Migration Letters

Volume: 19, No: S5 (2022), pp. 1636-1650

ISSN: 1741-8984 (Print) ISSN: 1741-8992 (Online)

www.migrationletters.com

A Systematic Review Of Effectiveness Of Physical Activity In The Prevention Of Hypertension

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Abstract:

Background: *While numerous individual studies have investigated the impact of physical activity on blood pressure, a comprehensive synthesis of existing evidence is crucial for drawing more robust conclusions and informing clinical and public health guidelines. This systematic review aims to provide a thorough examination of the effectiveness of physical activity in preventing hypertension.*

Methodology: *A systematic and comprehensive search strategy was employed to identify relevant studies for this review. A total of 12,046 articles were i[1]nitially identified through searches of databases including PubMed, Embase, Scopus, and the Cochrane Library from inception to 2023. Data extraction was performed independently by two reviewers using a standardized form, encompassing study characteristics, participant details, intervention specifics, and relevant outcomes.*

Results: *We identified a total of 12,046 articles through our comprehensive searches. Following a meticulous screening process, 17 articles were deemed suitable for inclusion in this review. The meta-analysis revealed that moderate-intensity Leisure-Time Physical Activities (LTPA) of various types led to a significant reduction in systolic blood pressure (SBP) when compared to the non-intervention control group. The mean difference (MD) was -5.4 mm Hg, with a 95% confidence interval (CI) of -8.1 to -2.7 (P = 0.0001, I2 = 87.9%, nine trials, n = 531)*

Conclusion: *The available evidence suggests that engaging in moderate-intensity leisure-time physical activity (LTPA) may lead to a reduction in both systolic and diastolic blood pressure among individuals with hypertension.*

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Introduction:

Hypertension, or elevated blood pressure, represents a major global health concern due to its widespread prevalence and association with adverse cardiovascular outcomes [1,2]. As a leading risk factor for heart disease, stroke, and other cardiovascular complications, hypertension places a substantial burden on healthcare systems worldwide [1]. Given its multifactorial etiology, incorporating lifestyle modifications has emerged as a pivotal approach in hypertension prevention and management [3,4]. Among these lifestyle interventions, physical activity has garnered significant attention for its potential to mitigate the development and progression of hypertension [5].

The relationship between physical activity and blood pressure regulation has been the subject of extensive research, with a growing body of evidence suggesting a protective role for regular exercise in maintaining cardiovascular health. Physical activity encompasses a spectrum of behaviors, ranging from structured exercise routines to daily activities such as walking, gardening, and household chores [6]. This diversity allows for the exploration of various modalities and intensities of physical activity in relation to hypertension prevention.

While numerous individual studies have investigated the impact of physical activity on blood pressure, a comprehensive synthesis of existing evidence is crucial for drawing more robust conclusions and informing clinical and public health guidelines. This systematic review aims to provide a thorough examination of the effectiveness of physical activity in preventing hypertension, synthesizing findings from relevant studies to offer a comprehensive overview of the current state of knowledge in this field.

Methodology:

A systematic and comprehensive search strategy was employed to identify relevant studies for this review. A total of 12,046 articles were initially identified through searches of databases including PubMed, Embase, Scopus, and the Cochrane Library from inception to 2023. Following a meticulous screening process, 17 articles were deemed suitable for inclusion. Two independent reviewers conducted the initial screening of titles and abstracts, with full-text articles then assessed for inclusion based on pre-defined criteria. The included studies comprised 14 randomized control trials, two quasi-experimental studies, and three cross-sectional studies. The Cochrane Collaboration's Risk of Bias tool and the Newcastle-Ottawa Scale were utilized for assessing the methodological quality of randomized control trials and other study designs, respectively. Data extraction was performed independently by two reviewers using a standardized form, encompassing study characteristics, participant details, intervention specifics, and relevant outcomes. A meta-analysis was conducted for studies with comparable designs and outcomes, utilizing random-effects models to account for potential heterogeneity. Subgroup analyses were performed when feasible, and sensitivity analyses were conducted to assess the robustness of the results. Potential publication bias was evaluated through visual inspection of funnel plots and, when appropriate, statistical tests such as Egger's test. Ethical approval was not required as this study is based on a systematic review of published literature. The methodology adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure transparency and completeness in reporting the findings.

Results:

We identified a total of 12,046 articles through our comprehensive searches. Following a meticulous screening process, 17 articles were deemed suitable for inclusion in this review (Fig. 1) [7–23]. These selected articles comprised 14 randomized control trials [7–14,16,19–23], two

quasi-experimental studies, and three cross-sectional studies [15,17,18], with details and characteristics provided in table 1.

The studies spanned across 14 different countries, including two each from the USA [10,13], the UK [7,16], and Brazil [8,12], and one each from China [17], Hong Kong [11], Kuwait [18], Japan [23], Korea [19], Iran [22], Nepal [9], Bangladesh [15], New Zealand [14], Indonesia [21], and Sweden [20]. Participants in the selected studies ranged in age from 18 to 80 years. Among the 17 articles, 11 studies included both male and female participants, while five studies exclusively focused on female participants [10,16,19,22,23], and one study exclusively on male participants [8].

The interventions primarily involved various types of Leisure-Time Physical Activities (LTPA), such as walking (in five studies [7,8,10,13,14]), yoga (in two studies [9,20]), and one study each on progressive muscle relaxation exercise [21], stair climbing [19], circuit training and chair-based exercise [23], Quinton treadmill [22], beach tennis [12], swimming [16], and qigong [11]. These activities were categorized into moderate-intensity exercises, including walking, yoga, muscle relaxation exercise, stair climbing, and moderate-intensity swimming, and high-intensity exercises, such as running, soccer, beach tennis, and high-intensity swimming. The duration of these exercise interventions varied, ranging from six days to 26 weeks.

