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REVIEW

The Impact of Aerobic Exercise on Health Management in Older Patients with Hypertension: A Systematic Review of Randomized Controlled Trials from the Past Decade

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Purpose: This study was based on the PICO framework to systematically evaluate the effects of aerobic exercise on key health management indicators such as blood pressure, heart rate and cardiorespiratory fitness in older hypertensive patients.

Patients and Methods: A systematic search of randomized controlled trials from four English language databases, Web of Science, PubMed, Cochrane, and Embase, and four Chinese language databases, CNKI, VIP, Wanfang, and Sinomed, was performed (April 2014 to April 2024). StataCorp Stata v.18.0 was used for data analysis. In a random-effects meta-analysis, continuous variables were represented by the mean difference, and each effect size was represented by a 95% confidence interval.

Results: Nine randomized controlled trials with 484 participants were included. The meta-analysis revealed that compared with the control group, participants engaging in aerobic exercise significantly reduced systolic blood pressure (SMD = −0.93, 95% CI = −1.48 to −0.39, P =0.001), diastolic blood pressure (SMD = −0.48, 95% CI = −0.75 to −0.21, P =0.001), and heart rate (SMD = −1.78, 95% CI = −3.31 to −0.24, P =0.024), and improved cardiorespiratory health (SMD =0.71, 95% CI =0.24 to 1.18, P =0.003).

Conclusion: Older patients with hypertension aged 60 years should engage in 120–150 minutes of low- to moderate-intensity aerobic exercise per week, maintaining 40–75% maximum HR or 40–60% VO_2max (20–30 minutes per day, 5 days per week, or 75–150 minutes of exercise only once or twice a week. However, it is crucial that individuals assess their own health conditions, make appropriate time adjustments, and gradually increase the duration and intensity of exercise. And central randomization with blinded assessment should be used in future randomized controlled trials to reduce implementation bias and measurement bias.

Keywords: exercise, hypertension, older, population health management, systematic review

Introduction

Essential hypertension is a multifactorial disease, in which the etiological factors that cause increased blood pressure (BP) are not clearly defined. Studies have shown that the pathogenesis of essential hypertension is related to genetic, environmental, and other factors.[1] Recently, American guidelines have defined a systolic BP (SBP) ranging from 130 to 139 mmHg as "high-normal".[2] Studies have shown that although this change significantly reduces the incidence of atherosclerotic cardiovascular disease and all-cause death, it can also increase the prevalence of hypertension to some extent. As a result, a higher proportion of adults should be recommended for antihypertensive therapy.[3,4] Currently, the global prevalence of hypertensive heart disease (HHD) is estimated to be 18.60 million cases, which corresponds to approximately 21.51 million disability-adjusted life year (DALY) rates.[5] Although the age-standardized DALY rates for HHD have declined, the global prevalence has risen markedly, with the majority of affected individuals over 70 years of

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age. Against the backdrop of the aging global population, more than 76.50% of Americans 65 years and older have hypertension.[6] Hypertension poses a severe threat to the physical health of older patients, not only increasing the likelihood of critical complications such as cardiovascular disease,[7] kidney disease,[8] and stroke,[9] but also profoundly affecting their mental well-being and social functioning, which in turn decreases their overall quality of life.[10] Today, the global burden of hypertension is becoming progressively more severe.[11] The direct medical cost of hypertension is estimated to be $370 billion per year globally, whereas effective management of BP is projected to yield savings of approximately $100 billion annually in healthcare costs.[12] Therefore, exploring more comprehensive and efficacious nonpharmacological interventions to complement or substitute drug therapy and optimize health management strategies for older patients with hypertension constitutes an important research direction in the current public health domain.

Among the numerous nonpharmacological interventions, exercise intervention stands out as a comprehensive approach.[13] The results of a systematic review that included 24 randomized controlled trials (RCTs) indicated that isometric resistance training (IRT) significantly reduces SBP in the central and brachial arteries and may be more beneficial in reducing the risk of cardiovascular disease than interventions focused solely on lowering brachial SBP.[14] Circuit resistance training has been used safely in people with metabolic disorders, where it can increase the strength of the upper and lower extremities. Compared with regular resistance training (RT), it is less demanding and the exercise time is shorter.[15] Despite the scientific validation that both RT and isometric exercise training can improve the health status of individuals with hypertension, the implementation of these two forms of exercise in clinical populations and frail older adults remains limited due to several factors.[15,16] Specifically, RT, which requires precise technique and force control, poses a relatively high risk of adverse events such as muscle strains and joint injuries.[14] Conversely, IRT, although effective, may induce a temporary increase in BP, and a universally applicable and standardized exercise protocol has yet to be established.[17] Aerobic exercise, as a safe, effective and easily implementable form of physical activity, has been shown to modulate the functional state of the cerebral cortex and subcortical vascular motor centers, while improving vagal tone and reducing sympathetic nerve excitability. This leads to vasodilation and a decrease in peripheral vascular resistance, which contributes to hypotensive effects.[18] As age increases, arteriosclerosis leads to a decrease in blood vessel elasticity; aerobic exercise can, by improving blood circulation and metabolism, slow the process of arteriosclerosis, increasing the elasticity of the vessel walls. Evidence in the literature suggests that hypertension in the aging process results in a decreased ability to perform activities of daily living, which can lead to physical disability, cognitive impairment, balance and gait disorders, and an increased risk of falls.[19,20] In contrast, aerobic exercise has been shown to effectively manage BP and reduce dependence on medication while ensuring safety.[21] It promotes circulation by enhancing myocardial contractility and cardiac output, thus improving cardiac function, and regulating the balance of the autonomic nervous system.[22] However, many older hypertensive patients face challenges such as low participation rates, limited exercise variety, and insufficient exercise duration.[23] Despite these issues, positive trends are emerging, including increasing health awareness gradually and strengthening community support.[24] Therefore, the objective of this study is to investigate the role of aerobic exercise in the regulation of BP and heart rate (HR) and other indices in older hypertensive patients, to provide a scientific and individualized theoretical basis for their health management.

In this study, health management is defined as the process of systematically regulating physiological indicators, functional status, and disease prognosis of patients with chronic diseases through evidence-based interventions, including systematically monitoring, analyzing, and evaluating their health risk factors and providing effective health intervention strategies.[25] The National Academy of Medicine advocates the use of the term "population health improvement". Activities related to population health management focus on maintaining and improving overall public health outcomes.[26] In older patients with hypertension, optimal health management is based on a triad of evidence-based metrics: rigorous BP control, systematic monitoring of cardiovascular events coupled with evaluation of resting HR, and measurable improvement in cardiorespiratory fitness.[2] As the cornerstone of hypertension management, BP regulation demonstrates dose-dependent correlations with cardiovascular outcomes,[27] while reduced HR variability serves as an independent predictor of adverse cardiovascular events.[28] Moreover, improved cardiorespiratory fitness not only improves quality of life, but also modifies the disease trajectory through improved metabolic equivalent (MET) capacity and endothelial function.[29] Previous meta-analyses have explored the dose-related effects of aerobic exercise in hypertensive adults on the reduction of ABP and resting BP as well as hemodynamic factors. A recent meta-analysis found that aerobic exercise leads to a substantial reduction in blood pressure in a dose-dependent manner, with the greatest reduction at 150 min/week and an approximate systolic blood pressure reduction of approximately 7.23 mmHg, but did not specify an optimal intensity or duration for older adults.[28] Therefore, examining and corroboration of the evidence base behind these recommendations is not straightforward when using the RCT on aerobic exercise is used. Based on the lack of evidence mentioned above, this study strictly follows the PICO framework to systematically evaluate the effect of aerobic exercise on key indicators of health management, such as blood pressure control, heart rate, and cardiorespiratory fitness, in older hypertensive patients compared with conventional treatment, in order to provide a solid scientific support for its wide application in the clinic, and the source of evidence is limited to RCTs from the past decade.

