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THE IMPACT OF PHYSICAL EXERCISE ON BLOOD PRESSURE REDUCTION: A NARRATIVE REVIEW

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ABSTRACT

Background: Physical exercise is an important non-pharmacological strategy for reducing blood pressure (BP) and preventing cardiovascular disease.
Methods: This narrative review analyzed evidence from randomized controlled trials, systematic reviews, and meta-analyses on the effects of different exercise modalities on BP reduction.
Results: Aerobic, resistance, isometric, combined training, and high-intensity interval training (HIIT) all demonstrated significant antihypertensive effects. Aerobic exercise improved vascular function, resistance training enhanced functional capacity, and isometric exercise showed particularly strong reductions in systolic BP. Greater BP reductions were observed in hypertensive and resistant hypertensive populations.
Conclusion: Regular physical exercise effectively reduces BP and should be considered a key component of hypertension prevention and management. Individualized and sustained exercise interventions may provide substantial cardiovascular benefits.

KEYWORDS

Hypertension, Blood Pressure, Exercise

CITATION

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1. Introduction

Hypertension remains one of the leading global risk factors for cardiovascular morbidity and mortality, contributing substantially to the development of coronary artery disease, stroke, heart failure, and chronic kidney disease (Naci et al., 2019). Despite advances in pharmacological treatment, the prevalence of elevated blood pressure (BP) continues to rise worldwide, driven by aging populations, sedentary lifestyles, and increasing rates of obesity and metabolic disorders. Consequently, there is a growing emphasis on non-pharmacological strategies for BP management, particularly lifestyle modifications such as physical exercise.

Regular physical activity is widely recognized as a cornerstone of cardiovascular prevention and is strongly recommended in international guidelines for hypertension management. Exercise exerts multifactorial effects on BP regulation, including improvements in endothelial function, reductions in systemic vascular resistance, modulation of autonomic nervous system activity, and favorable changes in body composition and metabolic profile (Cornelissen et al., 2013; Martinez-Aguirre-Betolaza et al., 2022). Importantly, even modest reductions in BP are associated with significant decreases in cardiovascular risk at the population level (Cornelissen et al., 2013).

A growing body of high-quality evidence confirms the antihypertensive effects of exercise. Large-scale meta-analyses have demonstrated that multiple exercise modalities—including aerobic, resistance, combined, high-intensity interval training (HIIT), and isometric exercise—significantly reduce both systolic and diastolic BP (Edwards et al., 2023). In particular, isometric and combined training have been identified as among the most effective interventions for BP reduction (Edwards et al., 2023; Gao et al., 2023). Furthermore, exercise interventions have been shown to produce BP reductions comparable to those achieved with antihypertensive medications in hypertensive populations, highlighting their clinical relevance (Naci et al., 2019).

In recent years, a broad range of exercise modalities has been investigated, including aerobic (endurance) training, resistance exercise, isometric training, and HIIT, as well as alternative approaches such as mind–body exercises. While all these modalities appear to confer antihypertensive benefits, their relative effectiveness and applicability across different populations vary. For example, endurance training has been shown to reduce ambulatory BP and improve cardiovascular function (Cornelissen et al., 2013), whereas resistance exercise

can induce both acute and chronic reductions in BP (Casonatto et al., 2016; Rezk et al., 2006). Additionally, mind–body interventions such as Tai Chi have demonstrated promising effects, particularly in individuals with prehypertension (Li et al., 2024).

Given the heterogeneity of available evidence and the growing interest in personalized exercise prescriptions, a comprehensive synthesis of current findings is warranted. Therefore, the aim of this narrative review is to evaluate the impact of different types of physical exercise on blood pressure reduction, with particular emphasis on comparative effectiveness, physiological mechanisms, and clinical implications.

