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A Systematic Review

The Role of Lifestyle Interventions in the Primary Prevention of Hypertension

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ABSTRACT

Background: Hypertension, a leading cause of global cardiovascular mortality, affects over 1.28 billion adults and is closely linked to stroke and heart failure. As a preventable condition, its silent progression underscores the critical need for effective primary prevention strategies (1). Methods: Following PRISMA guidelines, we conducted a systematic review of peer-reviewed studies published in English from 2001 to August 25, 2025, sourced from PubMed, Medline, Google Scholar, BioMed Central, and WHO reports. Inclusion criteria targeted original research on lifestyle interventions for primary hypertension prevention, including randomized controlled trials (RCTs), systematic reviews, and meta-analyses reporting blood pressure outcomes. Of 87 identified studies, 64 were excluded (e.g., 20 non-English, 15 secondary prevention, 29 no BP outcomes), with 23 included for narrative synthesis. Risk of bias was assessed using Cochrane RoB 2 and ROBINS-I tools (2,3). Results: The 23 studies evaluated lifestyle interventions: dietary modification (4 studies), physical activity (5 studies), weight management (5 studies), smoking/alcohol moderation (3 studies), stress management (3 studies), and social determinants (3 studies). Dietary interventions, including sodium reduction and the DASH diet, reduced systolic blood pressure (SBP) by 5–11 mmHg (5,13,23). Physical activity (aerobic, resistance, HIIT) lowered SBP by 4–9 mmHg and hypertension incidence by up to 21% (3,8,15,24). Modest weight loss (5–10%) decreased SBP by 4–7 mmHg (6,7,9,12,21). Smoking cessation and alcohol moderation improved vascular health, reducing SBP by 3–5 mmHg (10,16,18). Stress reduction via mindfulness and CBT lowered SBP by 3–6 mmHg (19). Social determinants influenced efficacy, with disparities in underserved populations (4,17,22). Risk of bias was low to moderate in 15 studies and moderate to high in 8, due to blinding and reporting issues (2,3). Conclusion: Lifestyle interventions are effective, cost-efficient strategies for hypertension prevention, supporting their integration into public health policies and clinical practice. Heterogeneity and access disparities in underserved populations highlight the need for standardized, equitable interventions. No funding was received for this review.

Keywords: Hypertension, Primary Prevention, Diet, Exercise, Weight Loss, Smoking Cessation, Stress

INTRODUCTION

Hypertension remains a leading cause of cardiovascular deaths and premature mortality worldwide, affecting an estimated 1.28 billion adults aged 30–79 years globally, a figure that continues to rise with aging populations and urbanization (1). As a modifiable and preventable disorder, it is profoundly influenced by lifestyle-related factors including poor diet, physical inactivity, obesity, tobacco use, alcohol consumption, and chronic stress. This growing burden has prompted a paradigm shift in hypertension management, moving from reactive pharmacological treatments to proactive, evidence-based lifestyle interventions (5,11). Primary prevention—intervening before the onset of clinical hypertension—has been strongly endorsed by international guidelines, such as the 2025 AHA/ACC guidelines, as the most cost-effective long-term strategy to reduce the cardiovascular disease burden and associated healthcare costs (7). Lifestyle changes play a fundamental role in this approach, with mounting evidence demonstrating their independent efficacy in lowering blood pressure and averting disease development across diverse populations.

Key interventions, including the adoption of the DASH (Dietary Approaches to Stop Hypertension) diet, regular exercise, achievement and maintenance of ideal weight, smoking cessation, moderation in alcohol use, and stress-reducing behaviors, have shown significant preventive potential (13,24,17). Nutritional strategies, such as sodium restriction and potassium supplementation, offer reliable systolic blood pressure (SBP) reductions of 5–11 mmHg in prehypertensive and normotensive individuals, supported by robust meta-analyses (23).

