Evidence Portfolio – Cardiometabolic Health and Weight Management Subcommittee, Question 2

In people with normal blood pressure or prehypertension, what is the relationship between physical activity and blood pressure?

a. Is there a dose-response relationship? If yes, what is the shape of the relationship?
b. Does the relationship vary by age, sex, race/ethnicity, socio-economic status, weight status, or resting blood pressure level?
c. Does the relationship vary based on frequency, duration, intensity, type (mode), or how physical activity is measured?

Source of Evidence: Existing Meta-Analyses

Conclusion Statements and Grades

Strong evidence demonstrates that physical activity reduces blood pressure among adults with prehypertension and normal blood pressure. **PAGAC Grade: Strong.**

Strong evidence demonstrates an inverse dose-response relationship between physical activity and incident hypertension among adults with normal blood pressure. **PAGAC Grade: Strong.**

Insufficient evidence is available to determine whether a dose-response relationship exists between physical activity and incident hypertension among adults with prehypertension. **PAGAC Grade: Not assignable.**

Insufficient evidence is available to determine whether the relationship between physical activity and blood pressure varies by age, sex, race/ethnicity, socioeconomic status, or weight status among adults with normal blood pressure and prehypertension. **PAGAC Grade: Not assignable.**

Strong evidence demonstrates the magnitude of the blood pressure response to physical activity varies by resting blood pressure level, with greater benefits occurring among adults with prehypertension than normal blood pressure. **PAGAC Grade: Strong.**

Insufficient evidence is available to determine whether the relationship between blood pressure and physical activity varies by the frequency, intensity, time, and duration of physical activity, or how physical activity is measured among adults with normal blood pressure and prehypertension. **PAGAC Grade: Not assignable.**

Moderate evidence indicates the relationship between resting blood pressure level and the magnitude of benefit does not vary by type (mode, i.e., aerobic, dynamic resistance, combined) of physical activity among adults with normal blood pressure and prehypertension. **PAGAC Grade: Moderate.**

Description of the Evidence

An initial search for systematic reviews, meta-analyses, pooled analyses, and reports identified sufficient literature to answer the research question as determined by the Cardiometabolic Health and Weight Management Subcommittee. Additional searches for original research were not needed.

Existing Meta-Analyses

Overview

A total of 10 existing reviews were included. All the included reviews were meta-analyses.[1-10] The reviews were published from 2007[6] to 2017.[8] The meta-analyses included a range of 9[1] to 93[4] studies.

Exposures

The meta-analyses examined physical activity interventions that incorporated a variety of types (i.e. modes) of physical activity. Three meta-analyses examined aerobic exercise training,[4, 6, 10] 3 examined resistance exercise training,[2, 3, 9] 1 examined combined concurrent exercise training (i.e. combined aerobic and resistance exercise training),[5] and 1 examined isometric resistance training.[1] Huai et al[7] and Liu et al[8] focused on leisure-time physical activity although they also assessed other domains.

Outcomes

All included reviews addressed blood pressure as an outcome. Two reviews[7, 8] examined incidence of hypertension.

Populations Analyzed

The table below lists the populations analyzed in each article.

Table 1. Populations Analyzed by All Sources of Evidence

	Sex	Race/ Ethnicity	Age	Weight Status	Chronic Conditions	Other
Carlson, 2014			Adults >18		Normal/ Optimal BP, Hypertension	
Casonatto, 2016	Male, Female		Adults 18–80 years		Normal/ Optimal BP, Hypertension	
Cornelissen, 2011			Adults 19–84 (50>,50<)		Normal/ Optimal BP, Pre-hypertension, Hypertension	
Cornelissen, 2013	Male, Female		Adults ≥18 (50<, 50>)		Normal/Optimal BP, Pre-hypertension, Hypertension	
Corso, 2016			Adults >19 (Mean 55.8)		Normal/Optimal BP, Pre-hypertension, Hypertension	
Fagard, 2007			Adults 20–83		Normal/ Optimal BP, Hypertension	
Huai, 2013			Adults		Normal/Optimal BP	
Liu, 2017	Male, Female		Adults <50, 50>	Normal/ Healthy Weight, Overweight AND Obese	Normal/Optimal BP	Nationality (American, European, Asian, Other), Smoking status
MacDonald, 2016		White	Adults ≥19 (Mean 47.4)		Normal/Optimal BP, Pre- hypertension, Hypertension	
Murtagh, 2015			Adults 30–83		Normal/Optimal BP/Pre-hypertension, Hypertension	