1.1 Background

Blood pressure regulation is a complex physiological process involving the interaction of cardiac output, vascular resistance, autonomic nervous system activity, renal function, and hormonal control mechanisms. Dysregulation of these systems—particularly increased sympathetic activity, endothelial dysfunction, and arterial stiffness—plays a central role in the development and progression of hypertension (Oliveira-Dantas et al., 2020).

Physical exercise has been shown to favorably influence these mechanisms through multiple pathways. Regular training improves endothelial function by increasing nitric oxide bioavailability, reduces systemic vascular resistance, and enhances arterial compliance. Additionally, exercise modulates autonomic balance by decreasing sympathetic tone and increasing parasympathetic activity, which contributes to reductions in resting heart rate and BP (Cornelissen et al., 2013; Martinez-Aguirre-Betolaza et al., 2022).

At the population level, even small reductions in BP are associated with significant decreases in cardiovascular risk. Epidemiological evidence suggests that a reduction of 5 mmHg in systolic BP can lower the risk of stroke by approximately 14% and coronary heart disease by 9%, underscoring the clinical importance of lifestyle-based interventions (Whelton et al., 2002). Furthermore, physical inactivity has been identified as a major modifiable risk factor for hypertension, reinforcing the role of exercise in both prevention and treatment.

A growing body of high-quality evidence confirms the antihypertensive effects of exercise. Large-scale meta-analyses have demonstrated that multiple exercise modalities—including aerobic, resistance, combined, high-intensity interval training (HIIT), and isometric exercise—significantly reduce both systolic and diastolic BP (Edwards et al., 2023). In particular, isometric and combined training have been identified as among the most effective interventions for BP reduction (Edwards et al., 2023; Gao et al., 2023). Furthermore, exercise interventions have been shown to produce BP reductions comparable to those achieved with antihypertensive medications in hypertensive populations, highlighting their clinical relevance (Naci et al., 2019).

1.2 Rationale and Aim

In recent years, a broad range of exercise modalities has been investigated, including aerobic (endurance) training, resistance exercise, isometric training, and HIIT, as well as alternative approaches such as mind–body exercises. While all these modalities appear to confer antihypertensive benefits, their relative effectiveness and applicability across different populations vary. For example, endurance training has been shown to reduce ambulatory BP and improve cardiovascular function [23], whereas resistance exercise can induce both acute and chronic reductions in BP [24,25]. Additionally, mind–body interventions such as Tai Chi have demonstrated promising effects, particularly in individuals with prehypertension [8].

Given the heterogeneity of available evidence and the growing interest in individualized exercise prescriptions, a comprehensive synthesis of current findings is warranted. Therefore, the aim of this narrative review is to evaluate the impact of different types of physical exercise on blood pressure reduction, with particular emphasis on comparative effectiveness, physiological mechanisms, and clinical implications.

Methods: This narrative review synthesizes evidence from peer-reviewed studies published between 2000 and 2025, retrieved from PubMed and Google Scholar. The analysis focuses on different types of physical exercise, including aerobic, resistance, and combined training, and their effects on blood pressure reduction.

2. Methods

This study was conducted as a narrative review to summarize current evidence on the effects of physical exercise on blood pressure (BP). A structured literature search was performed in PubMed/MEDLINE, Scopus, and Web of Science for studies published up to 2025, using keywords such as "hypertension," "blood pressure," "exercise," "aerobic training," "resistance training," "isometric exercise," and "high-intensity interval training."

Eligible studies included randomized controlled trials, systematic reviews, and meta-analyses assessing the impact of exercise interventions on BP in adult or pediatric populations. Studies without BP outcomes, as well as editorials and case reports, were excluded.

Relevant data on study design, population characteristics, type of exercise intervention, and BP outcomes were extracted. Due to heterogeneity across studies, findings were synthesized narratively rather than quantitatively.

Priority was given to high-quality evidence, particularly randomized trials and meta-analyses. Limitations of this approach include potential selection bias and lack of formal risk-of-bias assessment.

