Journal of Health Care and Prevention

Review Article Open Access

The Effect of Physical Activity on Lowering Blood Pressure among Adults with Prehypertension: A Meta-Analysis of RCT Studies

Nasser Sinha*

School of Nursing, Shepherd University, USA

Abstract

Background: Various combinations of physical activity (PA) interventions have been studied, and parallel outcomes found a lowering SBP/DBP among prehypertensive adults worldwide. Therefore, this meta-analysis evaluated the pooled effects of multiple PA interventions on reducing SBP/DBP among prehypertensive adults.

Methods: A systematic review and meta-analysis search were conducted, and sixteen RCT studies were identified. Among the 1,419 adult participants, 881 men and 538 women participated in the RCT studies. Random effects models were used to evaluate heterogeneity in the study. Estimate publication bias was assessed using a funnel plot and a modified Egger linear regression test. The pooled effects were evaluated by relative risk, 95% CI, and p-value < 0.05.

Results: The results of the random-effects meta-regression coefficient indicated that all the RCT studies had a risk-free bias. Homogeneity was found (I2SBP = 0.0% and I2DBP = 0.0%) and suggested that 0.0% of the physical activity intervention effect variability was due to the actual study similarity, and 100% is due to chance. The combined results, pooled relative risk (RR) for lowering SBP/DBP events in the adults with prehypertension, randomly assigned to physical activity was ⟦RR⟧_SBP=0.99; 95% CI (0.99-1.00),p=0.02; and ⟦RR⟧_DBP=0.99; 95% CI (0.98- 1.00),p=0.04; statistically significant, respectively. The pooled point estimate and the 95% CI be positioned entirely to the left of the line of no effect, demonstrating 100 x (1-0.99) % = 1% of SBP/DBP reduction is significantly in favor of PA intervention, p = 0.02 and p =0.04 respectively.

Conclusion: This meta-analysis demonstrated a significant PA intervention pooled effect on SBP and DBP reduction among adults with prehypertension worldwide. This meta-analysis finding provided statistically significant evidence for the association between physical activity and SBP/DBP reduction; and subsequently reduced risk of complications among prehypertensive adults worldwide. Hence, clinicians and public health professionals must integrate and reinforce the beneficial effects of physical activity through counseling, education, and support.

Keywords: Prehypertension; Adult; Meta-analysis; Physical activity; SBP/DBP reduction

Summary statement

What is already known on this topic?

Multiple lifestyle interventions have been studied with varying findings. Physical activity is one lifestyle intervention generating lowering blood pressure.

However, the literature did not demonstrate how much statistically significant weighted average of the pooled effects sizes the physical activity intervention shared with lowering SBP/DBP among adults with prehypertension.

Hence, it would be beneficial to first find out the shared weighted average of the pooled effect sizes and then search for the combined pooled effects on reducing SBP/DBP among prehypertensive adults.

What is added by this report?

1. This meta-analysis found that physical activity intervention contributes to the pooled effect estimate at 100 x (1-0.99) % = 1% of SBP/DBP reduction amongst prehypertensive adults.

2. What are the implications for practice and research?

3. This meta-analysis established statistical significance with worldwide RCT studies on physical activity intervention on SBP/DBP reduction.

4. Finding emphasized that physical activity generates a 1% reduction of SBP/DBP among prehypertensive adults. Clinicians may provide a package of lifestyle modification through education and counseling for lowering SBP/DBP.

5. Knowing that the combination of lifestyle modifications may impact the pooled effect sizes on SBP/DBP reduction.

6. Further meta-analysis needs to uncover the actual effect sizes of different components of lifestyle modification intervention on SBP/DBP and subsequently establish the magnitude of each specific category.

7. Policymakers may use this finding to design public policy and program interventions to prevent the surge of hypertension and cardiovascular diseases.

The Effects of Physical Activity on Lowering Blood Pressure among Adults with Prehypertension: A Meta-analysis of RCT Studies.

***Corresponding author:** Nasser Sinha, School of Nursing, Shepherd University, USA.

Received: 05-Oct-2024, Manuscript No: jhcpn-24-150655; **Editor assigned:** 07-Oct-2024, Pre-QC No: jhcpn-24-150655 (PQ); **Reviewed:** 21-Oct-2024, QC No: jhcpn-24-150655; **Revised:** 28-Oct-2024, Manuscript No: jhcpn-24-150655 (R); **Published:** 01-Nov -2024, DOI: 10.4172/jhcpn.1000284

Citation: Nasser N (2024) The Effect of Physical Activity on Lowering Blood Pressure among Adults with Prehypertension: A Meta-Analysis of RCT Studies. J Health Care Prev, 7: 284.

Physical inactivity is a significant risk for prehypertension and, subsequently a cardiovascular disease; less active adults have a 30% to 50% greater risk for high blood pressure [1,2]. Prehypertension is a silent major precursor and contributor to the world's burden of cardiovascular disease and coronary heart disease. An individual with prehypertension may frequently progress to hypertension and cardiovascular diseases [1,3,4]. Research studies indicated that there is a significant likely association with an increased risk of stroke, myocardial infarction, and heart failure [5,6] which causes a higher rate of death and disability in young women and men adults [7]. Young adults with prehypertension are known to be at high risk for developing hypertension and even for increasing cardiovascular risks [1,4,8]. Adults are more exposed to cardiovascular disease risk factors and are less exposed to prevention efforts [9].

