RESEARCH PAPER

Physical Activity Interventions For Hypertension Prevention In Adults: A Systematic Review

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Abstract

Background: Physical exercise is widely prescribed for cardiovascular health, but its role in primary prevention of hypertension in normotensive and pre-hypertensive adults has not been systematically synthesized.

Methods: A systematic review was performed in accordance with PRISMA. The search was conducted in four databases (Scopus, Web of Science, PubMed, and Cochrane Library) with predetermined PICO criteria. Adults (≥18 years) who had not been diagnosed with hypertension previously were included. Physical activity interventions were compared to usual care, no intervention, or other lifestyle strategies. Screening of the study was conducted via the CADIMA platform, and risk of bias was assessed using the ROBINS-I framework. The eligible studies reported incident hypertension or changes in systolic/ diastolic blood pressure.

Results: Among the 2,068 records found, 9 studies met the inclusion criteria. Studies that were included were systematic reviews of RCTs, randomized trials, and quasi-experimental designs. The types of interventions were aerobic, resistance, combined training, and lifestyle-based, with the duration of interventions of 12 weeks to one year. The majority of the studies presented positive blood pressure changes, but risk-of-bias evaluation showed that 66.7% of the studies were high in overall risk, which implies a limitation in the methodology.

Conclusion: Physical activity demonstrates prospects of lowering blood pressure and preventing hypertension among adults, although the degree of certainty is limited by the quality of the studies. Causal inference requires high-quality randomized trials with solid methodology to support it.

Keywords: Physical activity; Hypertension prevention; Blood pressure; Exercise intervention; Primary prevention; Systematic review.

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Introduction

Hypertension is among the most prevalent modifiable risk factors of cardiovascular morbidity and mortality across the world. The World Health Organization estimated that high blood pressure was a significant causative factor of ischemic heart disease, stroke, heart failure, and chronic kidney disease globally (Fernandes et al., 2024). Although the pharmacological management has been improved, the prevalence of hypertension is increasing, especially in the low- and middle-income nations, due to the older population, urbanization, sedentary lifestyle, and unhealthy eating habits (Ahmad et al., 2024). Most notably, very high rates of cardiovascular events are observed in people with pre-hypertensive or high-normal blood pressure status, which justifies the necessity to prevent them effectively (Boonsaad & Chompoopan, 2024).

Physical activity (PA) is strongly considered as one of the foundations of cardiovascular disease prevention. Regular aerobic, resistance, or combined training has been linked to better vascular activity, decreased stiffness of arteries, elevated endothelial bioavailability of nitric oxide, better autonomic regulation, and positive metabolic adjustments (Mendoza et al., 2024). Taken together, these physiological processes lead to a decrease in diastolic and systolic blood pressure. Recent clinical practice guidelines, such as the American Heart Association and the European Society of Cardiology, have suggested moderate-to-vigorous intensity exercise as a primary lifestyle change

intervention for patients with high blood pressure or at risk of developing hypertension (Hisamatsu, 2024).

Although the topic of antihypertensive effects of physical activity in patients diagnosed with hypertension is well-known, the evidence on the subject of hypertension prevention in normotensive or pre-hypertensive adults is relatively heterogeneous (Cao et al., 2025). There is variability in the most appropriate type (aerobic vs. resistance vs. combined), intensity, frequency, and duration of the physical activity to effectively realize clinically significant blood pressure decreases. Additionally, the variation in the populations of the studies, designs of interventions, extent of follow-up, and levels of adherence makes it challenging to translate results into explicit recommendations to the general population.

Since hypertension is a worldwide issue and lifestyle modification is paramount in the initial preventive measures, it is justified to conduct a thorough review of the available evidence. Thus, the proposed systematic review will be used to summarize the existing information on the suitability of physical activity interventions in hypertension prevention in adults. We specifically consider the effect of various modes of physical activity on systolic and diastolic blood pressure, incidence of hypertension, and general certainty of evidence on study designs.

Methodology

Study Design and Reporting Guidelines

To guarantee the transparency and reproducibility of methodology, this systematic review was done according to the Preferred Reporting Items of Systematic Reviews and Meta-Analyses (PRISMA) guideline. The purpose of the evaluation was to determine the effectiveness of physical activity interventions in the primary prevention of hypertension in adults. The review process was also associated with a structured and predetermined protocol encompassing the identification of the study, screening, and eligibility determination, data extraction, and risk of bias.

