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REVIEW ARTICLE

Impact of Aerobic, Resistance, and Combined Training on Blood Pressure in Patients with Chronic Diseases: A Narrative Review

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ABSTRACT

Background. Hypertension, a major contributor to heart disease, is linked to severe complications such as heart attacks, strokes, myocardial infarctions, and chronic kidney disease. Various types of exercise present a promising strategy for lowering BP in both hypertensive and normotensive individuals, thereby reducing the risk of cardiovascular diseases. **Objectives.** This study aimed to assess the impact of aerobic, resistance, and combined training on BP regulation in patients with chronic diseases. **Methods.** A comprehensive search was conducted using relevant keywords across SCOPUS, PubMed, the Cochrane Central Database, and Google Scholar. Eighteen articles meeting pre-defined inclusion and exclusion criteria were selected for review. The search covered papers published from January 1, 1995, through May 31, 2024. **Results.** The analysis revealed that aerobic exercise performed three times per week for 10 weeks led to significant reductions in systolic (SBP) and diastolic (DBP) blood pressure in obese patients with cardiovascular disease. Aerobic exercise showed a meaningful alteration in BP by reducing systemic vascular resistance in patients with metabolic syndrome. Moreover, aerobic and resistance training were more effective in lowering mean arterial pressure in individuals with pre- and stage-1 hypertension and type 2 diabetes. Combined aerobic and resistance training, performed three times per week for 12 weeks, led to a significant reduction in both SBP and DBP. **Conclusion.** These findings highlight the crucial role of exercise therapy as a non-pharmacological approach to managing BP and reducing cardiovascular risk factors.

KEYWORDS: ***Physical Activity, Cardiovascular Health, Health Outcomes, Exercise Prescription.***

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INTRODUCTION

Hypertension is a significant risk factor for cardiovascular disease (1). Cardiovascular diseases encompass a range of conditions, including coronary artery disease (CAD), arrhythmias, cardiomyopathy, and valvular disease (2). Among these, hypertension is a primary driver, leading to serious complications such as heart attack, myocardial infarction, stroke, and chronic kidney disease (3).

Cardiovascular disease mortality and morbidity increase in a curvilinear fashion with rising BP, without evidence of a definitive risk threshold (4, 5). Hypertension, a critical component of metabolic syndrome, is typically defined by a systolic blood pressure (SBP) of 130 mm Hg or higher or a diastolic blood pressure (DBP) of 85 mm Hg or higher (6). High BP is a significant public health issue in the United States, affecting approximately 50 million Americans (7). Over the past 80 years, the increasing cardiovascular disease mortality rate has led to annual healthcare costs nearing $320 billion, impacting around 60 million Americans (7). Therefore, Whelton, Chin (8) stated that uncontrolled high BP is a major contributor to coronary heart disease, stroke, end-stage renal disease, and congestive heart failure. Clinical research consistently shows that reducing BP can lower cardiovascular mortality (9). Even a modest reduction of 2 mm Hg in the average DBP across the general population could substantially decrease the risk of diseases associated with elevated BP (9).

Exercise can reduce the risk of numerous health disorders and chronic diseases (10). It is broadly defined as any bodily movement produced by skeletal muscles that requires energy expenditure. Various forms of exercise include cycling, jogging, walking, and participating in sports and recreational activities. Physical inactivity is a significant risk factor for cardiovascular disease, with individuals who are less physically active having a 30% to 50% higher risk of developing hypertension (11). Clinical studies have shown that regular physical activity can reduce BP in hypertensive and normotensive individuals, independent of weight loss (12). For instance, a study found that older women with metabolic syndrome experienced reductions in systolic, diastolic, and mean BP, along with improvements in heart rate variability, 24 hours after a low-intensity resistance exercise session with 60% to 80% blood flow restriction (13). However, there is conflicting evidence regarding how exercise contributes to BP reduction in the general population and specific subgroups (14).