Supporting Evidence

Existing Meta-Analyses

Table 2. Existing Meta-Analyses Individual Evidence Summary Tables

Meta-Analysis **Citation:** Carlson DJ, Dieberg G, Hess NC, Millar PJ, Smart NA. Isometric exercise training for blood pressure management: a systematic review and meta-analysis. *Mayo Clin Proc.* 2014;89(3):327-334. doi:10.1016/j.mayocp.2013.10.030.	
Purpose: To quantify the effects of isometric resistance training on the change in systolic blood pressure, diastolic blood pressure, and mean arterial pressure in subclinical populations. **Timeframe:** 1966–July 2013 **Total # of Studies:** 9 **Exposure Definition:** Isometric exercise training for 4 or more weeks. **Measures Steps:** No **Measures Bouts:** No **Examines HIIT:** No **Outcomes Addressed:** Normotensive: Systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP) calculated by adding DBP plus one-third pulse pressure, and resting heart rate (RHR) **Examine Cardiorespiratory Fitness as Outcome:** No	**Abstract:** OBJECTIVE: To conduct a systematic review and meta-analysis quantifying the effects of isometric resistance training on the change in systolic blood pressure(SBP), diastolic blood pressure (DBP), and mean arterial pressure in subclinical populations and to examine whether the magnitude of change in SBP and DBP was different with respect to blood pressure classification. PATIENTS AND METHODS: We conducted a systematic review and meta-analysis of randomized controlled trials lasting 4 or more weeks that investigated the effects of isometric exercise on blood pressure in healthy adults (aged >/=18 years) and were published in a peer-reviewed journal. PubMed, CINAHL, and the Cochrane Central Register of Controlled Trials were searched for trials reported between January 1, 1966, and July 31, 2013. We included 9 randomized trials, 6 of which studied normotensive participants and 3 that studied hypertensive patients, that included a total of 223 participants (127 who underwent exercise training and 96 controls). RESULTS: The following reductions were observed after isometric exercise training: SBP-mean difference (MD), -6.77 mm Hg (95% CI, -7.93 to -5.62 mm Hg; P<.001); DBP-MD, -3.96 mm Hg (95% CI, -4.80 to -3.12 mm Hg; P<.001); and mean arterial pressure-MD, -3.94 mm Hg (95% CI, -4.73 to -3.16 mm Hg; P<.001). A slight reduction in resting heart rate was also observed (MD, -0.79 beats/min; 95% CI, -1.23 to -0.36 beats/min; P=.003). CONCLUSION: Isometric resistance training lowers SBP, DBP, and mean arterial pressure. The magnitude of effect is larger than that previously reported in dynamic aerobic or resistance training. Our data suggest that this form of training has the potential to produce significant and clinically meaningful blood pressure reductions and could serve as an adjunctive exercise modality.
Populations Analyzed: Adults >18, Normal/Optimal BP, Hypertension	**Author-Stated Funding Source:** Not Reported

Meta-Analysis **Citation:** Casonatto J, Goessler KF, Cornelissen VA, Cardoso JR, Polito MD. The blood pressure-lowering effect of a single bout of resistance exercise: a systematic review and meta-analysis of randomised controlled trials. *Eur J Prev Cardiol.* 2016;23(16):1700-1714.	
Purpose: To use the aggregate data and apply a meta-analytic approach in order to determine the effects of a single session of resistance exercise on office and ambulatory blood pressure (BP) in healthy adults. The second objective was to examine the effects of exercise and patient characteristics on the BP reduction induced by a single bout of resistance exercise. **Timeframe:** Inception–July 2015 **Total # of Studies:** 30 **Exposure Definition:** Single session of conventional resistance training or circuit model exercise. Number of sets and repetition per set varied by studies. **Measures Steps:** No **Measures Bouts:** No **Examines HIIT:** No **Outcomes Addressed:** Normotensive: BP **Examine Cardiorespiratory Fitness as Outcome:** No	**Abstract:** BACKGROUND: Current exercise guidelines recommend aerobic types of exercises on most days of the week, supplemented with dynamic resistance exercise twice weekly. Whereas the blood pressure (BP)-lowering effects of a single session of aerobic exercise have been well studied, less is known about the hypotensive effect of a single bout of resistance exercise. OBJECTIVES: To evaluate the transient effect of resistance exercise on BP by means of meta-analytic techniques. METHODS: A systematic electronic search in Medline, Scientific Electronic Library Online (SciELO), Latin American and Caribbean Health Sciences Literature (LILACS), Elton B Stephens Company (EBSCO), EMBASE and SPORTDiscus was completed in March 2015 identifying randomised controlled trials investigating the effect of a single bout of resistance exercise on resting or ambulatory BP in healthy adults. A subsequent meta-analysis was performed. RESULTS: The meta-analysis involved 30 studies, 81 interventions and 646 participants (normotensive (n = 505) or hypertensive (n = 141)). A single bout of resistance exercise elicited small-to-moderate reductions in office systolic BP at 60 minutes postexercise [-3.3 (-4.0 to -2.6)/-2.7 (-3.2 to -2.1) mmHg (CI 95%)], 90 minutes postexercise [-5.3 (-8.5 to -2.1)/-4.7 (-6.9 to -2.4) mmHg (CI 95%)] and in 24-hour ambulatory BP [-1.7 (-2.8 to -0.67)/-1.2 (-2.4 to -0.022) mmHg (CI 95%)] compared to a control session. The reduction in office BP was more pronounced in hypertensive compared to normotensive individuals (p <0.01), when using larger muscle groups (p < 0.05) and when participants were recovering in the supine position (p < 0.01). CONCLUSION: A single bout of resistance exercise can have a BP-lowering effect that last for up to 24 hours. Supine recovery and the use of larger muscle groups resulted in greater BP reductions after resistance exercise.
Populations Analyzed: Male, Female, Adults 18–80 years, Normal/Optimal BP, Hypertension	**Author-Stated Funding Source:** Brazilian Council for Research Development (CNPq), Research Foundation Flanders