Distinct measures of secondary preventive approach, mainly regular physical activity (PA), have been studied and showed a more significant risk reduction of cardiovascular disease morbidity and mortality [10-12]. These studies have demonstrated a relevant reduction of prehypertension [13]. Studies have shown the protective effects of regular PA in reducing prehypertension among affected adults [14-16]. However, fewer investigations in meta-analysis demonstrated the pooled effect of PA associated with a decrease or increase in systolic blood pressure (SBP) and diastolic blood pressure (DBP) in the prehypertensive condition.

Another inquiry is the proportion of relative risk in SBP and DBP reduction after exercise (walking) intervention. It is still unclear whether patients diagnosed with prehypertension exposed to different types of PA increase or decrease their SBP and DBP and subsequently decrease cardiovascular events. The meta-analysis is a statistical technique for integrating quantitative findings from randomized control trial studies [17] The goal is to assess the clinical effectiveness of physical activity intervention by combining data from multiple randomized control trial (RCT) studies.

Moreover, a precise estimate of the effect of exercise (walking) intervention, giving appropriate power to the size of the different RCTs included, is relevant to reducing the prevalence of prehypertension and cardiovascular disease. Therefore, this research study emphasizes a meta-analysis to demonstrate available evidence (i.e., Intervention effect) from different RCTs on the association of physical activity with reduced risk of a prehypertension event.

The purpose of this meta-analysis RCT study was: (a) to establish whether there is evidence of a physical activity intervention effect on lowering SBP/DBP among prehypertensive adults; (b) to estimate the overall type of physical activity intervention actual effect (i.e., true effects across all studies) on SBP and DBP reduction, and (c) to examine whether the degree of variability in the true physical activity intervention effect is consistent across the sixteen studies. We selected a 95% confidence interval and a 5% significance level to compute the intervention effect. The meta-analysis findings are expected to corroborate or refute the association between SBP and DBP reduction and physical activity in adults with prehypertension.

Materials and methods

The CONSORT 2010 checklist guidelines for reporting parallel group randomized control trials [18] are applied for the literature search, study selection, data abstraction, summary measures calculation, and results synthesis. It was also used to assess the quality of the sixteen RCT studies. However, the preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement checklist and flow diagram were used to report this meta-analysis's results [19].

Study selection

A comprehensive search of the databases CINAHL Plus with Full Text, PubMed and Medline with Full Text (EBSCO -HOST), Google Scholar, Web of Science, Cochrane, and Eric databases through California State University, Los Angeles (CSULA) was conducted to identify all studies published between January 1, 2008, to August 10, 2024. The search terms used were physical activity, lowering blood pressure, prehypertension, and randomized controlled trials as subject headings in all fields. The search was also limited to randomized controlled trials; women and men adults aged 18 to 80 years. Additional search strategies included searches of the Google Scholar database and all references from articles that met eligibility criteria. To be included in this meta-analysis, a study had to meet the following criteria: (1) Study design: randomized controlled trial based on parallel: open or single, double-blind, and crossover double-blind or crossover open; (2) peer-reviewed English articles with original data; (3) participants having prehypertension without medication; (4) follow-up; (5) estimation of SBP and DBP values at baseline and the end of the intervention, (6) objective measurement of PA; and (7) at least one or more categories of PA. Sixteen articles met the eligibility criteria for inclusion in the meta-analysis, and Figure 1 presented detailed information on the study selection process.

Data abstraction and quality assessment

The Consort 2010 checklist was designed to facilitate the extraction process. For instance, the data abstraction encompassed identification as a randomized trial in the title, a trial design including participants' allocation ratio, eligibility criteria, and intervention for each group with sufficient details. Sufficient details were age, gender, mean SBP and DBP value at baseline and after intervention for each group, prehypertension status, nature of physical activity, exercise intervention, follow-up duration, outcomes, and estimation event in SBP and DB. Study quality was judged by the proper score of different items from the CONSORT 2010 checklist, abstraction results were submitted to two colleagues as reviewers, and discrepancies were adjudicated by consensus and based on the CONSORT 2010 checklist and PRISMA statement checklist.

Data analysis and synthesis

The random-effects model hypothesizes that the overall physical

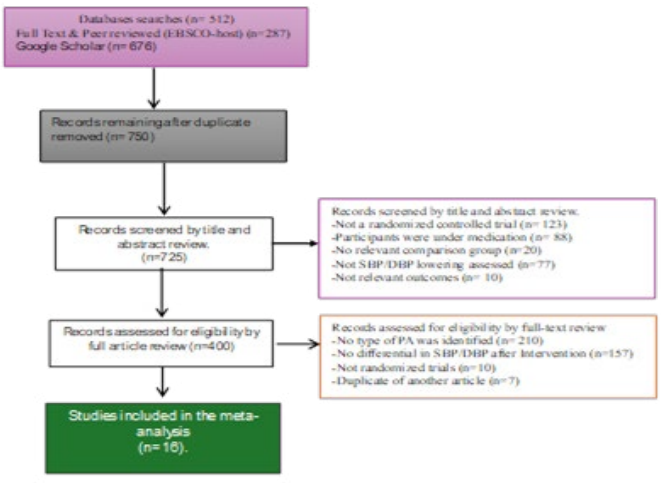

Figure 1: Selection of studies for a meta-analysis of randomized controlled trials on the association between physical activities and blood pressure.

activity's true effect is the same in all studies. It allows for generalization from the populations in the analysis to similar populations. The second hypothesis is centered on estimating separate physical activity effects for each trial and, lastly, evaluating the variability (i.e., the degree of heterogeneity or homogeneity) in the true physical activity intervention effects across selected trials. The individual study relative risk (RR) and the pooling overall RR based on a 95% confidence interval with a 5% significance level were computed for each outcome in the experimental group versus the control group after the intervention. Potential publication bias is assessed using the visual Begg's funnel plot, plotting the standard error against the natural log RR for each study [20,21].

