourage physical activity. Policymakers should expand school-based health programs and support further research. Community-based programs are also essential for reaching out-of-school adolescents, making both approaches complementary in prehypertension prevention.

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INTRODUCTION

According to the World Health Organization (WHO) 2019, non-communicable diseases (NCDs) such as heart disease, stroke, cancer, diabetes, and chronic lung disease account for 74% of deaths worldwide. The Centers for Disease Control and Prevention (CDC) also reported that NCDs cause 41 million deaths annually, with 7 out of 10 deaths globally attributed to these diseases (1).

Adolescence is a transitional phase from childhood to adulthood, encompassing biological, psychological, and social changes (2). According to the WHO, adolescents are individuals aged 10 to 19 years, further classified into early adolescence (10–13 years), middle adolescence (14–16 years), and late adolescence (17–19 years) (3). This transition leads to lifestyle modifications and metabolic changes that can influence long-term health.

Prehypertension, as defined by the Joint National Committee (JNC), refers to blood pressure levels ranging from 120/80 mmHg to 140/90 mmHg and is a precursor to hypertension (4). Individuals with prehypertension are three times more likely to develop hypertension and twice as likely to experience cardiovascular diseases compared to those with normal blood pressure. If left unmanaged, prehypertension can progress into more severe health conditions over time (5).

The prevalence of prehypertension among adolescents varies across countries. In Indonesia, 16.8% of adolescents aged 15–19 are affected, while in India, the prevalence among the 10–16 age group is 6.61% (6). Another study reported a prehypertension prevalence of 15.7% among adolescents aged 11–17 (7).

Prehypertension in adolescents is caused by multiple factors, including obesity, genetic predisposition, high salt intake, poor sleep quality, stress, smoking, caffeine and alcohol consumption, and physical inactivity. Preventing prehypertension requires encouraging adolescents to adopt healthier behaviors through targeted interventions (8). This scoping review aims to identify effective strategies for preventing prehypertension among adolescents in developing countries. Additionally, the findings can serve as a valuable resource for healthcare providers to develop more effective adolescent health interventions.

METHOD

Research Type

This scoping review was conducted following PRISMA-ScR guidelines, beginning with identification, screening, and eligibility assessment, ultimately selecting the studies included in this review.

Search strategy

The studies were obtained from various databases, including PubMed, Science Direct, and ProQuest, using advanced search tools combined with Boolean operators. Medical Subject Headings (MeSH) terms were applied to refine the search and ensure relevant results. The search strategies used in each database were as follows:

Table 1. Search Query from Databases

Databases	Search Query
PubMed	("prevention"[MeSH Terms] OR "intervention"[MeSH Terms]) AND ("knowledge" OR "education") AND ("DASH diet") AND ("psychological stress" OR "psychological factor") AND ("exercise" OR "physical activity") AND ("prehypertension") AND ("adolescent" OR "youth")
Science Direct	(prevention OR intervention) AND (knowledge OR education) AND "DASH diet" AND (psychological stress OR psychological factor) AND (exercise OR physical activity) AND prehypertension AND (adolescent OR youth)
ProQuest	(prevention OR intervention) AND (knowledge OR education) AND "DASH diet" AND (psychological stress OR psychological factor) AND (exercise OR physical activity) AND prehypertension AND (adolescent OR youth) AND fulltext(yes) AND peer-reviewed(yes)

Inclusion and exclusion criteria

The inclusion criteria for this study were: (1) studies focusing on prehypertension in adolescents, (2) articles published within the last five years (2019–2024), (3) articles written in English and available in full text, and (4) publications classified as original research.

The exclusion criteria were: (1) studies on prehypertension or hypertension in the elderly population, (2) research conducted in high-income countries, (3) publications categorized as reviews, encyclopedias, book chapters, or other non-original research, (4) articles that provided only abstracts, were not open access, or required payment for full access, and (5) articles published before 2019.

Study selection

Study selection followed PRISMA guidelines and was conducted using Mendeley Desktop software (v.1.19.8). The selection process involved a review of titles and abstracts by two reviewers (A.N.M.U. and B.W.) followed by the removal of duplicate articles. Any disagreements between the two reviewers were resolved through discussion with a third reviewer (Z.S.). Irrelevant and duplicate articles were excluded, and the remaining full-text articles were thoroughly screened to identify eligible studies.