Many systematic reviews and meta-analyses have investigated the impact of diverse exercise modalities on blood pressure. The findings indicate that aerobic exercise is associated with significant reductions in SBP, although the effect on DBP is less pronounced. These observations suggest that aerobic exercise may contribute to a reduction in cardiovascular disease risk. Such aerobic exercise-induced adaptations may be primarily attributed to the significant improvements in cardiac output, oxygen uptake, nitric oxide production, and stress levels that have antihypertensive properties (15-17). It has been well-documented that improved endothelial function and autonomic regulation, as well as reduced oxidative stress, are considered to be the potential physiological mechanisms responsible for these positive adaptations in BP levels (18). These advantageous effects of aerobic exercise are critical for middle-aged and older adults struggling with lifestyle-related chronic diseases commonly linked to impaired metabolic health that increases the risk of mortality (19).

Resistance training that involves muscle contraction against external forces has been demonstrated to enhance muscle strength, facilitate fat loss, and regulate blood pressure. A literature review reveals that studies comparing the effects of aerobic exercise and resistance training on BP in individuals with hypertension indicate that both types of exercise are effective in lowering BP, with no significant difference between them (20). However, it is possible that resistance training may be more beneficial in populations with metabolic dysregulation, as it has been shown to induce favorable effects on various glycolipid metabolism indicators (21).

The objective of the present review was to provide a synthesis of the research methods employed and the findings reported in studies where blood pressure was examined. A review article may disseminate the main research findings on blood pressure responses to exercise in various clinical populations to identify research issues, considerations, and gaps in the literature. Given the paucity of research on blood pressure responses to exercise, this narrative review aimed to provide a comprehensive overview of the existing evidence by capturing all published research on the topic, regardless of the study design. The review addressed the general question: What is known from published research about blood pressure adaptations to aerobic, resistance, and combined training in patients with chronic diseases?

MATERIALS AND METHODS

Protocol and Registration. This manuscript is a narrative review, which does not require protocol registration. Therefore, no registration code is applicable for this type of study.

Literature Search Strategy. The studies included in this review were selected based on freely accessible data. We identified relevant studies by searching multiple databases, including SCOPUS, PubMed, Cochrane Central Database, and Google Scholar.

Eligibility Criteria. Following a comprehensive literature search, all studies examining the effects of exercise on BP in patients with chronic diseases were reviewed. The search spanned papers published between January 1, 1995, and May 31, 2024, utilizing keywords such as "BP", "endurance training", "cardiovascular risk factors", "hypertension", "aerobic exercise", "meta-analysis", and "resistance training". Two authors (S.B. and N.K.) applied the PICOS method to assess the full texts of the identified studies and establish the inclusion and exclusion criteria. In cases of disagreement, a third author (A.B.) was consulted to reach a final decision.

Study Selection. Two authors (S.B. and N.O.) conducted the study selection process and applied the inclusion and exclusion criteria through a stepwise evaluation of titles, abstracts, and full texts. In cases where discrepancies arose, a third author (W.G.) was consulted to discuss and finalize the decision on whether to include or exclude articles for the current review.

Methodological Quality Assessment. The quality of the included studies was evaluated using the Joanna Briggs Institute (JBI) critical appraisal checklist (JBI, 2017), which examines nine key criteria: (i) appropriate sampling frame, (ii) suitable sampling technique, (iii) sufficient sample size, (iv) clear description of study subjects and setting, (v) thorough data analysis, (vi) valid methods for the conditions studied, (vii) consistent measurement across participants, (viii) appropriate statistical analysis, and (ix) adequate response rate. Each item was rated as yes, no, unclear, or not applicable. A "yes" received a score of 1, while "no" and "unclear" received 0. The average score for each study was calculated, and those with scores above the mean were classified as high-quality, while those below were deemed low-quality. The inclusion or exclusion of studies was based on this methodological quality assessment (Table 1).

Table 1. Inclusion and exclusion criteria were used for this review

Characteristics	Inclusion criteria	Exclusion criteria
Type of studies	Original studies from a peer-reviewed journal systematic review and meta-analysis.	Non-peer-reviewed or non-original research Editorials, opinions, and discussions
Publication Type	Full-text articles available Available in English	Studies without full-texts In a language other than English
Participants	Patients with Diabetes, hypertension, congestive heart failure, stroke, asthma, human immunodeficiency virus infection and acquired immune deficiency syndrome comorbidities, liver disease, and chronic obstructive pulmonary disease.	Patients without a history of chronic diseases.