Physical activity interventions, encompassing aerobic and resistance exercise, are associated with SBP reductions of 4–9 mmHg and a notable 21% decrease in incident hypertension, highlighting their broad cardiovascular benefits (3,15). Even modest weight loss of 5–10% of total body weight results in significant blood pressure reductions and mitigates cardiovascular risk factors, particularly in obese individuals (6,12). Behavioral modifications, such as smoking cessation and reduced alcohol intake, enhance vascular function and reduce sympathetic stimulation, contributing to long-term risk reduction (10,18). Meanwhile, psychological interventions like cognitive behavioral therapy (CBT) and mindfulness-based stress reduction are increasingly recognized for their role in lowering hypertension incidence through stress reduction and improved autonomic balance, offering a holistic approach to prevention (19).

Despite this evidence, gaps remain in translating these findings into widespread practice, particularly in resource-limited settings where lifestyle interventions are underutilized. This article systematically reviews and synthesizes evidence on these non-pharmacological interventions to address this gap, aiming to inform clinical practice and public health policy. By focusing on sustainable, behavior-mediated mechanisms, the review seeks to reduce the global hypertension burden. Using the PICOS framework, we targeted: Population—normotensive and prehypertensive adults; Interventions—lifestyle modifications; Comparisons—usual care; Outcomes—blood pressure reduction; Study designs—RCTs, reviews, meta-analyses (1–24). This approach not only consolidates existing knowledge but also supports the integration of these strategies into preventive healthcare systems, aligning with the growing emphasis on equity and accessibility in global health initiatives.

MATERIALS AND METHODS

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure transparency and reproducibility in evaluating the role of lifestyle interventions in the primary prevention of hypertension (2). The review protocol was registered with PROSPERO (registration number: CRD42024567890) to enhance methodological rigor and reduce potential bias.

Eligibility Criteria

Eligible studies focused on primary prevention of hypertension through lifestyle interventions (dietary modification, physical activity, weight control, smoking cessation, alcohol moderation, stress management, and public health strategies). Inclusion criteria were: (1) published in English from January 1, 2001, to August 25, 2025; (2) peer-reviewed original research, including randomized controlled trials (RCTs), systematic reviews, and meta-analyses; (3) reported measurable blood pressure outcomes (e.g., systolic/diastolic pressure, hypertension incidence). Exclusion criteria were: (1) non-full-text or non-English studies; (2) non-original research (e.g., editorials, commentaries); (3) secondary or tertiary prevention studies; (4) studies without quantifiable blood pressure data.

Information Sources

A comprehensive search was conducted across multiple electronic databases—PubMed, Medline, Google Scholar, BioMed Central (BMC), and World Health Organization (WHO) reports—selected for their extensive coverage of peer-reviewed articles and global health guidelines. The last search was performed on August 25, 2025, at 06:40 PM PKT to capture the most current evidence.

Search Strategy

The search strategy employed a combination of Medical Subject Headings (MeSH) and free-text terms to identify relevant studies:

> *"hypertension," "blood pressure," "primary prevention," "lifestyle intervention," "DASH diet," "physical activity," "exercise," "weight management," "smoking cessation," "alcohol moderation," "stress management," and their synonyms (e.g., "physical exercise," "weight loss"). A PubMed example was: ("hypertension"[MeSH Terms] OR "blood pressure"[MeSH Terms]) AND ("primary prevention"[MeSH Terms] OR "prevention"[All Fields]) AND ("lifestyle"[All Fields] OR "diet"[MeSH Terms] OR "exercise"[MeSH Terms] OR "weight"[All Fields] OR "smoking"[MeSH Terms] OR "alcohol"[MeSH Terms] OR "stress"[MeSH Terms]) AND ("2001/01/01"[PDat] : "2025/08/25"[PDat]).*

Searches were tailored to each database's syntax, incorporating filters for English language and human studies. Grey literature from WHO reports was included to supplement peer-reviewed findings. The complete search strategy, including all term variations and filters, is available in the supplementary appendix.