Moreover, the Egger regression test is used for publication bias and the asymmetry of the regression equation in the l'Abbe plot [20]. As the funnel plot has some limitations, the researcher used one of the formal statistical methods to test for heterogeneity. The percentage of the variability across the five studies attributable to heterogeneity beyond the chance was estimated using statistics [22,23]. A two-tailed p-value less than 0.05 was statistically considered significant, and statistical analyses were performed using SPSS Meta-Analysis version 29.0 was used to perform the analysis.

Results of the Meta-Analysis

Descriptive Results

The systematic search yielded 1475 articles, of which 287 were reviewed in full text and from which sixteen randomized controlled trials [24-31] reported in publications were identified (Figure 1). The sample characteristics of this meta-analysis included 1,419 adults who were not initially free from prehypertension (Table 1). Among the 1,419 adults in the meta-analysis sample, 881 adults were men, and 538 were women. The trials were published between January 1, 2008, and August 31, 2024, and varied from 24 to 330 participants with an age range from 18 to 71 years old and a median of 140 participants. The trial duration ranged from 30 minutes to 48 weeks. The mean and standard deviation of SBP/DBP of the intervention and control groups after the intervention were respectively: (a)M_(Exp Grp SBP)=124.51,SD=4.87 and M_(Exp Grp DBP)=77.65,SD=4.91, and (b) for the control group, SBP/DBP mean and standard deviation were: M_(Ctrl grp SBP)=130.11,SD=4.05 and M_(Ctrl grp DBP)=81,SD=4.72. The sixteen RCTs included men and women; four were led in the USA, three were from China, five were from India, and one was from Nigeria, Egypt, Germany, Malaysia, Brazil, and Denmark. In this meta-analysis, several selected studies have conducted multiple interventions using diverse types of physical activities [24,25,27-39] comparing to control groups.

Publication bias

A straightforward way to assess publication bias's likely presence is to examine a funnel plot [20]. The funnel plot demonstrated (Figure 1A and Figure 1B) that the distribution of SBP and DBP change estimates for each study was asymmetric around the pooled effect estimate for the trial comparing intervention with control. This suggests that the meta-analysis may have missed some trials [20].

The funnel plot has some limitations; for example, detecting asymmetry with eyes can sometimes be challenging [40]. As a result, Egger's regression test, as one of the formal statistical methods, was used to test for publication bias. The analysis result showed that the Egger regression equation intercepts differ from zero in SBP and DBP. In the SBP, Egger's test was D/SE= -0.016, t = -0.50, (95% CI = -0.83 to 0.50), p = 0.61, while in DBP, Egger's test was D/SE= -0.006, t = -0.123, (95% CI = -0.10 to 0.09), p = 0.9 which confirms the no-evidence of publication bias.

Random effects meta-analysis:

Multiple parameters were estimated to summarize evidence by assuming that the true effect of physical activity on prehypertension can vary from selected RCT studies. Moreover, the variation is due to heterogenicity.

The forest plot Weight Percentage:

The analysis indicated that all the selected RCT studies worldwide contribute slightly equally to the pooled effects reduction on SBP and DBP after physical activity intervention. The weight percentage varies between 3% to 4% in SBP and 3.2% to 4% in DBP. Selected RCTs from China, India, and the USA have a larger sample size with width boxes and large confidence intervals, allotting greater weight to pooled effects.

Heterogeneity

The researcher used statistical value to determine whether there is a variation in the true effect of physical activity intervention on reducing prehypertension, consistent across the sixteen selected RCT studies [41]. Further, a rule was suggested to use the percentage to assess the presence of heterogeneity between the outcomes of RCTs. For instance, 25% corresponds to low heterogeneity, 50% to moderate, and 75% to high [42]. The analysis results showed in SBP/DBP in Figure 2A and

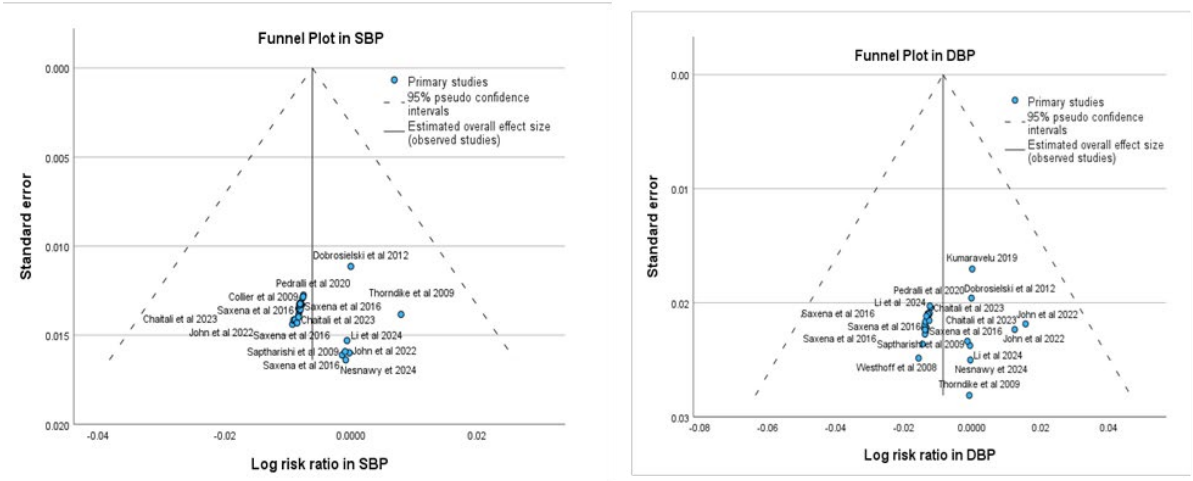

Figure 1A and Figure 1B: Funnel plot of 16 RCT Studies.