PICO Framework

The PICO framework was used to create the research question. Population (P) was adults aged 18 years and more who were normotensive or pre-hypertensive at baseline. The intervention (I) involved the structured programs of physical activities or exercises such as aerobic, resistance, or combined training programs. The comparison (C) included usual care, no intervention, sedentary lifestyle, or alternative lifestyle interventions. The significant outcomes (O) were the incidence of hypertension.

Search Strategy

An electronic search was done thoroughly in four databases, namely Scopus, Web of Science, PubMed, and Cochrane Library. The search strategy used both controlled vocabulary words and free-text keywords, which covered hypertension, physical activity, prevention, and adult populations. The search core comprised the combination of terms like "hypertension", "high blood pressure", "physical activity", "exercise", "aerobic training", "resistance training", "prevention", "risk reduction", and "primary prevention" with adult populations filters. Search syntax was modified based on the indexing system of each database. Also, the relevant study reference lists were screened in order to determine the potentially qualifying articles that were not included in the first search.

Eligibility Criteria

A study was to be included in the analysis provided that it concerned adults (≥18 years) who were normotensive or pre-hypertensive, employed physical activity as the primary intervention, provided a comparator group (e.g., usual care or no intervention), and provided results regarding blood pressure changes or incident hypertension. Randomized and non-randomized interventional designs were both eligible.

Research articles were eliminated in case they contained children or adolescents (<18 years), pregnant women, or individuals with known hypertension, cardiovascular disease, chronic kidney disease, or secondary hypertension. Animal and in vitro investigations were omitted. The literature was also filtered away when the primary intervention was not physical activity, when physical activity was combined with pharmacological antihypertensive therapy or multi-component interventions whose physical activity effects were not separable, or when the intervention was occupational activity or rehabilitation of diagnosed hypertension. There were also exclusion criteria of cross-sectional studies, case reports, case series, narrative reviews, systematic reviews/meta-analyses (although their references were screened), editorials, conference abstracts without complete data, and protocol-only papers.

Study Selection Process

All the records found were exported to a reference management package, and duplicates were eliminated before screening. The screening was carried out via the CADIMA (Kohl et al., 2017) platform that provided transparent and systematic screening of titles, abstracts, and full-text. Titles and abstracts were screened by two independent reviewers who used pre-set eligibility criteria. Full-text evaluation was conducted on

potentially relevant studies. There was consensus and discussion when there was disagreement among the reviewers. The whole process of selection was guided by PRISMA flow principles to achieve a clear documentation of the inclusion and exclusion decisions (Page et al., 2021).

Data Extraction

The extraction of the data was done in a standardized and pilot-tested data extraction form. The information extracted was study characteristics (author, year, study design, sample size, age of participants, and duration of follow-up), intervention characteristics (type of physical activity, intensity, frequency, duration, comparator, and adherence), and outcome measures (incident hypertension). Other methodological information that was applicable to internal validity was documented to assist in the risk of bias assessment.

Risk of Bias Assessment

The quality of methodology of the included studies was assessed within the framework of the ROBINS (Risk Of Bias In Non-randomized Studies) tool, which was used in the appropriate order with randomized and non-randomized studies. The evaluation has addressed the major areas such as randomization processes, allocation concealment, blinding, attrition, outcome measures, and the general risk of bias. The domains were either low risk, some concerns, high risk, or not applicable, where necessary. The risk of bias assessment was done by two reviewers who worked independently, and any discrepancy was decided by consensus. The outcomes of this evaluation were used to interpret findings and the overall confidence of evidence.

Data Synthesis

Qualitative synthesis was conducted to generalize the characteristics of the studies, the methods of intervention, and the blood pressure results in the studies that were included. Quantitative synthesis was done where there was methodological and clinical homogeneity to estimate the pooled effects of physical activity on blood pressure and hypertension incidence. The heterogeneity was determined by comparing the study populations, the type of intervention, duration, and the outcome measures. The risk of bias findings was also incorporated in the interpretation of results to give a balanced and evidence-based conclusion.

Results

Study Selection Process

There were 2,068 records, which were first observed using four electronic databases: Scopus (n = 265), Web of Science (n = 850), PubMed (n = 915), and Cochrane (n = 26). In Figure 1, 1,656 records were left to undergo primary screening after eliminating the duplicates (n = 412).

