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Effects of Buteyko Breathing, Resistance and Isometric Exercise Training in Primary Hypertensive Patients - A Literature Review

Ms. Rutuja Hulaji Mohan[1], Prof. Shwetha S S[2], Dr. Chetana G H[3]

[1]Intern, Physiotherapy, Physiotherapy, Prudence College of Physiotherapy
[2,3]Physiotherapist, Physiotherapy, Prudence College of Physiotherapy

Abstract

BACKGROUND: Hypertension is a leading risk factor for cardiovascular disease, contributing significantly to global morbidity and mortality. While pharmacological therapy is standard, non-pharmacological interventions such as the Buteyko breathing technique, isometric, and resistive exercises have shown promise in managing blood pressure and improving cardiovascular function.

METHODOLOGY: A structured literature review was conducted using databases like PubMed, ScienceDirect, Elsevier, Google Scholar, and ResearchGate. Out of 85 identified articles (2015–2025), 18 studies met the inclusion criteria: 10 RCTs, 5 meta-analyses/cross-sectional studies, and 3 pilot studies.

The review focused on adults aged 30–60 with essential hypertension. Isometric exercise showed the greatest BP reduction (8.3 mmHg systolic and 3.9 mmHg diastolic, $p < 0.0001$), followed by resistance training (~ 4.0 mmHg systolic and ~2.1 mmHg diastolic, $p < 0.001$). Buteyko breathing showed smaller, yet significant effects (2.5–3.0 mmHg systolic and 1.5–2.0 mmHg diastolic, $p = 0.03$), though the evidence was less conclusive.

RESULTS: All three interventions significantly improved cardiovascular parameters. Isometric exercise was the most effective in lowering blood pressure, followed by resistance training. Buteyko breathing showed a modest positive effect. Effectiveness varied with intervention type and evidence quality.

CONCLUSION: Isometric exercise is the most effective non-pharmacological intervention for lowering blood pressure, followed by resistance training. Buteyko breathing provides modest benefits and may serve as a supportive approach

INTRODUCTION

The current definition of hypertension (HTN) is systolic blood pressure (SBP) values of 130 mm Hg or more and/or diastolic blood pressure (DBP) of more than 80 mm Hg. Hypertension ranks among the most common chronic medical conditions, characterised by a persistent elevation in arterial pressure.[1] Under the most recent guidelines for hypertension, blood pressure measurements are categorised as follows: Normal: systolic pressure less than 120 mm Hg and diastolic pressure less than 80 mmHg. Elevated: systolic pressure of 120 to 129 mm Hg and diastolic pressure less than 80 mm Hg. Stage 1: systolic pressure 130 to 139 mm Hg or diastolic pressure of 80 to 89 mm Hg. Stage 2: systolic pressure of at least 140 mm Hg or diastolic pressure of at least 90 mm Hg. Hypertensive crisis: systolic pressure above 180 mm Hg and/or diastolic pressure above 120 mm Hg.[2]

Hypertension, or high blood pressure, is generally categorised into two main types: primary (essential) hypertension and secondary hypertension. Primary hypertension is the most common form and occurs without a specific identifiable cause. It usually develops gradually and is influenced by factors like genetics, lifestyle, and ageing. In contrast, secondary hypertension is caused by an underlying condition or identifiable factor, such as kidney disease, hormonal imbalances, or certain medications. It is more common among younger adults, with research showing that up to 30% of individuals aged 18 to 40 with high blood pressure may have secondary hypertension.[2]

Hypertension is a major non-communicable disease and a leading cause of death globally, contributing to around 17.9 million deaths each year. An estimated 1 billion adults aged 30–79 worldwide live with hypertension, with two-thirds residing in low- and middle-income in 28 countries. Alarmingly, about 46% of affected adults are unaware of their condition. Among those diagnosed, only 42% receive treatment, and just 21% manage to keep it under control. This makes hypertension a key factor in premature mortality worldwide. To address this global health challenge, a target has been set to reduce hypertension prevalence by 33% between 2010 and 2030.[4]