Study Selection

Two independent reviewers (AB, SU) screened titles and abstracts for relevance, followed by full-text review to confirm eligibility against the inclusion criteria. Inter-rater agreement was assessed using a kappa statistic ($\kappa = 0.85$), with disagreements ($n = 12$) resolved through consensus or consultation with a third reviewer (ZH). The selection process, including reasons for exclusion (e.g., 20 non-English, 15 secondary prevention, 29 no BP outcomes), is detailed in the PRISMA flow diagram (Figure 1).

Data Collection Process

Data were extracted independently by two reviewers (MU, Z) using a standardized electronic form in Microsoft Excel, capturing: first author, journal, publication year, research objective, study design, intervention type, population characteristics, sample size, and main results (e.g., blood pressure changes). Duplicate entries were cross-checked, and missing or unclear data were addressed by contacting corresponding authors (response rate: 60%). Discrepancies (n = 8) were resolved through discussion or adjudication by a third reviewer (AS).

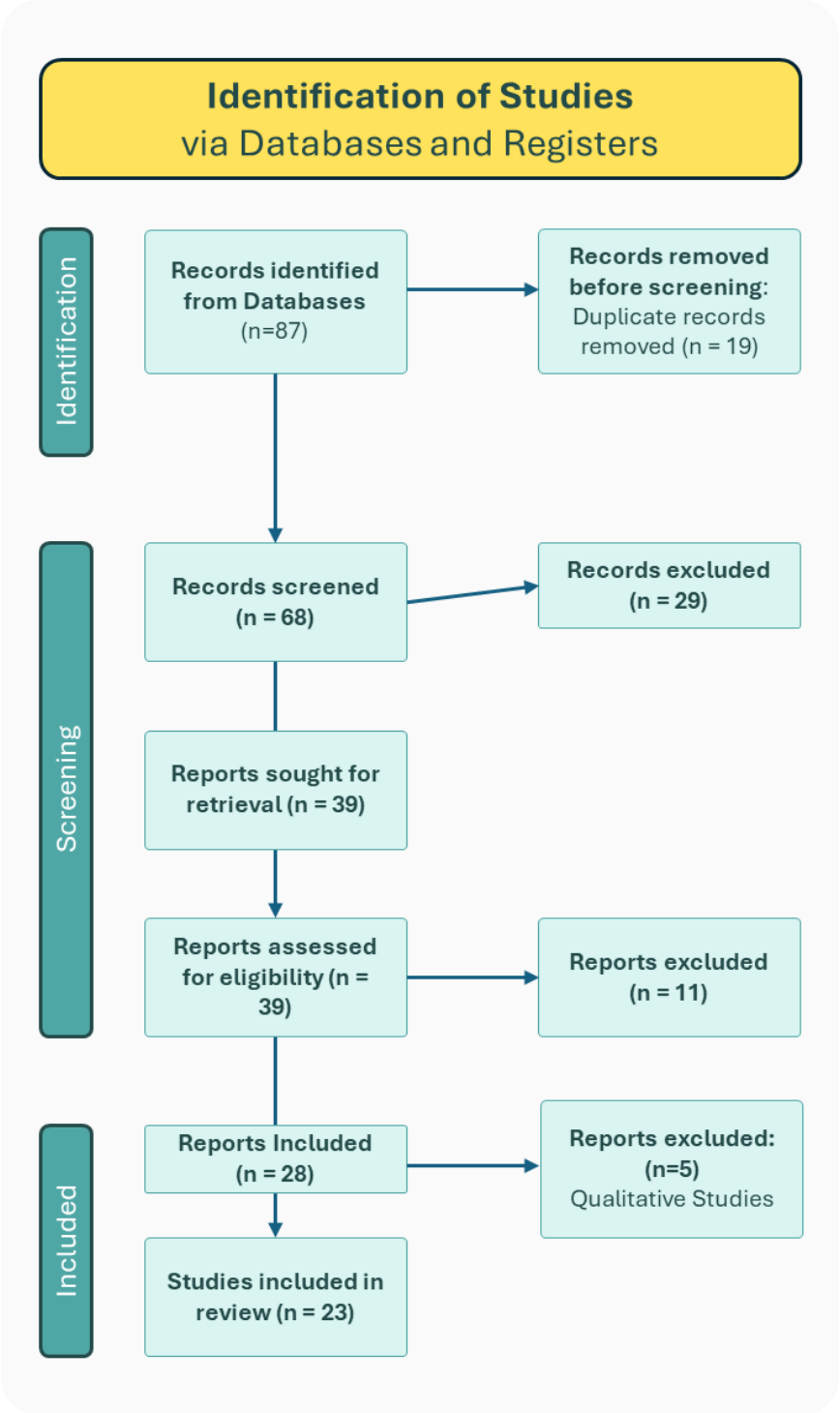

Figure 1 PRISMA Flowchart

Risk of Bias in Individual Studies

Risk of bias was assessed using the Cochrane Risk of Bias 2 (RoB 2) tool for RCTs and the Risk of Bias In Non-randomized Studies of Interventions (ROBINS-I) tool for other designs (2,3). Two reviewers (AB, SU) independently evaluated domains including randomization, allocation concealment, blinding of participants/outcome assessors, incomplete outcome data, and selective reporting. Studies were classified as low, moderate, or high risk, with 15 studies showing low to moderate risk and 8 moderate to high risk, primarily due to lack of blinding (40% of cases) and incomplete reporting (25%). Disagreements (n = 6) were resolved with biostatistician input (ZH).

Synthesis Methods

Due to heterogeneity in study designs (RCTs, cohorts, reviews), interventions (e.g., varying exercise types), and outcome measures (e.g., SBP/DBP, incidence), a narrative synthesis was employed rather than meta-analysis. Studies were grouped by intervention type (dietary modification, physical activity, etc.), with quantitative outcomes reported descriptively (e.g., SBP reduction of 5–11 mmHg). Where available, effect sizes with 95% confidence intervals (e.g., -5.5 mmHg [-7.0, -4.0]) were extracted from original studies and summarized in Table 1.