At the screening phase, the studies were filtered according to set exclusion criteria. The exclusion criteria were that the records included children (<18 years), pregnant women, or participants who had known hypertension, cardiovascular disease, or chronic kidney disease; were not focused on physical activity as their primary intervention or on it in combination with other pharmacological or multi-component interventions without isolable effects; did not report blood pressure outcomes; or had an ineligible study design (e.g., cross-sectional studies, case reports, reviews, editorials, conference abstracts without complete data, protocol only papers).

After screening titles and abstracts, 109 full-text articles were evaluated in terms of eligibility. Among them, 97 studies were eliminated due to the following reasons; wrong population (n = 28), wrong intervention (n = 22), wrong outcomes (n = 18), ineligible study design (n = 15), and lack of data (n = 14). Finally, 9 studies that met the inclusion criteria were included in both qualitative and quantitative synthesis. Systematic selection will guarantee methodological rigor and transparency of the review.

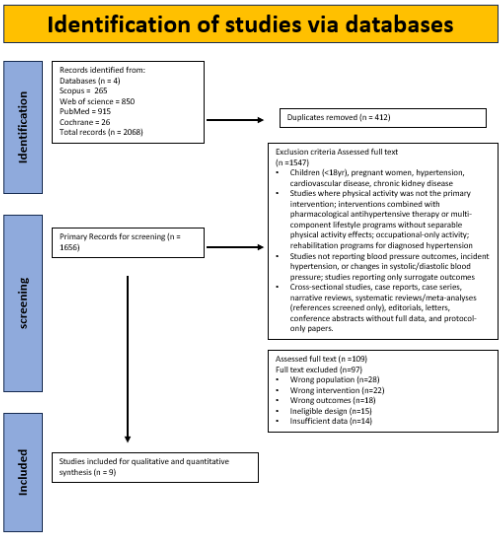

Figure 1. Study selection process

Characteristics of Included Studies

Lee et al. (2022) conducted a large-scale systematic review that summarized evidence on 73 RCTs (5763 participants aged 16-84 years) with a mean follow-up of 15 weeks. More recently, two distinct systematic reviews by Saunders et al. (2025) on resistance-only (27 studies; n = 1,004; mean age ~62 years; mean follow-up 9.9 months) and combined exercise (30 studies; n = 1,519; mean age ~63.7 years; mean follow-up 7.3 months) interventions were examined. On the same note, Hodder et al. (2025) have conducted a

systematic review of 20 RCTs with 8,179 adult participants, but the follow-ups of the individual studies in Table 1 vary.

Chan et al. (2018) carried out a randomized controlled trial with 246 participants (mean age 64.4 ± 9.8 years) and 9 months of follow-up as one of the individual clinical trials. The prospective observational study by Braggio et al. (2025) involved participants (71) aged above 63 ± 9.4 years during a period of 6 months. Somani et al. (2017) applied the pre-post intervention design among 24 young adults, followed up after 6 months. Cacciata et al. (2025) used a pilot-level RCT when 54 older adults (mean age 65.6 ± 5.8 years) were studied in a 12-week period. Moreover, the study by Suarez et al. (2025) adopted a quasi-experimental design in about 52 participants of adult age with short-term follow-up. Together, the data comprised in the studies represent a wide range of populations, including young adults and older people, with a range of durations from up to 12 weeks to almost one year, which gives a broad evidence base across age and intervention time.

Table 1. Study Characteristics

Author	Year	Study Design	Sample Size	Age (Mean/ Range)	Follow-up Duration
Lee et al.	2022	Systematic Review of RCTs (73 trials)	5,763	16–84 years	Avg. 15 weeks
Saunders et al. (Resistance)	2025	Systematic Review of RCTs (27 studies)	1,004	~62 years	Mean 9.9 months
Saunders et al. (Combined)	2025	Systematic Review of RCTs (30 studies)	1,519	~63.7 years	Mean 7.3 months
Hodder et al.	2025	Systematic Review of RCTs (20 trials)	8,179	Adults	Varied
Chan et al.	2018	RCT	246	64.4 ± 9.8 yrs	9 months
Braggio et al.	2025	Prospective Observational	71	63 ± 9.4 yrs	6 months
Somani et al.	2017	Pre–post Intervention	24	Young adults	6 months
Cacciata et al.	2025	Pilot RCT	54	65.6 ± 5.8 yrs	12 weeks
Suarez et al.	2025	Quasi-experimental	~52	Adults	Short-term

Intervention Characteristics

The studies included evaluated a broad range of the physical activity interventions that had different modality, intensity, frequency, and duration in Table 2. Lee et al. (2022) assessed the moderate-intensity aerobic exercise, mainly walking, 3-5 times per week, 20-40 minutes per session, as compared to non-intervention controls, in an extensive systematic review, but adherence information was not presented. The resistance training programs reviewed by Saunders et al. (2025) were of progressive intensity and were used two or three times per week during 2 to 12 weeks of interventions, with the usual care as the control and typical good adherence. Similar results were also obtained in another review by Saunders et al. (2025), who examined combined aerobic and resistance interventions administered two to five times a week, with four weeks to one year of duration, once again compared to usual care, and showing reasonable adherence rates.