Data extraction

To minimize bias, the data extraction process was conducted systematically by multiple researchers. After screening, relevant articles were selected, and data extraction was performed independently by two reviewers (A.N.M.U. and B.W.). The extracted data included author information, study location, study design, and key findings from each study.

Quality Assessment

The quality assessment of the articles was conducted using ten questions based on the critical appraisal guidelines from the Joanna Briggs Institute (JBI) for Randomized Controlled Trials (RCTs) and cross-sectional studies. The quality and risk of bias for each article were categorized as high bias (if the "yes" responses were less than 30%), moderate bias (if the "yes" responses ranged between 31% and 70%), and low bias (if the "yes" responses exceeded 70%.

To ensure objectivity in the study selection process, two researchers independently reviewed articles based on predefined inclusion and exclusion criteria. Any disagreements were resolved through discussion with a third researcher. The Cohen's kappa reliability analysis indicated a high level of agreement between the two reviewers, confirming that the study selection process was conducted with strong consistency and could be trusted and replicated by other researchers. The high Cohen's kappa value also demonstrated that the selection criteria were applied clearly and systematically, minimizing potential bias in the study selection process.

RESULTS

The study selection process followed PRISMA flow guidelines (Figure 1). The search was conducted using predefined keywords in three major databases: PubMed, Science Direct, and ProQuest. The initial search yielded 2,425 articles, with 712 articles from PubMed, 1,597 articles from Science Direct, and 116 articles from ProQuest. After removing 786 duplicate articles, a total of 1,639 articles remained for further screening. These remaining articles were reviewed based on their titles and abstracts by two independent researchers.

During the title and abstract screening phase, 1,639 articles were evaluated, with an agreement between the two researchers on 1,500 articles, while 139 articles were marked as disagreements. The Cohen's kappa coefficient for this phase was 0.83, indicating a very good level of agreement. Articles that were irrelevant to adolescent prehypertension, not original research, or conducted in high-income countries were excluded. As a result, 1,266 articles were removed, leaving 373 articles for full-text review.

In the full-text review phase, 373 articles were evaluated, with 340 articles agreed upon by both researchers and 33 articles marked as disagreements. The Cohen's kappa coefficient for this phase was 0.82, indicating a good level of agreement. Out of the 373 articles, only 10 articles met all the inclusion criteria. The excluded articles consisted of 57 studies focusing on elderly populations, articles discussing metabolic diseases without a direct connection to blood pressure and dietary patterns, and experimental studies that did not involve human subjects. Additionally, 44 studies were conducted in high-income countries, 79 articles were review papers, encyclopedias, or book chapters, 96 articles lacked full-text access or were behind paywalls, and 87 articles were published before

2019. After completing the entire selection process, 10 of the most relevant articles were selected for further analysis. From 10 studies, 5 were Randomized Controlled Trial (RCT) and 5 with cross-sectional design.