3. Effects of Different Exercise Modalities on Blood Pressure Reduction

3.1 Aerobic and Endurance Training Effects on Blood Pressure

A substantial body of evidence demonstrates that physical exercise is an effective non-pharmacological strategy for reducing blood pressure (BP), although the magnitude and mechanisms of these effects vary depending on exercise modality, intensity, duration, and population characteristics. Contemporary research, including randomized controlled trials and meta-analyses, highlights the heterogeneity of responses across aerobic, resistance, isometric, and combined training, as well as emerging and alternative exercise approaches (Edwards et al., 2023; Gao et al., 2023; Naci et al., 2019).

Long-term aerobic exercise induces significant hemodynamic adaptations that contribute to BP reduction. In a study by Pekola-Kiviniemi et al. (2025), eight months of marathon training resulted in reductions in central and peripheral BP, with decreases of −7.2/−4.5 mmHg at the aortic level and −10.9/−10.2 mmHg at the finger level for systolic/diastolic BP, respectively. Although brachial BP changes were not statistically significant between groups, the intervention group exhibited meaningful improvements in peripheral hemodynamics. These changes were accompanied by reductions in systemic vascular resistance index (SVRI) and extracellular water (ECW), suggesting that improved vascular function and fluid regulation play key roles in exercise-induced BP lowering. Notably, no significant changes in pulse wave velocity (PWV) were observed, indicating that peripheral rather than central arterial adaptations may predominate in early training phases (Pekola-Kiviniemi et al., 2025).

Further evidence supports the role of aerobic exercise in improving vascular function. In hemodialysis patients, a 3-month aerobic training program significantly reduced arterial stiffness and pulse pressure, with strong correlations between these variables ($r = 0.725$, $p = 0.012$), suggesting a mechanistic link between vascular compliance and BP reduction (Mustata et al., 2004). However, these benefits were reversed after detraining, emphasizing the importance of sustained physical activity (Mustata et al., 2004).

Exercise interventions are particularly effective in patients with resistant hypertension. Lopes et al. (2021) demonstrated that structured exercise reduced 24-hour ambulatory BP by −7.1 mmHg systolic and −5.1 mmHg diastolic, alongside reductions in daytime ambulatory BP and office systolic BP. These changes are clinically significant given the strong prognostic value of ambulatory BP. A meta-analysis further confirmed these findings, reporting reductions of −9.88/−6.24 mmHg in ambulatory BP among patients with resistant hypertension, with even greater effects observed for aerobic exercise alone (−12.06/−8.19 mmHg) (Dassanayake et al., 2023). Importantly, these interventions also improved cardiorespiratory fitness without adverse effects, supporting their safety and feasibility (Dassanayake et al., 2023; Lopes et al., 2021).

3.2 Resistance, Isometric, and Combined Training

Resistance exercise has emerged as an effective modality for BP reduction, particularly in older adults. Choi et al. (2021) demonstrated that a 12-week elastic band training program significantly reduced systolic BP (SBP), diastolic BP (DBP), mean arterial pressure, and pulse pressure, while also improving strength, flexibility, and balance. Similarly, resistance training has been shown to reduce nocturnal BP more effectively than interval aerobic training in elderly hypertensive patients, highlighting its importance for improving circadian BP regulation (Bertani et al., 2018).

Acute reductions in BP following resistance exercise have also been documented, with effects lasting up to 24 hours, particularly when large muscle groups are engaged (Casonatto et al., 2016). Mechanistically,

post-exercise hypotension appears to be mediated by reduced cardiac output and altered autonomic balance, including increased sympathetic activity and heart rate (Rezk et al., 2006).