Materials and Methods

This systematic review followed the guidelines recommended by the statement Preferred Reporting Items for Systematic Review and Meta-analyses (PRISMA) statement.[30] The results of the present study were previously recorded with PROSPERO (CRD42024569634).

Search Strategy

The relevant published literature was searched and screened in four English databases from April 2014 to April 2024, including Web of Science, PubMed, Cochrane, and Embase, as well as four Chinese databases, such as CNKI (China National Knowledge Infrastructure), the VIP database (Chinese scientific journal database), the Wanfang database, and SinoMed (Chinese biomedical literature database). Furthermore, to ensure that we did not miss any relevant literature, we manually reviewed the citation lists of relevant studies to identify other studies that met the screening criteria. The search strategy included the keywords "older", "hypertension", "high blood pressure*", "elder* hypertension", "exercise", "aerobic exercise", and "aerobic training". These medical subject headings (MeSH) and free words were combined using the Boolean operators "AND" and "OR" (Table 1).

Eligibility Criteria

The articles selected for this systematic review were subject to the following criteria: they had to be RCTs conducted in older patients with hypertension (persons 60 years and older, including men or women) in which aerobic exercise was used as an intervention and other physiological indicators such as BP were measured.

Only studies that met the following criteria were eligible for inclusion: (1) the type of study was an RCT; (2) the study was published in English or Chinese; (3) the study included patients 60 years and older with hypertension; (4) the exercise group performed an aerobic exercise program, whereas the control group received usual care or standard therapy that did not include any form of exercise activity; and (5) changes in ABP and resting BP were assessed, along with a variety of laboratory indicators as the final outcome.

Table 1 Literature Retrieval Strategy

Search	Query
#4	#1 AND #2 AND #3
#3	(("exercise"[MeSH Terms]) OR ("aerobic exercise"[Title/Abstract])) OR ("aerobic training"[Title/Abstract])
#2	(("hypertension"[MeSH Terms]) OR ("high blood pressure*"[Title/Abstract])) OR ("elder* hypertension"[Title/Abstract])
#1	("aged"[MeSH Terms]) OR ("elderly"[Title/Abstract])

Abbreviation: MeSH, Medical Subject Headings.

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Studies that met the following criteria were excluded: (1) the exercise group received aerobic exercise in combination with any other type of exercise; (2) the exercise group received aerobic exercise in combination with other treatments, whereas the control group did not use the same combination of interventions; (3) the control group performed any exercises; (4) a crossover design; (5) reviews, conference summaries, news, etc.; and (6) repeated publications or incomplete data.

Study Selection and Data Extraction

All relevant articles titles, authors, and abstracts were imported into the NoteExpress V4X software based on the retrieval strategy. Two researchers independently evaluated articles based on the inclusion and exclusion criteria, first eliminating articles that were clearly ineligible and subsequently reading in detail the full texts of the articles that might meet the inclusion criteria. For any disagreements during the screening process, a consensus was reached through discussion or negotiation with the participation of a third researcher. Finally, relevant data were extracted from the included literature via a predesigned information extraction form.

Quality Assessment

The same two independent researchers assessed the risk of bias of the included RCTs through the Cochrane Handbook of Systematic Reviewers.[31] These methods include randomized grouping; distribution hiding; the use of a blinded method; completeness of data results, including whether the baseline level before the intervention was consistent; the number of dropouts/lost to follow-up; intentionality analysis; measurement bias; reporting bias; and other methods. The included RCTs were classified as high-risk, unclear-risk, or low-risk. When differences existed, an agreement was reached through in-depth deliberation or consultation with a third researcher.

Data Analysis

The statistical software StataCorp Stata v.18.0 was used for statistical analysis. In this study, continuous variables were measured via the mean difference (MD) and the size of each effect size was represented through a 95% confidence interval (CI). Publication bias in the literature was analyzed using funnel graphs, and the asymmetry of the funnel graph suggested the existence of publication bias. The χ^2 test was used to assess heterogeneity between outcomes. When P >0.100 and $I^2 < 50.0\%$, there was no statistical heterogeneity or little heterogeneity, and data analysis was performed using a fixed effects model. When P <0.100, and $I^2 \geq 50.0\%$, but the clinical judgment was consistent among studies, a comprehensive analysis in conjunction with a random effects model was still needed. If P <0.100 and the source of heterogeneity cannot be specified, then systematic analysis was be performed and descriptive methods of analysis were used instead.

Results

Search Process and Results

This is a brief description of the literature search process. In the initial search of the database, we found a total of 12,108 studies related to the topic. No relevant articles were obtained by other means. After using NoteExpress V4X software to remove duplicate articles, 9625 studies were obtained. After reviewing the titles and abstracts of the articles, 9504 irrelevant articles were screened out. A total of 121 articles were further read in full, and this systematic review included 483 eligible participants from 9 articles, including 7 English studies and 2 Chinese studies (Figure 1).[32–40]

Characteristics of the Included Studies and Participants

This systematic review integrated data from nine RCTs, with 483 subjects included. Specifically, the exercise intervention group included 239 individuals, whereas the control group included 244 individuals. More women (n = 303, 62.7%) were included than men (n = 180, 37.3%) from two women-only studies[32,35] and seven studies on either sex.[33,34,36–40] Among the nine RCTs, seven of the included trials were conducted in the general hypertensive population,[32,33,35–37,39,40] whereas the remaining two trials were conducted in an overweight and obese population of patients.[34,38] In the nine aerobic