Table 1: List of Randomized Controlled Studies included in the Meta-analysis.

Study Authors, Year	No of Participants	Study Design and country of origin	Duration of the intervention	Age Range	SBP mmHg	DBP mmHg	Decreased DBP mmHg	Decreased SBP mmHg	Decreased pre-HTN
Thorndike et al. (2012)	330	RCT/USA	10 weeks	55-71	124.6	71.3	0.9	-2.4	yes
Dobrosielski et al. (2012)	140	RCT/USA	26 weeks	40-65	126.9	72.4	0.4	-0.4	yes
Westhoff et al. (2008)	24	RCT/Germany	12 weeks	58 -80	134	73	3	-7	yes
Christensen et al. (2011)	98	RCT/Denmark	12 weeks	18-40	134.1	83.7	4	-7.52	yes
Collier et al. 2009	29	RCT/USA	4 Weeks	33-60	136	78	4	4	yes
Collier et al. 2009	29	RCT/USA	4 Weeks	33-60	142	80	3	5	yes
Vickhe et al (2023)	34	RCT/India	2 Weeks	18-25	127.29	85.82	5.94	8.17	yes
Vickhe et al (2023)	34	RCT/India	2 Weeks	18-25	127.41	86	4	4.06	yes
John et al (2022)	32	RCT/Malaysia	4 weeks	18-25	122.76	78.57	2.94	3.76	yes
John et al (2022)	32	RCT/Malaysia	4 weeks	18-25	125.23	77.23	1.5	1.56	yes
Saptharishi et al (2009).	102	RCT/India	6 weeks	22 -25	128.6	87.4	8,1	5.3	Yes
Clark et al (2020)	28	RCT/Australia	6 weeks	18-45	128.9	75.6	3.5	4.6	yes
Punia et al (2022)	63	RCT/India	8 weeks	18-55	135	87	6.5	7.30	yes
Pedralli et al (2020)	37	RCT/Brazil	8 weeks	50-55	137	88	3.2	5.10	yes
Saxena et al (2016)	40	RCT/India	30 min	20-40	131	80	7.3	8.2	yes
Saxena et al (2016)	40	RCT/India	30 min	20-40	131	80	1,5	3.4	yes
Saxena et al (201)6	40	RCT/india	30 min	20-40	131	80	0.4	1,2	yes
Li et al (2024)	173	RCT/China	48 weeks	18-65	132.4	84.2	7.0	3.73	yes
Li et al (2024)	169	RCT/China	48 weeks	18-65	132.6	84.5	4.61	2.56	yes
Li et al (2024)	173	RCT/China	24 weeks	18-65	132.4	84.2	6.18	3.88	yes
Li et al (2024)	169	RCT/China	24 weeks	18-65	132.4	84.2	3.52	2.60	yes
Nesnawy et al (2024)	120	RCT/Egypt	2 weeks	18-65	125.3	80.6	2.9	2.47	yes
Nesnawy et al (2024)	120	RCT/Egypt	4 weeks	18-65	124.4	79.9	6.4	2.4	yes

Figure 2B, ⟦(I)⟧_SBP^2=0.0% and I_DBP^2=0.0%) suggesting that 0.0% of the variability of physical activity intervention effect is due to the actual study similarity (Homogeneity) and 100% is due to chance. The random effect model summary result of -0.01 (95% confidence interval -0.01% to -0.0) in SBP (χ_SBP^2=2.387, DF=26, p=1); and the result of -0.01(95% CI -0.02 to -0.01) in DBP (χ_DBP^2=3.887, DF=26, p=1); provide an estimate of the average physical activity intervention effect, respectively. As the confidence interval does not contain zero, there is strong evidence that, on average, the physical activity effect is beneficial in lowering prehypertension among participants. These intervals are entirely below zero and show that physical activity is beneficial when applied in at least 95% of the adults with prehypertension, an important finding for clinical practice.

According to Higgins et al. (2003) suggestions, when statistics is equal to zero, there is no heterogeneity among the outcomes of different studies, which means that in this meta-analysis study, there is homogeneity among the 16 RCTs related to the size of the physical activity intervention effect. The hypothesis of homogeneity between the physical activity intervention and the effects of lowering prehypertension was not rejected. The analysis confirmed a high level of homogeneity among the 16 RCTs. Q =2.36, df =26, p-value = 0.

Intervention effect measure (relative risk)

In this study, Figures 2A and Figure 2B presented the forest plot demonstrating physical activity intervention and lowering SBP/DBP for adults with prehypertension. Each RCT is represented by a square (the relative risk found for this trial) and a horizontal line, which represents the 95%.