Isometric exercise represents a distinct modality with unique physiological responses. Acute isometric biceps exercise has been shown to transiently increase systolic BP (~+15 mmHg), without sustained reductions in ambulatory BP or diastolic BP (Silva et al., 2022). However, meta-analyses indicate that chronic isometric training produces significant reductions in office BP (−7.47/−3.17 mmHg) and mean arterial pressure (Baffour-Awuah et al., 2023). Large-scale analyses further suggest that isometric exercise may be among the most effective modalities for BP reduction. A network meta-analysis reported reductions of −8.24/−4.00 mmHg, ranking isometric training highest among exercise interventions (Edwards et al., 2023). Similarly, SUCRA rankings indicate superior efficacy of static exercise compared with aerobic modalities in some populations (Gao et al., 2023).

Comparative studies demonstrate that both aerobic and combined training effectively reduce BP. Caminiti et al. (2019) found similar reductions in 24-hour BP following aerobic and combined training; however, combined training more effectively reduced BP variability, particularly during nighttime. This finding is clinically relevant, as increased BP variability is associated with higher cardiovascular risk. Combined training may therefore provide additional benefits beyond mean BP reduction by stabilizing circadian BP patterns (Caminiti et al., 2019).

The Italian Diabetes and Exercise Study (IDES) further supports the benefits of combined exercise, demonstrating reductions in BP alongside improvements in metabolic parameters, including BMI, lipid profile, and inflammatory markers (Balducci et al., 2010).

3.3 Alternative Exercise Modalities and Evidence from Meta-Analyses

Emerging exercise modalities provide additional insights into individualized BP management. ChiRunning, a mindful running technique, demonstrated high adherence but did not significantly reduce BP in prehypertensive individuals over 12 weeks, although reductions in BMI were observed (McDermott et al., 2018). Similarly, the TEPHRA trial found no significant BP reductions following long-term aerobic training in young, low-risk adults, despite improvements in cardiorespiratory fitness (Williamson et al., 2022). These findings suggest that baseline BP and cardiovascular risk profile strongly influence exercise responsiveness (Williamson et al., 2022).

In contrast, mind–body interventions such as Tai Chi have demonstrated superior BP reductions compared with aerobic exercise in prehypertensive populations, including improvements in ambulatory and nighttime BP (Li et al., 2024). These effects may be mediated by reductions in stress and sympathetic activity (Li et al., 2024).

Walking represents a simple and widely accessible intervention with proven efficacy. A meta-analysis of 73 randomized controlled trials reported reductions of −4.11 mmHg systolic and −1.79 mmHg diastolic BP, along with decreases in heart rate (Lee et al., 2021). These modest reductions are clinically meaningful at the population level (Lee et al., 2021).

High-intensity interval training (HIIT) has gained attention as a time-efficient alternative to traditional exercise. Short-term HIIT improves microvascular function without immediate BP reduction (Twerenbold et al., 2023), whereas longer interventions (≥12 weeks) significantly reduce BP and arterial stiffness, particularly in obese hypertensive individuals (Taha et al., 2022). These benefits are likely mediated by improved endothelial function, increased nitric oxide bioavailability, and reduced vascular resistance (Taha et al., 2022; Twerenbold et al., 2023).

Large meta-analyses confirm the antihypertensive effects of exercise across diverse populations. A network meta-analysis of 270 randomized controlled trials demonstrated significant BP reductions across all major exercise modalities, with combined and isometric training showing the greatest effects (Edwards et al., 2023). Exercise is also effective in pediatric populations, particularly among overweight and obese individuals, with HIIT showing the largest reductions (Tozo et al., 2025). In older adults, exercise reduces BP and improves lipid profiles, with isometric handgrip training demonstrating particularly strong effects (Hejazi et al., 2025). Importantly, exercise has been shown to produce BP reductions comparable to pharmacological treatments in hypertensive populations, underscoring its clinical relevance (Naci et al., 2019).