<table>
<tr><td colspan="2">Meta-Analysis
Citation: Cornelissen VA, Fagard RH, Coeckelberghs E, Vanhees L. Impact of resistance training on blood pressure and other cardiovascular risk factors: a meta-analysis of randomized, controlled trials. Hypertension. 2011;58(5):950-958. doi:10.1161/HYPERTENSIONAHA.111.177071.</td></tr>
<tr><td>Purpose: To update the meta-analysis of the effect of resistance training (RT) on blood pressure (BP) and to assess a potential relation between different RT characteristics and the BP response; and to examine the simultaneous effect of RT on other cardiovascular risk factors.</td><td rowspan="5">Abstract: We reviewed the effect of resistance training on blood pressure and other cardiovascular risk factors in adults. Randomized, controlled trials lasting >/=4 weeks investigating the effects of resistance training on blood pressure in healthy adults (age >/=18 years) and published in a peer-reviewed journal up to June 2010 were included. Random- and fixed-effects models were used for analyses, with data reported as weighted means and 95% confidence limits. We included 28 randomized, controlled trials, involving 33 study groups and 1012 participants. Overall, resistance training induced a significant blood pressure reduction in 28 normotensive or prehypertensive study groups [-3.9 (-6.4; -1.2)/-3.9 (-5.6; -2.2) mm Hg], whereas the reduction [-4.1 (-0.63; +1.4)/-1.5 (-3.4; +0.40) mm Hg] was not significant for the 5 hypertensive study groups. When study groups were divided according to the mode of training, isometric handgrip training in 3 groups resulted in a larger decrease in blood pressure [-13.5 (-16.5; -10.5)/-6.1(-8.3; -3.9) mm Hg] than dynamic resistance training in 30 groups [-2.8 (-4.3; -1.3)/-2.7 (-3.8; -1.7) mm Hg]. After dynamic resistance training, Vo(2) peak increased by 10.6% (P=0.01), whereas body fat and plasma triglycerides decreased by 0.6% (P<0.01) and 0.11 mmol/L (P<0.05), respectively. No significant effect could be observed on other blood lipids and fasting blood glucose. This meta-analysis supports the blood pressure-lowering potential of dynamic resistance training and isometric handgrip training. In addition, dynamic resistance training also favorably affects some other cardiovascular risk factors. Our results further suggest that isometric handgrip training may be more effective for reducing blood pressure than dynamic resistance training. However, given the small amount of isometric studies available, additional studies are warranted to confirm this finding.</td></tr>
<tr><td>Timeframe: Inception–June 2010</td></tr>
<tr><td>Total # of Studies: 28</td></tr>
<tr><td>Exposure Definition: Resistance training (dynamic vs. static or isometric) of at least four weeks duration as sole intervention. Interventions ranged 6–52 weeks (median 16) for dynamic and 8–10 weeks (median 8) for isometric. Median frequency three times/week with varying intensity, number of sets (1–6), number of exercise performed (1–14) and repetitions for each set (6–30).
Measures Steps: No
Measures Bouts: No
Examines HIIT: No</td></tr>
<tr><td>Outcomes Addressed: Normotensive: BP; Pre-hypertension: BP
Examine Cardiorespiratory Fitness as Outcome: Yes</td></tr>
<tr><td>Populations Analyzed: Adults 19–84 (50>,50<), Normal/Optimal BP, Pre-hypertension, Hypertension</td><td>Author-Stated Funding Source: Research Foundation Flanders</td></tr>
</table>

Meta-Analysis

Citation: Cornelissen VA, Smart NA. Exercise training for blood pressure: a systematic review and meta-analysis. *J Am Heart Assoc.* 2013;2(1):e004473. doi:10.1161/JAHA.112.004473.

Purpose: To (1) conduct a systematic review and meta-analysis of randomized controlled trials to compare the effects of endurance training, dynamic resistance training, isometric resistance training, or combined endurance and resistance training on the magnitude of change in systolic blood pressure (SBP) and diastolic blood pressure (DBP) in subclinical populations; (2) examine whether magnitude of change in SBP and DBP was different with respect to sex, age, and BP classification; and (3) examine whether magnitudes of change in SBP and DBP were related to exercise program characteristics, that is, program duration, exercise session duration, exercise intensity, exercise mode, weekly exercise duration, or weekly session frequency.

Timeframe: November 2003–February 2012

Total # of Studies: 93

Exposure Definition: Exercise intervention 4–52 weeks, 1–7x/week of varied time and intensity. Tested for differences with type of exercise (endurance training, dynamic resistance training, combined training, isometric resistance training) and for endurance training and dynamic resistance training. Subgroups: dynamic aerobic endurance training, dynamic resistance training, and combined training.

Measures Steps: No

Measures Bouts: No

Examines HIIT: No

Outcomes Addressed: Normotensive: BP; Pre-hypertension: BP

Examine Cardiorespiratory Fitness as Outcome: No

Abstract: BACKGROUND: We conducted meta-analyses examining the effects of endurance, dynamic resistance, combined endurance and resistance training, and isometric resistance training on resting blood pressure (BP) in adults. The aims were to quantify and compare BP changes for each training modality and identify patient subgroups exhibiting the largest BP changes. METHODS AND RESULTS: Randomized controlled trials lasting >/=4 weeks investigating the effects of exercise on BP in healthy adults (age >/=18 years) and published in a peer-reviewed journal up to February 2012 were included. Random effects models were used for analyses, with data reported as weighted means and 95% confidence interval. We included 93 trials, involving 105 endurance, 29 dynamic resistance, 14 combined, and 5 isometric resistance groups, totaling 5223 participants (3401 exercise and 1822 control). Systolic BP (SBP) was reduced after endurance (-3.5 mm Hg [confidence limits -4.6 to -2.3]), dynamic resistance (-1.8 mm Hg [-3.7 to -0.011]), and isometric resistance (-10.9 mm Hg [-14.5 to -7.4]) but not after combined training. Reductions in diastolic BP (DBP) were observed after endurance (-2.5 mm Hg [-3.2 to -1.7]), dynamic resistance (-3.2 mm Hg [-4.5 to -2.0]), isometric resistance (-6.2 mm Hg [-10.3 to -2.0]), and combined (-2.2 mm Hg [-3.9 to -0.48]) training. BP reductions after endurance training were greater (P<0.0001) in 26 study groups of hypertensive subjects (-8.3 [-10.7 to -6.0]/-5.2 [-6.8 to -3.4] mm Hg) than in 50 groups of prehypertensive subjects (-2.1 [-3.3 to -0.83]/-1.7 [-2.7 to -0.68]) and 29 groups of subjects with normal BP levels (-0.75 [-2.2 to +0.69]/-1.1 [-2.2 to -0.068]). BP reductions after dynamic resistance training were largest for prehypertensive participants (-4.0 [-7.4 to -0.5]/-3.8 [-5.7 to -1.9] mm Hg) compared with patients with hypertension or normal BP. CONCLUSION: Endurance, dynamic resistance, and isometric resistance training lower SBP and DBP, whereas combined training lowers only DBP. Data from a small number of isometric resistance training studies suggest this form of training has the potential for the largest reductions in SBP.