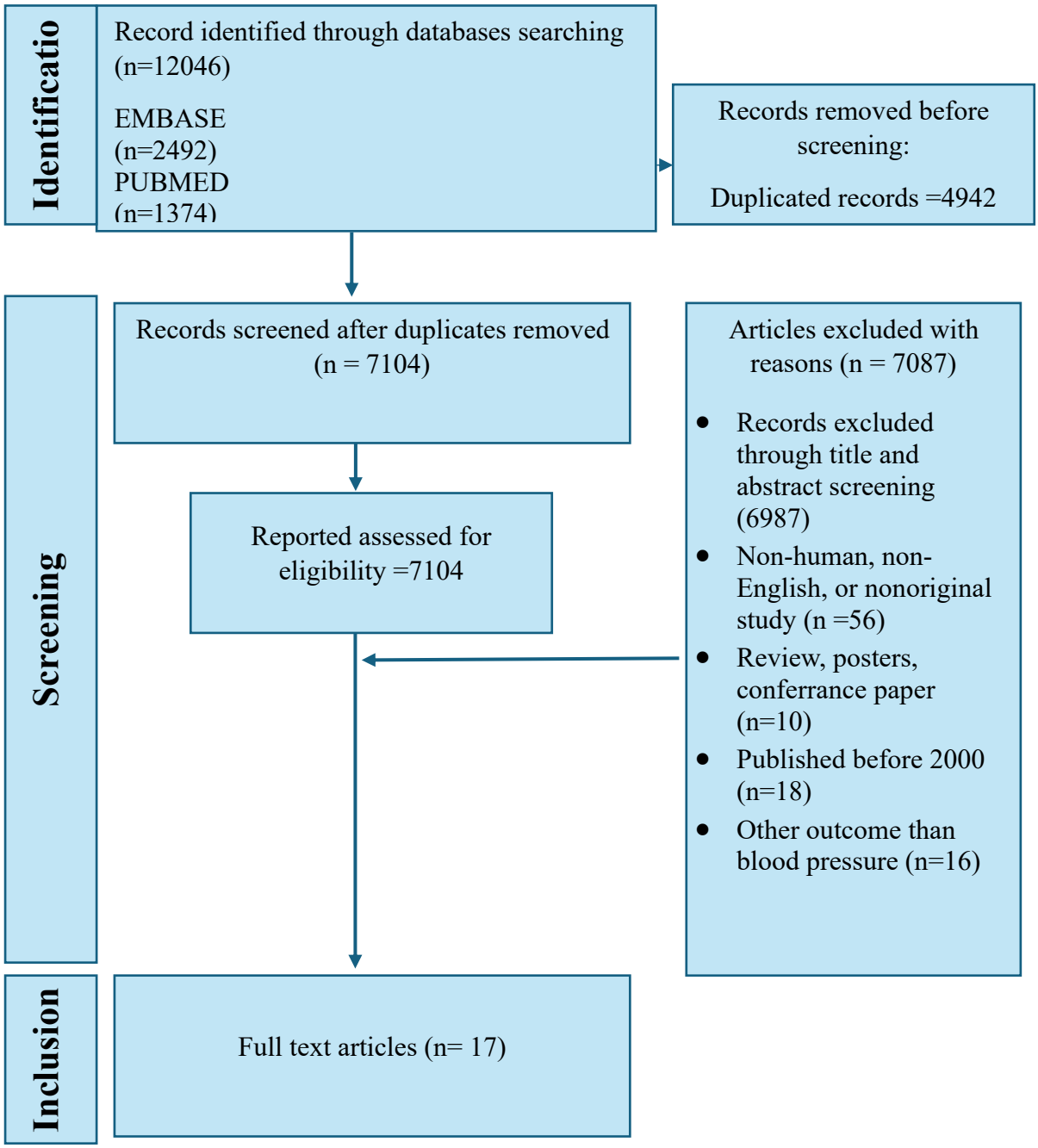


Figure 1: The PRISMA figures showing the steps to choose the studies for systematic review

The quality assessment scores for the randomized control trials (RCT) ranged from 7 to 12 out of 13, while the quasi-experimental studies scored 7 and 5 out of 9 [8,21], and the cross-sectional studies scored 7 out of 8. Quality was evaluated across domains, including inclusion criteria, study subjects and setting details, reliability of exposure measurement, criteria of measurement, identification and handling of confounders, outcomes measurement methods, and statistical analyses. The reliability of exposure measurement was deemed unclear in both quasi-experimental studies, while all other criteria were rated positively in both studies.

Among the 12 randomized control trials (RCTs), a meta-analysis focused on studies involving moderate-intensity physical activity with a weekly duration of 150 minutes, non-crossover trial design, and a non-exercise control group. Nine studies meeting these criteria were identified [7,9,10,13,16,19,20,22,23].

The meta-analysis revealed that moderate-intensity Leisure-Time Physical Activities (LTPA) of various types led to a significant reduction in systolic blood pressure (SBP) when compared to the non-intervention control group. The mean difference (MD) was -5.4 mm Hg, with a 95% confidence interval (CI) of -8.1 to -2.7 (P = 0.0001, I2 = 87.9%, nine trials, n = 531) (Figure 2). Sensitivity analysis indicated a slightly larger effect when including cross-over trials (MD -5.7 mm Hg, 95% CI -8.0 to -3.4, P < 0.000, I2 = 84.9%, 11 trials, n = 617). Excluding studies with uncertain randomization and allocation reduced the effect (MD -4.0 mmHg, 95% CI -7.7 to -0.3, P < 0.03, I2 = 91.2%, 11 trials, n = 617). Subgroup analysis focusing on leisure-time walking showed a mean SBP reduction of -8.4 mmHg (95% CI -13.4 to -3.3, P = 0.001, I2 = 87.0%, 3 trials, n = 128) (Figure 3).