RESULTS

The data from the studies were imported into the EndNote X9 citation manager. Articles were then reviewed for relevance to the review's objectives, and duplicates were removed. Initially, 2,735 articles were identified. Following the application of predefined inclusion and exclusion criteria, 17 articles met the established criteria and were selected for inclusion in this review (as detailed in Table 2 and Figure 1).

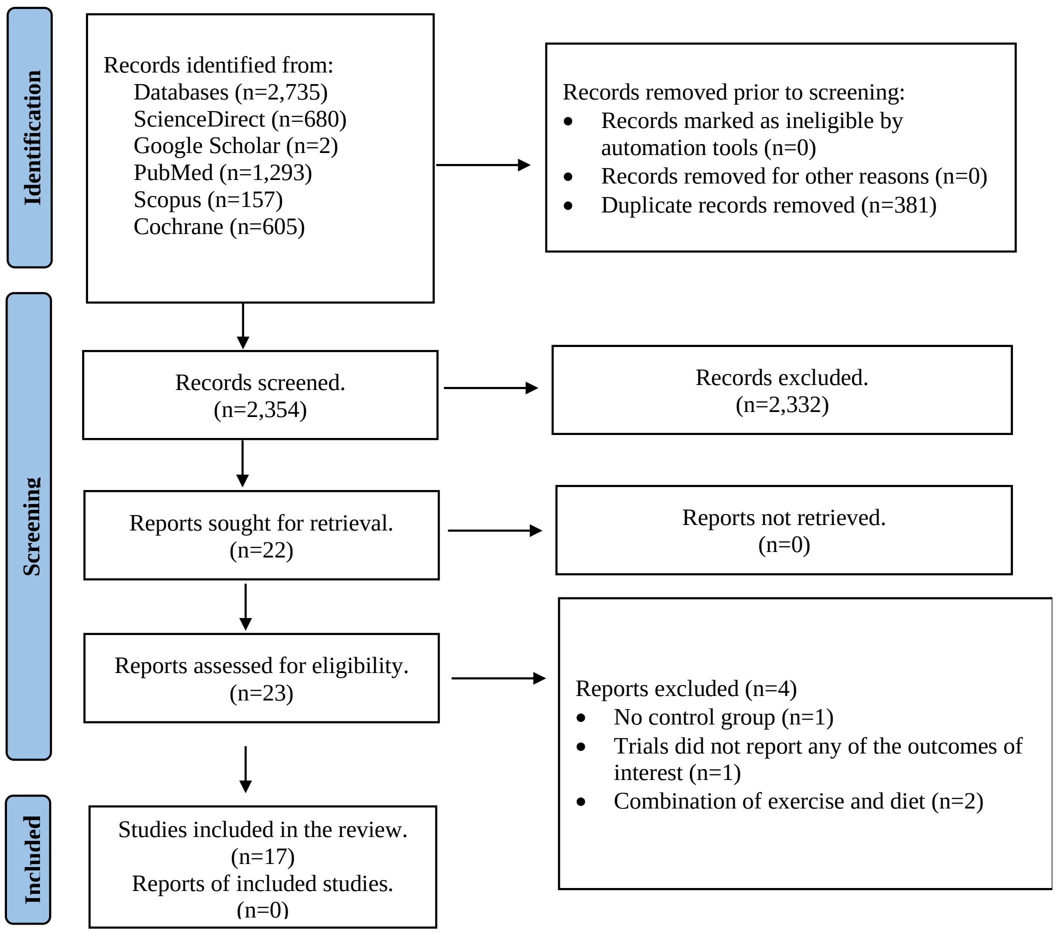

Figure 1. PRISMA flowchart for search strategy.

Our review of relevant studies indicates that aerobic exercise is associated with significant benefits for individuals with obesity and cardiovascular disease. For instance, Banz, Maher (22) found that obese patients with cardiovascular disease who participated in 40 minutes of aerobic exercise three times a week for ten weeks, at intensities between 60% and 80% of their maximum heart rate, experienced significant reductions in both SBP and DBP. Similarly, Grant, Todd (23) observed that overweight women also experienced a reduction in BP following aerobic exercise interventions.

Furthermore, a meta-analysis examining hypertensive and non-hypertensive adults aged 20 to 72 years demonstrated that engaging in aerobic exercise—specifically, three sessions per week, each lasting 40 minutes at 65% of maximum heart rate—resulted in significant reductions in both resting and daytime ambulatory BP over durations ranging from 4 to 52 weeks. This observed decrease in BP was linked to a reduction in systemic vascular resistance (24).