Populations Analyzed: Male, Female, Adults ≥18 (50<, 50>), Normal/Optimal BP, Pre-hypertension, Hypertension

Author-Stated Funding Source: Research Foundation Flanders

Meta-Analysis **Citation:** Corso LM, Macdonald HV, Johnson BT, et al. Is concurrent training efficacious antihypertensive therapy? A meta-analysis. *Med Sci Sports Exerc.* 2016;48(12):2398-2406.	
Purpose: To determine the efficacy of concurrent exercise training as antihypertensive therapy and to examine important potential moderators of the blood pressure response to concurrent exercise training. **Timeframe:** Inception–January 2015 **Total # of Studies:** 68 **Exposure Definition:** Concurrent exercise training (CET) that combines aerobic exercise and dynamic resistance training. On average CET performed at moderate intensity, 58 minutes/session, 2.9 times/week. Some performed aerobic and resistance on separate days and some performed both on same using circuit training (alternating between aerobic and resistance); majority were supervised interventions. **Measures Steps:** No **Measures Bouts:** No **Examines HIIT:** No **Outcomes Addressed:** Normotensive: Blood Pressure (BP); Pre-hypertension: BP **Examine Cardiorespiratory Fitness as Outcome:** No	**Abstract:** Aerobic exercise training and, to a lesser degree, dynamic resistance training, are recommended to lower blood pressure (BP) among adults with hypertension. Yet the combined influence of these exercise modalities, termed concurrent exercise training (CET), on resting BP is unclear. PURPOSE: This study aimed to meta-analyze the literature to determine the efficacy of CET as antihypertensive therapy. METHODS: Electronic databases were searched for trials that included the following: adults (>19 yr), controlled CET interventions, and BP measured pre- and postintervention. Study quality was assessed with a modified Downs and Black Checklist. Analyses incorporated random-effects assumptions. RESULTS: Sixty-eight trials yielded 76 interventions. Subjects (N = 4110) were middle- to older-age (55.8 +/- 14.4 yr), were overweight (28.0 +/- 3.6 kg.m), and had prehypertension (systolic BP [SBP]/diastolic BP [DBP] = 134.6 +/- 10.9/80.7 +/- 7.5 mm Hg). CET was performed at moderate intensity (aerobic = 55% maximal oxygen consumption, resistance = 60% one-repetition maximum), 2.9 +/- 0.7 d.wk for 58.3 +/- 20.1 min per session for 19.7 +/- 17.8 wk. Studies were of moderate quality, satisfying 60.7% +/- 9.4% of quality items. Overall, CET moderately reduced SBP (db = -0.32, 95% confidence interval [CI] = -0.44 to -0.20, -3.2 mm Hg) and DBP (db = -0.35, 95% CI = -0.47 to -0.22, -2.5 mm Hg) versus control (P < 0.01). However, greater SBP/DBP reductions were observed among samples with hypertension in trials of higher study quality that also examined BP as the primary outcome (-9.2 mm Hg [95% CI = -12.0 to -8.0]/-7.7 mm Hg [95% CI = -14.0 to -8.0]). CONCLUSIONS: Among samples with hypertension in trials of higher study quality, CET rivals aerobic exercise training as antihypertensive therapy. Because of the moderate quality of this literature, additional randomized controlled CET trials that examine BP as a primary outcome among samples with hypertension are warranted to confirm our promising findings.
Populations Analyzed: Adults >19 (Mean 55.8), Normal/Optimal BP , Pre-hypertension, Hypertension	**Author-Stated Funding Source:** Institute for Collaboration on Health, Intervention, and Policy (InCHIP), the Office of the Vice President for Research, Research Excellence Program, University of Connecticut (Storrs, CT, USA), Brazilian Council for the Scientific and Technological Development (CNPq)

Meta-Analysis **Citation:** Fagard RH, Cornelissen VA. Effect of exercise on blood pressure control in hypertensive patients. *Eur J Cardiovasc Prev Rehabil.* 2007;14(1):12-17.	
Purpose: To perform a comprehensive meta-analysis of randomized controlled trials on the effects of exercise on blood pressure, blood pressure-regulating mechanisms, and cardiovascular risk factors. **Timeframe:** Inception–2003 **Total # of Studies:** 72 (for dynamic aerobic endurance training) and 9 (resistance training) **Exposure Definition:** Dynamic aerobic endurance training (training programs that involve large muscle groups in dynamic activities to increase endurance performance) or resistance training (training programs that involve strength, weight, static or isometric exercises to increase muscular strength, power and endurance). **Measures Steps:** No **Measures Bouts:** No **Examines HIIT:** No **Outcomes Addressed:** Normotensive: Blood Pressure (BP) **Examine Cardiorespiratory Fitness as Outcome:** Yes	**Abstract:** Several large epidemiological studies have reported an inverse relationship between blood pressure and physical activity. However, longitudinal intervention studies are more appropriate for assessing the effects of physical activity. We performed meta-analyses of randomized controlled trials involving dynamic aerobic endurance training or resistance training. The meta-analysis on endurance training involved 72 trials and 105 study groups. After weighting for the number of trained participants, training induced significant net reductions in resting and daytime ambulatory blood pressure of, respectively, 3.0/2.4 mmHg (P<0.001) and 3.3/3.5 mmHg (P<0.01). The reduction in resting blood pressure was more pronounced in the 30 hypertensive study groups (-6.9/-4.9) than in the others (-1.9/-1.6; P<0.001 for all). Systemic vascular resistance decreased by 7.1% (P<0.05), plasma norepinephrine by 29% (P<0.001), and plasma renin activity by 20% (P<0.05). Body weight decreased by 1.2 kg (P<0.001), waist circumference by 2.8 cm (P<0.001), percentage body fat by 1.4% (P<0.001) and the homeostasis model assessment index of insulin resistance by 0.31 units (P<0.01); high-density lipoprotein cholesterol increased by 0.032 mmol/l (P<0.05). Resistance training has been less well studied. A meta-analysis of nine randomized controlled trials (12 study groups) on mostly dynamic resistance training revealed a weighted net reduction in blood pressure of 3.2 (P=0.10)/3.5 (P<0.01) mmHg associated with exercise. Endurance training decreases blood pressure through a reduction in systemic vascular resistance, in which the sympathetic nervous system and the renin-angiotensin system appear to be involved, and favourably affects concomitant cardiovascular risk factors. The few available data suggest that resistance training can reduce blood pressure. Exercise is a cornerstone therapy for the prevention, treatment and control of hypertension.
Populations Analyzed: Adults 20–83, Normal/Optimal BP, Hypertension	**Author-Stated Funding Source:** Not Reported