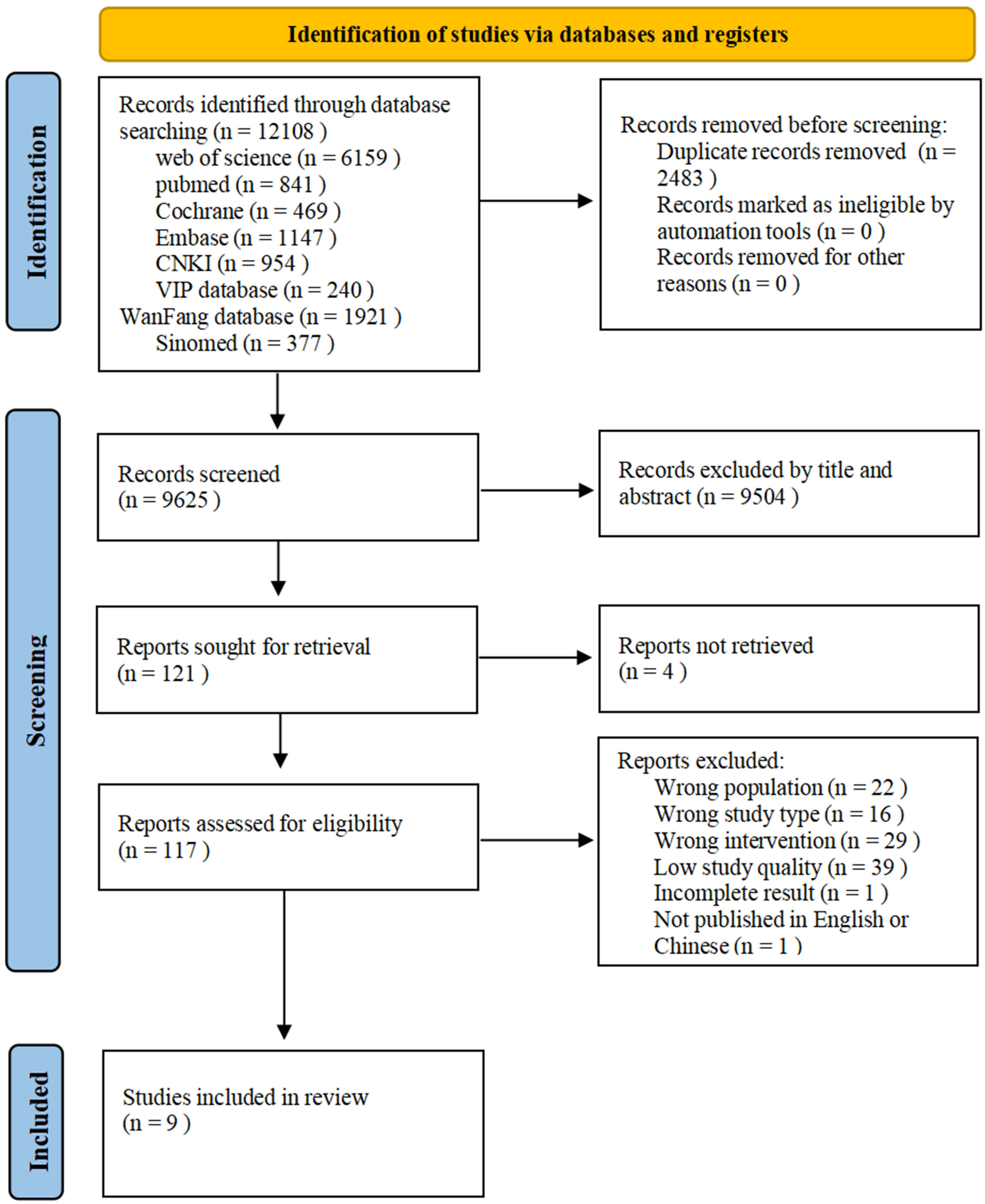

Figure 1 Flow Diagram for The Search and Selection of The Included Studies.
Abbreviations: CNKI, China national knowledge infrastructure; VIP database, Chinese scientific journal database; Sinomed, Chinese biomedical literature database.

exercise trials, various intensities of exercise were employed, notably self-selected training intensity,[32] and high intensity interval training,[37] and the rest of the seven trials used low-to-moderate intensity aerobic exercise programs, or at the minimum exercises performed from a moderate intensity level starting point.[33–36,38–40] Since part of the trial used a progressive aerobic exercise regimen, we first calculated the duration of aerobic exercise per week and then averaged it throughout the exercise period. Furthermore, when computing the exercise dose (time), we did not account for the time spent in warm-up and cooling sessions. In addition to a single session of aerobic exercise in the exercise group of one study,[33] the mean duration of aerobic exercise was 11.25 ± 3.99 weeks, with a mean frequency of 3.25 ±.46 sessions per week and an average session duration of 41.25 ± 13.71 min in the remaining eight trials (Table 2).

Table 2 Characteristics of the Included Studies

Study	Participants (Sample Size, Sex (mean age), BMI)	Intervention Content		Total Time	Outcome Indicator
		Intervention Group	Control Group		
Júlio Sócrates[32]	1.Eight of the 40 participants lost to follow-up due to health issues and lack of time. 2.EG:n(female)=20(64.7±3.3 y), BMI=29.1 ±5.6 3.CG:n(female)=20(64.2±3.9 y), BMI=31.1 ±6.1	1. **Modality**: aerobic running and walking. 2. **Frequency**: 3 times/week for eight weeks. 3.**Duration per session**: It is increased from week 1 (30 minutes) to week 5 (50 minutes) and lasts 50 minutes from week 5 to week 8. A 10 minutes warm-up and cool-down routine was included. 4. **Intensity**: self-selected training intensity	1.Standard care 2.Health education meetings had 60 minutes of duration once per week 3.Group dynamics, ludic activities and board games were also conducted	8 weeks	1.Primary outcome: ABP 2.Secondary outcome: 6MWT
Joana Oliveira[33]	1.No dropped data or lost participants 2.EG:n=9(83.4±3.2 y), 7female/2male, BMI=28.5±2.0 3.CG:n=9(82.7±2.5 y), 6female/3male, BMI=28.0±2.5	1. **Modality**: aerobic exercise (walking). 2.**Duration per session**: The exercise lasted 35 minutes and consisted of a 5-minute warm-up, two 10-minute walking aerobics sessions with a 5-minute recovery interval, and a 5-minute cooling down. 3. **Intensity**: The exercise intensity for the 2 periods of 10 minutes of walking was calculated as 40% to 60% of the heart rate reserve.	Did not engage in any physical exercise, remaining seated during the 35 minutes.		HR, SBP, DBP
Raphael Miranda Ramos[34]	1.No dropped data or lost participants 2.EG:n=12(60.5±0.2 y), 10female/2male, BMI=30.5±1.5 3.CG:n=12(60.7±0.4 y), 10female/2male, BMI=33.1±2.8	1. **Modality**: Moderate intensity aerobic training. 2. **Frequency**: 3 days/week for 12 weeks. 3.**Duration per session**: warm-up (10 minutes) and main part (50 minutes). 4. **Intensity**: Moderate intensity aerobic training at 60% of maximal HR.	Maintained normal lifestyle and did not participate in regular physical exercise programs.	12 weeks	SBP, DBP, MAP, HR, RPP, PP
Chawin Sarinuku[35]	1.Six out of 40 participants were excluded due to not meeting inclusion criteria, declining participation, or for other reasons. 2.EG:n(female)=17(68.1±3.4 y), BMI=23.8 ±0.9 3.CG:n(female)=17(64.6±3.6 y), BMI=26.0 ±4.1	1.**Modality**: no medical contraindications for aerobic stepping exercise consisted of ascending and descending phases continuously over the bench. 2. **Frequency**: 60 minutes exercise began at 8:00 am, 3 times per week in each group for 8 weeks. 3. **Duration per session**: warm-up (5 minutes), moderate-intensity stepping exercise (50 minutes), and cool-down (5 minutes). 4. **Intensity**: The target intensity was controlled by a metronome at a tempo of 100 beats/min. For the first two weeks, the stepping rate was set as tolerated for the participants. Then, the metronome rate was set for 90 and 100 beats/minute at the end of Week 2 and 4, respectively.	Standard care	8 weeks	1.Primary outcome: SBP, DBP 2.Secondary outcome: quality of life score, 6MWT, FTSST, TUGT

(*Continued*)

Table 2 (Continued).