Additionally, aerobic exercise has been shown to lower both SBP and DBP in individuals with metabolic syndrome, indicating its potential as an effective intervention for improving BP and alleviating chronic diseases (25).

Our literature review indicates that DBP significantly decreased after 16 and 32 weeks of exercise interventions, leading to reductions in both blood BP and left ventricular hypertrophy in individuals with severe hypertension (25). Maeda, Tanabe (26) reported that exercise training resulted in elevated plasma concentrations of nitric oxide and cyclic guanosine monophosphate, which were associated with significant reductions in BP.

Similarly, Ruangthai and Phoemsapthawee (27) observed that combined aerobic and resistance training led to substantial decreases in SBP, correlated with increased plasma total nitrite/nitrate levels. Conversely, while aerobic and resistance training have been shown to reduce mean arterial pressure in individuals with prehypertension and stage-1 hypertension, resistance training alone did not result in significant BP changes (28) (Table 2).

Table 2. Characteristics of the included studies

Study	Total sample size/ Gender	Population	Age (Mean years ± SD)	Intervention	Duration (week)	Session per week	Main finding	Quality assessment JBI score out of 9 criteria
Whelton et al., 2002 (8)	A meta-analysis of 54 RCT included 2419 subjects	hypertensive and non hypertensive patients	-	Aerobic exercise	12	3	A significant decrease in mean systolic and diastolic BP was observed in both hypertensive and normotensive participants.	6
Banz et al., 2003 (22)	26/M	Obesity and at least one other heart disease	48±6	Aerobic and resistance training	10	3	No significant differences in BP were noted across groups; however, aerobic exercise significantly reduced DBP ($P<0.05$). Resistance training reduced systolic BP.	8
Grant et al., 2004 (23)	26/F	Overweight/obese hypertensive patients	63±4	Aerobic and resistance training	12	2	Both training significantly reduced DBP SBP ($P<0.05$) compared to the control group	9
Fagard and Cornelissen, 2007 (24)	A meta-analysis of 105 studies included 72 trials	hypertensive and non-hypertensive	20 to 72	Aerobic exercise	4-52	3	The exercise intervention significantly decreased BP resting and daytime ambulatory BP ($P<0.001$) through decreased systemic vascular resistance.	6
Kokkinos et al., 1995 (25)	46/M	Hypertensive patients	35-76	Aerobic exercise	16	3	Intervention decreases DBP, BP, and left ventricular hypertrophy.	7
Maeda et al., 2004 (26)	15/F	Chronic diseases	59-69	Aerobic exercise	12	5	The intervention significantly reduced resting BP ($P<0.05$) and increased the plasma concentration of NO and cGMP.	7
Ruangthai et al., 2019 (27)	54/M	Hypertension	67±6 years	Aerobic and resistance training	12	3	Endurance training, combined training, and strength training reduced SBP by 7.9%, 8.2%, and 19.1%, respectively, correlating with increased plasma NO concentrations.	7
Collier et al., 2008 (28)	30/M & F	Hypertensive patients	48.2±1.3	Aerobic and resistance training	4	3	Significantly reduced in resistance and aerobic training SBP and DBP. resistance training increases central and peripheral arterial stiffness, while aerobic training decreases arterial stiffness.	8
Katzmarzyk et al., 2003 (29)	621/M & F	Chronic diseases, participants with BP<160/100 mm Hg)	45.8±13.9	Aerobic exercise	20	3	Aerobic exercise Significantly decreases BP, SBP, and DBP ($P<0.05$).	8
Figueroa et al., 2011 (30)	24/F	Postmenopausal women	47-68	Circuit resistance training followed	12	-	Significantly reduced SBP and DBP compared with the control. The 12 weeks of moderate-intensity combined circuit	8