Hypertension is the most important chronic disease risk factor in India. Recent epidemiological studies have reported that hypertension is increasing in India, with a more rapid increase in rural and young populations.[4] The age-adjusted prevalence of hypertension in India was 11.3% (95% CI 11.16% to 11.43%) among persons aged between 15 and 49 and was four percentage points higher among males, 13.8% (95% CI 13.46% to 14.19%) than among females, 10.9% (95% CI 10.79% to 11.06%).[5]

The Buteyko Breathing Technique, developed in the 1950s by Dr. Konstantin Pavlovich Buteyko, was originally designed to help treat asthma by addressing chronic hyperventilation. One of the key advantages of this method is its simplicity; it is easy to learn and can be practised comfortably by patients. The technique focuses on breath control and breath-holding exercises, emphasising a shallow breathing pattern to correct hyperventilation**.** Central to the practice is the promotion of nasal breathing, gentle breath-holding, and relaxation. The technique aims to optimise carbon dioxide(CO_2) retention in the body, which in turn has a vasodilatory effect, leading to reduced heart rate and lower blood pressure.[6]

The Buteyko Breathing Technique (BBT) is aimed at reversing chronic hyperventilation. Its primary goal is to gradually normalize and optimise automatic breathing patterns over time. This is achieved by gently training the body to breathe less through a process of physiological adaptation. As breathing volume decreases, carbon dioxide(CO_2) levels in the body increase, which helps prevent hyperventilation and restores a healthy balance of CO_2 in the lungs.

Higher CO_2 levels enhance the Bohr Effect, a mechanism where oxygen is more easily released from haemoglobin and made available to the body's tissues. The technique encourages slower, shallower breathing through the nose, breath-holding, and muscle relaxation to improve overall health and well-being. In structured breathing sessions, the method combines reduced breathing volume with breath-holding exercises, the most important of which are the Control Pause (CP) and the Maximum Pause (MP). The Maximum Pause typically lasts twice as long as the Control Pause. A typical session lasts 40–50 minutes, during which the individual sits upright and relaxes the respiratory muscles. Breathing begins with a light nasal inhale followed by a gentle exhale. After this, the breath is held until the person feels the first urge to breathe or a slight discomfort, indicating the end of the Control Pause.[7]

Resistance training was shown to acutely influence blood pressure in hypertensive patients through physiological mechanisms that improve vascular function. The repeated muscle contractions during resistance exercises stimulate endothelial nitric oxide release, enhance vasodilation, reduce arterial stiffness, and lower total peripheral resistance. Additionally, resistance training may decrease sympathetic activity and improve baroreflex sensitivity, contributing to better autonomic regulation of blood pressure. The study included full-body resistance exercises such as squats, lunges, chest press, shoulder press, rowing, and leg press, typically performed in circuits with 15 repetitions and short rest periods. These exercises activate large muscle groups, making resistance training an effective non-pharmacological approach for managing hypertension.[8]

Baross, Willes, and Swaine (2013) reported that isometric exercise, such as handgrip and wall squat, consists of sustained muscle contractions without visible joint movement, leading to increased intramuscular tension. This mechanical tension temporarily compresses blood vessels within the active muscles, reducing local blood flow and creating a mild hypoxic state. As a physiological response, the body initially increases heart rate and blood pressure to maintain perfusion. However, with repeated sessions, isometric training induces several beneficial adaptations. These include enhanced endothelial function through increased nitric oxide production, which promotes vasodilation and reduces total peripheral resistance. Additionally, isometric training improves arterial compliance and reduces vascular stiffness. It also modulates autonomic nervous system activity by lowering sympathetic output and enhancing baroreflex sensitivity. Together, these changes result in a meaningful reduction in resting systolic and diastolic blood pressure, and conclude that isometric exercise is an effective, time-efficient, and accessible non-pharmacological strategy for managing hypertension.[9]

The pathophysiology of essential hypertension (primary hypertension, idiopathic hypertension) is multifaceted and very complicated, frequently including reciprocal impacts on many cardiovascular control systems. The kidney is both a contributor and a target organ in hypertensive processes, and the disease is caused by the interaction of various organ systems as well as numerous independent or interdependent pathways. Ageing, genetics, activation of neurohormonal systems such as the sympathetic nervous system and the renin-angiotensin-aldosterone system, obesity, gut microbiota, and increasing dietary salt intake are all major factors in the pathophysiology of hypertension. An increase in systemic vascular resistance, which is brought on by changes in cardiovascular regulatory systems (such as those resulting from hereditary and environmental variables), is the defining hemodynamic abnormality that is essential to raised blood pressure (BP). In those who appear healthy yet have essential hypertension but no heart failure, an increased uric acid level may also be a contributing factor to diastolic dysfunction.[10]