Study	Participants (Sample Size, Sex (mean age), BMI)	Intervention Content		Total Time	Outcome Indicator
		Intervention Group	**Control Group**		
Abdulrahman A. Alzahrani[36]	1.Three of the 27 participants dropped out due to relocation, loss of follow-up, and withdrawal from the trial. 2.EG:n=12(74.7±8.7 y), 3female/9male, BMI=26.1±4.9 3.CG:n=12(74.1±8.5 y), 2female/10male, BMI=24.6±7.2	1. **Modality**: mild to moderate intensity aerobic exercise. 2. **Frequency**: 3 times/week for eight weeks. 3.**Duration per session**: 45 minutes of each session, a 10 minutes warm-up and cool-down routine was included. 4. **Intensity**: participants started from 20 minutes with 30% of their heart rate and progressed gradually to 45 min with 50%.	Standard care	8 weeks	1.Primary outcome: SBP, DBP 2.Secondary outcome: HR, body fat, TC, LDL, HDL, functional status
Kouji Tsuda[37]	1.24 of the 98 participants in the intervention group and 19 of the 100 participants in the control group were excluded due to missing blood pressure values or other reasons. 2.EG:n(Male)=27(75.9±4.6 y) n(Female)=47(74.6±4.4 y), BMI(Male)=23.0 ±1.7, BMI(Female)=22.2±3.3 3.CG:n(Male)=28(75.0±5.7 y) n(Female)=53(74.4±4.8 y), BMI(Male)=23.2 ±2.7, BMI(Female)=22.5±3.5	1. **Modality**: Interval-walking training (IWT). 2. **Frequency**: 3 minutes at least 5 times a day, at least 4 days a week for 5 months. 3.**Duration per session**: An IWT series in a walking day consisted of ≥5 cycles of normal-speed (low-intensity) walking for 3 minutes and fast (high-intensity) walking for 3 minutes. 4. **Intensity**: Fast (high-intensity) walking at 70–85% of the peak aerobic capacity and normal (light-intensity) walking at approximately 40% of the peak aerobic capacity.	Maintain usual lifestyle	5 months	SBP, DBP, MAP, VO2peak
Raphael Miranda Ramos[38]	1.No dropped data or lost participants 2.EG:n=10(60.5±0.2 y), 8female/2male, BMI=30.5±1.5 3.CG:n=8(61.7±0.8 y), 6female/2male, BMI=32.5±3.7	1. **Modality**: aerobic exercise (running, walking, jumping). 2. **Frequency**: 3 times/week for 12 weeks. 3.**Duration per session**: warm-up (10 minutes) and main part (50 minutes). Warm-up comprised 5 minutes race technical exercises (dribbling, skipping) and 5 minutes light jogging. 4. **Intensity**: moderate-intensity aerobic training	Standard care	12 weeks	VO2max, muscular flexibility, muscle power, muscular endurance
Sun Yangli[39]	1.No dropped data or lost participants 2.EG:n=39(69.78±8.43 y), 18female/21male, BMI=26. 88±4. 65 3.CG:n=39(69.49±8.36 y), 16female/23male, BMI=27. 35±4. 76	1. **Modality**: Aerobic exercise (running). 2. **Frequency**: 3 times/week for 3 months. 3.**Duration per session**: The exercise time is generally 15 minutes or more. 4. **Intensity**: 30% VO2max for the first week and 10% VO2max for each week thereafter. The intensity was increased to 60% VO2max until the end of the experiment.	Standard care	3 months	HR, SBP, DBP
Wu Jie[40]	1.No dropped data or lost participants 2.EG:n=46(69.03±3.16 y), 22female/24male 3.CG:n=46(68.36±3.27 y), 21female/25male	1. **Modality**: Aerobic exercise (fast walking, jogging and other exercise methods) chose in an environment with high oxygen density. 2. **Frequency**: 4 times/week for 10 weeks. 3.**Duration per session**: 30 minutes/time in the first week, increase the exercise time by 10 minutes each time from the second week, the upper limit is 60 minutes/ time. 4. **Intensity**: The reserve heart rate is 60% in week 1 and increases by 5% each time from week 2 to a maximum of 80%.	1.Conventional drug therapy2.Health education: smoking cessation, alcohol withdrawal, low salt and low fat diet	10 weeks	TC, TG, HDL-C, LDL-C, FPG, FINS, ISI, SBP, DBP

Abbreviations: EG, exercise group; CG, control group; SE, step exercise; SBP, systolic blood pressure; DBP, diastolic blood pressure; 6MWT, 6-min walk test; FTSST, five times sit-to-stand test; TUGT, timed up-and-go test; HR, heart rate; TC, total cholesterol; LDL, low-density lipoprotein; HDL, high-density lipoprotein; SSTI, Self-selected training intensity intervention; ABP, ambulatory blood pressure; VO2max, maximum aerobic capacity; IWT, interval-walking training; MAP, mean arterial pressure; VO2peak, peak aerobic capacity; MIAT, moderate intensity aerobic training; RPP, rate pressure product; PP, pulse pressure; TG, triglyceride; HDL-C, high density lipoprotein cholesterol; LDL-C, low density lipoprotein cholesterol; FPG, fasting blood glucose; FINS, insulin; ISI, insulin sensitivity index; RPE, rating of perceived exertion.

Quality Assessment and Publication Bias

Among the included studies, four trials did not indicate that allocation concealment was used. Due to the recommendation that blinding should not to serve as a decisive factor in assessing bias in the context of rehabilitation and the specificity of the intervention method,[41] the study participants and interveners were occasionally unable to be blinded during the study design. One trial used a nonblinded RCT design, two trials were single-blinded, and five trials did not report implementation bias. As most outcome indicators were objective, five trials followed the outcome assessor blind method in measuring bias (Figure 2).