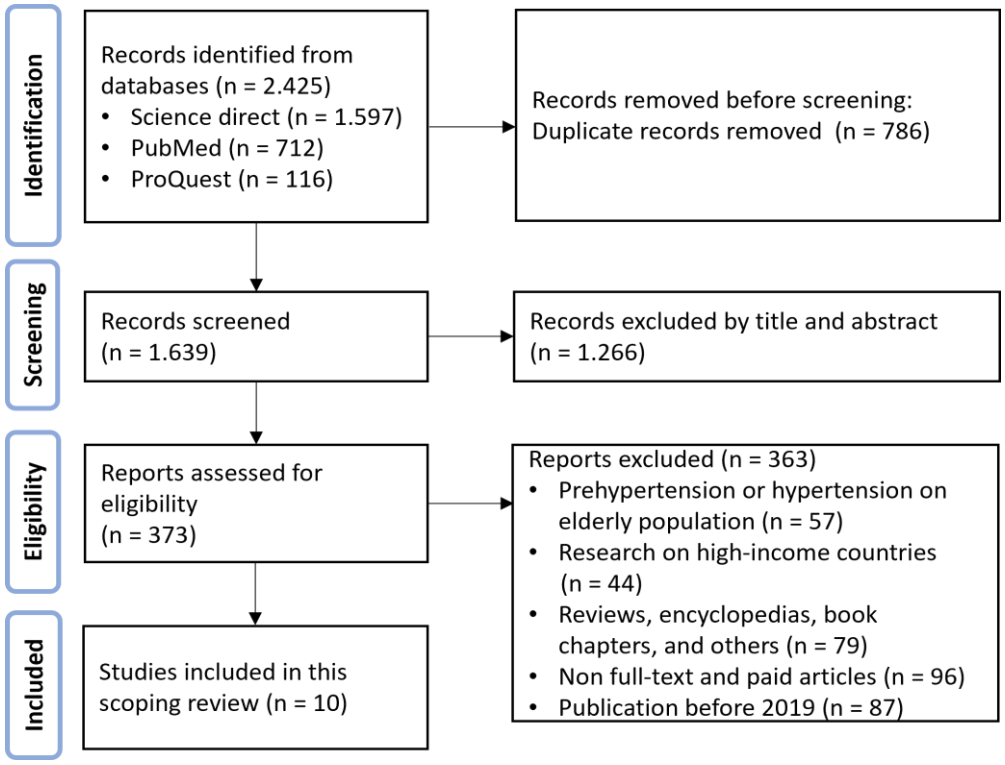

Figure 1. PRISMA Flow

The overall included studies were conducted in developing countries. India had the most studies with 3 studies included. One limitation of this study is the geographical imbalance in the included studies, with limited representation from regions such as the Middle East and parts of sub-Saharan Africa. This gap may be attributed to both the search strategy and the actual scarcity of studies conducted in these regions. Although our search included major global databases, some relevant studies may have been missed due to language restrictions, indexing limitations, or differences in publication practices. Additionally, the lack of studies from these regions may reflect broader challenges in research funding, infrastructure, and data availability, highlighting the need for more studies on adolescent prehypertension in diverse geographical settings. The characteristics of studies were classified in Table 2.

Table 2. Characteristics of the Studies

Author, year	Country	Methods, Design	Effect Size/Correlation (r)	BP Reduction (mmHg)	Prevention	Findings
Couch, 2020 (9)	Brazil	Quantitative, randomized controlled trial	Cohen's d: 0.40–0.50 ($p < 0.05$)	Systolic: -5.2 Diastolic: -3.0	DASH diet	The DASH intervention was effective in reducing systolic and diastolic blood pressure and improving endothelial function. Participants who adhered to the DASH diet showed a significant reduction in hypertension risk and improved dietary quality over time.
Anyanwu, 2022 (10)	Indonesia	Quantitative, cross-sectional study	-0.41 ($p<0.001$)	N/A	DASH diet	Different dietary patterns have a significant relationship with the incidence of hypertension and obesity in Indonesia. The results show that traditional and modern high-energy diets are associated with an increased risk of hypertension and obesity.
Amoah, 2021 (11)	Ghana	Quantitative, a cluster-randomized controlled trial	0.45 – 0.65 ($p < 0.05$)	Systolic: -3.2 Diastolic: -1.8	Health education, physical activity	The intervention led to increased physical activity, improved dietary habits, and a significant reduction in diastolic blood pressure and body mass index. Participants also reduced their intake of high-sodium and high-fat foods.
Sudiasih, 2019 (12)	Indonesia	Quantitative, cross-sectional study	OR = 5.19 (salt), 5.87 (physical activity) ($p < 0.05$)	N/A	Physical activity, diet	Higher salt intake and lack of physical activity were strongly associated with increased hypertension risk among obese adolescents. The findings emphasize the need for interventions promoting physical activity and balanced diets.