Meta-Analysis **Citation:** Huai P, Xun H, Reilly KH, Wang Y, Ma W, Xi B. Physical activity and risk of hypertension: a meta-analysis of prospective cohort studies. *Hypertension*. 2013;62(6):1021–1026. doi:10.1161/HYPERTENSIONAHA.113.01965.	
Purpose: To investigate the association between PA and incidence of hypertension. **Timeframe:** Inception–November 2012 **Total # of Studies:** 13 **Exposure Definition:** Recreational PA, occupational PA, or commuting PA. PA was categorized in three levels: low-level PA, high level PA, and all categories in between were pooled to represent moderate-level PA. **Measures Steps:** No **Measures Bouts:** No **Examines HIIT:** No **Outcomes Addressed:** Normotensive: Hypertension incidence **Examine Cardiorespiratory Fitness as Outcome:** No	**Abstract:** Published literature reports controversial results about the association of physical activity (PA) with risk of hypertension. A meta-analysis of prospective cohort studies was performed to investigate the effect of PA on hypertension risk. PubMed and Embase databases were searched to identify all related prospective cohort studies. The Q test and I(2) statistic were used to examine between-study heterogeneity. Fixed or random effects models were selected based on study heterogeneity. A funnel plot and modified Egger linear regression test were used to estimate publication bias. Thirteen prospective cohort studies were identified, including 136,846 persons who were initially free of hypertension, and 15,607 persons developed hypertension during follow-up. The pooled relative risk (RR) of main results from these studies suggests that both high and moderate levels of recreational PA were associated with decreased risk of hypertension (high versus low: RR, 0.81; 95% confidence interval, 0.76-0.85 and moderate versus low: RR, 0.89; 95% confidence interval, 0.85-0.94). The association of high or moderate occupational PA with decreased hypertension risk was not significant (high versus low: RR, 0.93; 95% confidence interval, 0.81-1.08 and moderate versus low: RR, 0.96; 95% confidence interval, 0.87-1.06). No publication bias was observed. The results of this meta-analysis suggested that there was an inverse dose-response association between levels of recreational PA and risk of hypertension, whereas there was no significant association between occupational PA and hypertension.
Populations Analyzed: Adults, Normal/Optimal BP	**Author-Stated Funding Source:** Independent Innovation Foundation of Shandong University, the Research Fund for the Doctoral Program of Higher Education of China, the Foundation for Outstanding Young Scientist in Shandong Province

<table>
<tr><td colspan="2">Meta-Analysis
Citation: Liu X, Zhang D, Liu Y, et al. Dose-response association between physical activity and incident hypertension: a systematic review and meta-analysis of cohort studies. Hypertension. 2017;69(5):813–820. doi:10.1161/HYPERTENSIONAHA.116.08994.</td></tr>
<tr><td>Purpose: To investigate the dose-response association between PA and incident hypertension among adults.</td><td rowspan="5">Abstract: Despite the inverse association between physical activity (PA) and incident hypertension, a comprehensive assessment of the quantitative dose-response association between PA and hypertension has not been reported. We performed a meta-analysis, including dose-response analysis, to quantitatively evaluate this association. We searched PubMed and Embase databases for articles published up to November 1, 2016. Random effects generalized least squares regression models were used to assess the quantitative association between PA and hypertension risk across studies. Restricted cubic splines were used to model the dose-response association. We identified 22 articles (29 studies) investigating the risk of hypertension with leisure-time PA or total PA, including 330,222 individuals and 67,698 incident cases of hypertension. The risk of hypertension was reduced by 6% (relative risk, 0.94; 95% confidence interval, 0.92-0.96) with each 10 metabolic equivalent of task h/wk increment of leisure-time PA. We found no evidence of a nonlinear dose-response association of PA and hypertension (Pnonlinearity=0.094 for leisure-time PA and 0.771 for total PA). With the linear cubic spline model, when compared with inactive individuals, for those who met the guidelines recommended minimum level of moderate PA (10 metabolic equivalent of task h/wk), the risk of hypertension was reduced by 6% (relative risk, 0.94; 95% confidence interval, 0.92-0.97). This meta-analysis suggests that additional benefits for hypertension prevention occur as the amount of PA increases.</td></tr>
<tr><td>Timeframe: Inception–November 2016</td></tr>
<tr><td>Total # of Studies: 29</td></tr>
<tr><td>Exposure Definition: Highest versus lowest category leisure-time PA and total PA; dose-response analysis (MET h/wk).
Measures Steps: No
Measures Bouts: No
Examines HIIT: No</td></tr>
<tr><td>Outcomes Addressed: Normotensive: Hypertension incidence
Examine Cardiorespiratory Fitness as Outcome: No</td></tr>
<tr><td>Populations Analyzed: Male, Female, Adults <50, 50>, Normal/Healthy Weight, Overweight and Obese, Normal/Optimal BP</td><td>Author-Stated Funding Source: The National Natural Science Foundation of China, the Science and Technology Development Foundation of Shenzhen, the National Science Foundation of Shenzhen University</td></tr>
</table>