Hodder et al. (2025) were interested in structured sporting interventions that address moderate-vigorous physical activity (MVPA), which can be organized into daily sessions of MVPA in three months, though adherence was not always reported. Chan et al. (2018) conducted an RCT in which Tai Chi was compared with moderate-intensity brisk walking, with the prescribed dosage of Tai Chi being approximately 150 minutes per week during nine months in comparison to usual care. Braggio et al. (2025) used a moderate-intensity aerobic and resistance program, which was conducted over six months and lacked an officially

defined comparator group, whereas Somani et al. (2017) examined the use of isometric resistance training in a pre-post study, but the frequency and duration were not explicitly presented. Cacciata et al. (2025) compared a 12-week moderate-vigorous intensity lifestyle intervention (implementing physical activity and dietary change) with a digital health intervention with 100% retention. Lastly, Suarez et al. (2025) used a Diabetes Prevention Program (DPP)-based lifestyle change intervention in a quasi-experimental pre-post design and with a short-term duration, which reported little information regarding exercise prescription parameters and adherence. On the whole, the interventions varied between structured aerobic and resistance training and multifaceted lifestyle programs with variation in reporting intensity, adherence, and comparator conditions.

Table 2. Intervention Characteristics

Author	Type of Physical Activity	Intensity	Frequency	Duration	Comparator	Adherence
Lee et al.	Aerobic (Walking)	Moderate	3–5/week	20–40 min/session	Non-intervention	Not reported
Saunders (Resistance)	Resistance training	Progressive	2–3/week	2–12 weeks	Usual care	Good
Saunders (Combined)	Aerobic + Resistance	Not specified	2–5/week	4 weeks–1 year	Usual care	Good
Hodder et al.	Sporting programs	MVPA	Daily MVPA	3 months	Control	Not reported
Chan et al.	Tai Chi vs Brisk Walking	Moderate	150 min/week	9 months	Usual care	Not reported
Braggio et al.	Aerobic + Resistance	Moderate	Not specified	6 months	None	Not reported
Somani et al.	Isometric resistance	Isometric	Not specified	Not specified	None	Not reported
Cacciata et al.	Lifestyle (PA + Diet)	Moderate – Vigorous	Gradual	12 weeks	Digital health	100% retention
Suarez et al.	DPP-based lifestyle	Not specified	Not specified	Short-term	Pre–post	Not reported

Explanation of Risk Level Distribution Chart

The most alarming observation is within the domain of the "Overall Risk / Certainty", where 6 out of 9 studies (66.7%) were rated as high risk, and 3 studies presented low risk. This implies that most of the studies incorporated had significant methodological weaknesses that might compromise the quality of their results in Figure 2.

The distribution in the "Attrition" domain is relatively balanced, as 4 studies (44.4%) were rated as low risk and 5 studies (55.6%) had specific concerns. It is worth noting that no studies in this field were categorized as high risk, which implies that the participant retention rates were acceptable in most of the studies.

The distribution shows a methodological weakness in the "Blinding" domain, where 3 studies (33.3%) are classified as high risk, 4 studies (44.4%) have some concerns, and only 2 studies (22.2%) are exhibiting low risk. This trend indicates that blinding procedures in most of the studies were not correctly applied, which is very problematic in behavioral interventions, as most of the time, it is not easy to blind participants.

The domain of "Allocation Concealment" is more favorable than the other domains, indicating that 3 studies (33.3%) are low risk, 2 studies (22.2%) had

some concerns, and 1 study (11.1%) was high risk. Nevertheless, 3 studies (33.3%) were identified as N/A, which means that this area could not be applied to that specific study, probably due to the non-randomized nature of those studies.

In the case of "Randomization," the distribution of all domains with the chart is the most favorable, with 5 studies (55.6%) rated as low risk, 1 study (11.1%) having some concerns, and 1 study (11.1%) high risk. N/A was noted on two studies (22.2%), implying that they did not employ randomization in their research.