Author, year	Country	Methods, Design	Effect Size/Correlation (r)	BP Reduction (mmHg)	Prevention	Findings
Vikhe, 2023 (13)	India	Quantitative, randomized controlled trial	Cohen's d: 0.40 – 0.55 ($p < 0.05$)	Systolic: 3.5 – 5 Diastolic: 2 – 3	Physical activity	A short-term walking program led to significant reductions in both systolic and diastolic blood pressure, demonstrating the effectiveness of regular physical activity in managing prehypertension.
Chadha, 2023 (14)	India	Quantitative, cross-sectional study	$\chi^2 = 7.08$ ($p = 0.029$)	N/A	Stress management	Participants who engaged in stress management techniques, including mindfulness and cognitive-behavioral therapy, showed a reduction in blood pressure and reported improved mental well-being.
Shah, 2019 (15)	Pakistan	Quantitative, cross-sectional study	$r = 0.42$ ($p < 0.05$)	N/A	Stress management	There was a notable association between prehypertension and perceived stress levels. Students experiencing higher levels of stress were more likely to exhibit prehypertensive conditions.
Kallianta, 2021 (16)	Greece	Quantitative, randomized controlled trial	Cohen's d: 0.40 – 0.60 ($p < 0.05$)	Systolic: 3 – 6 Diastolic: 2 – 4	Stress management	The intervention group, which received the stress management training, showed significant improvements in resilience, reduced stress and anxiety, and better cognitive skills compared to the control group.
Bricarello, 2020 (17)	Brazil	Quantitative, a cross-sectional school-based study	$r = -0.38$ (Systolic) $r = -0.29$ (Diastolic) ($p < 0.05$)	N/A	DASH diet	The research highlighted higher adherence to the DASH diet was significantly associated with lower systolic and diastolic blood pressure.

Author, year	Country	Methods, Design	Effect Size/Correlation (r)	BP Reduction (mmHg)	Prevention	Findings
Kaur, 2024 (18)	India	Quantitative, a cluster randomized controlled trial	Cohen's d: 0.45 – 0.65 ($p < 0.05$)	Systolic: 4 – 6 Diastolic: 2 – 4	Health education	The results showed that school-based programs are effective in reducing the risk of prehypertension by promoting a healthy lifestyle.

The findings from the reviewed studies demonstrate the effectiveness of various interventions in preventing prehypertension among adolescents. Randomized Controlled Trials (RCTs) provide strong evidence for causal relationships, while cross-sectional studies highlight associations between lifestyle factors and blood pressure outcomes.

Health Education

Health education plays a crucial role in preventing prehypertension by promoting awareness, behavior change, and long-term adherence to healthy lifestyles. A study in Ghana demonstrated that an intervention combining health education and physical activity modules led to increased physical activity levels, healthier food consumption, reduced diastolic blood pressure and body mass index, and decreased smoking and alcohol consumption among students. Amoah (2021) reported a BP reduction of 3.2 mmHg (SBP) and 1.8 mmHg (DBP), with an effect size of 0.45–0.65 ($p < 0.05$), demonstrating the effectiveness of school-based education combined with physical activity (11).

The intervention effectively improved healthy lifestyle behaviors, highlighting the potential of school-based programs in reducing cardiovascular disease (CVD) risk factors among adolescents (19). The program included sessions on health education, physical activity, and dietary guidance, which significantly increased fruit and vegetable consumption and improved physical activity levels. Participants experienced a reduction in blood pressure, indicating a decreased risk of hypertension, and reported enhanced health-related knowledge, behaviors, and attitudes (18). These findings emphasize the importance of integrating such programs into school curricula to ensure long-term health benefits.

Dietary Approaches to Stop Hypertension (DASH) Diet

The DASH dietary intervention has proven effective in lowering blood pressure and improving vascular health among adolescents with elevated blood pressure. This diet emphasizes reducing sodium intake while increasing the consumption of essential nutrients such as potassium, calcium, and magnesium, which help regulate blood pressure. Couch (2020) reported that adherence to the DASH diet resulted in a systolic BP reduction of 5.2 mmHg and a diastolic BP reduction of 3.0 mmHg, with a moderate effect size (Cohen's d: 0.40–0.50, $p < 0.05$), suggesting a clinically significant impact on adolescent hypertension prevention (9). In addition, Bricarello (2020) found a negative correlation between DASH diet adherence and blood pressure ($r = -0.38$ for SBP, $r = -0.29$ for DBP, $p < 0.05$), indicating that a higher adherence to a balanced diet was associated with lower blood pressure levels. This suggests that maintaining a healthy diet can contribute to better cardiovascular outcomes, even in the absence of structured interventions (17).