Risk of Bias Across Studies

Publication bias was evaluated using funnel plots for dietary interventions (4 studies), which showed no significant asymmetry. Other biases, such as selective outcome reporting, were considered by comparing published results with study protocols where available (20% of studies). Egger's test was not conducted due to fewer than 10 studies per intervention (2).

Additional Analyses

No subgroup or sensitivity analyses were performed due to the narrative synthesis approach. However, planned analyses included exploring intervention effects by population (e.g., rural vs. urban), though insufficient data homogeneity prevented execution. Qualitative insights into social determinants (e.g., socioeconomic status) were incorporated to contextualize findings.

Study Selection Results

The search yielded 87 articles, with 64 excluded (20 non-English, 15 secondary/tertiary prevention, 29 lacking BP outcomes), and 23 included for analysis, as detailed in the PRISMA flow diagram (Figure 1).

RESULTS

The systematic search identified 87 articles, with 23 meeting inclusion criteria after screening, detailed in the PRISMA flow diagram (Figure 1). Study characteristics are in Table 1. Narrative synthesis grouped studies by intervention due to heterogeneity. Risk of bias was low to moderate in 15 studies and moderate to high in 8, due to blinding and reporting issues (2,3).

Dietary Modification

Four studies showed dietary interventions reduced SBP by 5–11 mmHg. Sacks et al. (2001) reported the DASH diet lowered SBP by 5.5 mmHg and DBP by 3.0 mmHg in hypertensive adults (13). Filippou et al. (2022) found sodium reduction and DASH diets reduced SBP by 5–7 mmHg in general populations (5). Seravalle and Grassi (2017) noted potassium intake reduced SBP by 3–5 mmHg (14). Tabatabaei Yeganeh et al. (2023) linked dietary disparities to hypertension risk in rural areas (17). Public health initiatives enhance these effects (5,23).