Meta-Analysis **Citation:** MacDonald HV, Johnson BT, Huedo-Medina TB, et al. Dynamic resistance training as stand-alone antihypertensive lifestyle therapy: a meta-analysis. *J Am Heart Assoc.* 2016;5(10):e003231. doi:10.1161/JAHA.116.003231.	
Purpose: To provide more precise estimates regarding the efficacy of dynamic resistance training as stand-alone antihypertensive therapy, and identify potential moderators of this response to provide insight into the optimal dose of dynamic resistance training to lower blood pressure among adults with high blood pressure. **Timeframe:** Inception–January 2014 **Total # of Studies:** 64 **Exposure Definition:** Dynamic resistance training intervention varied widely by study, most were 65–70% one repetition maximum for 2–3 days for 15 weeks. **Measures Steps:** No **Measures Bouts:** No **Examines HIIT:** No **Outcomes Addressed:** Normotensive: Blood pressure (BP); Pre-hypertensive: BP **Examine Cardiorespiratory Fitness as Outcome:** No	**Abstract:** BACKGROUND: Aerobic exercise (AE) is recommended as first-line antihypertensive lifestyle therapy based on strong evidence showing that it lowers blood pressure (BP) 5 to 7 mm Hg among adults with hypertension. Because of weaker evidence showing that dynamic resistance training (RT) reduces BP 2 to 3 mm Hg among adults with hypertension, it is recommended as adjuvant lifestyle therapy to AE training. Yet, existing evidence suggests that dynamic RT can lower BP as much or more than AE. METHODS AND RESULTS: We meta-analyzed 64 controlled studies (71 interventions) to determine the efficacy of dynamic RT as stand-alone antihypertensive therapy. Participants (N=2344) were white (57%), middle-aged (47.2+/-19.0 years), and overweight (26.8+/-3.4 kg/m(2)) adults with prehypertension (126.7+/-10.3/76.8+/-8.7 mm Hg); 15% were on antihypertensive medication. Overall, moderate-intensity dynamic RT was performed 2.8+/-0.6 days/week for 14.4+/-7.9 weeks and elicited small-to-moderate reductions in systolic BP (SBP; d+=-0.31; 95% CIs, -0.43, -0.19; -3.0 mm Hg) and diastolic BP (DBP; d+=-0.30; 95% CIs, -0.38, -0.18; -2.1 mm Hg) compared to controls (Ps<0.001). Greater BP reductions occurred among samples with higher resting SBP/DBP: approximately 6/5 mm Hg for hypertension, approximately 3/3 mm Hg for prehypertension, and approximately 0/1 mm Hg for normal BP (Ps<0.023). Furthermore, nonwhite samples with hypertension experienced BP reductions that were approximately twice the magnitude of those previously reported following AE training (-14.3 mm Hg [95% CIs, -19.0, -9.4]/-10.3 mm Hg [95% CIs, -14.5, -6.2]). CONCLUSIONS: Our results indicate that for nonwhite adult samples with hypertension, dynamic RT may elicit BP reductions that are comparable to or greater than those reportedly achieved with AE training. Dynamic RT should be further investigated as a viable stand-alone therapeutic exercise option for adult populations with high BP.
Populations Analyzed: White, Adults ≥19 (Mean 47.4), Normal/Optimal BP, Pre-hypertension, Hypertension	**Author-Stated Funding Source:** Office of the Vice President for Research, Institute for Collaboration on Health, Intervention, and Policy (InCHIP), Brazilian Council for the Scientific and Technological Development (CNPq)

<table>
<tr><td colspan="2">Meta-Analysis
Citation: Murtagh EM, Nichols L, Mohammed MA, et al. The effect of walking on risk factors for cardiovascular disease: an updated systematic review and meta-analysis of randomised control trials. Prev Med. 2015;72:34–43. doi:10.1016/j.ypmed.2014.12.041.</td></tr>
<tr><td>Purpose: To assess the effect of walking intervention on risk factors for cardiovascular disease in previously inactive adults.</td><td rowspan="5">Abstract: OBJECTIVE: To conduct a systematic review and meta-analysis of randomised control trials that examined the effect of walking on risk factors for cardiovascular disease. METHODS: Four electronic databases and reference lists were searched (Jan 1971-June 2012). Two authors identified randomised control trials of interventions >/= 4 weeks in duration that included at least one group with walking as the only treatment and a no-exercise comparator group. Participants were inactive at baseline. Pooled results were reported as weighted mean treatment effects and 95% confidence intervals using a random effects model. RESULTS: 32 articles reported the effects of walking interventions on cardiovascular disease risk factors. Walking increased aerobic capacity (3.04 mL/kg/min, 95% CI 2.48 to 3.60) and reduced systolic (-3.58 mm Hg, 95% CI -5.19 to -1.97) and diastolic (-1.54 mm Hg, 95% CI -2.83 to -0.26) blood pressure, waist circumference (-1.51 cm, 95% CI -2.34 to -0.68), weight (-1.37 kg, 95% CI -1.75 to -1.00), percentage body fat (-1.22%, 95% CI -1.70 to -0.73) and body mass index (-0.53 kg/m(2), 95% CI -0.72 to -0.35) but failed to alter blood lipids. CONCLUSIONS: Walking interventions improve many risk factors for cardiovascular disease. This underscores the central role of walking in physical activity for health promotion.</td></tr>
<tr><td>Timeframe: September 2004–September 2012</td></tr>
<tr><td>Total # of Studies: 32</td></tr>
<tr><td>Exposure Definition: Walking as the only intervention, minimum duration of four weeks.
Measures Steps: No
Measures Bouts: No
Examines HIIT: No</td></tr>
<tr><td>Outcomes Addressed: Normotensive: Systolic and Diastolic Blood Pressure (BP)
Examine Cardiorespiratory Fitness as Outcome: Yes</td></tr>
<tr><td>Populations Analyzed: Adults 30–83, Normal/Optimal BP/Pre- hypertension, Hypertension</td><td>Author-Stated Funding Source: The Mary Immaculate College Research Directorate</td></tr>
</table>