Moreover, increased fiber intake—primarily from fruits, vegetables, and whole grains—has been linked to a reduced risk of prehypertension, particularly in obese adolescents. Conversely, excessive salt consumption is strongly associated with an increased risk of prehypertension, as it contributes to elevated blood pressure. Adolescents who adhered more strictly to the DASH diet exhibited a lower prevalence of hypertension, even after adjusting for confounding variables, suggesting that the DASH diet independently contributes to blood pressure reduction. Research in Indonesia further indicates that a traditional dietary pattern is inversely associated with hypertension risk, reinforcing the need to promote healthier traditional diets while addressing the high energy density of both modern and traditional foods (10).

Stress Management

Adolescence is a critical period marked by various stressors that can significantly impact health. Stress is a transactional process between an individual and their environment, while resilience refers to the ability to adapt successfully to stress. An 8-week stress management program has been shown to enhance resilience, cognitive skills, and academic performance while reducing stress, anxiety, and social media use among adolescents. Stress management interventions, as demonstrated by Kallianta (2021), significantly reduced SBP (3–6 mmHg) and DBP (2–4 mmHg), with a moderate effect size (Cohen's d: 0.40–0.60, $p < 0.05$), supporting psychological interventions as part of hypertension prevention strategies (16). Additionally, research indicates that students with higher perceived stress levels tend to have higher blood pressure. Shah (2019) reported a positive correlation between stress and prehypertension ($r = 0.42$, $p < 0.05$), suggesting that elevated stress levels increase the risk of hypertension (15).

A study in India further revealed a high prevalence of prehypertension among medical students, with those experiencing higher stress levels exhibiting greater cognitive failures. Both stress and anxiety were significantly associated with hypertension and cognitive impairments, with academic pressure being a major contributing factor (14). These findings emphasize the need for integrating mental health education and stress management strategies into school curricula to promote adolescent well-being and reduce hypertension risk.

Physical Activities

Physical activity plays a fundamental role in preventing prehypertension by promoting cardiovascular fitness and regulating blood pressure. A 14-day walking program was found to be effective in lowering blood pressure in young adults with prehypertension, with participants showing significant reductions in blood pressure compared to the control group. Vikhe (2023) reported an SBP reduction of 3.5–5 mmHg and a DBP reduction of 2–3 mmHg, with an effect size of 0.40–0.55 ($p < 0.05$), reinforcing the importance of regular exercise in blood pressure regulation (13).

In addition to structured exercise, an active lifestyle—including sufficient fiber intake and salt restriction—also contributes to improved blood pressure management and a lower risk of hypertension, particularly in obese adolescents. Furthermore, studies show that adolescents who engage in less physical activity have a significantly higher risk of developing hypertension compared to those who maintain an active lifestyle (12). These findings underscore the necessity of integrating structured physical activity programs into school settings and promoting community-based exercise initiatives to ensure widespread engagement and accessibility.

DISCUSSION

Various strategies have been effective in preventing prehypertension in developing countries, with health education and school-based programs playing a crucial role in raising awareness, promoting healthy behaviours, providing practical skills, and creating supportive environments (20). These interventions not only address immediate health needs but also lay the groundwork for long-term health and well-being. However, implementing health education programs in developing countries faces significant challenges, including a lack of trained educators and standardized curricula. Many teachers and healthcare providers receive inadequate training in delivering health-related topics, leading to inconsistencies and, at times, inaccurate information being provided to students and communities. Additionally, health education is often not prioritized in school curricula, as academic subjects take precedence, leaving limited time for discussions on nutrition, physical activity, and stress management. In rural and low-income areas, limited access to educational materials and technology further restricts the effectiveness of these initiatives, while cultural beliefs and misconceptions about diet, exercise, and mental well-being create resistance to adopting healthier lifestyles.