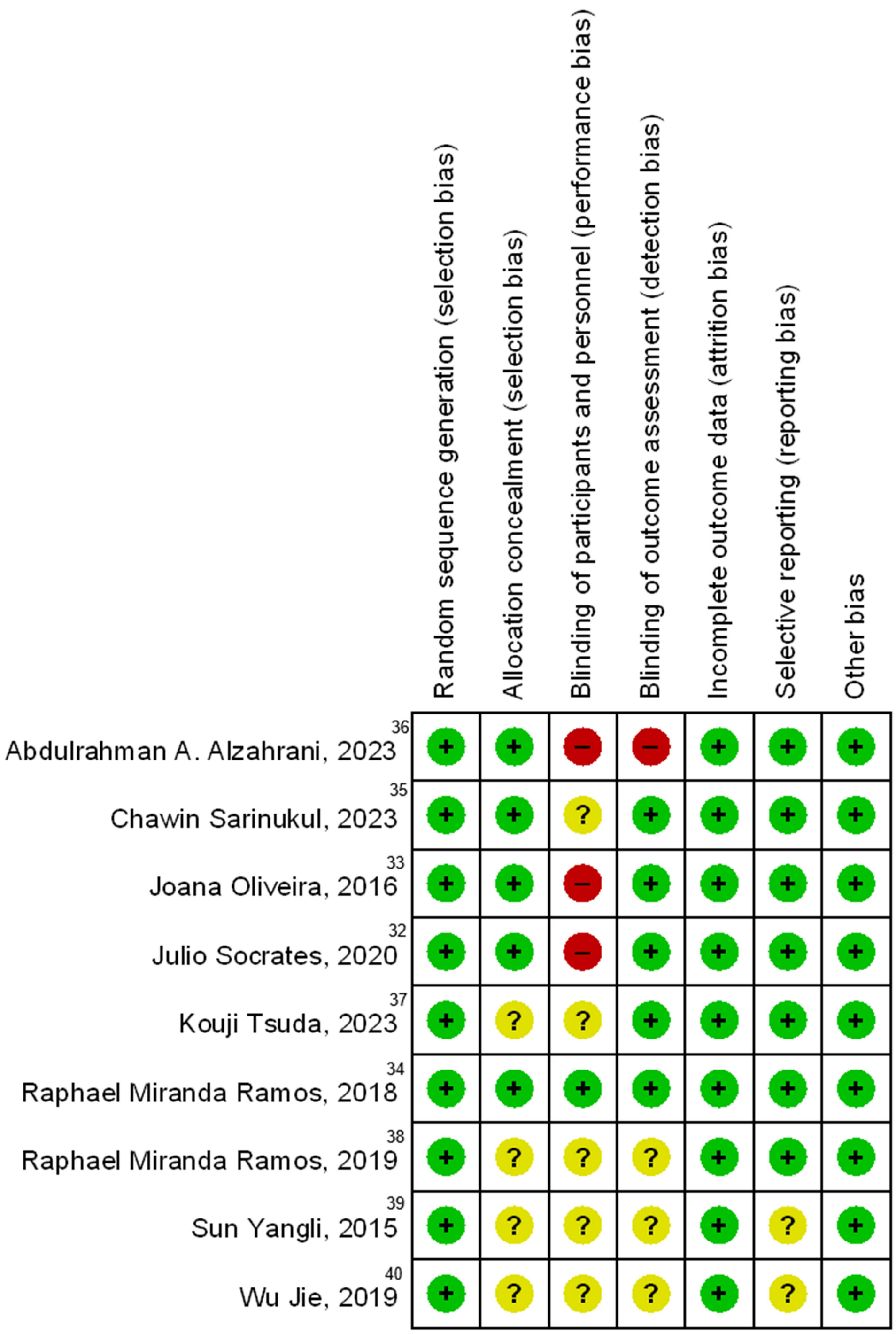

Figure 2 Risk of Bias Summary. Positive and negative marks represent low and high risk of bias, respectively. A question mark represents unknown risk of bias.

Main Results of Systematic Review

Effect of Aerobic Exercise on Blood Pressure

Eight studies with 465 participants examined BP in older hypertensive patients.[32–37,39,40] An RCT exploring the effect of step exercise on BP among older women with stage 1 hypertension reported significant improvements in diastolic BP (DBP) compared to the control group (P <0.010).[35] Furthermore, in another RCT investigating the effects of self-selected training intensity intervention (SSTI) on ABP in older hypertensive women exhibited that no significant differences in BP (24-h, awake, and asleep) were found between the SSTI group and the control group (P >0.050).[32] A study cited data separately for men and women in the interval-walking training (IWT) and control groups, and BP variations were not significantly different between the IWT group and the control group after five months in either sex (P >0.050).[37] In another single session of the aerobic exercise trial, there was a significant change in SBP over time, with a notable decrease observed in the SBP of the intervention group at 20 (127.30 ± 20.90 mmHg) and 40 minutes (123.70 ± 21.00 mmHg) postexercise in comparison with baseline (135.60 ± 20.60 mmHg), but DBP did not differ significantly.[33] In the remaining five trials, the data were amenable to analysis and comparison, as they involved low-to-moderate intensity aerobic exercise over a duration of 8–12 weeks. SBP from the remaining five trials (n = 252) were analyzed via Stata 18.0.[34–36,39,40] Due to the high heterogeneity (P <0.001, I^2 = 82.4%) (Figure 3) found for this variable in this comparison, the source of heterogeneity was found after the heterogeneity test, and the heterogeneity decreased after removal of the article (P =0.019, I^2 = 70.0%).[34] Data analyses via a random effects model demonstrated that the exercise group had a greater effect than the control group did, and the difference between the two groups was statistically significant (SMD = −0.93, 95% CI = −1.48 to −0.39, P =0.001) (Figure 4). Analysis of the reasons for heterogeneity revealed that the excluded RCT had study participants who were older hypertensive combined with obese patients and whose SBP levels did not change significantly before or after the exercise intervention after 12 weeks of continuous moderate-intensity aerobic exercise. In the main analysis, data on the influence of aerobic exercise on DBP were based on four studies with 218 participants.[34,36,38,40] The results of the heterogeneity analysis were P =0.115, and I^2 = 49.4%, and the analysis was expanded with fixed-effects models. The impact of aerobic exercise on DBP was significantly different between the two groups (SMD = −0.48, 95% CI = −0.75 to −0.21, P =0.001) (Figure 5).

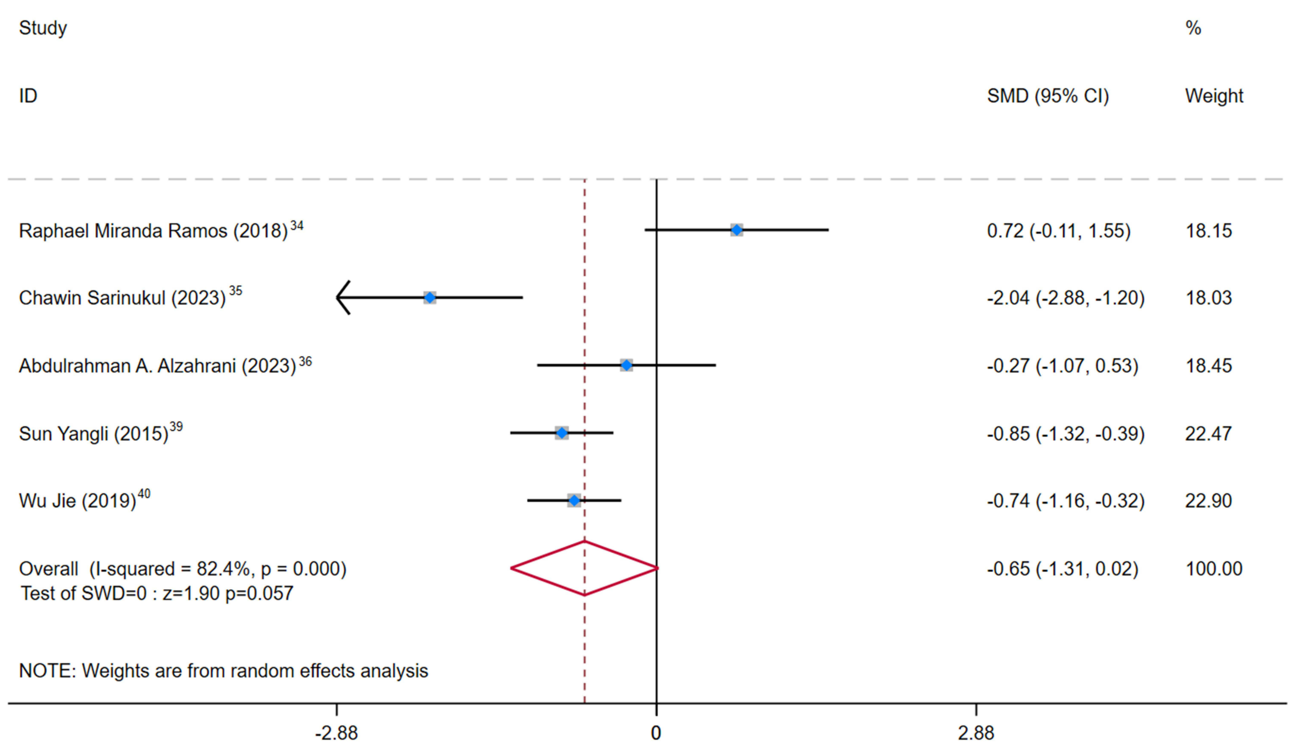

Figure 3 Effect of Aerobic Exercise on SBP Before Analyzing The Sources of Heterogeneity.
Abbreviations: CI, confidence interval; SMD, standardized mean difference.