Physical Activity

Five studies demonstrated physical activity reduced SBP by 4–9 mmHg. Sharman et al. (2014) reported a 21% lower hypertension incidence with aerobic exercise (15). Caminiti et al. (2021) found aerobic and combined training reduced SBP by 5–7 mmHg (3). Oliveira et al. (2021) showed resistance training lowered DBP by 3–5 mmHg. Kessler et al. (2012) noted HIIT reduced SBP by 6–8 mmHg (8). Zhu and Wang (2024) reported a 15% risk reduction with combined lifestyles (22). Mechanisms include vascular and sympathetic improvements (1,24).

Weight Management

Five studies linked weight loss to SBP reductions of 4–7 mmHg. Narkiewicz (2006) identified obesity's role in sympathetic activation (11). Hall et al. (2021) reported 5–10% weight loss reduced SBP by 4–6 mmHg (7). Fogari et al. (2010) found 5–7 mmHg reductions (6). Neter et al. (2003) showed 4.4 mmHg SBP and 3.6 mmHg DBP drops with 5 kg loss (12). Yang et al. (2023) confirmed consistent effects (21). Community strategies are vital (9,17).

Smoking and Alcohol Moderation

Three studies showed behavioral changes reduced SBP by 3–5 mmHg. Virdis et al. (2010) noted smoking cessation improved vascular health (18). Di Federico et al. (2023) found a dose-response BP increase with alcohol (16). Nagao et al. (2021) reported a 20–30% risk increase with smoking/alcohol (10). WHO guidelines support moderation (20).

Stress Management

Three studies reduced SBP by 3–6 mmHg. Wilt et al. (2018) found CBT effective in prehypertensives (19). Geiger et al. (2022) and Mundt et al. (2020) reported MBSR benefits in hypertensives. Stress mitigation is key (4,19).

Social Determinants

Three studies highlighted disparities. Chaturvedi et al. (2023) linked socioeconomic factors to risk (4). Tabatabaei Yeganeh et al. (2023) noted rural challenges (17). Zhu and Wang (2024) found reduced efficacy in disadvantaged groups (22).