Confidence interval for both SBP/DBP, respectively (Figure 2A and Figure 2B). The analysis indicated that in SBP, the relative risk of 19 on 26 physical activity interventions is less than one, except one RR is more significant than one, and six RRs are equal to one. This result indicates that 19 physical activity interventions decrease the risk of prehypertension by 100 (1-0.99) = 1% but not statistically significant ($p > 0.05$), and 95% CI of each PA intervention crosses the line of no effect (RR=1). In addition, the combined results, pooled relative risk (RR) for lowering SBP/DBP events in the adults with prehypertension, randomly assigned to physical activity was ⟦RR⟧_SBP=0.99; 95% CI (0.99-1.00), p=0.02; and ⟦RR⟧_DBP=0.99; 95% CI (0.98- 1.00), p=0.04; statistically significant, respectively (Figure 2A and Figure 2B). This result indicates that the pooled point estimate and the 95% CI lie entirely to the left of the line of no effect, demonstrating 100 x (1- 0.99) % = 1% of SBP/DBP reduction is significantly in favor of PA intervention, p =0.02 and p =0.04 respectively. This finding also explained that there is a significant relationship between PA intervention and lowering SBP and DBP in participants diagnosed with prehypertension.

Furthermore, the results indicated that any RR of each selected RCT study in the right-side column of the Forest plot (Figure 2A and Figure 2B) exceeds one. In Figure 2A, one study intervention presented a relative risk exceeding one (RR =1.01); six study interventions displayed an RR equal to one (RR= 1), and 20 study interventions showed an RR below one (RR= 0.98). None of them disclosed any statistical significance ($p > 0.05$), and their 95% CI includes one and crosses the line of no effect. Similar to Figure 2B, 18 study interventions indicated an RR below one (RR=0.99), and six study interventions displayed an RR equal to one (RR= 1), whereas two study interventions revealed an RR above one (RR> 1). Compared to the results in Figure 2A, it is not statistically significant ($p>0.05$), and 95% CI includes one and crosses the line of no effect.

Each RCT study's whisker depicts the length of the confidence interval across the line of no effect, and each confidence interval contains the value one. All the sixteen RCTs [25,29] have similar lengths of confidence intervals, and four RCTs [24] presented a significant sample with a narrower confidence interval. The longer the

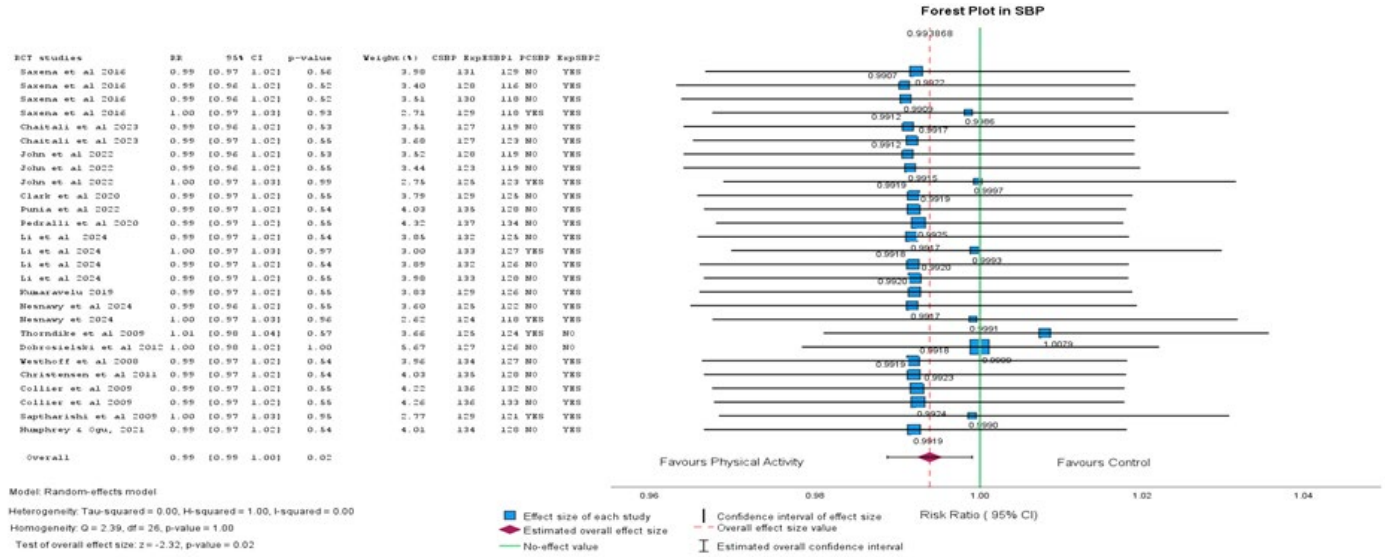

Figure 2A: Random effects meta-analysis of 16 RCT studies that examine the effect of physical activity on lowering prehypertensive events in adults with prehypertension.