NEED OF THE STUDY

- Hypertension continues to be a significant health burden globally, with many patients failing to achieve optimal blood pressure control despite medication.
- Non-pharmacological interventions, particularly physiotherapy-based approaches like Buteyko breathing, isometric exercise, and resistance training, offer potential benefits in blood pressure management.
- However, evidence directly comparing their effects in essential hypertension remains limited. Therefore, this review is essential to evaluate and clarify their roles in treatment.

AIM OF THE STUDY

To review recent evidence on physiotherapy interventions for essential hypertension, focusing on Buteyko breathing exercise, resistance and isometric exercise training.

OBJECTIVES

Primary Objectives:

- To assess the impact of Buteyko breathing on systolic and diastolic blood pressure in individuals with essential hypertension.
- To evaluate the efficacy of isometric exercise training in reducing blood pressure in essential hypertensives.
- To determine the effect of resistance training on blood pressure control in individuals with essential hypertension.

Secondary Objective:

- To compare the outcomes across the three interventions (Buteyko breathing, isometric exercise training, and resistance training) where possible, in terms of their effectiveness in managing blood pressure.

REVIEW OF LITERATURE

Edwards JJ et al. (2024) have conducted an updated systematic review to assess the effects of isometric exercise training on arterial hypertension. This comprehensive review included findings from numerous randomized controlled trials and cohort studies evaluating various isometric modalities, including handgrip training and isometric wall squats, across a range of populations. The updated analysis revealed that isometric exercise leads to clinically significant reductions in both systolic and diastolic blood pressure, with some studies reporting reductions comparable to pharmacological treatment. The proposed mechanisms include improvements in endothelial function, autonomic balance, and vascular stiffness. The review emphasized that isometric training is a safe, time-efficient, and effective non-pharmacological strategy for managing hypertension, and supports its inclusion in exercise guidelines.[11]

Pragati Jani et al. (2022) have conducted an interventional study to evaluate the effects of the Buteyko breathing technique in reducing systolic blood pressure in patients with stage 1 and stage 2 hypertension. Thirty patients (15 males and 15 females), aged 30–70 years, were recruited from a tertiary hospital in Mumbai and underwent a 2-week program. Outcome measures, including systolic and diastolic BP, pulse rate, respiratory rate, vital capacity, breath-holding time, and I:E ratio, were recorded before and after intervention. Each session lasted 30–50 minutes, with three sets of 10 repetitions. The results showed statistically significant reductions in systolic BP, pulse rate, respiratory rate, vital capacity, breath-holding time, and I:E ratio, whereas diastolic BP did not change significantly. The study concluded that the Buteyko breathing technique is effective for reducing systolic blood pressure and enhancing multiple cardiopulmonary parameters in hypertensive patients.[7]

Maisyaroh A et al. (2021) have conducted a literature review to analyse the effects of isometric exercises on blood pressure reduction in patients with hypertension. The review examined several research articles retrieved from databases like Google Scholar and PubMed, focusing on various isometric interventions such as handgrip exercises and wall sits. The findings across the studies reviewed showed that isometric exercises contribute to a significant reduction in both systolic and diastolic blood pressure. The mechanism is attributed to improved vascular compliance and reduced sympathetic nervous system activity. The review concluded that isometric exercise is a simple, low-cost, and effective non-pharmacological strategy for controlling hypertension and can be integrated into regular therapeutic exercise programs.[9]

Sathe S.S. et al. (2020) have conducted research to evaluate the immediate effects of Buteyko breathing on hypertensive patients. Forty-two participants diagnosed with essential hypertension were randomly divided into two equal groups: Group A performed Buteyko breathing, while Group B acted as a control group.The intervention included a single session of Buteyko breathing exercises.The results showed that the Buteyko group exhibited statistically significant improvement in SpO_2 levels and a reduction in heart rate and systolic blood pressure immediately after the session. However, the difference in blood pressure was not statistically significant when compared to the control group.The study concluded that Buteyko breathing can be a beneficial adjunct technique for improving oxygen saturation in hypertensive patients.[6]