Table 3. Existing Meta-Analyses Quality Assessment Chart

AMSTARExBP: SR/MA					
	Carlson, 2014	Casonatto, 2016	Cornelissen, 2011	Cornelissen, 2013	Corso, 2016
Review questions and inclusion/exclusion criteria delineated prior to executing search strategy.	Yes	Yes	Yes	Yes	Yes
Population variables defined and considered in methods.	Yes	Yes	Yes	Yes	Yes
Was a comprehensive literature search performed?	Yes	Partially Yes	Yes	Yes	Yes
Duplicate study selection and data extraction performed.	No	No	No	Yes	Yes
Search strategy clearly described.	Yes	Yes	Yes	Yes	Yes
Relevant grey literature included in review.	No	No	No	No	No
List of studies (included and excluded) provided.	No	No	No	No	Yes
Characteristics of included studies provided.	Yes	Yes	Yes	Yes	Yes
FITT defined and examined in relation to outcome effect sizes.	No	Yes	Yes	Yes	No
Scientific quality (risk of bias) of included studies assessed and documented.	Yes	Yes	Yes	Yes	Yes
Results depended on study quality, either overall, or in interaction with moderators.	Yes	No	Yes	Yes	Yes
Scientific quality used appropriately in formulating conclusions.	Yes	No	Yes	Yes	Yes
Data appropriately synthesized and if applicable, heterogeneity assessed.	Yes	Yes	Yes	Yes	Yes
Effect size index chosen justified, statistically.	Yes	Yes	Yes	Yes	Yes
Individual-level meta-analysis used.	No	No	No	No	No
Practical recommendations clearly addressed.	Yes	Yes	Yes	No	Yes
Likelihood of publication bias assessed.	Yes	Yes	Yes	Yes	Yes
Conflict of interest disclosed.	No	Yes	Yes	Yes	Yes

AMSTARExBP: SR/MA					
	Fagard, 2007	Huai, 2013	Liu, 2017	MacDonald, 2016	Murtagh, 2015
Review questions and inclusion/exclusion criteria delineated prior to executing search strategy.	Yes	Yes	Yes	Yes	Yes
Population variables defined and considered in methods.	No	No	Yes	Yes	No
Was a comprehensive literature search performed?	No	Yes	Yes	Yes	Yes
Duplicate study selection and data extraction performed.	No	No	No	Yes	Yes
Search strategy clearly described.	No	Yes	Yes	Yes	Yes
Relevant grey literature included in review.	No	No	No	No	No
List of studies (included and excluded) provided.	No	No	No	No	No
Characteristics of included studies provided.	No	No	Yes	Yes	Yes
FITT defined and examined in relation to outcome effect sizes.	No	No	Yes	Yes	No
Scientific quality (risk of bias) of included studies assessed and documented.	No	Yes	Yes	Yes	Yes
Results depended on study quality, either overall, or in interaction with moderators.	N/A	Yes	Yes	Yes	No
Scientific quality used appropriately in formulating conclusions.	N/A	Yes	Yes	Yes	Yes
Data appropriately synthesized and if applicable, heterogeneity assessed.	No	Yes	Yes	Yes	Yes
Effect size index chosen justified, statistically.	Partially Yes	Yes	Yes	Yes	Yes
Individual-level meta-analysis used.	No	No	No	No	No
Practical recommendations clearly addressed.	Yes	Yes	Yes	Yes	Yes
Likelihood of publication bias assessed.	No	Yes	Yes	Yes	Yes
Conflict of interest disclosed.	No	Yes	Yes	Yes	Yes

Appendices

Appendix A: Analytical Framework

Topic Area
Cardiometabolic Health and Weight Management

Systematic Review Questions

In people with normal blood pressure or pre-hypertension, what is the relationship between physical activity and blood pressure?

a. Is there a dose-response relationship? If yes, what is the shape of the relationship?
b. Does the relationship vary by age, sex, race/ethnicity, socio-economic status, weight status, or resting blood pressure level?
c. Does the relationship vary based on frequency, duration, intensity, type (mode), or how physical activity is measured?

Population

Adults, ages 18 and older with normal blood pressure or pre-hypertension

Exposure

All types and intensities of physical activity including lifestyle activities, leisure activities, and sedentary behavior

Comparison

Adults who participate in varying levels of physical activity, including no reported physical activity

Endpoint Health Outcomes

- Blood pressure
  - Systolic
  - Diastolic
  - Mean
- Disease progression (normal BP to pre-hypertension or hypertension; pre-hypertension to hypertension)

Key Definitions

- Hypertension or high blood pressure is defined as having blood pressure higher than 140/90 mmHg or being on antihypertensive medications regardless of the BP level.
- Pre-hypertension is defined as having blood pressure between 120–139 or 80–89 mmHg or 139/89 mmHg.
- Normal blood pressure is defined as having blood pressure below 120 and 80 mmHg.