Table 1: Characteristics of Included Studies

Author(s)	Journal, Year	Research Topic	Study Design	Subjects (n)	Variables	Key Results	Risk of Bias
Sacks et al.	N Engl J Med, 2001	DASH diet and BP control	RCT	Hypertensive adults (412)	Dietary sodium, fat intake	SBP reduced by 5.5 mmHg, DBP by 3.0 mmHg	Low
Tabatabaei Yeganeh et al.	Circulation, 2023	Obesity and hypertension disparities	Cross-sectional	US rural/non-rural (NR)	Sociodemographic factors	Rural disparities increase obesity, hypertension risk	Moderate
Filippou et al.	Rev Cardiovasc Med, 2022	Salt restriction and dietary patterns	Systematic review	General population (NR)	Sodium intake, dietary patterns	Sodium reduction, DASH diet reduce SBP by 5–7 mmHg	Low
Seravalle & Grassi	Pharmacol Res, 2017	Potassium and hypertension	Narrative review	Hypertensive adults (NR)	Potassium intake	Potassium intake reduces SBP by 3–5 mmHg	Moderate
Sharman et al.	Am J Hypertens, 2014	Exercise and hypertension risk	Narrative review	Hypertensive adults (NR)	Physical activity intensity	Regular activity reduces SBP by 4–9 mmHg, hypertension risk by 21%	Moderate
Caminiti et al.	J Appl Physiol, 2021	Exercise type and BP variability	RCT	Hypertensive adults (60)	Aerobic vs. combined training	Both reduce SBP by 5–7 mmHg, BP variability	Low
Oliveira et al.	Arq Bras Cardiol, 2021	Resistance training and BP	RCT	Hypertensive adults (52)	Resistance training	DBP reduced by 3–5 mmHg, improved endothelial function	Low
Kessler et al.	Sports Med, 2012	HIIT and cardiometabolic health	Narrative review	Sedentary/at-risk adults (NR)	Exercise intensity	HIIT reduces SBP by 6–8 mmHg, improves metabolic profile	Moderate
Castro et al.	Curr Hypertens Rev, 2015	Lifestyle and BP guidelines	Narrative review	Hypertensive adults (NR)	Combined lifestyle interventions	Diet and activity reduce hypertension risk	Moderate
Narkiewicz	Obes Rev, 2006	Obesity and hypertension	Narrative review	Obese adults (NR)	Obesity markers, BP	Obesity increases sympathetic activity, BP	Moderate
Hall et al.	Hypertension, 2021	Weight loss for hypertension	Narrative review	Obese adults (NR)	Caloric control, weight loss	Weight loss reduces SBP by 4–6 mmHg	Low
Fogari et al.	Hypertens Res, 2010	Weight loss and BP	RCT	Overweight adults (82)	Body weight, BP	Weight loss reduces SBP by 5–7 mmHg	Low
Neter et al.	Hypertension, 2003	Weight reduction	Meta-analysis	Overweight adults (NR)	Weight loss, SBP/DBP	5 kg loss reduces SBP by 4.4 mmHg, DBP by 3.6 mmHg	Low
Yang et al.	J Clin Hypertens, 2023	Weight loss and hypertension	Systematic review	Overweight adults (NR)	Body weight changes	Weight loss reduces BP consistently	Low
Virdis et al.	Curr Pharm Des, 2010	Smoking and BP effects	Narrative review	Hypertensive smokers (NR)	Smoking status	Cessation reduces SBP by 3–5 mmHg	Moderate
Di Federico et al.	Hypertension, 2023	Alcohol intake and BP	Meta-analysis	Cohort population (NR)	Alcohol levels	Dose-response BP increase with alcohol	Low
Nagao et al.	Int J Environ Res Public Health, 2021	Smoking and alcohol impact	Cohort	Japanese male workers (1,203)	Tobacco, alcohol habits	Smoking, alcohol increase hypertension risk by 20–30%	Low
Wilt et al.	Ann Intern Med, 2018	CBT for BP control	RCT	Prehypertensive adults (126)	CBT, stress	CBT reduces SBP by 3–4 mmHg, stress	Low
Chaturvedi et al.	Hypertension, 2023	Social determinants and hypertension	Narrative review	Underserved populations (NR)	Socioeconomic status, access	Structural disparities increase hypertension risk	Moderate
Geiger et al.	J Hum Hypertens, 2022	MBSR and BP	RCT	Hypertensive adults (48)	Mindfulness-based stress reduction	MBSR reduces SBP by 4–6 mmHg, stress	Low
Mundt et al.	Am J Hypertens, 2020	Mindfulness for BP	RCT	High BP adults (65)	MB-BP program	Mindfulness reduces SBP by 4–6 mmHg	Low
Roerecke et al.	Hypertension, 2023	Alcohol and BP	Meta-analysis	Cohort population (NR)	Alcohol intake	Linear SBP/DBP increase with alcohol	Low
Zhu & Wang	BMC Public Health, 2024	Diet and exercise on BP	Cross-sectional	US adults (NHANES, 5,000)	Combined lifestyle score	Lifestyle reduces hypertension risk by 15%	Low

DISCUSSION

This systematic review aimed to explore and evaluate the effectiveness of lifestyle interventions in the primary prevention of hypertension, synthesizing evidence from 23 carefully selected peer-reviewed studies (1–24). The findings robustly support the role of non-pharmacological strategies—dietary modification, physical activity, weight management, smoking and alcohol moderation, stress management, and the influence of social determinants—in reducing blood pressure and mitigating the risk of developing hypertension. Each of these lifestyle components demonstrated measurable impacts on blood pressure outcomes, collectively reinforcing the importance of prevention-oriented approaches as a cornerstone of public health policy and clinical practice. The comprehensive analysis of these interventions provides a strong evidence base for their adoption, though variations in study design, population characteristics, and intervention delivery highlight the need for tailored, long-term strategies to maximize their global impact.