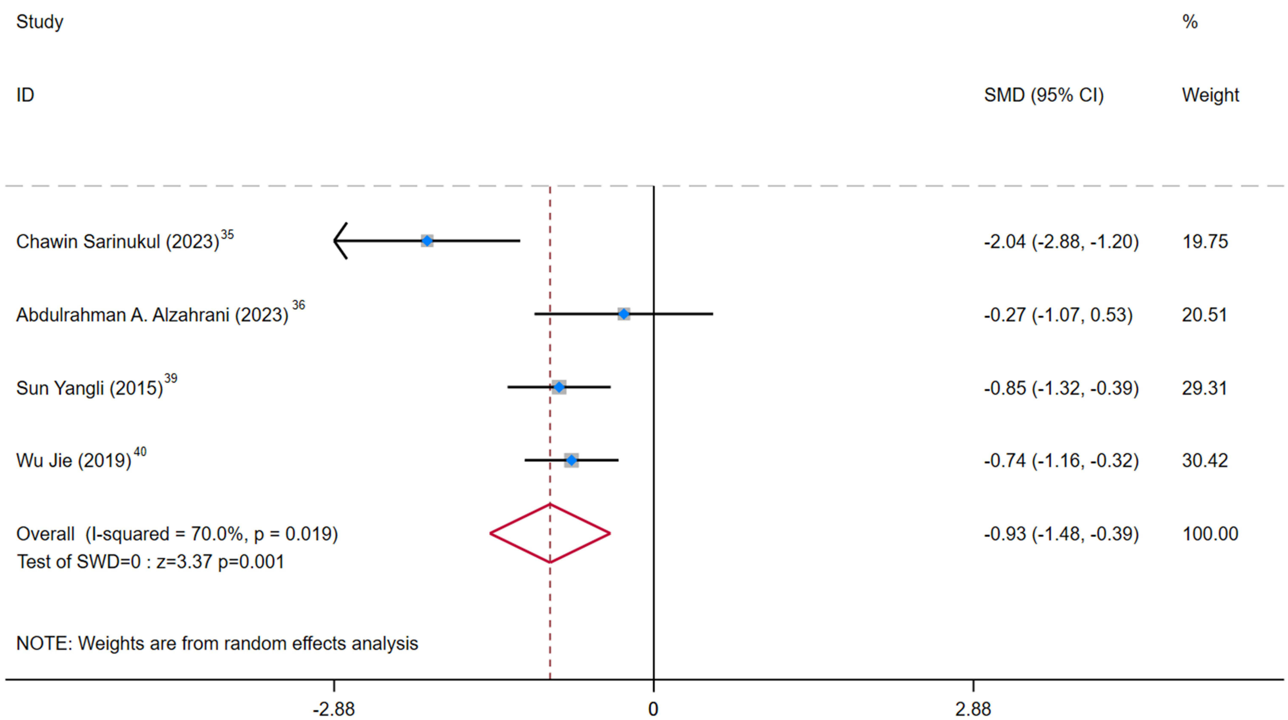

Figure 4 Effect of Aerobic Exercise on SBP After Removing Heterogeneous Sources.
Abbreviations: CI, confidence interval; SMD, standardized mean difference.

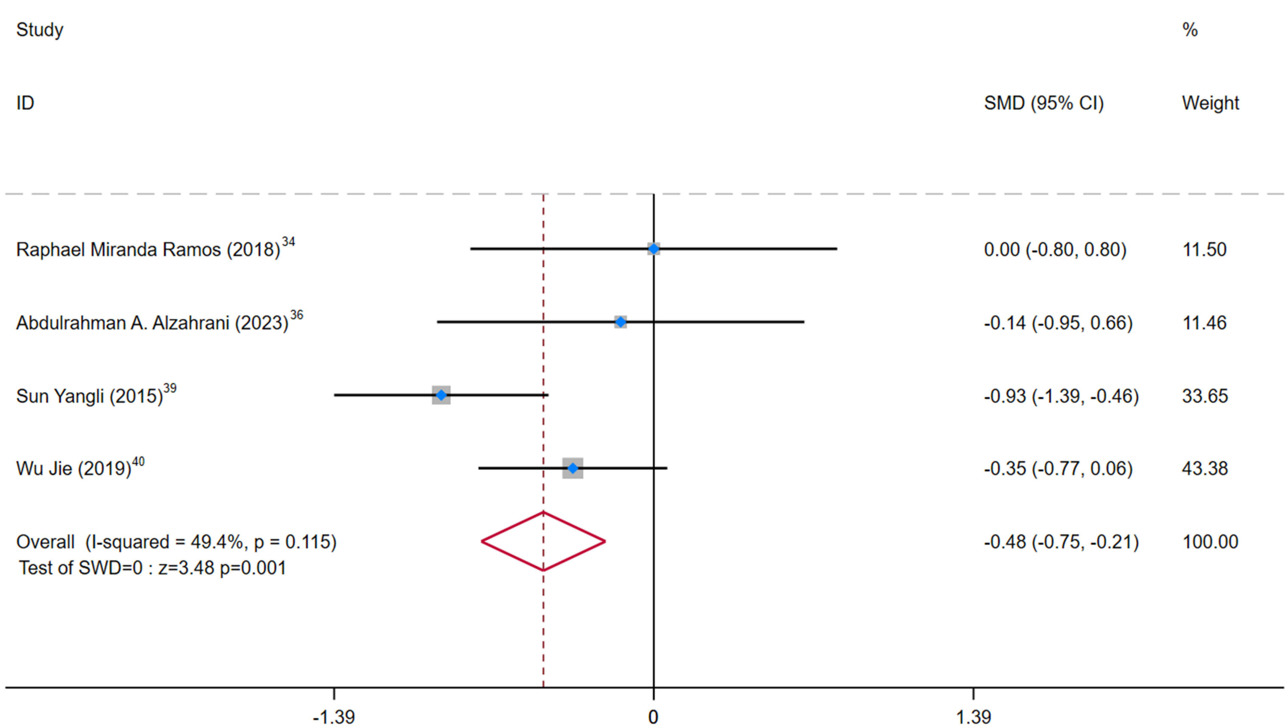

Figure 5 Effect of Aerobic Exercise on DBP.
Abbreviations: CI, confidence interval; SMD, standardized mean difference.

Effect of Aerobic Exercise on Heart Rate

Four studies mentioned the effect of aerobic exercise on HR in older patients with essential hypertension.[33,34,36,39] A single aerobic exercise trial in older patients with hypertension revealed that HR measured after the cool-down period (84.30 ± 7.60) was significantly greater in the exercise group than at baseline (70.20 ± 10.00), 20 (68.70 ± 11.60) and 40 (69.00 ± 10.20) minutes after exercise, but the control group did not change.[33] The results of the heterogeneity analysis results of the remaining three studies revealed that the heterogeneity was high (P <0.001, I^2 = 90.1%), and the random effects model was used. Moreover, the results also revealed that the intervention group was better than the control group at reducing HR, and the difference was statistically significant (SMD = −1.78, 95% CI = −3.31 to −0.24, P =0.024) (Figure 6).