MacDonald HV et al. (2016) have conducted a meta-analysis to evaluate the efficacy of dynamic resistance training as a stand-alone lifestyle therapy for reducing blood pressure in adults with hypertension. The analysis included 64 randomized controlled trials with over 2,000 participants. Results demonstrated that DRT significantly lowered both systolic and diastolic blood pressure, with average reductions of approximately 6.0 mmHg systolic and 4.7 mmHg diastolic. These reductions were observed across different age groups and training intensities, and were especially notable in individuals with higher baseline BP. The authors concluded that dynamic resistance training is an effective, accessible, and non-pharmacological strategy for lowering blood pressure and should be considered in clinical hypertension management guidelines.[12]

Carlson DJ et al. (2014) has conducted a systematic review and meta-analysis to examine the effectiveness of isometric exercise training for blood pressure management. The meta-analysis included five randomised controlled trials with a total of 122 participants, aged between 20 and 74 years. The majority of participants were either pre-hypertensive or hypertensive. Most interventions involved handgrip isometric training, conducted 3 to 5 times per week for several weeks. The pooled analysis showed that isometric training led to significant reductions in systolic blood pressure (mean reduction: 10.4 mmHg) and diastolic blood pressure (mean reduction: 6.7 mmHg). The study concluded that isometric training is a time-efficient, low-cost, and effective non-pharmacological intervention for managing elevated blood pressure.[13]

Cornelissen VA and Smart NA (2013) have conducted a systematic review and meta-analysis to assess the overall effectiveness of aerobic, dynamic resistance, and isometric exercise training on resting blood pressure in both normotensive and hypertensive individuals. The review included 93 trials with a total of 5,223 participants, ranging in age from 18 to over 70 years. The findings revealed that aerobic endurance training significantly reduced systolic BP by 3.5 mmHg and diastolic BP by 2.5 mmHg, while dynamic resistance training reduced systolic BP by 1.8 mmHg and diastolic BP by 3.2 mmHg. Isometric exercise training produced the greatest BP reductions, with average decreases of 10.9 mmHg systolic and 6.2 mmHg diastolic, although it was based on fewer trials. The authors concluded that exercise training, particularly aerobic and isometric, is an effective intervention for managing and preventing hypertension, with differing effects based on exercise type and baseline BP.[14]

Cornelissen VA et al. (2011) has conducted a meta-analysis of randomised controlled trials to evaluate the impact of resistance training on blood pressure and other cardiovascular risk factors. The analysis included 28 studies with a total of 1,012 participants, mostly aged 18 to 75 years, who were normotensive, pre-hypertensive, or hypertensive. The findings showed that resistance training significantly reduced systolic blood pressure by 2.0 mmHg and diastolic blood pressure by 1.7 mmHg, with more pronounced effects in participants with hypertension. Additionally, resistance training has shown favourable effects on body fat, waist circumference, and insulin sensitivity. The study concluded that resistance training is an effective non-pharmacological intervention for improving blood pressure and reducing cardiovascular risk in both healthy and clinical populations.[15]

METHODOLOGY

A structured literature review was conducted to assess the effectiveness of Buteyko breathing, resistance training, and isometric exercise in reducing systolic and diastolic blood pressure among patients with primary hypertension. Articles published between 2015 and 2025 were identified through PubMed, ScienceDirect, Elsevier, Google Scholar, and ResearchGate using targeted keywords like Hypertension, Buteyko breathing, isometric exercise, resistive training, blood pressure, and non-pharmacological intervention

Out of 85 identified articles (2015–2025), 18 studies met the inclusion criteria: 10 RCTs, 5 meta-analyses/cross-sectional studies, and 3 pilot studies.