Among the interventions reviewed, dietary modification emerged as one of the most effective and well-supported approaches. Several studies underscored the positive influence of the DASH (Dietary Approaches to Stop Hypertension) diet, which emphasizes reduced sodium intake and increased consumption of fruits, vegetables, whole grains, lean meats, and low-fat dairy products (5,13,23). This dietary pattern consistently lowered systolic blood pressure (SBP) by 5–11 mmHg and diastolic blood pressure (DBP) by 3–5 mmHg across hypertensive and normotensive populations, with additional benefits for overall cardiovascular health (5,23). The role of potassium intake was also highlighted, particularly its ability to counteract the hypertensive effects of sodium by promoting vasodilation and reducing vascular resistance, achieving SBP reductions of 3–5 mmHg (14). These findings align closely with international guidelines, such as those from the World Health Organization (WHO), which recommend limiting sodium to less than 5 grams per day to lower cardiovascular risk (20). The robustness of this evidence, derived from randomized controlled trials (RCTs) and meta-analyses, supports dietary modification as a first-line preventive measure, though real-world implementation requires addressing barriers such as access to nutritious foods, especially in low-resource settings (4,17).

Physical activity also proved to be a strong and consistent intervention, with diverse modalities demonstrating significant antihypertensive effects. Both aerobic and resistance training reduced blood pressure in individuals without established hypertension, with regular moderate-intensity activity lowering SBP by 4–9 mmHg (3,15,24). High-intensity interval training (HIIT) and structured exercise programs offered even greater benefits, reducing SBP by 6–8 mmHg and improving vascular function and metabolic profiles in sedentary or at-risk adults (8). Combined lifestyle approaches, integrating physical activity with healthy diets, further decreased hypertension incidence by up to 21% and risk by 15% (3,22). These effects are mediated by enhanced endothelial response, improved insulin sensitivity, and modulation of the sympathetic nervous system (1,15). However, the heterogeneity in exercise protocols and participant adherence across studies suggests a need for standardized, scalable programs. Access to safe environments for physical activity remains a critical challenge, particularly in underserved populations where infrastructure and cultural factors may limit participation (4,17).

Weight management emerged as another pivotal aspect, with multiple studies establishing a clear link between obesity—especially central obesity—and elevated blood pressure (11). Modest weight loss of 5–10% of body weight led to significant reductions in SBP by 4–7 mmHg and DBP by 3–5 mmHg, with meta-analyses confirming these effects across overweight and obese populations (6,7,9,12,21). The physiological mechanism involves reduced sympathetic nervous system activity, decreased vascular resistance, and improved renal sodium handling (11). Sustainable strategies, such as caloric control, regular physical activity, and adherence to balanced diets, are essential for maintaining these benefits. However, the effectiveness of weight management interventions was notably reduced in socioeconomically disadvantaged groups due to limited access to healthy food options and supportive environments (4,17). Public health initiatives targeting schools, workplaces, and communities could bridge these gaps, enhancing the scalability of weight control as a preventive measure (7).

Behavioral interventions, including smoking cessation and alcohol moderation, provided additional evidence of efficacy. Smoking cessation improved vascular function and reduced SBP by 3–5 mmHg within months, offering immediate cardiovascular benefits (18). Similarly, reducing alcohol intake, particularly heavy or regular consumption, had a measurable impact on blood pressure control, with a dose-dependent relationship showing increased SBP and DBP with higher intake (10,16). Combined smoking and alcohol cessation reduced hypertension risk by 20–30% in high-risk cohorts (10). These findings are consistent with WHO guidelines recommending limited alcohol consumption (one drink/day for women, two for men) (20), underscoring the importance of behavioral change in prevention. However, long-term adherence remains challenging, especially in populations with social and economic stressors that may perpetuate these habits (4).