Effect of Aerobic Exercise on Cardiorespiratory Fitness

Only two studies have assessed the effect of aerobic exercise on cardiorespiratory fitness using the 6-minute walk test (6MWT).[32,35] The results of the heterogeneity analysis were P =0.964, I^2 = 0.0%, expanded with fixed effects models. The results revealed a statistically significant difference in 6MWT between the control and intervention groups (SMD =0.71, 95% CI =0.24 to 1.18, P =0.003) (Figure 7).

Discussion

A comprehensive review of the studies included in this review revealed that various forms of aerobic exercise, including 120–150 minutes per week of low- to moderate-intensity activities such as step exercises, jogging, cycling, and aquatic exercises, effectively reduced both 24-hour and daytime ABP as well as office SBP. Studies have demonstrated that appropriate exercise in older patients with hypertension can stimulate the vascular motor center, and restrict the hyperfunction of the sympathetic nerve and the level of vascular oxidative stress. This in turn improves the function of the vascular endothelium, reduces peripheral vascular resistance, and has the effect of decreasing BP.[42] For patients with refractory hypertension, the implementation of a 12-week regimen of consistent aerobic exercise significantly improves the treatment of central arterial BP, reduces BP volatility, and helps optimize the levels of biomarkers associated with cardiovascular disease risk, which primarily involves 40 minutes of walking and cycling three times

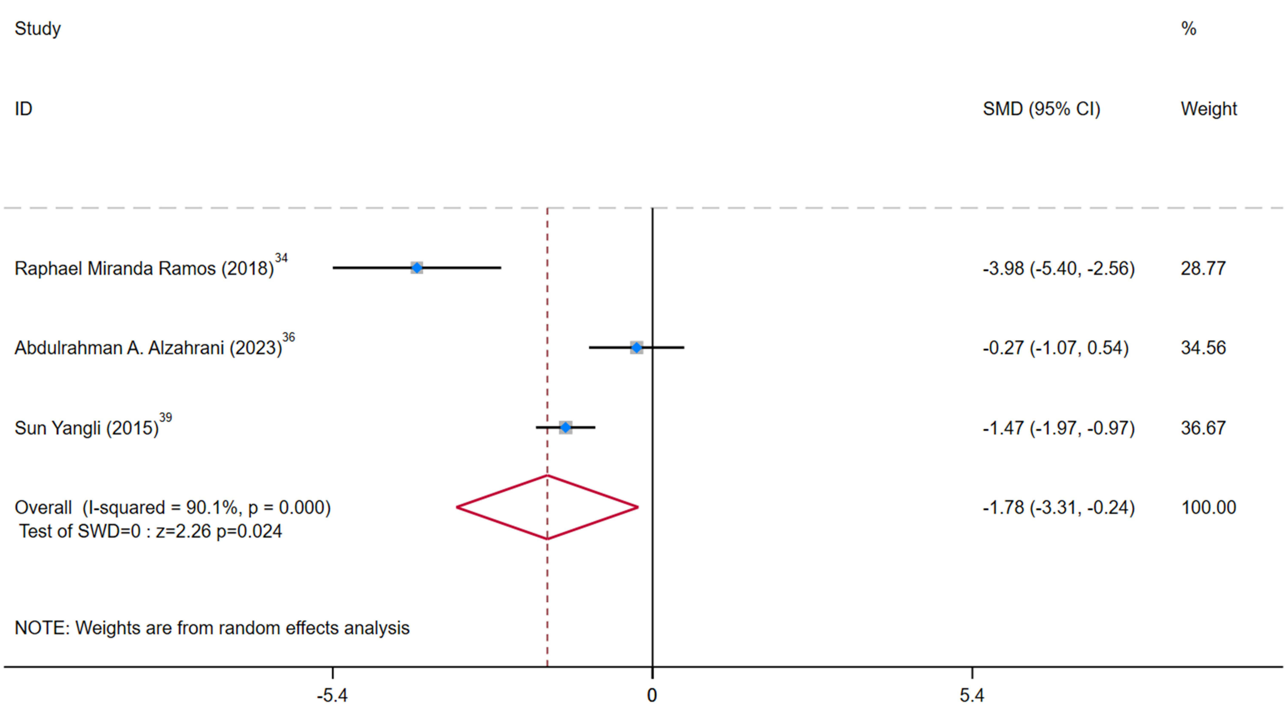

Figure 6 Effect of Aerobic Exercise on HR.

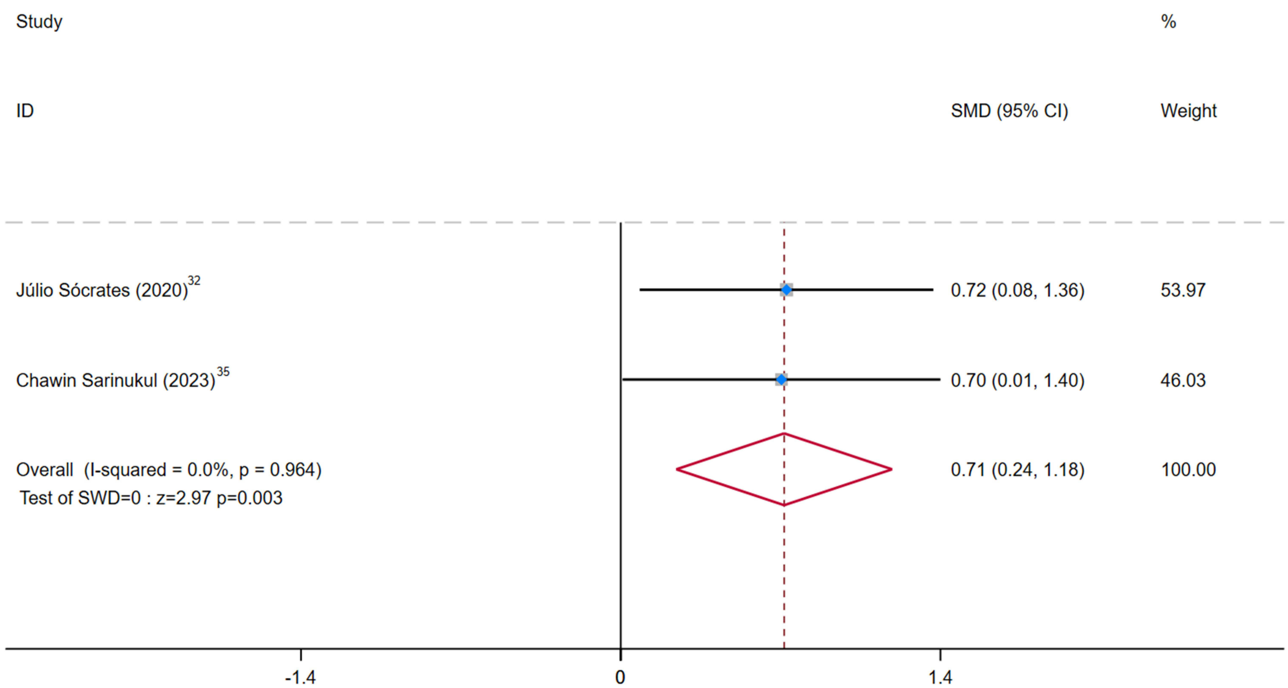

Figure 7 Effect of Aerobic Exercise on Cardiorespiratory Fitness.
Abbreviations: CI, confidence interval; SMD, standardized mean difference.