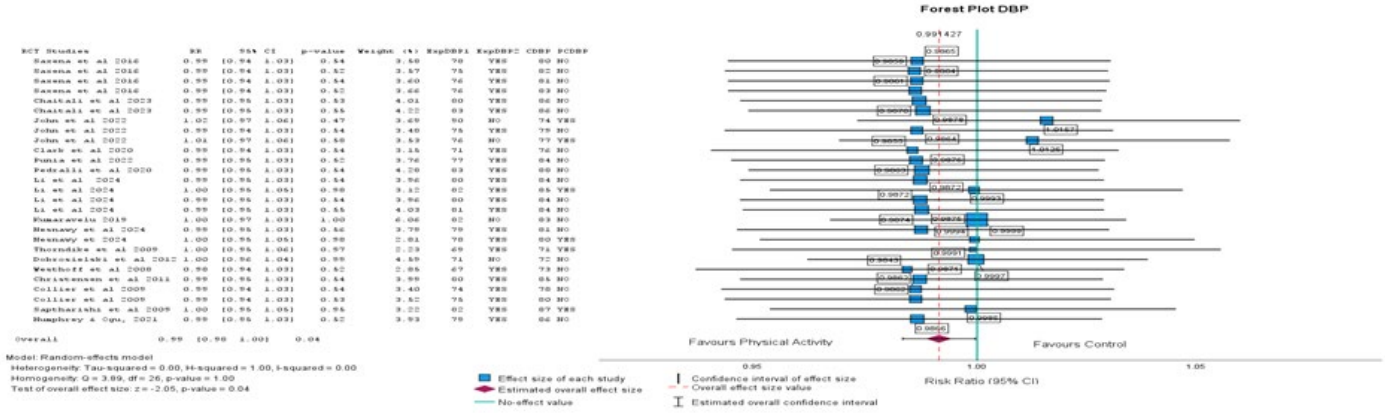

Figure 2B: Random effects meta-analysis of 16 RCT studies that examine the effect of physical activity on lowering prehypertensive events in adults with prehypertension.

whiskers, the more comprehensive the CI, and the less precise the study results [42].

Discussion

This present meta-analysis examined whether there is evidence of a physical activity intervention effect on lowering SBP/DBP among prehypertensive adults; a degree of variability in the actual physical activity intervention effect is consistent across the sixteen studies; and subsequently estimate the overall effects of physical activity intervention actual effect (i.e., true effects across all studies) on SBP and DBP reduction. The overall population size in this meta-analysis was 1,419 adults aged 18 to 71 years old, with both genders. For all RCT studies selected, the duration of follow-up ranged from 10 to 48 weeks. Various physical activities have been proven to be beneficial to adults with prehypertension and even cardiovascular diseases.

The United States 2024 physical activity guidelines showed that adult gender who participates in any amount of physical activity increased health benefits [43]. Current meta-analyses demonstrated evidence of the intervention effect of physical activity and risk of cardiovascular disease [44]. To hypothetically corroborate the effect of physical activity on SBP and DBP among prehypertensive adults, the investigators gave weight to the random effects of the sixteen selected RCT studies worldwide. This meta-analysis finding demonstrated a pooled significant relative risk of reduction of SBP and DBP among individual adult women and men diagnosed with prehypertension after diverse physical activity interventions. The sensitivity analysis suggested that the relative risk effect of physical activity in SBP and DBP was consistent across study types and analysis methods. This finding is consistent with the meta-analysis by Henkin et al. (2023), which found an adequate estimate of resistance training on SBP/DBP reduction with 450 participants with prehypertension. The findings showed a 1% and 3% decrease in SBP and DBP, respectively [45]. Sousa et al. (2017) also conducted a meta-analysis of 5 RCTs on the effect of physical activity intervention on SBP and DBP, which included 201 adults. Thus, the findings showed significant reductions for SBP (effect size = −0.97, $p < 0.05$) and DBP (effect size = −0.60), $p < 0.05$) [33].

Regarding the heterogeneity, this meta-analysis found homogeneity, demonstrating that the variability of the effect of physical activity intervention is due to chance among all selected RCT studies worldwide. This finding is consistent with a current meta-analysis, which found homogeneity in SBP and DBP in all 5 RCTs, respectively [33]. As a dynamic aerobic physical activity, walking, running, jogging,

yoga, and Thai-chi (i.e., 5-10 min; 10-20 min; 20-30min; 30-50 min; 60-120 min) involve significant muscle contractions of more than 50% of the body's total muscle mass [46,47]. Physical activity expends energy and has important public health implications, particularly for inactive adults with prehypertension. Our meta-analysis demonstrates how the percentage of physical activity contributes to lowering SBP and DBP across the 16 RCTs. Another recent meta-analysis [48] used 14 studies with 2451 participants and found that combining a healthy diet and physical activity had the highest mean SBP and DBP reduction. However, the recent meta-analysis did not provide a separate random effect of a healthy diet and PA on SBP and DBP, respectively.

Strengths and limitations

The strengths of this meta-analysis included rigorous methods that adhered to PRISMA standards. In addition, the selected studies examined a wide range of physical activity interventions on SBP and DBP among adults with prehypertension worldwide (USA, China, India, Africa, Malaysia, Europe, Australia, and Brazil). This meta-analysis showed conclusive pooled effects of physical activity intervention on improving SBP/ DBP reduction from 16 selected RCTs from diverse countries worldwide. Another strength is a significant association between physical activity intervention and lowering SBP and DBP among adults with prehypertension worldwide. Further, in this meta-analysis, there is also a homogeneous physical activity intervention effect in each selected RCT, which allowed the team investigator to draw generalized conclusions regarding the efficacy of PA interventions on SBP and DBP.

Nonetheless, there is a limitation in the review of peer-reviewed literature due to the potential unpublished meta-analysis articles. Bias and heterogeneity from the quality of original RCT studies included in the meta-analysis can impact the validity of the overall effect size. However, this meta-analysis of selected 16 RCTs was free from bias and heterogeneity, which allows us to extrapolate a generalized conclusive physical activity intervention effect on SBP/DBP reduction among adults with prehypertension.