Study	Total sample size/ Gender	Population	Age (Mean years ± SD)	Intervention	Duration (week)	Session per week	Main finding	Quality assessment JBI score out of 9 criteria
				by aerobic exercise			resistance training and aerobic exercise improve hemodynamics, arterial stiffness, and muscle strength	
Dimeo et al., 2012 (31)	50/M & F	Hypertension	67.9±6.2	Aerobic exercise	12	3	It significantly reduced SBP and DBP (P=0.03). Exercise decreased BP on exertion and improved physical performance even in subjects with low responsiveness to medication.	8
Ho et al., 2011 (32)	20/F	Hypertensive women	50-67 years	Aerobic and resistance training	12	3	significantly reduced in SBP and DBP. A moderate-intensity 30-minute bout of resistance or aerobic training could decrease cardiovascular disease risk factors.	9
Carpio-Rivera et al., 2016 (33)	A meta-analysis included 1408 participants	Chronic disease	36.1±15.1 years	Aerobic and resistance training	12	3	Intervention decreased significantly both DBP and SBP (p<0.05). The decrease in blood pressure was significant irrespective of the subjects' initial blood pressure levels, sex, or physical activity levels.	6
Park et al., 2021 (34)	-	Hypertension and T2DM.	-	Aerobic/resistance And combined training	-	-	Exercise improved SBP (95% CI, −8.39 to −2.12) and DBP (95% CI, −4.91 to −1.40). Aerobic activity showed the greatest impact on reducing SBP and DBP.	6
Lopes et al., 2021 (35)	A meta-analysis included 642 participants	hypertension	-	Aerobic, resistance, and combined aerobic and resistance	-	-	Exercise training, particularly aerobic, combined, and isometric resistance exercises, reduced pulse wave velocity in adults with hypertension; however, dynamic resistance training did not demonstrate this effect.	6
Al-Mhanna et al., 2024c (36)	A meta-analysis / 1,148 F	overweight/ obese T2DM patients	66±6	Aerobic and resistance training	12	3	The training intervention showed significant improvements in SBP and DBP.	6
Al-Mhanna et al., 2024d (37)	A meta-analysis. Included 1,192 participants	Cancer	57±7	Aerobic and resistance training	12	3	Combined aerobic and resistance training demonstrated significant improvements in SBP and DBP	6

BP: Blood Pressure; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; JBI criteria: (1) appropriate sampling frame, (2) proper sampling technique, (3) adequate sample size, (4) study subject and setting description, (5) sufficient data analysis, (6) use of valid methods for the identified conditions, (7) valid measurement for all the participants, (8) using appropriate statistical analysis, and (9) adequate response rate; T2DM: Type 2 Diabetes Mellitus; F: Female; M: Male.

DISCUSSION

The study aimed to assess the effects of different exercise modalities on blood pressure in patients with chronic diseases. The analysis showed that consistent aerobic and resistance training significantly lowered SBP and DBP in individuals with cardiovascular disease. Furthermore, the current evidence suggests that mind-body fitness modalities, such as Pilates, yoga, and tai chi, benefit BP and enhance physical fitness (38-40). A meta-analysis further indicated that aerobic exercise can significantly lower resting and daytime ambulatory BP, primarily due to reduced systemic vascular resistance. Moreover, exercise-induced elevations in nitric oxide and cyclic guanosine monophosphate levels were identified as fundamental mechanisms contributing to BP reduction (41).

Exercise plays a crucial role in promoting the formation of new blood vessel angiogenesis by increasing the expression of vascular endothelial growth factor (VEGF) and stimulating blood flow to tissues. This enhanced blood vessel formation improves oxygen delivery and reduces vascular resistance, which contributes to lowering blood pressure (42). Regular aerobic and resistance exercise can help regulate blood pressure by improving endothelial function and increasing nitric oxide production, leading to vasodilation. These effects collectively support cardiovascular health and help manage conditions like hypertension (42). Aerobic and resistance training have been shown to reduce mean arterial pressure in individuals with prehypertension and stage-1 hypertension, consistent with findings from previous studies (8). This finding may suggest that a combined approach involving aerobic and resistance training may be efficient in managing BP in individuals with hypertension or cardiovascular disease, as it potentially targets multiple physiological pathways involved in BP regulation. MacDonald, Johnson (43) conducted a meta-analysis involving 64 trials and 2,344 participants, demonstrating that resistance training is equally as practical as aerobic training in improving SBP, DBP, and overall health outcomes.