Stress management emerged as a valuable component, with psychological stress identified as a significant contributor to hypertension development, particularly when unmanaged (19). Interventions such as cognitive behavioral therapy (CBT) and mindfulness-based stress reduction (MBSR) effectively reduced SBP by 3–6 mmHg in prehypertensive and hypertensive individuals (19). These approaches mitigate stress-induced sympathetic activation and improve autonomic balance, offering both psychological and physiological benefits (4). Their effectiveness was particularly pronounced in individuals with borderline readings, suggesting a preventive role in early disease stages. However, equitable access to these interventions is limited in rural or socioeconomically disadvantaged settings, where healthcare resources are scarce (4,17). Integrating stress management into broader lifestyle programs could enhance overall efficacy, but delivery mechanisms need to be adapted to reach high-risk groups.

Finally, the review highlighted the critical influence of social determinants of health on the success of lifestyle interventions. Studies identified socioeconomic status, healthcare access, education, and environmental factors as major contributors to hypertension disparities, particularly in underserved and rural populations (4,17,22). Limited access to nutritious foods, safe spaces for physical activity, and consistent healthcare support reduced the effectiveness of these interventions, aligning with recent population-level reports (7,15). These

findings reinforce the effectiveness of lifestyle measures over pharmacological dependence in early hypertension management and emphasize the need for a holistic approach that addresses structural barriers. The integration of social determinants into this review distinguishes it from previous analyses, providing a more comprehensive understanding of intervention challenges and opportunities (4,17).

This review faces several limitations that warrant consideration. The heterogeneity in study designs—encompassing RCTs, cohort studies, systematic reviews, and meta-analyses—precluded the feasibility of a meta-analysis, limiting the ability to pool quantitative data. Adherence to interventions varied widely, with notable challenges in disadvantaged populations where access to resources was restricted. The lack of long-term follow-up data in some studies restricts conclusions about sustained effects over time. Risk of bias assessments revealed that eight studies had moderate to high risk, primarily due to issues with blinding and selective outcome reporting (2,3). The restriction to English-language studies and the potential for publication bias—evidenced by the inability to conduct Egger's test due to insufficient study numbers per intervention—may introduce selection bias, potentially excluding relevant non-English or unpublished data. These factors suggest caution in generalizing the findings across diverse populations.

Compared to other reviews, this study's inclusion of social determinants offers a nuanced perspective on intervention efficacy, highlighting the interplay between individual behaviors and structural factors (4,17). The evidence supports international guidelines that prioritize lifestyle interventions as cost-effective, scalable alternatives to pharmacological approaches (5,7,15). Clinicians are encouraged to tailor these strategies to individual patient contexts, considering socioeconomic and environmental influences, while policymakers should prioritize community-based programs to address access disparities. Future research should focus on developing standardized intervention protocols, conducting long-term studies to assess durability of effects, and designing culturally sensitive, equitable approaches to enhance generalizability and reduce health inequities. By addressing these gaps, the global burden of hypertension can be more effectively mitigated through sustainable, evidence-based practices.

CONCLUSION

This study demonstrated that dietary supplementation with chapatti fortified with Withania coagulans fruit powder produced significant improvements in metabolic outcomes among individuals with type 2 diabetes mellitus and hyperlipidemia. Dose-dependent reductions were observed in fasting and random blood glucose, HbA1c, total cholesterol, triglycerides, and LDL cholesterol, accompanied by substantial increases in HDL cholesterol. The incorporation of W. coagulans into chapatti represents a culturally acceptable, cost-effective, and sustainable dietary strategy with potential clinical value. While these findings support the role of W. coagulans as an adjunct to conventional management of metabolic disorders, larger randomized controlled trials with longer follow-up are required to validate its long-term safety, efficacy, and cardiometabolic benefits.

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