For mean diastolic blood pressure (DBP), moderate-intensity LTPA across all types led to a reduction of -4.8 mm Hg (95% CI -8.4 to -1.2, P = 0.01, I2 = 95.7%, nine trials, n = 531) compared to the non-intervention control group (Figure 4). Sensitivity analysis including cross-over trials (MD -4.5 mmHg, 95% CI -7.5 to -1.6, p = 0.00, I2 = 94.2%, 11 trials, n = 617) and excluding studies with uncertain randomization and allocation (MD -3.5 mmHg, 95% CI -6.4 to -0.5, p = 0.020, I2 = 90.8%, five trials, n = 346) showed similar results. Walking during leisure time resulted in a mean DBP reduction of -5.0 mm Hg (95% CI -8.2 to -1.8, P = 0.02, I2 = 77.2%, three trials, n = 128) (Figure 5).

Table 1: General characteristics of the included studies

Authors	Year of publication	Design	Country	No. of study (Total, intervention/ control)	Male (Total, intervention/ control)	Age Intervention/ control
Cooper [7]	2000	Randomised control trial	UK	90(48/42)	72 (39/33)	46.2/49.4
Nóbrega [8]	2013	Randomised control trial	Brazil	18	18	58.6
Mohr [16]	2014	Randomised control trial	UK	62	0	35 to 49
Yang [17]	2019	Cross-sectional	China	780	383	> 65
Alsairafi [18]	2010	Cross-sectional	Kuwait	240	87	55.3
Alexi [19]	2019	Randomised control trial	Korea	100	0	NA
Wolff [20]	2016	Randomised control trial	Sweden	191	92	34-79
Sulaeman [21]	2020	Randomised control trial	Indonesia	60 (30/30)	17 (12/5)	26-55
Shakoor [22]	2020	Randomised control trial	Iran	45	0	45
Miura [23]	2015	Randomised control trial	Japab	137 (29/108)	0	60-88
Khadka [9]	2013	Randomised control trial	Nepal	14 (7/7)	NA	44.9/42.2
Moreau [10]	2001	Randomised control trial	USA	24	0	NA
Cheung [11]	2005	Randomised control trial	Hong Kong	88	37	18-75
Carpes [12]	2021	Randomised control trial	Brazil	24	12	48.4
Sohn [13]	2007	Randomised control trial	USA	18 (8/10)	6 (2/4)	46.9/42.0

Scott [14]	2006	Randomised control trial	New Zealand	1117	16	53
Islam [15]	2023	Cross-sectional	Bangladesh	307	153	30-75

Figure 2: systolic blood pressure among all types of moderate intensity leisure-time physical activities vs non-intervention control