To address these challenges, governments and educational institutions must invest in teacher training programs that equip educators with the skills needed to deliver engaging, evidence-based health education. Integrating health topics into existing subjects, such as biology or physical education, can ensure consistent exposure to essential health information (21). Community-based education programs, supported by local healthcare workers and NGOs, can extend these efforts beyond schools to reach underserved populations (22). Additionally, leveraging digital tools—such as mobile applications, online courses, and interactive educational content—can help bridge gaps in areas with limited access to printed materials or healthcare professionals. Public awareness campaigns, backed by media and

community leaders, can further dispel misconceptions and encourage positive health behaviors (23). By combining formal education, community engagement, and technology-driven solutions, health education can become more accessible, sustainable, and impactful in resource-limited settings.

Reducing sodium intake is one of the core principles of the DASH diet, as high sodium consumption is a major risk factor for developing hypertension (24,25). By following a low-sodium diet, adolescents can lower their risk of prehypertension while benefiting from the DASH diet's emphasis on essential nutrients, weight management, and healthier eating habits (26). This comprehensive dietary approach addresses multiple factors that contribute to blood pressure regulation and overall cardiovascular health. However, implementing DASH diet strategies in developing countries presents several challenges, primarily limited access to healthy food options. In low-income communities, processed and high-sodium foods are often more affordable and widely available than fresh fruits and vegetables, making it difficult for individuals to adopt healthier dietary practices.

Addressing these barriers requires a multi-faceted approach involving government policies, community initiatives, and education. At the policy level, subsidies for fresh produce, whole grains, and other nutritious foods can improve affordability, while higher taxes on processed and high-sodium foods can discourage excessive consumption. Strengthening local food systems through agricultural incentives and farm-to-market programs can further enhance access to nutritious foods in underserved areas. At the community level, initiatives such as urban farming, community gardens, and food distribution programs can provide fresh produce to those in need (27). Schools and local organizations should integrate nutrition education into their programs, teaching individuals how to make affordable, healthy food choices (22). Practical cooking and meal preparation workshops can empower families to create nutritious meals using locally available ingredients. Additionally, public health campaigns, supported by media and social influencers, can help shift societal norms and encourage healthier eating habits. By combining policy interventions, community engagement, and education, countries can improve food accessibility and promote greater adherence to the DASH diet, ultimately reducing the prevalence of hypertension and related health issues.

Chronic stress can lead to elevated blood pressure, as the body's stress response triggers the release of hormones like cortisol and adrenaline, which increase heart rate and blood pressure (28). Managing stress is essential in preventing prehypertension by reducing both its physiological and behavioral impacts (29). Effective stress management techniques, such as relaxation exercises, mindfulness, and cognitive-behavioral strategies, can help lower blood pressure, prevent stress-related unhealthy behaviors, improve overall well-being, and promote healthier lifestyle choices (30). However, integrating stress management techniques into school settings remains a significant challenge in developing countries, particularly due to limited access to mental health resources. Many schools in resource-limited areas lack trained counselors, and stress reduction programs are often not prioritized in the curriculum.

To address this issue, policymakers and educators must prioritize mental health education in school curricula by implementing low-cost, scalable interventions such as mindfulness exercises, breathing techniques, and peer support programs that can be facilitated by teachers without requiring specialized training (27). Providing basic mental health training for educators can equip them with the skills to identify stress-related issues and offer appropriate guidance to students. Additionally, incorporating relaxation techniques into daily classroom routines can help students develop effective coping mechanisms to manage academic and social pressures. Beyond the classroom, schools should establish partnerships with healthcare providers, universities, and non-governmental organizations (NGOs) to offer periodic mental health workshops and counseling sessions. Leveraging digital platforms and mobile applications can also provide accessible stress management resources, particularly in areas where in-person counseling services are unavailable. Encouraging parental involvement in stress reduction strategies can further reinforce healthy coping mechanisms at home. By combining school-based initiatives with community and technological support, schools in resource-limited settings can foster a more supportive environment for students' mental well-being, ultimately enhancing their academic performance and overall health.