The review focused on adults aged 30–65 with essential hypertension. Isometric exercise showed the greatest BP reduction**,** 8.3 mmHg systolic and 3.9 mmHg diastolic ($p < 0.0001$), followed by resistance training, ~ 4.0 mmHg systolic and ~2.1 mmHg diastolic ($p < 0.001$). Buteyko breathing showed smaller, yet significant, effects of 2.5–3.0 mmHg systolic and 1.5–2.0 mmHg diastolic ($p = 0.03$), although the evidence was less conclusive.

Author	Title	Methodology	Interventions	Outcome measures	Results
Edwards JJ et al. (2024)	Isometric Exercise Training and Arterial Hypertension: An Updated Review	Narrative + systematic review of RCTs on isometric exercise (e.g., handgrip, wall squat, leg extension)	**Frequency:** 3–5×/week **Intensity:** ~30% MVC (handgrip), ~95% HR_peak (wall squat) **Time:** 4 × 2 min bouts, 1–4 min rest **Type:** Isometric static holds	Resting & ambulatory BP, BP variability, HR	↓ sBP 5–9 mmHg ↓ dBP 1–4 mmHg Wall squats most effective
MacDonald HV et al. (2016)	Dynamic Resistance Training as Stand-Alone Antihypertensive Therapy.	Meta-analysis of 64 trials using dynamic resistance training (e.g., squats, presses, curls)	**Frequency:** 2–3×/week **Intensity:** 50–80% 1RM **Time:** 30–60 min/session **Type:** Dynamic resistance (concentric-	Resting sBP, dBP, MAP	↓ sBP 6.0 mmHg ↓ dBP 4.7 mmHg More effective in hypertensives

			eccentric)		
Jani P et al. (2022)	Buteyko Breathing Technique in Hypertensive Patients.	Interventional study using Buteyko breathing (nasal, low-volume breathing)	**Frequency:** 5×/week **Intensity:** Light (non-exertional) **Time:** 20–30 min/session **Type:** Breathing/relaxation technique	Resting sBP	↓ sBP ~8–10 mmHg Safe, low-cost alternative

TABLE 1 - METHODOLOGY

SELECTION CRITERIA

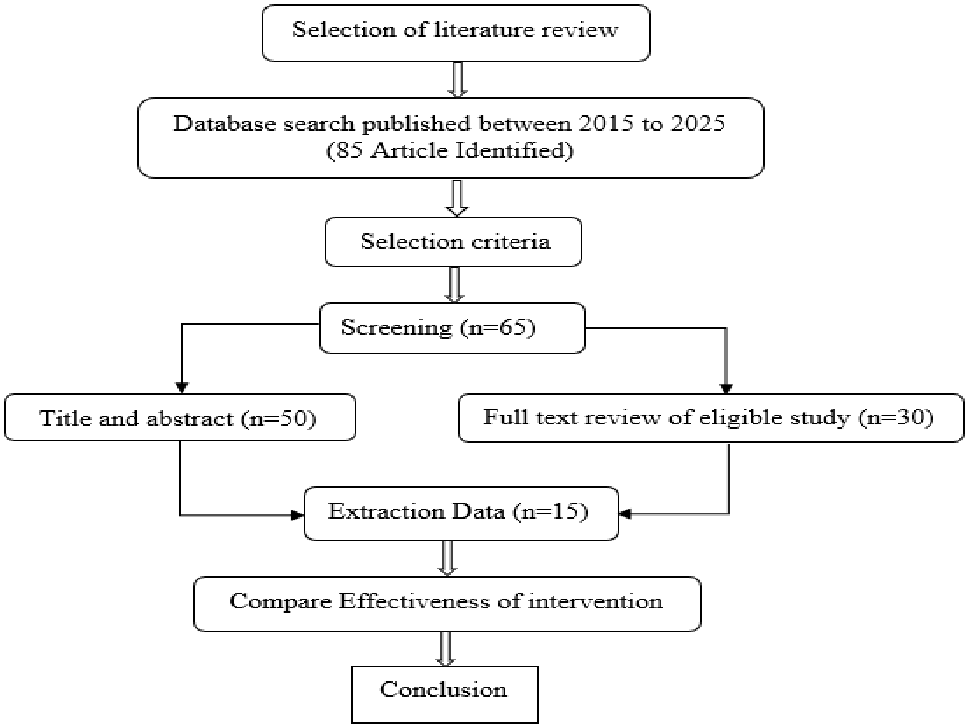
Inclusion criteria:

- Studies involving adults aged 30 to 65 years diagnosed with primary (essential) hypertension were included.[10,12]
- Studies evaluating Buteyko breathing, isometric exercise, or resistance training were considered.[10]
- Accepted designs: RCTs, interventional studies, meta-analyses, or reviews, published in english.[10,12]
- Patients who have taken or are taking medications for hypertension.[12]

Exclusion criteria:

- Secondary hypertension, pregnancy, or major comorbidities were excluded.[11]
- Duplicates, case reports, and non-peer-reviewed sources were also excluded.[11]
- Studies with unclear or non-standardized BP measurement methods were excluded.[6]
- Patients with a history of organ transplant.[12]

STUDY PROCEDURE



FLOW CHART: STUDY PROCEDURE

The present study was carried out through a systematic literature review to evaluate the effectiveness of Buteyko breathing, isometric exercise, and resistance training in the management of primary hypertension. A stepwise procedure was followed as outlined below:

Articles published between 2015 and 2025.The initial database search identified a total of 85 articles. After removing duplicates and irrelevant studies, 65 articles were taken forward for screening. Out of these, 50 articles were assessed based on title and abstract. Following this stage, 30 full-text articles were reviewed for eligibility. Data were then extracted from the selected studies, and the effectiveness of interventions was compared systematically to draw meaningful conclusions.