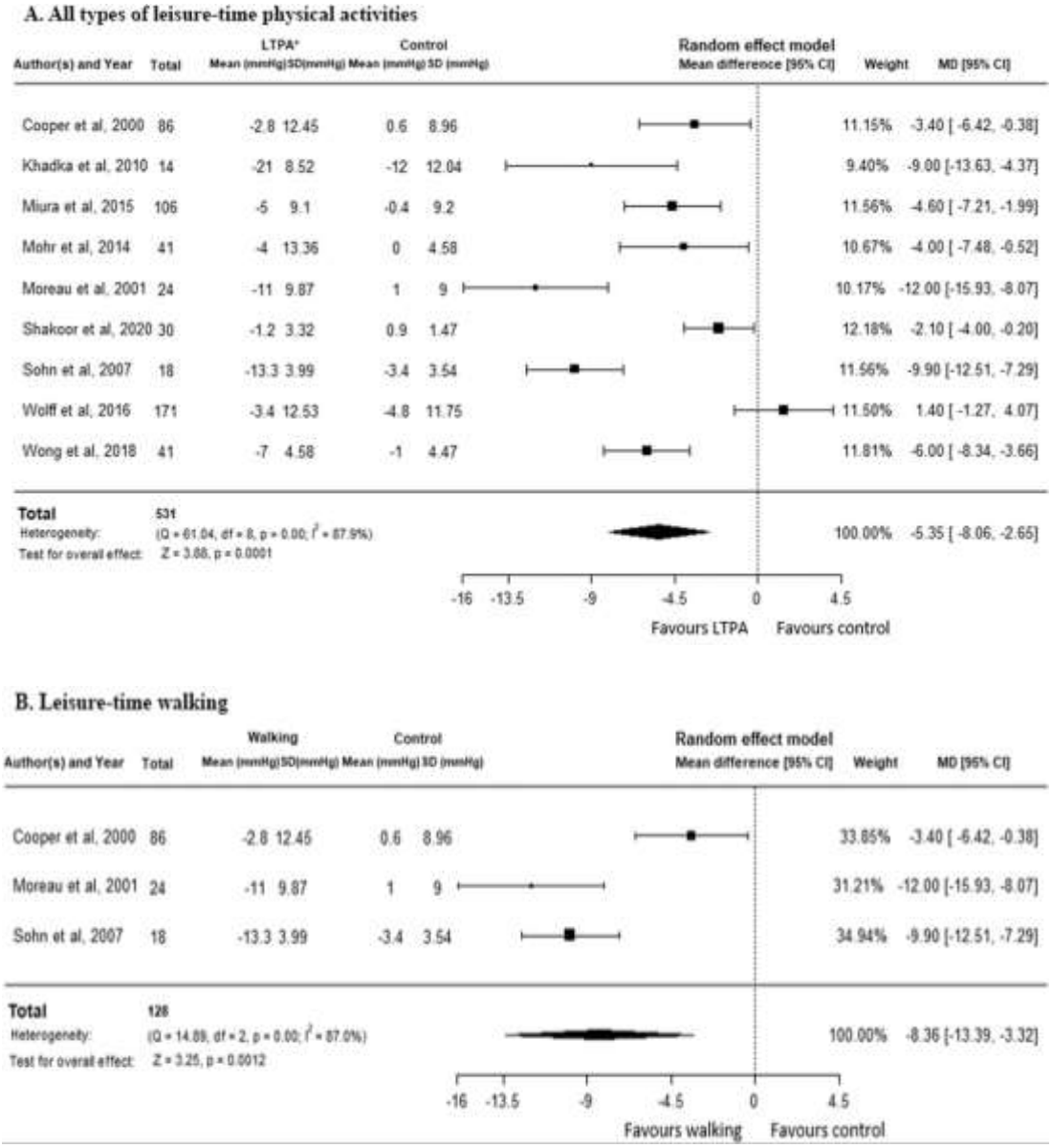


Figure 3: systolic blood pressure among Leisure-time walking vs non-intervention control.

Overall, the synthesized evidence suggests that moderate-intensity LTPA can effectively reduce both systolic and diastolic blood pressure in adults with hypertension. However, the certainty of evidence is considered low according to the GRADE approach (Table 2).

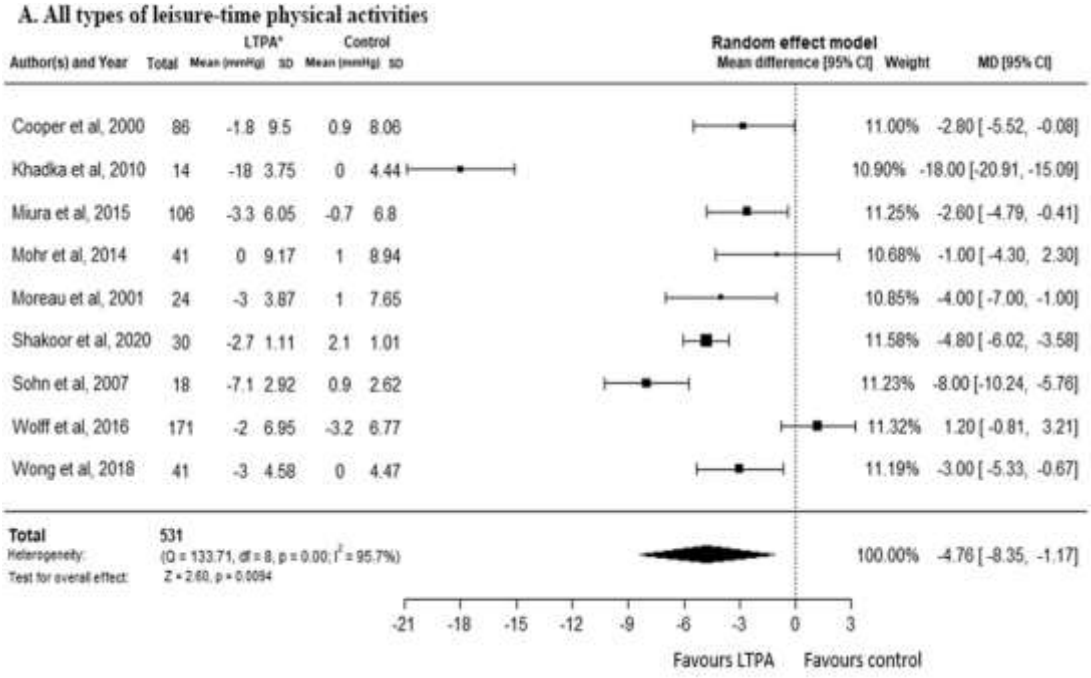
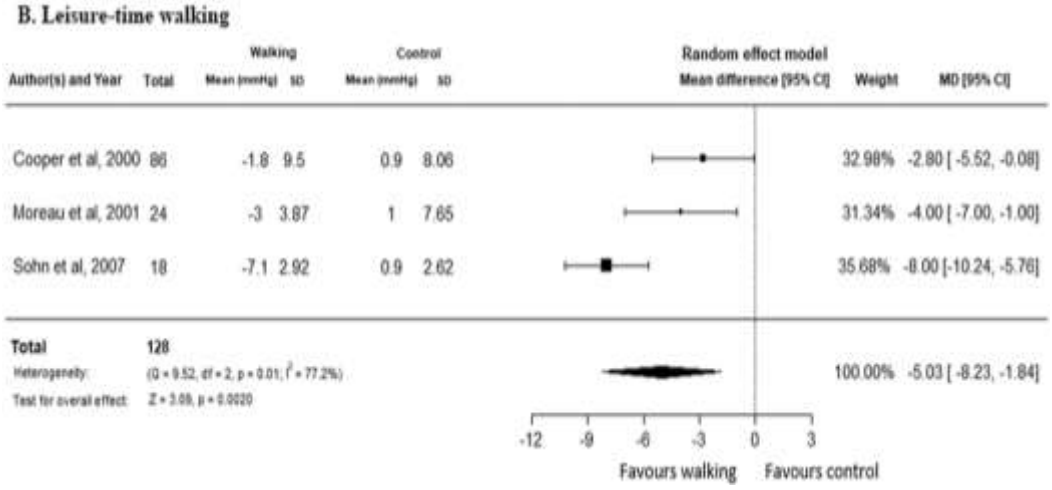


Figure 4: Diastolic blood pressure among all types of moderate intensity leisure-time physical activities vs non-intervention control.