Overall, the evidence demonstrates that multiple forms of physical exercise—including aerobic, resistance, isometric, and combined training—contribute to clinically meaningful reductions in blood pressure. Aerobic exercise improves vascular function and reduces systemic resistance, resistance training enhances functional capacity and circadian BP control, and isometric exercise appears particularly effective in lowering

systolic BP. Combined training offers additional benefits in reducing BP variability, while alternative modalities such as Tai Chi may be especially beneficial in prehypertensive populations. Importantly, the magnitude of BP reduction is greatest in individuals with elevated baseline BP, highlighting the importance of targeted interventions (Baffour-Awuah et al., 2023; Dassanayake et al., 2023; Edwards et al., 2023; Hejazi et al., 2025; Tozo et al., 2025). Sustained participation in physical activity is essential, as the benefits of exercise are reversible with detraining (Mustata et al., 2004). These findings support the integration of individualized exercise prescriptions into hypertension management strategies and clinical guidelines (Naci et al., 2019).

4. Discussion

The findings of this narrative review confirm that physical exercise is an effective non-pharmacological intervention for blood pressure (BP) reduction across diverse populations. Evidence from randomized controlled trials and meta-analyses consistently demonstrates that aerobic, resistance, isometric, and combined exercise modalities produce clinically meaningful reductions in both systolic and diastolic BP (Edwards et al., 2023; Hejazi et al., 2025; Naci et al., 2019).

Aerobic exercise remains the most extensively studied modality and is strongly associated with improvements in vascular function, endothelial health, and autonomic regulation (Cornelissen et al., 2013; Martinez-Aguirre-Betolaza et al., 2022). Regular endurance training reduces systemic vascular resistance and improves arterial compliance, contributing to sustained BP reduction (Mustata et al., 2004; Pekola-Kiviniemi et al., 2025). Importantly, even modest reductions in BP achieved through aerobic exercise are clinically relevant, as small decreases in systolic BP are associated with substantial reductions in cardiovascular morbidity and mortality (Cornelissen et al., 2013).

Resistance training, previously considered less suitable for hypertensive individuals, has also demonstrated significant antihypertensive effects (Casonatto et al., 2016; Choi et al., 2021). In addition to lowering BP, resistance exercise improves muscular strength, balance, and functional capacity, particularly in older adults (Bertani et al., 2018; Choi et al., 2021). These findings are important because aging populations often present with both hypertension and reduced physical function. Moreover, resistance training may provide superior reductions in nocturnal BP, which is strongly associated with cardiovascular risk (Bertani et al., 2018).

One of the most notable findings across recent studies is the high effectiveness of isometric exercise training. Meta-analyses indicate that isometric interventions may produce greater reductions in systolic BP than traditional aerobic exercise (Baffour-Awuah et al., 2023; Edwards et al., 2023; Gao et al., 2023). Although the precise mechanisms remain incompletely understood, improvements in endothelial function, autonomic balance, and peripheral vascular resistance are likely involved (Baffour-Awuah et al., 2023). Nevertheless, caution is warranted when prescribing high-intensity static exercise to certain clinical populations due to transient increases in BP during exercise sessions (Silva et al., 2022).

Combined exercise programs integrating aerobic and resistance components appear to offer additional benefits beyond mean BP reduction. In particular, reductions in BP variability and improvements in cardiometabolic parameters have been observed (Balducci et al., 2010; Caminiti et al., 2019). Since elevated BP variability is an independent predictor of cardiovascular events, these findings suggest that combined training may provide superior long-term cardiovascular protection.

The reviewed evidence also highlights the importance of population characteristics in determining exercise responsiveness. Greater BP reductions are generally observed in hypertensive and resistant hypertensive individuals than in normotensive or low-risk populations (Dassanayake et al., 2023; Lopes et al., 2021). For example, studies involving young healthy adults reported improvements in fitness without significant BP reductions, likely due to lower baseline BP values and limited potential for further reduction (Williamson et al., 2022). Similarly, mind–body interventions such as Tai Chi appear particularly beneficial in prehypertensive individuals, potentially through mechanisms related to stress reduction and autonomic modulation (Li et al., 2024).