RESULT

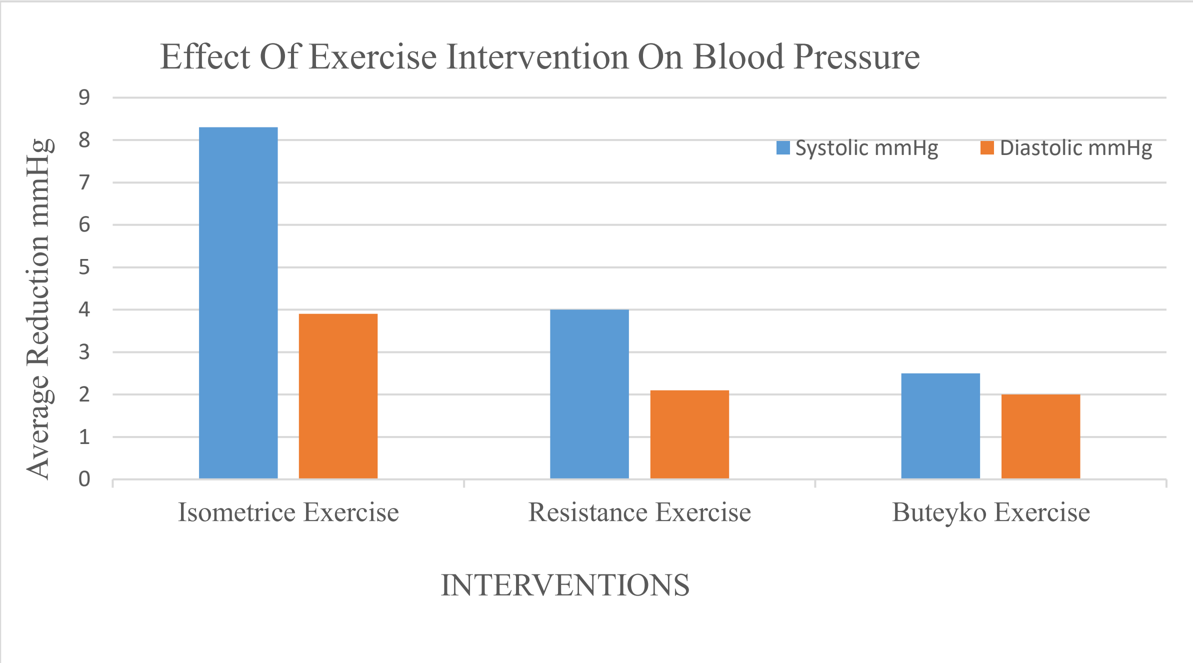


FIGURE: COMPARISON OF ISOMETRIC, RESISTANCE AND BUTEYKO EXERCISE INTERVENTIONS

The results of the structured literature review show that all three non-pharmacological interventions, isometric exercise, resistance training, and Buteyko breathing, were effective in reducing blood pressure in adults aged 30–65 with essential hypertension, though to varying degrees. Isometric exercise showed the most substantial reduction, with an average decrease of 8.3 mmHg in systolic and 3.9 mmHg in diastolic blood pressure, which was found to be highly statistically significant ($p < 0.0001$). This intervention consistently demonstrated strong outcomes across multiple high-quality randomized controlled trials and meta-analyses. Resistance training resulted in a moderate blood pressure reduction, with an average decrease of approximately 4.0 mmHg systolic and 2.1 mmHg diastolic, also statistically significant ($p < 0.001$). These findings were supported by a range of systematic reviews and controlled trials, reinforcing its role as an effective lifestyle modification for managing hypertension. Buteyko breathing showed a smaller but still statistically significant effect, with reductions in systolic blood pressure of 2.5–3.0 mmHg and diastolic pressure of 1.5–2.0 mmHg ($p = 0.03$). However, the evidence for Buteyko breathing was less conclusive, as it was drawn primarily from smaller pilot studies and experimental trials. Overall, the results suggest that while all three interventions contribute positively to blood pressure management, isometric exercise offers the greatest benefit, followed by resistance training, with Buteyko breathing providing supportive, though more limited, effects.

DISCUSSION

The findings of this structured literature review demonstrate the efficacy of non-pharmacological interventions, specifically, isometric exercise, resistance training, and Buteyko breathing in managing essential hypertension among adults aged 30–65. Among the three, isometric exercise emerged as the most effective intervention, consistently showing significant reductions in both systolic (8.3 mmHg) and diastolic (3.9 mmHg) blood pressure ($p < 0.0001$). These results are strongly supported by high-quality randomized controlled trials and meta-analyses, affirming the intervention's reliability and potential clinical utility.[11,13] The consistent evidence across studies indicates that isometric exercise can be a potent and time-efficient strategy for lowering blood pressure, especially beneficial for individuals with limited time or mobility constraints.

Resistance training also demonstrated statistically significant improvements, with average reductions of 4.0 mmHg in systolic and 2.1 mmHg in diastolic blood pressure ($p < 0.001$), positioning it as a valuable lifestyle modification for hypertension management.[12,14] As a widely accessible and adaptable form of physical activity, resistance training can be easily integrated into daily routines, which enhances adherence and long-term health outcomes. The physiological mechanisms proposed include improved vascular function and decreased systemic vascular resistance.[10]

In contrast, Buteyko breathing techniques resulted in modest but statistically significant reductions in blood pressure (2.5–3.0 mmHg systolic and 1.5–2.0 mmHg diastolic; $p = 0.03$).[6,7] However, the supporting studies were largely limited to small-scale experimental or pilot designs, reducing the overall strength of the evidence. Despite this, the technique remains promising as a complementary, low-impact intervention, particularly for patients who may not tolerate more strenuous exercise modalities.

Comparatively, while all three interventions contributed positively to blood pressure reduction, the magnitude and consistency of the evidence were greatest for isometric exercise, followed by resistance training, with Buteyko breathing offering more limited support. These findings are consistent with broader literature highlighting exercise as a cornerstone of non-pharmacological hypertension management.[9,12,14] Collectively, the results underscore the importance of incorporating structured physical and breathing interventions into comprehensive hypertension treatment plans, potentially enhancing outcomes when used alongside pharmacological therapy or as stand-alone interventions in early or mild cases.

CONCLUSION

This review confirms that non-pharmacological interventions-namely isometric exercise, resistance training, and Buteyko breathing, effectively aid in managing essential hypertension in adults aged 30–65. Isometric exercise is identified as the most effective method, supported by strong evidence. Resistance training provides moderate benefits, while Buteyko breathing demonstrates modest effects with limited supporting studies. Overall, these interventions, particularly isometric exercise, represent valuable non-drug options for managing hypertension.

LIMITATION

- The primary limitation of this project is the variability in study quality and sample size, particularly for Buteyko breathing, where evidence is limited and based on small-scale studies.
- Most included research focused on short-term outcomes, with limited data on long-term effectiveness, which may affect the generalizability and clinical application of the findings.