per week, incorporating a progressive increase of 5 minutes in duration and a 5.0% increase in VO_2max, commencing with an initial 20-minute session at 50.0% VO_2max intensity, ultimately reaching up to 40 minutes at 70.0% VO_2max.[43]

Furthermore, our findings suggest that 120–150 minutes of low-to-moderate weekly aerobic exercise can effectively lower HR. In a RCT analysis, low- to moderate-intensity aerobic exercise, with an intensity corresponding to 30% to 60% of HRmax, was found to produce immediate benefits in reducing BP among older patients with hypertension.[32] In a meta-analysis of RCTs, an analysis of the dose-related effect of aerobic exercise on the resting HR revealed that the resting HR decreased proportionally with increasing duration of aerobic exercise, but the maximum value did not change significantly.[29] The cause of the decline in the resting HR could be that heart activity is influenced by the combined effect of the sympathetic nerve and the vagus nerve. After aerobic exercise training, the activity of the sympathetic nerve is attenuated, whereas the action of the vagus nerve is increased, which restricts heart activity and decelerates the heartbeat.[44]

In our systematic review, an increase in 6MWT performance was observed in the intervention group compared with the control group.[32,35] Participants in the exercise group engaged in aerobic exercise in an SSTI, autonomously allowing them to adjust their pace at any point during the activity. The implementation of SSTIs resulted in improved 6MWT scores among older adults, indicating that SSTIs enhance cardiorespiratory fitness and may offer potential cardioprotective benefits.[32] It is widely recognized that moderate-intensity aerobic exercise contributes to increased cardiorespiratory fitness in older individuals. One study suggested a marked positive correlation between 6MWT alterations and aerobic exercise, which also contributed to the postponed onset of fatigue.[45] Future RCTs should explore the long-term impacts of aerobic exercise on cardiovascular and health-related consequences in older patients with hypertension.[46,47]

The intensity of exercise is usually represented by the percentage of VO_2max used by an individual during the exercise process. Furthermore, the improvement in exercise endurance was concomitant with an increase in the respiratory buffer index after aerobic exercise. In this study, the effectiveness of moderate-intensity aerobic exercise on the VO_2max of obese hypertensive older adults was also reported in this study.[38] Although the number of studies included in this review is insufficient to support research on the impact of exercise intensity on hypertension among older patients, in an analysis of a RCT, low-intensity cycling exercise at 50% VO_2max for 45 minutes significantly reduced ABP in older hypertensive patients 22 hours after exercise.[48] Furthermore, healthcare professionals should advise older hypertensive patients about the importance of regularly evaluating their health status and adjusting their activity levels accordingly. It is recommended to maintain a slightly elevated respiratory rate above normal without experiencing significant fatigue the following day.[49] In addition to this, the intensity of aerobic exercise of older people can also be gauged by whether they can continue talking during the activity. If conversation cannot be maintained, this indicates that the intensity of exercise may be excessive.[50]

However, with respect to reporting adverse events, only one trial in the included literature mentioned that a participant was excluded due to knee pain during exercise.[32] A 5- to 10-minute warm-up and cooling program should be included during each aerobic exercise session, along with stretching exercises when older patients with hypertension are about to finish the exercise to prevent injuries and other adverse events. Due to the particularity of the research subjects in this study, older hypertensive patients face a more diverse set of cardiovascular disease risk factors. Older people face an elevated risk of musculoskeletal injuries during physical activity, as well as a higher likelihood of more severe yet less prevalent complications such as arrhythmias, cardiac arrest, and myocardial infarction. Therefore, to ensure that researchers and clinicians can comprehensively and accurately assess the safety and efficacy of aerobic exercise in older patients with hypertension, future studies, in their design and execution, should not only focus on their potential benefits but also consider any possible adverse events that may occur. Even if the study results indicate that no significant adverse events were observed under specific research conditions, such information should still be explicitly reported.

A systematic review suggested that aerobic exercise combined with resistance exercise could reduce BP, the body mass index, fat mass, glucose, total cholesterol and triglyceride levels.[51] Our study primarily explored the impact of different types of aerobic exercise on the health management of older patients with hypertension, and the control group included in the trial mainly received general care or standard treatment, without any additional exercise-based interventions. Future systematic review should focus on integrating aerobic exercise with various forms of group interventions or comparing the differences between the effects that aerobic exercise produces in older hypertensive patients and other types of exercise interventions, such as aerobic exercise versus resistance exercise, and aerobic exercise versus isometric exercise.

Limitations to our study should also be considered. A limited number of trials in our study met the inclusion criteria and the number of subjects studied was insufficient. Therefore, in the future, RCTs with larger sample sizes is essential to validate and amplify the observed effects, in order to generalize the results to more populations. Another limitation was the limited duration of the aerobic exercise training interventions included in the studies. Although this study has indicated that aerobic exercise can reduce resting BP to a certain extent, a longer intervention period may have a different or more notable effect on BP control. Future RCTs should explore the impacts of prolonged exercise training on BP in older adults. In the included studies, only the direct impact of aerobic exercise training on participants was considered, without considering long-term follow-up evaluations after the completion of aerobic exercise. Long-term follow-up assessments are essential to evaluate the sustainability of health improvements in older people with hypertension and to evaluate the long-term effectiveness of interventions. Consequently, future RCTs should prioritize an extended long-term follow-up period. The primary factor contributing to the elevated risk of bias in the literature reviewed in this study is that both subjects and interveners were not blinded during the experiment and the measurement process was not blinded, which was mainly due to the fact that the exercise intervention required active participation of subjects in the training (mastery of the movement and cooperation with the training program), which resulted in the inability to implement effective blinding of subjects and interveners, which, in turn, affected the concealment of the random allocation. Although the presence of implementation bias and measurement bias is prevalent in exercise interventions, it is imperative that these issues are addressed in future trials to increase the quality of the evidence.

Conclusion

Aerobic exercise, as a safe and feasible way to exercise, can effectively lower BP levels and slow HR, thus improving cardiorespiratory function and strengthening overall health status to a certain extent. Individuals 60 years and older should engage in 120–150 min of low to moderate intensity aerobic exercise per week. The intensity of exercise should be maintained at 40–75% HRmax or 40–60% VO_2max. In addition, both the duration and intensity of exercise should increase progressively over time. For the duration of each session, a 5- to 10-minute warm-up and cool-down routine was included. The guidelines recommend that future research should emphasize an integrated approach that involves aerobic exercise, balance training, and flexibility exercises, in addition to moderate to high intensity strength training conducted at least three times per week, to increase functional capacity and mitigate the risk of falls. Therefore, based on the results of this study and the available clinical evidence, it is recommended that a structured aerobic exercise program be integrated into a geriatric hypertension management program. However, it is crucial to emphasize that while aerobic exercise can demonstrate these remarkable benefits in the short term, limitations such as study heterogeneity and short-term intervention duration should be addressed in future studies, and it is recommended that RCTs should focus on long-term adherence, safety, and optimal intensity threshold studies in the older patients and reduce implementation bias and measurement bias through blinded evaluations with a central randomized design to improve the quality of evidence.

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Disclosure

The authors declare no conflicts of interest in this work.

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