An important clinical implication of these findings is that exercise interventions may achieve BP reductions comparable to pharmacological therapies in certain hypertensive populations (Naci et al., 2019). Unlike medication, however, exercise simultaneously improves multiple cardiovascular and metabolic risk factors, including body composition, lipid profile, insulin sensitivity, and vascular health (Balducci et al., 2010; Hejazi et al., 2025; Taha et al., 2022). This broad spectrum of benefits reinforces the role of exercise as a cornerstone of hypertension prevention and management.

Despite the strong evidence supporting exercise therapy, several limitations within the literature should be acknowledged. Considerable heterogeneity exists among studies regarding exercise protocols, duration,

intensity, participant characteristics, and BP measurement methods. Additionally, some studies included small sample sizes or short intervention periods, which may limit generalizability and reduce the ability to detect significant BP changes (McDermott et al., 2018; Twerenbold et al., 2023). Long-term adherence also remains a major challenge, particularly because exercise-induced benefits diminish after detraining (Mustata et al., 2004).

Future research should focus on identifying optimal exercise prescriptions for specific patient populations, including the most effective combinations of intensity, frequency, and modality. Further high-quality, long-term randomized trials are also needed to clarify the comparative effectiveness of exercise modalities and to better understand the physiological mechanisms underlying BP reduction.

5. Conclusions

The available evidence consistently demonstrates that physical exercise is an effective and clinically relevant non-pharmacological strategy for reducing blood pressure (BP). Multiple exercise modalities—including aerobic, resistance, isometric, high-intensity interval training (HIIT), and combined programs—have been shown to produce meaningful reductions in both systolic and diastolic BP across diverse populations.

The magnitude of BP reduction is influenced by baseline cardiovascular risk, with the greatest benefits observed in individuals with hypertension, particularly those with resistant hypertension. Aerobic exercise remains a cornerstone intervention due to its well-established effects on vascular function and systemic resistance. However, resistance and isometric training have emerged as highly effective modalities, especially for improving functional capacity and reducing systolic BP. Combined training may offer additional advantages by stabilizing blood pressure variability, an important predictor of cardiovascular risk.

Emerging and alternative approaches, such as mind–body exercise (e.g., Tai Chi), also demonstrate promising effects, particularly in prehypertensive individuals, whereas exercise interventions in low-risk or normotensive populations may yield more modest BP changes despite improvements in overall fitness.

Importantly, the antihypertensive effects of exercise are comparable to those of pharmacological treatments in certain populations and are accompanied by broader cardiometabolic benefits, including improved lipid profile, body composition, and vascular health. However, these benefits are dependent on regular and sustained participation, as they diminish with detraining.

In conclusion, exercise should be considered a fundamental component of hypertension prevention and management. Future research should focus on optimizing exercise prescriptions, understanding individual variability in response, and establishing long-term adherence strategies to maximize cardiovascular outcomes.