Exercise therapy is a well-established nonpharmacological intervention for managing hypertension and other cardiovascular disorders. Among the various forms of exercise, aerobic continuous training is endorsed by international guidelines for primary and secondary hypertension prevention (44). A notable phenomenon associated with exercise is post-exercise hypotension (PEH), where BP decreases to levels below the pre-exercise baseline following a single bout of exercise. This transient BP reduction is considered a predictor of the long-term effects of exercise training on chronic hypertension (44). The occurrence and magnitude of PEH have been observed in both normotensive and hypertensive individuals, with varying observation periods following exercise (45). The precise mechanisms underlying the reduction in BP associated with exercise remain unclear. However, insulin resistance and hyperinsulinemia have been implicated in the development of hypertension (46). Clinical trials have demonstrated that aerobic exercise improves insulin resistance and reduces insulin levels in hypertensive patients (47). Moreover, changes in BP during exercise have been closely associated with decreased overall cholesterol levels and improved insulin resistance (48).

One proposed mechanism for the antihypertensive effects of exercise is the enhancement of endothelium-dependent vasodilation. Aerobic exercise has increased nitric oxide bioavailability, improving endothelium-dependent vasorelaxation in hypertensive individuals (48). Reductions in SBP due to exercise are linked to increases in plasma total nitrite/nitrate concentrations. Additionally, previous research indicates that aerobic exercise can lower BP in pre-hypertensive and hypertensive populations (46). The endothelial adaptation associated with exercise is believed to be driven by exercise-induced increases in shear stress, which result in the upregulation of endothelial nitric oxide synthase and greater nitric oxide bioavailability (49). It has been suggested that this adaptation is primarily due to a significant increase in nitric oxide production and/or a decrease in nitric oxide scavenging by reactive oxygen species (49). Furthermore, strength training has been reported to enhance endothelial-dependent vasodilation, although this effect appears localized to the trained limbs (50).

Circuit resistance training followed by endurance exercise at 60% of maximal heart rate performed three times per week for 12 weeks has been shown to significantly reduce SBP and DBP while improving hemodynamics, arterial stiffness, and muscle strength compared to a control group (30). Circuit-based resistance training interventions conducted in various settings demonstrated favorable changes in cardiovascular disease risk factors, including BP (51-53). Recent systematic reviews and meta-analyses on the effects of exercise in adults with both hypertension and type 2 diabetes mellitus (T2DM) have further confirmed these benefits. Specifically, exercise interventions appear to improve SBP and DBP, with aerobic exercise being the most effective modality. Moreover, combined aerobic and isometric resistance training has been shown to reduce pulse wave velocity reducing arterial stiffness (34). These findings suggest that exercise reduces BP by lowering systemic vascular resistance, potentially through modulating the sympathetic nervous system and the renin-angiotensin system, which collectively positively impact cardiovascular risk factors. The antihypertensive effects of exercise appear to be more pronounced in hypertensive individuals than those with normal BP, indicating that regular physical activity helps regulate BP in hypertensive patients and may also serve as a preventative measure against hypertension in normotensive individuals (24). However, it is essential to note that not all studies report significant reductions in BP following exercise interventions. For instance, García-Hermoso, Alonso-Martinez (54) found that higher-intensity exercise did not produce a greater antihypertensive effect in patients with chronic kidney disease, highlighting the potential influence of underlying health conditions on exercise outcomes. These results underscore the importance of tailored exercise interventions for managing BP and reducing cardiovascular disease risk in hypertensive and normotensive individuals, contributing to improved quality of life and long-term health outcomes. It is also noteworthy that interval training programs appear to be a promising exercise strategy for inducing beneficial alterations in SBP and DBP in individuals with metabolic derangements (55, 56). Such positive effects may be attributed to the advantageous role of vigorous-intensity, intermittent-type exercise regimens in several mental health indicators associated with vascular function (57). This highlights the need for further research in this particular area.