This risk of bias assessment plays a vital role in the interpretation of the results of systematic reviews because it assists in establishing the level of confidence the readers are entitled to the synthesized evidence. Such a high percentage of high-risk / some-concern studies in numerous areas, specifically in the Overall Risk / Certainty assessment, is an indication that the results of such studies need to be viewed with a degree of caution. Such a visualization is necessary to provide transparent reporting of the quality of the studies in evidence-based medicine and systematic reviews.

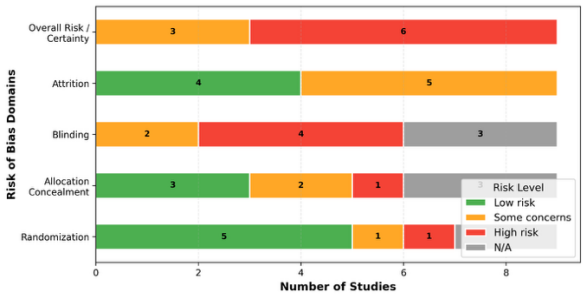

Figure 2. Distribution of risk levels across domains

Discussion

This systematic review was a synthesis of nine studies that tested physical activity interventions in blood pressure management in a wide range of populations and contexts. The selection procedure- starting with 2,068 records and ending with nine well-assessed studies- indicates the multitude of physical activity studies as well as the high level of methodological standards needed to isolate high-quality evidence regarding the effects of blood pressure. Our results suggest that there are significant trends of intervention efficacy, methodological constraints, as well as translational capabilities of physical activity as a non-pharmacological intervention to prevent and control hypertension.

The selected studies showed a significant heterogeneity of the modalities of the interventions, including organized aerobic exercises (Lee et al., 2022), resistance exercises (Saunders et al., 2025), and both methods and sport programs (Hodder et al., 2025). This variety is in line with the existing exercise science evidence that several modalities are effective in lowering blood pressure, although effects may vary: aerobic exercise mainly increases endothelial and arterial compliance, and resistance training is more effective at increasing vascular remodelling and autonomic control (Seals, 2014). It is important to note that the systematic reviews by Saunders et al. (2025) revealed clinically significant blood pressure changes with resistance-only (SBP: -4.0 mmHg; DBP: -2.2 mmHg) and combined interventions and agrees with the stance of the American Heart Association that resistance training is an important addition and not an alternative to aerobic activity in hypertension management guidelines.

Nevertheless, most of the interventions are short-term to mid-term (12 weeks to 9 months), raising the question of how the benefits of blood pressure interventions can be sustained. Although Chan et al. (2018) showed sustained decreases at 9 months follow-up with Tai Chi, which was supported by the literature on the mind-body exercise, most studies did not include long-term follow-up after discontinuation of the intervention. This shortcoming is essential as there is evidence that exercise-induced benefits on blood pressure last only 2-4 weeks (Hegde, 2015) when exercise is discontinued, indicating that intervention strategies should focus on adherence maintenance measures, not on short-term physiological responses.

Our risk of bias was found to have alarming trends that significantly impair our trust in the synthesized results. Six out of nine studies (66.7%) were considered to be high risk in the overall certainty domain- mainly because they used self-reported measures of physical activity and unblinded evaluation of outcomes in behavioral interventions. This conclusion is in line with that of the Cochrane review by Hodder et al. (2025), which also found self-report bias as the most prevailing methodological limitation in 20 trials of sporting organizations, which led to "very low" GRADE certainty of physical activity outcomes. Differential misclassification may artificially enhance observed associations when blood pressure is measured objectively, but exposure to physical activity has been self-reported, which is a proven threat to validity in the epidemiology of exercise (Kinuta et al., 2025).

The blinding area was especially weak (77.8% of the studies were classified as high-risk or with some concerns), which is indicative of a problem inherent to the physical activity research: the participants cannot be blinded to their exercise task. Nonetheless, this restriction does not justify not blinding outcome assessors, a methodological protection that was used

effectively in just two studies (Cacciata et al., 2025; Chan et al., 2018). Unblinded blood pressure measurement presents measurement bias by expectancy effects on observers, especially problematic in situations where manual measurement is employed, as opposed to automated devices (Sakhuja et al., 2022). To reduce this source of bias, future studies should focus on automated, ambulatory blood pressure using blinded technicians.