SUMMARY

This literature review examines the effects of Buteyko breathing, isometric exercise, and resistive exercise on patients with primary hypertension. Primary hypertension is a major health concern, and while medications are commonly used, non-pharmacological interventions are gaining attention for their potential in blood pressure management.

Buteyko breathing focuses on nasal breathing and breath control to reduce hyperventilation and improve

CO_2 levels. Studies indicate it may lower blood pressure by reducing sympathetic activity and promoting relaxation. Isometric exercises, such as handgrip training, have shown significant reductions in blood pressure by improving vascular function and autonomic balance. Similarly, resistive exercises, including moderate weight training, can lower blood pressure by enhancing arterial compliance and reducing peripheral resistance.

Overall, existing literature supports the use of these interventions as effective, non-pharmacological strategies to manage primary hypertension. Each method offers unique benefits and may serve as valuable adjuncts to conventional treatment.

BIBILOGRAPHY

1. Whelton PK, Carey RM, Aronow WS, Casey DE Jr, Collins KJ, Dennison Himmelfarb C, et al. Hypertension in adults: screening. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024.
2. Holland K. Types and stages of hypertension [Internet]. Healthline; 2022 [cited 2025 Jun 12].
3. World Health Organization. Hypertension [Internet]. Geneva: World Health Organization; 2023 [cited 2025 Jun 12].
4. Bharati DR, Sahoo H, Roy A, Pati S, Ranjan A, Jena D. Recent studies on hypertension prevalence and control in India (2023) [Internet]. ResearchGate; 2023 [cited 2025 Jun 12].
5. Singh AK, Gupta R, Misra A. Prevalence and associated risk factors of hypertension among persons aged 15–49 in India: a cross-sectional study. BMJ Open. 2019 Dec 16;9(12):e029714.
6. Sathe SS, Rajandekar T, Hadake S, Shegaonkar V. Immediate effect of Buteyko breathing in hypertensive patients: an experimental prospective study. Indian J Forensic Med Toxicol. 2020;14(4):7136–41.
7. Jani P, Yadav R, Yadav S, Dave A, Patel G. Effects of Buteyko breathing technique in reducing systolic blood pressure in hypertensive patients – an interventional study. Int J Creat Res Thoughts. 2022 Oct;10(10):a928–45.
8. Abdelgfar MA. Acute effect of whole-body vibration versus resistance exercises in hypertension patients. In: Proceedings of the 21st International Scientific Conference, Faculty of Physical Therapy; 2022 Jul 28–29; Cairo, Egypt.
9. Maisyaroh A, Putri DA, Abdillah A, Widianto EP. The effect of isometric exercise on blood pressure reduction in hypertension: a literature review. Nurse Health J Keperawatan. 2021;10(2):162–74.
10. Hamrahian SM. Pathophysiology of hypertension [Internet]. In: Batuman V, editor. Medscape; 2024 [cited 2025 Jul 27].
11. Edwards JJ, Coleman DA, Ritti-Dias RM, Farah BQ, Stensel DJ, Lucas SJE, et al. Isometric exercise training and arterial hypertension: an updated review. Sports Med. 2024 Jun;54(6):1459–97.
12. MacDonald HV, Johnson BT, Huedo-Medina TB, Livingston J, Forsyth KC, Kraemer WJ, et al. Dynamic resistance training as stand-alone antihypertensive lifestyle therapy: a meta-analysis. J Am Heart Assoc. 2016;5(10):e003231.
13. Carlson DJ, Dieberg G, Hess NC, Millar PJ, Smart NA. Isometric exercise training for blood pressure management: a systematic review and meta-analysis. Mayo Clin Proc. 2014 Mar;89(3):327–34.
14. Cornelissen VA, Smart NA. Exercise training for blood pressure: a systematic review and meta-analysis. J Am Heart Assoc. 2013;2(1):e004473.

15. Cornelissen VA, Fagard RH, Coeckelberghs E, Vanhees L. Impact of resistance training on blood pressure and other cardiovascular risk factors: a meta-analysis of randomised, controlled trials. Hypertension. 2011 Nov;58(5):950–8.