Conclusion

This meta-analysis demonstrated a significant PA intervention pooled effect on SBP and DBP reduction among adults with prehypertension worldwide. Each selected RCT demonstrated no significant magnitude, $p > 0.05$, and the 95% confidence interval crossed the line of no effect, which included one. With the random effect output, the meta-analysis finding showed a 1% significantly reduced risk of SBP ($p < 0.02$) and DBP ($p < 0.04$) in the intervention compared to the control group. Lying entirely to the left side of the line of no effect (RR=1), the pooled estimate and the 95% indicate a magnitude statistical difference in the lowering SBP /DBP between groups. This finding perhaps was also explained by the absence of publication bias and heterogeneity among the RCT studies. On the other hand, this meta-analysis finding provided evidence for the association between physical activity and SBP and DBP reduction and subsequently reduced risk of prehypertension after the intervention among adults living across the world. Further, the risk of developing prehypertension tends to decrease if physical activity (e.g., 30 to 60 minutes, 60 to 120 minutes of any PA) is regularly maintained for a lifespan (US-HHS, 2018).

References

1. Barone GB, Hivert MF, Jerome GJ, Kraus WE, Rosenkranz SK, et al. (2021) Physical activity as a critical component of first-line treatment for elevated blood pressure or cholesterol: who, what, and how?: a scientific statement from the American Heart Association. Hypertension 78: 26-37.
2. Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, et al. (2003) The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. Hypertension 19: 1206-1252.
3. Godwin M, Pike A, Kirby A, Jewer C, Laura Murphy, et al. (2008) Prehypertension and hypertension in a primary care practice. Cana Fam Physician 10: 1418-1423.
4. Kariuki JK, Imes CC, Engberg, SJ, Scott PW, Klem ML, et al. (2024) Impact of lifestyle-based interventions on absolute cardiovascular disease risk: a systematic review and meta-analysis. JBI evid synth 22: 4-65.
5. Hsia J, Margolis KL, Eaton CB, Wenger NK, Allison M, et al. (2007) Prehypertension and Cardiovascular Disease Risk in the Women's Health Initiative. Circulation 115: 855-860.
6. Qureshi AI, Suri MFK, Kirmani JF, Divani AA, Mohammad Y, et al. (2005) Is Prehypertension a Risk Factor for Cardiovascular Diseases? Stroke 36: 1859-1863.
7. Smith SC (2011) Reducing the global burden of ischemic heart disease and stroke: a challenge for the cardiovascular community and the United Nations. Circulation 124: 278-279.
8. Erem C, Hacihasanoglu A, Kocak M, Deger O, Topbas M, et al. (2009) Prevalence of prehypertension and hypertension and associated risk factors among Turkish adults: Trabzon hypertension study. Journal of Public Health, 31: 47-58.
9. World Health Organization (2024) Tackling NCDs: best buys and other recommended interventions for the prevention and control of noncommunicable diseases. World Health Organization.
10. O'Keefe JH, Carter MD, Lavie CJ (2009) Primary and secondary prevention of cardiovascular diseases: a practical, evidence-based approach. Mayo Clin Proc 84: 741-757.
11. Shiroma EJ, Lee IM (2010) Physical activity and cardiovascular health: Lessons learned from Epidemiological studies across age, gender, and race/ethnicity. Circulation 122: 743-752.
12. Whelton SP, Chin A, Xin X, He J (2002) Effect of aerobic exercise on blood pressure: A meta-analysis of randomized controlled trials. Ann Intern Med 136: 493-503.
13. Sofi F, Capalbo A, Cesari F, Abbate R, Gensini GF, et al. (2008) Physical activity during leisure time and primary prevention of coronary heart disease: an updated meta-analysis of cohort studies. Euro J Cardiovasc Prev Rehabil 15: 247-257.
14. Bushman B (2014) Promoting exercise as medicine for prediabetes and prehypertension. Curr sports med rep 13: 233-239.
15. Williamson W, Foster C, Reid H, Kelly P, Lewandowski AJ, et al. (2016) Will exercise advice be sufficient for treatment of young adults with prehypertension and hypertension? A systematic review and meta-analysis. Hypertension 68: 78-87.
16. Xi Y, Liu X, Chen Y (2024) Exercise Prescription in Individuals with Prehypertension and Hypertension: Systematic Review and Meta-Analysis. Reviews in Cardiovascular Medicine 25: 117.
17. Polit DF, Beck CT (2008) Nursing research: generating and assessing evidence for nursing practice: Wolters Kluwer Health.
18. Schulz KF, Altman DG, Moher D (2010) CONSORT 2010 Statement: updated guidelines for reporting parallel group randomized trials.
19. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gøtzsche PC, Ioannidis JPA, et al. (2009) The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration.
20. Egger M, Smith GD, Schneider M, Minder C (1997) Bias in meta-analysis was detected by a simple, graphical test. 315: 629-634.
21. Fleiss, J. L. (1993) The statistical basis of meta-analysis. Statistical Methods in Medical Research, 2: 121-145.
22. DerSimonian R, Laird N (1986) Meta-analysis in clinical trials. Controlled Clinical Trials 7: 177-188.
23. Woodward M (2005) Epidemiology: Study Design And Data Analysis: Taylor & Francis Group.