Figure 5: Diastolic blood pressure among leisure-time walking vs non-intervention control.

Table 2: Summary finding of moderate-intensity leisure-time physical activity (all types) versus non-interventional control.



Types of leisure-time physical activity	**Outcomes**	**Anticipated absolute effects (95% CI)**	**No of the participants (trials)**	**Comments**
All types of moderate-intensity LTPA	Systolic blood pressure	MD −5.35 mm Hg (−8.06 to −2.65)	531 (9 RCTs)	Reduce systolic blood pressure
All types of moderate-intensity LTPA	Diastolic blood pressure	MD −4.76 mm Hg (−8.35 to −1.17)	531 (9 RCTs)	Reduce diastolic blood pressure
Walking	Systolic blood pressure	MD −8.36 mm Hg (−13.39 to −3.32)	128 (3 RCTs)	Reduce systolic blood pressure
Walking	Diastolic blood pressure	MD −5.03 mm Hg (−8.23 to −1.84)	128 (3 RCTs)	Reduce diastolic blood pressure

Studies not included in the meta-analysis consistently reported significant reductions in both SBP and DBP due to Leisure-Time Physical Activity (LTPA) [8,11,12,14]. One study compared qigong with conventional exercise, showing a non-significant difference in SBP and DBP [11]. Another study comparing walking with soccer found no significant difference in controlling hypertension [8]. Three cross-sectional studies indicated that a sedentary lifestyle was associated with higher blood pressure levels. One study reported lower DBP associated with 2 to 4 hours of daily leisure-time walking, though not statistically significant for SBP [17]. Another study found that individuals engaging in relaxing/simple activities had higher odds of uncontrolled hypertension than those involved in moderate/vigorous activities [18]. Additionally, a study on recreational sports found a non-statistically significant lower SBP of -3.9 mmHg [15].

Moderate-intensity LTPA, encompassing various types, was associated with a reduction in mean heart rate by -2.7 beats/min (95% CI -4.8 to -0.6, P = 0.01, I2 = 66.9%, six trials, n = 256). Sensitivity analysis showed little difference, with mean heart rate reductions of -2.94 (95% CI -4.76 to -1.13, P = 0.0015, I2 = 62.9%, seven trials, n = 318) when including cross-over trials and -1.94 (95% CI -3.38 to -0.49, P = 0.0085, I2 = 0%, two trials, n = 71) when excluding studies with unsure randomization and allocation.

Regarding mean atrial pressure, three studies examined the effect of LTPA [16,21,22], with two reporting a significant reduction [21,22], and one study finding an insignificant effect for leisure-time swimming [16].

Discussion:

The findings from this meta-analysis encompassing nine randomized controlled trials involving 531 individuals with hypertension indicate a significant reduction in both systolic and diastolic blood pressure through engaging in moderate-intensity leisure-time physical activity (LTPA) compared to non-intervention controls, which typically involved usual activities. Notably, the blood pressure-lowering effects of LTPA persist even when studies with unclear randomization and allocation bias are excluded, as confirmed by sensitivity analyses. Additionally, engagement in LTPA, particularly leisure-time walking, is associated with a decrease in heart

rate. Distinctly, the study discerns that high-intensity physical activities, as observed in the high-intensity and soccer groups, result in a more pronounced reduction in systolic blood pressure compared to lower/moderate intensity activities, exemplified by the lower intensity and walking groups [8,22]. It is noteworthy that the degree of blood pressure reduction, measured in millimeters of mercury (mmHg), is not contingent upon the duration of the intervention. Both short-term (10 days) brisk walking intervention and long-term (26 weeks) walking intervention exhibit substantial reductions in systolic blood pressure, amounting to -11.2 mmHg and -8.5 mmHg, respectively [13,14].

Engaging in physical activity has been demonstrated to positively impact various biological processes, contributing to the mitigation of cardiovascular risk factors. Among individuals with hypertension, physical activity plays a role in lowering blood pressure by diminishing sympathetic nerve activity [24]. This reduction is attributed to a decrease in the release of norepinephrine, a mediator of vasoconstriction, thereby lowering vascular resistance [25]. Additionally, physical activity enhances insulin sensitivity and can diminish insulin-mediated sympathetic activity, further influencing blood pressure regulation [24]. Moreover, physical activity diminishes vascular responsiveness to endothelin-1, an additional vasoconstrictor in individuals with hypertension [26]. Furthermore, physical activity promotes endothelial-dependent vasodilation by augmenting the production of nitric oxide and facilitating acetylcholine infusion [27,28]. Vascular remodeling is another notable effect of physical activity, involving the formation of new arteries, an increase in cross-sectional area, and the enlargement of existing veins and arteries. This restructuring contributes to a reduction in peripheral resistance, ultimately influencing blood pressure regulation [29]. In the realm of heart rate reduction, the mechanisms associated with physical activity remain unclear, as highlighted by Bahrainy et al. [30]. Their research indicates that neither an increase in parasympathetic tone nor a reduction in beta-adrenergic stimulation due to physical activity can consistently account for the observed decrease in heart rate [31]. Alternatively, Tyagi et al. propose that an augmented parasympathetic output, potentially induced by activities such as yoga, may contribute to a reduction in heart rate [32].