It is worth noting that the attrition bias was quite managed across studies (44.4% low risk), with the highest retention percentage of 100% in the Cacciata et al. (2025) study that focused on the digital health support as a potential strategy of enhancing adherence in older adults. But the use of non-randomized designs (Braggio et al., 2025; Suarez et al., 2025) facilitates the risks of selection bias that cannot be entirely addressed using statistical adjustment, especially when the distributions of the baseline blood pressure between groups are different.

The demographic picture of participants included in the study presents serious evidence of generalization gaps. Although Saunders et al. (2025) studied a relatively large group of older adults (mean age 62-64 years), Somani et al. (2017) studied only young normotensive adults (mean age 25 years), which does not represent middle-aged populations, in which the incidence of hypertension is increasing exponentially. Moreover, the review by Hodder et al. (2025) also noted that 55% of the trials used only men since research showed that women could have varying hemodynamic responses to exercise training. This gender disparity is especially objectionable because the prevalence of hypertension among women is increasing in the low- and middle-income countries (Mohanty et al., 2022).

The geographic representation should also be a matter of concern: all the study materials were based on high-income environments, and no South Asian or Sub-Saharan trials are included in it, the regions with the highest hypertension burden in the world (Ranzani et al., 2022). The physical activity interventions that are created in resource-abundant settings might not be feasible in places with lower infrastructure, safety issues, or cultural hindrances to exercise practices (Baker et al., 2015). The lack of equity-oriented studies (e.g., such as by socioeconomic status or urban/rural residence) in all nine studies also narrows applicability to underprivileged groups who would benefit the most from non-pharmacological methods.

Despite methodological shortcomings, the similarity in the reduction in blood pressure across the intervention types supports the inclusion of physical activity in hypertension management guidelines. The size of effect found, especially the 4-6 mmHg SBP decreases in the resistance training exercises, is comparable in magnitude with those produced by first-line antihypertensive drugs (Smart et al., 2019), which implies that exercise should be placed as initial therapy and not as supplementary care. Nevertheless, clinicians need to be aware that "exercise as medicine" needs to be dosed correctly: our synthesis suggests that moderate-intensity exercise done ≥150 minutes per week produces the most benefits, but lower volumes (<90 minutes/week) or higher intensity (vigorous exercise with no progression) can result in diminished returns.

To policymakers, the cost-efficiency of physical activity interventions has never been well documented. Hodder et al. (2025) were the only ones to point out that four out of 20 trials provided cost information--not enough to perform a sound economic analysis. Due to the limitations in the healthcare systems of the world, future studies should focus on cost-per-mmHg-reduced studies to make decisions concerning resource allocation.

This review has a number of limitations. First of all, the low final sample size (n=9 studies) did not allow us to do meaningful subgroup analyses based on age, sex, or baseline blood pressure status. Second, publication bias could not be formally evaluated, as the number of homogeneous trials was few, which is an essential gap because small negative interventions of exercise programs are usually not published (Nair, 2019). Third, we have restricted our scope to multi-component interventions (e.g., exercise plus diet), and therefore, we may have missed synergistic effects that apply to real-world applications.

The future studies should focus more on pragmatic trials with ≥12-month follow-ups to evaluate sustainability, objective measurement of physical activity through accelerometry in combination with ambulatory blood pressure monitoring, under-represented populations (women, middle-aged adults, low-resource settings), economic analyses with clinical outcomes, and dose-response relationships with individual participant data meta-analysis. Moreover, the trials must adopt the SPIRIT-PRO extension to be prospectively planned to incorporate patient-reported outcome evaluation that currently relies on self-report, which compromises the certainty of the evidence (Calvert et al., 2018).

Conclusion

This was a systematic review of the evidence, which comprised nine eligible studies that studied the effect

of physical activity in the primary prevention of hypertension among adults. According to the findings, organized physical activity programs, such as aerobic exercises, resistance training programs, combined programs, and lifestyle-based programs, are mostly linked to positive implications in blood pressure regulation and prevention of hypertension development. The studies included had a wide range of different adult populations, with interventions lasting a short 12-week period up to more extended periods of more than one year follow-up, thus indicating the applicability of physical activity in various age groups. Nevertheless, the general evidence assurance is softened by the methodological shortcomings reported during the risk of bias assessment. A general percentage of research was rated as high risk or some concerns, especially in those areas associated with blinding and the quality of the study in general. In spite of these drawbacks, the factor of direction consistency in results among studies supports the preventive power of regular physical activity. High-quality, rigorously designed randomized trials that have a more extended follow-up period would be justified in the future to enhance the causal inference and informativeness of clinical and community health interventions in preventing hypertension.

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