Current American and European hypertension guidelines emphasize the importance of regular physical activity as a primary recommendation for managing high BP (58). Engaging in physical activity has been demonstrated to lower BP, even in individuals who exhibit a limited response to medical treatments, highlighting its critical role in managing resistant hypertension (58). Therefore, exercise intervention represents a fundamental element in the treatment and prevention of chronic diseases, with a significant impact on BP control. The current evidence base supports the recommendation of engaging in moderate-intensity physical activity for a minimum of 30 minutes daily, with the optimal approach being daily participation. This regimen should include aerobic exercise modalities daily (24). Prior to undertaking vigorous exercise (≥60% of maximum intensity), individuals with hypertension should undergo medically supervised peak or symptom-limited exercise testing, incorporating electrocardiogram and BP monitoring (59). Asymptomatic individuals at low risk participating in light-to-moderate physical activity (<60% of maximum intensity) generally do not require additional testing beyond routine care. However, asymptomatic high-risk patients may benefit from exercise testing before engaging in moderate-intensity activities (40–60% of maximum intensity), though not for light or very light activities (<40% of maximum intensity). Patients experiencing symptoms such as chest discomfort, exertional dyspnea, or palpitations should be closely monitored and may need further evaluation with tests like Holter monitoring, echocardiography, or a combination of these. Alongside physical activity, patients are encouraged to follow non-pharmacological strategies, including increasing fruit and vegetable intake, reducing salt and saturated fat consumption, quitting smoking, limiting alcohol intake, and incorporating daily moderate exercise. For those at elevated or high risk of cardiovascular complications, prompt initiation of antihypertensive drug therapy is recommended (24). For BP prevention and management, moderate-intensity whole-body aerobic exercise (50–65% of maximum oxygen intake) focusing on major muscle groups is recommended. The optimal duration for each session is between 30 and 60 minutes, with a frequency of three to four times per week (60). Additionally, resistance training should be conducted at low intensity without breath-holding. Individuals with hypertension who experience chest problems, such as chest pain, should avoid resistance training (60). Thus, clinicians and practitioners should be aware of the latest research findings on the pivotal role of various exercise types in resting cardiovascular function parameters among patients with several lifestyle-related chronic diseases (61). Future research should explore the long-term effects of various exercise modalities on blood pressure regulation and vascular health in diverse populations with chronic diseases. Investigating the molecular mechanisms, such as nitric oxide production and VEGF expression, could provide deeper insights into the role of exercise in cardiovascular disease management. Randomized controlled trials with larger sample sizes and extended follow-up periods would strengthen the evidence for tailored exercise prescriptions.

CONCLUSION

The study compiles evidence on the effects of different types of exercise on BP. Aerobic and resistance training has been demonstrated to confer significant benefits for individuals with obesity and cardiovascular disease, leading to notable reductions in SBP and DBP. Combined aerobic and resistance training may provide the most effective strategy for managing BP in individuals with hypertension or cardiovascular disease. These findings highlight the importance of exercise therapy as a nonpharmacological treatment, potentially benefiting both normotensive and hypertensive individuals by regulating BP and reducing cardiovascular risk factors.

APPLICABLE REMARKS

- The study demonstrates that both aerobic and resistance training, when performed consistently, can effectively lower systolic and diastolic blood pressure in patients with chronic conditions, emphasizing the potential of exercise therapy in managing cardiovascular risk factors.
- Aerobic exercise, in particular, significantly reduces systemic vascular resistance, making it a viable non-pharmacological intervention for patients with metabolic syndrome and those at risk of developing cardiovascular diseases.
- Combining aerobic and circuit-based resistance training over 12 weeks was particularly beneficial in reducing mean arterial pressure, especially in individuals with pre- and stage-1 hypertension and type 2 diabetes.
- These findings reinforce the importance of integrating structured exercise programs into the treatment plans for hypertensive patients, offering a complementary approach to traditional pharmacological treatments to manage blood pressure better and mitigate cardiovascular risks.

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AUTHORS' CONTRIBUTIONS

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CONFLICT OF INTEREST

The authors reported no potential conflict of interest.

FINANCIAL DISCLOSURE

The authors declare that they have no financial interests or relationships that could influence the content or outcomes of this study. No financial conflicts of interest are associated with this research.

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ETHICAL CONSIDERATION

Not applicable.

ROLE OF THE SPONSOR

The sponsor had no role in the study design, data collection, data analysis, interpretation of results, manuscript preparation, or decision to submit the article for publication.

ARTIFICIAL INTELLIGENCE (AI) USE

Artificial intelligence tools were not utilized in this manuscript's conceptualization, data analysis, or writing, except for general-purpose language models used for proofreading or editing assistance, where applicable.

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