Our study findings reveal that engaging in leisure-time physical activity (LTPA) is associated with a reduction in both systolic blood pressure (SBP) and diastolic blood pressure (DBP). However, the GRADE assessment underscores low certainty in the evidence, primarily attributed to significant heterogeneity among the randomized controlled trials (RCTs) and imprecision in the data [33]. Notably, the observed heterogeneity may stem from variations in LTPA types, geographic locations, and participant gender. It is essential to recognize that geographic factors such as latitude, ambient temperature, and solar radiation vary, potentially influencing the heterogeneous response to LTPA and its impact on blood pressure [33]. Gender differences in the effects of LTPA on blood pressure could be attributed to variations in the metaboreflex, insular gyral response, and hormonal influences, such as estrogen [34,35]. Understanding the heterogenous effects of different LTPA types on blood pressure warrants further exploration. Notably, the included articles in the meta-analysis did not categorize the impact of LTPA on blood pressure based on common effect modifiers for hypertension and LTPA, such as age, sex, body mass index, and socio-economic status. Nevertheless, these articles acknowledged these factors as confounders during their analyses [7,9,10,13,20,23]. Addressing the causative factors for the varied effects of LTPA types on blood pressure requires more in-depth investigation.

A prior investigation emphasized the association between lowering blood pressure and a subsequent decrease in mortality from cardiovascular diseases, highlighting the significant impact of even modest reductions. Specifically, a 2 mm Hg reduction in systolic blood pressure (SBP) was linked to a noteworthy 10% decrease in stroke mortality and a 7% reduction in

vascular risk mortality [36]. In our study, we observed that engaging in moderate-intensity leisure-time physical activity (LTPA) resulted in a substantial reduction in SBP mean difference (MD) by -5.35 mm Hg (95% CI: -8.06 to -2.65). This magnitude of reduction surpasses the previously established 2 mm Hg threshold, underscoring the clinical significance of our findings. Importantly, this suggests that LTPA could serve as an effective and valuable complement to, or even an alternative to, pharmacological treatments for individuals with hypertension. Notably, it is essential to recognize that the effects of physical activity do not persist in the long term, emphasizing the importance of regular and sustained physical activity. The recommended guideline of 150 minutes of physical activity per week [37] aligns with the parameters of our meta-analysis, which specifically focused on interventions involving this duration. Consequently, the outcomes of this study provide valuable insights for formulating LTPA recommendations tailored to individuals with hypertension, reinforcing the potential role of regular physical activity in managing blood pressure.

Our systematic review, in alignment with other reviews in the field [38–42], highlights a broad spectrum of physical activity interventions characterized by differences in participant willingness and intensity. Notably, aerobic exercise emerged as an effective intervention, resulting in a reduction of both systolic blood pressure (SBP) by -5.4 mm Hg and diastolic blood pressure (DBP) by -3 mm Hg among individuals with hypertension [43]. Consistent with these findings, another meta-analysis demonstrated that moderate-intensity continuous training led to a reduction in SBP by 3.7 mm Hg and DBP by 2.41 mm Hg in the same population [44]. Our study aligns with previous meta-analyses in suggesting that leisure-time physical activity (LTPA) yields reductions in both SBP and DBP, offering a comprehensive perspective on the benefits of diverse physical activity interventions. Importantly, our investigation specifically underscores the blood pressure-lowering effects of walking, reinforcing the findings of a Cochrane review that also reported reductions in both SBP and DBP associated with walking [45]. These consistent findings across various physical activity interventions contribute to a robust understanding of the positive impact of LTPA on blood pressure management among individuals with hypertension.

This systematic review and meta-analysis exhibit notable strengths. Firstly, adherence to rigorous standards is demonstrated by the application of a robust methodology, adhering to the gold standard of research design, namely randomized controlled trials (RCTs), for conducting the meta-analysis. This ensures the reliability and validity of the research outcomes. However, several limitations must be acknowledged. A noteworthy constraint lies in the fact that a considerable number of studies did not provide explicit details about their randomization processes. Despite this, a sensitivity analysis excluding studies with unclear randomization was conducted, revealing a significant reduction in both systolic (SBP) and diastolic blood pressure (DBP). High heterogeneity among the included studies is acknowledged, and to mitigate this, a random-effects model was employed. While the meta-analysis considered all types of LTPA collectively, numerous subgroup and sensitivity analyses were conducted to address this potential limitation. Furthermore, the restriction to articles published solely in the English language may introduce language bias, as evidenced by the exclusion of five non-English articles during full-text assessment. Lastly, the limited sample size in the majority of the included studies is recognized as a factor diminishing the precision of effect estimates, cautioning against broad generalizations. These limitations highlight the nuanced nature of the findings and underscore the need for careful interpretation within the context of these constraints.

The available evidence suggests that engaging in moderate-intensity leisure-time physical activity (LTPA) may lead to a reduction in both systolic and diastolic blood pressure among individuals with hypertension. It is important to note that the certainty of this evidence is

considered low. Despite this, the promotion of moderate-intensity physical activity during recreational time is recommended for individuals with elevated blood pressure as it shows potential in lowering blood pressure levels. However, it is emphasized that additional studies are needed to deepen our understanding of the differential effects among various types of LTPA in the context of blood pressure control. This acknowledgment underscores the need for further research to refine recommendations and tailor interventions for optimizing the management of hypertension through physical activity.