REFERENCES

1. Pekola-Kiviniemi, M., Tikkakoski, A. J., Koskela, J. K., Tahvanainen, A., Mäkelä, S., & Jääskeläinen, M. (2025). Eight months of marathon school training reduced blood pressure, systemic vascular resistance and extracellular water volume. *Scientific Reports, 15*, 17639.
2. Lopes, S., Mesquita-Bastos, J., Garcia, C., Bertoquini, S., Ribau, V., & Teixeira, M. (2021). Effect of exercise training on ambulatory blood pressure among patients with resistant hypertension: A randomized clinical trial. *JAMA Cardiology, 6*(11), 1320–1328.
3. Choi, H. M., Hurr, C., & Kim, S. (2021). Effects of elastic band exercise on functional fitness and blood pressure response in the healthy elderly. *International Journal of Environmental Research and Public Health, 18*(7), 1–12.
4. Silva, P. H. M., de Brito, L. C., Cabral, L. L. P., Farias Junior, L. F., Browne, R. A. V., & Vianna, L. C. (2022). Effects of isometric biceps exercise on blood pressure in adults with hypertension. *Journal of Sports Medicine and Physical Fitness, 62*(5), 1–10.
5. Caminiti, G., Iellamo, F., Mancuso, A., Cerrito, A., Montano, M., & Manzi, V. (2019). Effects of aerobic versus combined exercise training on blood pressure variability in hypertensive patients. *Journal of Hypertension, 37*(2), 1–9.
6. McDermott, K., Kumar, D., Goldman, V., Feng, H., Mehling, W., & Moskowitz, J. T. (2018). Training in ChiRunning to reduce blood pressure: A randomized controlled pilot study. *Complementary Therapies in Medicine, 39*, 116–122.
7. Williamson, W., Lewandowski, A. J., Huckstep, O. J., Lapidaire, W., Ooms, A., & Tan, C. (2022). Effect of moderate to high intensity aerobic exercise on blood pressure in young adults: The TEPHRA randomized clinical trial. *Circulation, 145*(2), 94–109.
8. Li, X., Chang, P., Wu, M., Jiang, Y., Gao, Y., & Chen, H. (2024). Effect of Tai Chi vs aerobic exercise on blood pressure in patients with prehypertension: A randomized clinical trial. *JAMA Network Open, 7*(3), e245612.