Regular physical activity plays a crucial role in maintaining cardiovascular health by lowering both systolic and diastolic blood pressure (31). Exercise enhances cardiovascular fitness, promotes efficient heart function, and improves blood vessel flexibility, ultimately reducing the risk of prehypertension and hypertension (32,33). Incorporating regular exercise into daily routines significantly lowers the risk of developing prehypertension and supports long-term cardiovascular health. However, in developing countries, several barriers hinder participation in

physical activity, including inadequate public infrastructure, a lack of safe exercise spaces, limited school sports programs, and urban environments that do not support active transportation.

To address these challenges, governments and urban planners must prioritize the development of safe and accessible public spaces for physical activity. This includes constructing parks, sports facilities, and pedestrian-friendly pathways to encourage walking and cycling. Schools should be required to implement structured physical education programs and provide recreational spaces for students. Additionally, community-based sports programs can create inclusive opportunities for exercise, particularly in low-income areas where access to private fitness facilities is limited. Beyond infrastructure, promoting active transportation is essential for integrating physical activity into daily routines. Governments should improve public transportation systems by developing walkable routes, safe sidewalks, and designated cycling lanes, making walking and biking viable options. Employers and schools can support active lifestyles by implementing flexible work hours for exercise and incorporating movement-based learning activities into classrooms. Public health campaigns and community initiatives should also be utilized to raise awareness about the benefits of regular physical activity and encourage participation in sports and fitness programs (27). By addressing both structural and behavioral challenges, these strategies can help foster a culture of active living and reduce the prevalence of hypertension and other non-communicable diseases.

Limitations

This study has several limitations. First, the geographical representation of the included studies is limited, with most research originating from a few developing countries, while others, particularly in sub-Saharan Africa, Latin America, and the Middle East, are underrepresented. This may affect the generalizability of the findings. Second, the study designs of the included articles vary, with some relying on observational studies rather than Randomized Controlled Trials (RCTs), which could impact the strength of the evidence presented. Third, the heterogeneity of intervention methods and outcome measures across studies makes direct comparisons challenging, limiting the ability to determine the most effective approach. Lastly, language and publication bias may be present, as this review only included English-language, peer-reviewed, and full-text articles, potentially excluding relevant research published in other languages or non-indexed sources.

Recommendation for Future Research

Future research should focus on expanding geographical diversity by including studies from underrepresented regions to provide a more comprehensive understanding of prehypertension prevention strategies. Additionally, large-scale, long-term RCTs are needed to establish causal relationships between interventions and prehypertension outcomes. Standardizing intervention protocols and outcome measures across studies would facilitate comparisons and meta-analyses to determine the most effective strategies. Lastly, research should explore the socioeconomic and cultural barriers affecting intervention implementation and adherence, ensuring that strategies are tailored to diverse populations and resource-limited settings.

CONCLUSION

These studies highlight the importance of a multifaceted approach in managing adolescent health. Health education, dietary interventions such as the DASH diet, stress management, and regular physical activity are all critical components in promoting healthy behaviors and reducing the risk of prehypertension among adolescents. Based on the findings of this study, the most evidence-based and feasible strategy in resource-limited settings is school-based interventions, as they offer broad coverage, high accessibility, and lower implementation costs compared to community-based programs. Clinicians can support school-based blood pressure screening and nutrition education programs by collaborating with educators to ensure long-term student health monitoring. Educators play a crucial role in integrating health topics into the curriculum, providing healthier food options in school canteens, and promoting structured physical activities. Policymakers should expand school-based policies by providing training for educators on cardiovascular health and the early detection of prehypertension in adolescents while also supporting further research to evaluate intervention effectiveness. While school-based programs are highly promising, community-based approaches remain essential for reaching out-of-school populations, making both strategies complementary in adolescent prehypertension prevention.

AUTHOR'S CONTRIBUTION STATEMENT

Annisa Novanda Maharani Utami played a significant role in designing the study, collecting data, selecting studies, extracting data, interpreting the results, and making substantial revisions to the manuscript. Bagoes Widjanarko and Zahroh Shaluhiyah contributed to the literature review, validated the research methodology, and provided final edits to the manuscript. All authors have reviewed and approved the final version for submission.

CONFLICTS OF INTEREST

The authors confirm that there are no conflicts of interest regarding this study or its publication. All data and findings presented are entirely independent and have not been influenced by sponsors or any external institutions.

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