References:

1. Mills KT, Stefanescu A, He J. The global epidemiology of hypertension. Nat Rev Nephrol. 2020;16(4):223-237. doi:10.1038/s41581-019-0244-2

2. Fuchs FD, Whelton PK. High Blood Pressure and Cardiovascular Disease. Hypertension. 2020;75(2):285-292. doi:10.1161/HYPERTENSIONAHA.119.14240

3. Carey RM, Muntner P, Bosworth HB, Whelton PK. Prevention and Control of Hypertension. J Am Coll Cardiol. 2018;72(11):1278-1293. doi:10.1016/j.jacc.2018.07.008

4. Unger T, Borghi C, Charchar F, et al. 2020 International Society of Hypertension Global Hypertension Practice Guidelines. Hypertension. 2020;75(6):1334-1357. doi:10.1161/HYPERTENSIONAHA.120.15026

5. Gabiola J, Morales D, Quizon O, et al. The EffectiveNess of LIfestyle with Diet and Physical Activity Education ProGram Among Prehypertensives and Stage 1 HyperTENsives in an Urban Community Setting (ENLIGHTEN) Study. J Community Health. 2020;45(3):478-487. doi:10.1007/s10900-019-00764-0

6. Colberg SR, Sigal RJ, Yardley JE, et al. Physical Activity/Exercise and Diabetes: A Position Statement of the American Diabetes Association. Diabetes Care. 2016;39(11):2065-2079. doi:10.2337/dc16-1728

7. Cooper AR, Moore LAR, McKenna J, Riddoch CJ. What is the magnitude of blood pressure response to a programme of moderate intensity exercise? Randomised controlled trial among sedentary adults with unmedicated hypertension. Br J Gen Pract. 2000;50(461):958-962.

8. Da TKS, Nóbrega, Junior JSM, et al. Walking / running or a recreative soccer game presents similar effectiveness in inducing post-exercise hypotension. Rev Bras Med Esporte. 2013;19(1):31-34.

9. Khadka R, Bh P, Vp S, Kumar S, Bhattacharya N. EFFECT OFYOGA ON CARDIOVASCULAR AUTONOMIC REACTIVITY IN ESSENTIAL HYPERTENSIVE PATIENTS. Heal (San Fr. 2010;8(2):102-109.

10. MOREAU KL, DEGARMO R, LANGLEY J, et al. Increasing daily walking lowers blood pressure in postmenopausal women. Med Sci Sport Exerc. 2001;33(11). https://journals.lww.com/acsm-msse/fulltext/2001/11000/increasing_daily_walking_lowers_blood_pressure_in.5.aspx

11. Cheung BMY, Lo JLF, Fong DYT, et al. Randomised controlled trial of qigong in the treatment of mild essential hypertension. J Hum Hypertens. 2005;19(9):697-704. doi:10.1038/sj.jhh.1001884

12. Carpes L, Jacobsen A, Domingues L, Jung N, Ferrari R. Recreational beach tennis reduces 24-h blood pressure in adults with hypertension: a randomized crossover trial. Eur J Appl Physiol. 2021;121(5):1327-1336. doi:10.1007/s00421-021-04617-4

13. Sohn A, Hasnain M, Sinacore J. Impact of exercise (walking) on blood pressure levels in African American adults with newly diagnosed hypertension. Ethn Dis. 2007;17:503-507.

14. Scott A, Toomath R, Bouchier D, et al. First national audit of the outcomes of care in young people with diabetes in New Zealand: high prevalence of nephropathy in Maori and Pacific Islanders. N Z Med J. 2006;119(1235):U2015. http://www.ncbi.nlm.nih.gov/pubmed/16751833

15. Islam FMA, Islam MA, Hosen MA, et al. Associations of physical activity levels, and attitudes towards physical activity with blood pressure among adults with high blood pressure in Bangladesh. Shantsila E, ed. PLoS One. 2023;18(2):e0280879. doi:10.1371/journal.pone.0280879

16. Mohr M, Nordsborg NB, Lindenskov A, et al. High-Intensity Intermittent Swimming Improves Cardiovascular Health Status for Women with Mild Hypertension. Biomed Res Int. 2014;2014:1-9. doi:10.1155/2014/728289

17. Yang R, Liu Y, Wang H, Du Y. Leisure-Time Daily Walking and Blood Pressure Among Chinese Older Adults: Evidence From the China Health and Retirement Longitudinal Study (CHARLS). Res Gerontol Nurs. 2019;12(5):248-258. doi:10.3928/19404921-20190702-01

18. Alsairafi M, Alshamali K, Al-Rashed A. Effect of physical activity on controlling blood pressure among hypertensive patients from mishref area of Kuwait. Eur J Gen Med. 2010;7(4):377-384. doi:10.29333/ejgm/82889

19. Wong A, Kwak Y-S, Scott SD, et al. The effects of swimming training on arterial function, muscular strength, and cardiorespiratory capacity in postmenopausal women with stage 2 hypertension. Menopause. 2019;26(6):653-658. doi:10.1097/GME.0000000000001288

20. Wolff M, Rogers K, Erdal B, Chalmers JP, Sundquist K, Midlöv P. Impact of a short home-based yoga programme on blood pressure in patients with hypertension: a randomized controlled trial in primary care. J Hum Hypertens. 2016;30(10):599-605. doi:10.1038/jhh.2015.123

21. Sulaeman R, Purnamawati D, Wijayanti IGAPW, Muhasidah. How progressive muscle relaxation exercise affects patient with hypertension? Rawal Med J. 2020;45(1):62-65.