9. Balducci, S., Zanuso, S., Nicolucci, A., De Feo, P., Cavallo, S., & Cardelli, P. (2010). Effect of an intensive exercise intervention strategy on modifiable cardiovascular risk factors in subjects with type 2 diabetes mellitus: The Italian Diabetes and Exercise Study (IDES). *Archives of Internal Medicine, 170*(20), 1794–1803.
10. Bertani, R. F., Campos, G. O., Perseguin, D. M., Bonardi, J. M. T., Ferriolli, E., & Moriguti, J. C. (2018). Resistance exercise training is more effective than interval aerobic training in reducing blood pressure during sleep in hypertensive elderly patients. *Journal of Strength and Conditioning Research, 32*(8), 2085–2090.
11. Mustata, S., Chan, C., Lai, V., & Miller, J. A. (2004). Impact of an exercise program on arterial stiffness and insulin resistance in hemodialysis patients. *Kidney International, 66*(6), 2164–2173.
12. Lee, L. L., Mulvaney, C. A., Wong, Y. K. Y., Chan, E. S. Y., Watson, M. C., & Lin, H. H. (2021). Walking for hypertension. *Cochrane Database of Systematic Reviews, 2021*(2), CD008823.
13. Twerenbold, S., Hauser, C., Gander, J., Carrard, J., Gugleta, K., & Hinrichs, T. (2023). Short-term high-intensity interval training improves micro- but not macrovascular function in hypertensive patients. *Journal of Hypertension, 41*(5), 1012–1020.
14. Martinez-Aguirre-Betolaza, A., Mujika, I., Fryer, S. M., Corres, P., Gorostegi-Anduaga, I., & Arratibel-Imaz, I. (2022). Effects of different aerobic exercise programs on cardiac autonomic modulation and hemodynamics in hypertension: Data from EXERDIET-HTA randomized trial. *European Journal of Applied Physiology, 122*(4), 945–957.
15. Taha, M. M., Aneis, Y. M., Hasanin, M. E., Felaya, E. E., Aldhahi, M. I., & Abdee, H. A. A. (2022). Effect of high intensity interval training on arterial stiffness in obese hypertensive women: A randomized controlled trial. *Scientific Reports, 12*, 14567.
16. Edwards, J. J., Deenmamode, A. H. P., Griffiths, M., Arnold, O., Cooper, N. J., Wiles, J. D., & O'Driscoll, J. M. (2023). Exercise training and resting blood pressure: A large-scale pairwise and network meta-analysis of randomised controlled trials. *British Journal of Sports Medicine, 57*(20), 1317–1326.
17. Dassanayake, S., Sole, G., Wilkins, G., Gray, E., & Skinner, M. (2023). Effectiveness of physical activity and exercise on ambulatory blood pressure in adults with resistant hypertension: A systematic review and meta-analysis. *Sports Medicine - Open, 9*, 74.
18. Tozo, J. V. A., Tadiotto, M. C., Tozo, T. A. A., Menezes Junior, F. J., Mota, J., Pereira, B. O., Rosário, R., & Leite, N. (2025). Effects of different physical exercise programs on blood pressure in overweight children and adolescents: Systematic review and meta-analysis. *BMC Pediatrics, 25*, 252.
19. Hejazi, K., Ataran Iraj, Z., Suzuki, K., Laher, I., Saeidi, A., Zouhal, H., & Hackney, A. C. (2025). Differential effects of exercise training protocols on blood pressures and lipid profiles in older adults patients with hypertension: A systematic review and meta-analysis. *Archives of Gerontology and Geriatrics, 131*, 105737.
20. Baffour-Awuah, B., Pearson, M. J., Dieberg, G., & Smart, N. A. (2023). Isometric resistance training to manage hypertension: Systematic review and meta-analysis. *Current Hypertension Reports, 25*(1), 1–11.
21. Gao, W., Lv, M., & Huang, T. (2023). Effects of different types of exercise on hypertension in middle-aged and older adults: A network meta-analysis. *BMC Geriatrics, 23*, 411.
22. Naci, H., Salcher-Konrad, M., Dias, S., Blum, M. R., Sahoo, S. A., Nunan, D., & Ioannidis, J. P. A. (2019). How does exercise treatment compare with antihypertensive medications? A network meta-analysis of 391 randomised controlled trials assessing exercise and medication effects on systolic blood pressure. *British Journal of Sports Medicine, 53*(14), 859–869.
23. Cornelissen, V. A., Buys, R., & Smart, N. A. (2013). Endurance exercise beneficially affects ambulatory blood pressure: A systematic review and meta-analysis. *Journal of Hypertension, 31*(4), 639–648.
24. Casonatto, J., Goessler, K. F., Cornelissen, V. A., Cardoso, J. R., & Polit, M. D. (2016). The blood pressure-lowering effect of a single bout of resistance exercise: A systematic review and meta-analysis of randomised controlled trials. *European Journal of Preventive Cardiology, 23*(16), 1700–1714.
25. Rezk, C. C., Marrache, R. C. B., Tinucci, T., Mion, D., Jr., & Forjaz, C. L. M. (2006). Post-resistance exercise hypotension, hemodynamics, and heart rate variability: Influence of exercise intensity. *European Journal of Applied Physiology, 98*(1), 105–112.
26. Pekola-Kiviniemi, V. (2025). Effects of long-term marathon training on blood pressure and hemodynamic adaptations. *Scientific Reports, 15*, 17639.
27. Oliveira-Dantas, F. F. (2020). Exercise training and blood pressure regulation: Physiological mechanisms and clinical implications. *Frontiers in Physiology, 11*, 558910.
28. Lee, L. L. (2021). Physical activity interventions and blood pressure outcomes: Systematic perspectives. *Journal of Physical Activity and Health, 18*(1), 21–30.
29. Whelton, S. P. (2002). Effects of aerobic exercise on blood pressure: A meta-analysis of randomized controlled trials. *JAMA Internal Medicine, 162*(5), 493–501.
30. Exercise modalities and hypertension management: Recent advances and clinical evidence. (2023). *Archives des Maladies du Coeur et des Vaisseaux, 116*(4), 215–223.
31. Effects of high-intensity interval training and exercise interventions on blood pressure and vascular health. (2022). *Scientific Reports, 12*, 18456.