24. Christensen J, Faber A, Ekner D, Overgaard K, Holtermann A, et al (2011) Diet, physical exercise and cognitive behavioral training as a combined workplace based intervention to reduce body weight and increase physical capacity in health care workers - a randomized controlled trial. BMC Public Health, 11: 671.

25. Dobrosielski D, Gibbs B, Ouyang P, Bonekamp S, Clark J, et al. (2012) Effect of exercise on blood pressure in type 2 diabetes: A randomized controlled trial. J Gen Intern Med 27: 1453-1459.

26. Elley CR, Kerse N, Arroll B, Robinson E (2003) Effectiveness of counselling patients on physical activity in general practice: cluster randomised controlled trial. BMJ 326: 793.

27. Li X, Chang P, Wu M, Jiang Y, Gao Y, et al. (2024) Effect of Tai Chi vs Aerobic Exercise on Blood Pressure in Patients With Prehypertension: A Randomized Clinical Trial. JAMA Netw Open 7: 937-937.

28. Saptharishi L, Soudarssanane M, Thiruselvakumar D, Navasakthi D, Mathanraj S, et al. (2009) Community-based randomized controlled trial of non-pharmacological interventions in prevention and control of hypertension among young adults. Indian J Community Med 3: 329-334.

29. Thorndike AN, Sonnenberg L, Healey E, Myint UK, Kvedar JC, et al. (2012) Prevention of weight gain following a worksite nutrition and exercise program: A randomized controlled trial. Am J Prev Med 43: 27-33.

30. Vikhe CS, Kumar P, Meshram VK (2023) Effect Of 14 Days Physical Activity Walking Regime on Blood Pressure in Prehypertensive Young Adults: A Randomised Controlled Trial. Indian J Physiotherapy & Occupational Ther 17: 16.

31. Westhoff TH, Schmidt S, Gross V, Joppke M, Zidek W, et al. (2008) The cardiovascular effects of upper-limb aerobic exercise in hypertensive patients. J hypertens 26: 1336-1342.

32. Collier S, Kanaley J, Carhart JR, Frechette V, Tobin M, et al. (2009) Cardiac autonomic function and baroreflex changes following 4 weeks of resistance versus aerobic training in individuals with prehypertension. Acta physiol 195: 339-348.

33. De Sousa EC, Abrahin O, Ferreira ALL, Rodrigues RP, Alves EAC, et al. (2017) Resistance training alone reduces systolic and diastolic blood pressure in prehypertensive and hypertensive individuals: meta-analysis. Hypertension Research 40: 927-931.

34. John AT, Chowdhury M, Islam MR (2022) Effectiveness of high-intensity interval training and continuous moderate-intensity training on blood pressure in physically inactive prehypertensive young adults. Journal of Cardiovascular Development and Disease 9: 246.

35. Kumaravelu P (2019) Effect of Moderate Intensity Walking On Blood Pressure in Prehypertensive Adults. Think India Journal 22:14362-14366.

36. Nesnawy S, Abd El Monim Mohamed E (2024) Evaluating Brisk Walking, Deep Breathing, and Stress Disclosure for Blood Pressure Reduction in Individuals with Prehypertension and Stress. International Egyptian Journal of Nursing Sciences and Research 5: 52-69.

37. Pedralli ML , Marschner RA, Kollet DP, Neto SG, Eibel B, et al. (2020) Different exercise training modalities produce similar endothelial function improvements in individuals with prehypertension or hypertension: A randomized clinical trial. Scientific reports 10: 7628.

38. Punia S, Singh V, Joshi S, Malik M, Saini M (2022) Effects of walking in individuals with prehypertension and stage 1 hypertension in India: a randomized controlled trial. International Journal of Therapy And Rehabilitation 29: 1-10.

39. Saxena Y, Gupta R, Moinuddin A, Narwal R (2016) Blood pressure reduction following accumulated physical activity in prehypertensive. Journal of family medicine and primary care 5: 349-356.

40. Terrin N, Schmid CH, Lau J (2005) In an empirical evaluation of the funnel plot, researchers could not visually identify publication bias. Journal of clinical epidemiology, 58: 894-901.

41. Higgins JPT, Thompson SG, Deeks JJ, Altman DG (2003) Measuring inconsistency in meta-analyses. BMJ 327: 557-560.

42. Ried K (2006) Interpreting and understanding meta-analysis graphs--a practical guide. Australian Family Physician 35: 635-638.

43. U.S. Department of Health and Human Services [US-HHS] (2018) Physical Activity Guidelines for Americans 2018.

44. Li J, Siegrist J (2012) Physical activity and risk of cardiovascular disease—a meta-analysis of prospective cohort studies. International journal of environmental research and public health, 9: 391-407.

45. Henkin JS, Pinto RS, Machado CL, Wilhelm EN (2023) Chronic effect of resistance training on blood pressure in older adults with prehypertension and hypertension: a systematic review and meta-analysis. Experimental Gerontology.

46. Hoffmann CM, Petrov ME, Lee RE (2021) Aerobic physical activity to improve memory and executive function in sedentary adults without cognitive impairment: A systematic review and meta-analysis. Prev Med Rep.

47. Morris JN, Hardman AE (1997) walking to health. sports medicine 23: 306-332.

48. Krishnamoorthy Y, Nagarajan R, Murali S (2023) Effectiveness of multiple combined lifestyle interventions in reducing blood pressure among patients with prehypertension and hypertension: a network meta-analysis. Journal of Public Healthm 45: 319-331.