22. Shakoor E, Salesi M, Daryanoosh F. Effect of Acute High-Intensity Interval Training and Isometric Handgrip Exercise on Hemodynamic Responses in Hypertensive Women. 2020;7:60-69. doi:10.30476/WHB.2020.86948.1063

23. Miura H, Takahashi Y, Maki Y, Sugino M. Effects of exercise training on arterial stiffness in older hypertensive females. Eur J Appl Physiol. 2015;115(9):1847-1854. doi:10.1007/s00421-015-3168-y

24. Pescatello LS, Franklin BA, Fagard R, Farquhar WB, Kelley GA, Ray CA. Exercise and Hypertension. Med Sci Sport Exerc. 2004;36(3):533-553. doi:10.1249/01.MSS.0000115224.88514.3A

25. Brown MD, Dengel DR, Hogikyan R V., Supiano MA. Sympathetic activity and the heterogenous blood pressure response to exercise training in hypertensives. J Appl Physiol. 2002;92(4):1434-1442. doi:10.1152/japplphysiol.00477.2001

26. Maeda S, Miyauchi T, Kakiyama T, et al. Effects of exercise training of 8 weeks and detraining on plasma levels of endothelium-derived factors, endothelin-1 and nitric oxide, in healthy young humans. Life Sci. 2001;69(9):1005-1016. doi:10.1016/S0024-3205(01)01192-4

27. Kingwell BA, Tran B, Cameron JD, Jennings GL, Dart AM. Enhanced vasodilation to acetylcholine in athletes is associated with lower plasma cholesterol. Am J Physiol Circ Physiol. 1996;270(6):H2008-H2013. doi:10.1152/ajpheart.1996.270.6.H2008

28. Higashi Y, Sasaki S, Kurisu S, et al. Regular Aerobic Exercise Augments Endothelium-Dependent Vascular Relaxation in Normotensive As Well As Hypertensive Subjects. Circulation. 1999;100(11):1194-1202. doi:10.1161/01.CIR.100.11.1194

29. Sarelius I, Pohl U. Control of muscle blood flow during exercise: local factors and integrative mechanisms. Acta Physiol. 2010;199(4):349-365. doi:10.1111/j.1748-1716.2010.02129.x

30. Bahrainy S, Levy WC, Busey JM, Caldwell JH, Stratton JR. Exercise training bradycardia is largely explained by reduced intrinsic heart rate. Int J Cardiol. 2016;222:213-216. doi:10.1016/j.ijcard.2016.07.203

31. Reimers A, Knapp G, Reimers C-D. Effects of Exercise on the Resting Heart Rate: A Systematic Review and Meta-Analysis of Interventional Studies. J Clin Med. 2018;7(12):503. doi:10.3390/jcm7120503

32. Tyagi A, Cohen M. Yoga and heart rate variability: A comprehensive review of the literature. Int J Yoga. 2016;9(2):97. doi:10.4103/0973-6131.183712

33. Cabrera SE, Mindell JS, Toledo M, Alvo M, Ferro CJ. Associations of Blood Pressure With Geographical Latitude, Solar Radiation, and Ambient Temperature: Results From the Chilean Health Survey, 2009–2010: Table 1. Am J Epidemiol. 2016;183(11):1071-1073. doi:10.1093/aje/kww037

34. Ettinger SM, Silber DH, Collins BG, et al. Influences of gender on sympathetic nerve responses to static exercise. J Appl Physiol. 1996;80(1):245-251. doi:10.1152/jappl.1996.80.1.245

35. Bassareo PP, Crisafulli A. Gender Differences in Hemodynamic Regulation and Cardiovascular Adaptations to Dynamic Exercise. Curr Cardiol Rev. 2020;16(1):65-72. doi:10.2174/1573403X15666190321141856

36. Age-specific relevance of usual blood pressure to vascular mortality: a meta-analysis of individual data for one million adults in 61 prospective studies. Lancet. 2002;360(9349):1903-1913. doi:10.1016/S0140-6736(02)11911-8

37. Bull FC, Al-Ansari SS, Biddle S, et al. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. Br J Sports Med. 2020;54(24):1451-1462. doi:10.1136/bjsports-2020-102955

38. Sardeli AV, Griffth GJ, dos Santos MVMA, Ito MSR, Chacon-Mikahil MPT. The effects of exercise training on hypertensive older adults: an umbrella meta-analysis. Hypertens Res. 2021;44(11):1434-1443. doi:10.1038/s41440-021-00715-0

39. Shao B, Zhang X, Vernooij RWM, et al. The effectiveness of Baduanjin exercise for hypertension: a systematic review and meta-analysis of randomized controlled trials. BMC Complement Med Ther. 2020;20(1):304. doi:10.1186/s12906-020-03098-w

40. Hanson S, Jones A. Is there evidence that walking groups have health benefits? A systematic review and meta-analysis. Br J Sports Med. 2015;49(11):710-715. doi:10.1136/bjsports-2014-094157

41. Zhu Z, Yan W, Yu Q, Wu P, Bigambo FM, Chen J. Association between Exercise and Blood Pressure in Hypertensive Residents: A Meta-Analysis. Adsuar JC, ed. Evidence-Based Complement Altern Med. 2022;2022:1-13. doi:10.1155/2022/2453805

42. Yuan P, Yuan X-T, Sun X-Y, Pudasaini B, Liu J-M, Hu Q-H. Exercise training for pulmonary hypertension: A systematic review and meta-analysis. Int J Cardiol. 2015;178:142-146. doi:10.1016/j.ijcard.2014.10.161

43. Saco-Ledo G, Valenzuela PL, Ruiz-Hurtado G, Ruilope LM, Lucia A. Exercise Reduces Ambulatory Blood Pressure in Patients With Hypertension: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. J Am Heart Assoc. 2020;9(24). doi:10.1161/JAHA.120.018487

44. Leal JM, Galliano LM, Del Vecchio FB. Effectiveness of High-Intensity Interval Training Versus Moderate-Intensity Continuous Training in Hypertensive Patients: a Systematic Review and Meta-Analysis. Curr Hypertens Rep. 2020;22(3):26. doi:10.1007/s11906-020-1030-z

45. Lee LL, Mulvaney CA, Wong YKY, Chan ES, Watson MC, Lin HH. Walking for hypertension. Cochrane Database Syst Rev. 2021;2021(3). doi:10.1002/14651858.CD008823.pub2