Appendix B: Final Search Strategy

Search Strategy: PubMed (Systematic Reviews, Meta-Analyses, Pooled Analyses, and High-Quality Reports)

Database: PubMed; Date of Search: 4/7/17; 590 results

Set	Search Strategy
Limit: Language	(English[lang])
Limit: Exclude animal only	NOT ("Animals"[mh] NOT ("Animals"[mh] AND "Humans"[mh]))
Limit: Exclude child only	NOT (("infant"[mh] OR "child"[mh] OR “child, preschool”[mh] OR "adolescent"[mh]) NOT (("infant"[mh] OR "child"[mh] OR “child, preschool”[mh] OR "adolescent"[mh]) AND "adult"[mh]))
Limit: Exclude subheadings	NOT (“diet therapy”[subheading] OR "epidemiology"[Subheading])
Limit: Publication Date (Systematic Reviews/Meta-Analyses)	AND ("2006/01/01"[PDAT] : "3000/12/31"[PDAT])
Limit: Publication Type Include (Systematic Reviews/Meta-Analyses)	AND (systematic[sb] OR meta-analysis[pt] OR “systematic review”[tiab] OR “systematic literature review”[tiab] OR metaanalysis[tiab] OR "meta analysis"[tiab] OR metanalyses[tiab] OR "meta analyses"[tiab] OR "pooled analysis"[tiab] OR “pooled analyses”[tiab] OR "pooled data"[tiab])
Limit: Publication Type Exclude (Systematic Reviews/Meta-Analyses)	NOT (“comment”[Publication Type] OR “editorial”[Publication Type])
Physical activity	AND (("Aerobic endurance"[tiab] OR "Bicycl*"[tiab] OR "Endurance training"[tiab] OR "Exercise"[mh] OR "Exercise"[tiab] OR "Exercises"[tiab] OR "Free living activities"[tiab] OR "Free living activity"[tiab] OR "Functional training"[tiab] OR "Leisure-time physical activity"[tiab] OR "Lifestyle activities"[tiab] OR "Lifestyle activity"[tiab] OR "Muscle stretching exercises"[mh] OR "Physical activity"[tiab] OR "Qi gong"[tiab] OR "Recreational activities"[tiab] OR "Recreational activity"[tiab] OR "Resistance training"[tiab] OR "Running"[tiab] OR "Sedentary lifestyle"[mh] OR "Speed training"[tiab] OR "Strength training"[tiab] OR "Tai chi"[tiab] OR "Tai ji"[mh] OR "Tai ji"[tiab] OR "Training duration"[tiab] OR "Training frequency"[tiab] OR "Training intensity"[tiab] OR "Treadmill"[tiab] OR "Walking"[tiab] OR "Weight lifting"[tiab] OR "Weight training"[tiab] OR "Yoga"[mh] OR "Yoga"[tiab]) OR (("Aerobic activities"[tiab] OR "Aerobic activity"[tiab] OR "Cardiovascular activities"[tiab] OR "Cardiovascular activity"[tiab] OR "Endurance activities"[tiab] OR "Endurance activity"[tiab] OR "Physical activities"[tiab] OR "Physical conditioning"[tiab] OR "Sedentary"[tiab]) NOT medline[sb]))
Outcome	AND ("mean arterial"[tiab] OR "blood pressure"[tiab] OR "blood pressure"[mh] OR "blood pressures"[tiab] OR "arterial pressure"[tiab] OR "arterial pressures"[tiab] OR

	“hypertension”[tiab] OR “hypotension”[tiab] OR “normotension”[tiab] OR “hypertensive”[tiab] OR “hypotensive”[tiab] OR "normotensive”[tiab] OR "systolic pressure"[tiab] OR "diastolic pressure"[tiab] OR "pulse pressure"[tiab] OR "venous pressure"[tiab] OR "pressure monitor"[tiab] OR "pre hypertension"[tiab] OR "bp response"[tiab] OR "bp decrease"[tiab] OR "bp reduction"[tiab] OR "bp monitor"[tiab] OR "bp monitors"[tiab] OR "bp measurement"[tiab])

Search Strategy: CINAHL (Systematic Reviews, Meta-Analyses, Pooled Analyses, and High-Quality Reports)

Database: CINAHL; Date of Search: 4/7/17; 6 results

Terms searched in title or abstract

Set	Search Terms
Physical activity	("Aerobic endurance" OR "Bicycl*" OR "Endurance training" OR "Exercise" OR "Exercises" OR "Free living activities" OR "Free living activity" OR "Functional training" OR "Leisure-time physical activity" OR "Lifestyle activities" OR "Lifestyle activity" OR "Muscle stretching exercises" OR "Physical activity" OR "Qi gong" OR "Recreational activities" OR "Recreational activity" OR "Resistance training" OR "Running" OR "Sedentary lifestyle" OR "Speed training" OR "Strength training" OR "Tai chi" OR "Tai ji" OR "Tai ji" OR "Training duration" OR "Training frequency" OR "Training intensity" OR "Treadmill" OR "Walking" OR "Weight lifting" OR "Weight training" OR "Yoga" OR "Aerobic activities" OR "Aerobic activity" OR "Cardiovascular activities" OR "Cardiovascular activity" OR "Endurance activities" OR "Endurance activity" OR "Physical activities" OR "Physical conditioning" OR "Sedentary")
Outcomes	AND ("mean arterial" OR "blood pressure" OR "blood pressure" OR "blood pressures" OR "arterial pressure" OR "arterial pressures" OR “hypertension” OR “hypotension” OR “normotension” OR “hypertensive” OR “hypotensive” OR “normotensive” OR "systolic pressure" OR "diastolic pressure" OR "pulse pressure" OR "venous pressure" OR "pressure monitor" OR "pre hypertension" OR "bp response" OR "bp decrease" OR "bp reduction" OR "bp monitor" OR "bp monitors" OR "bp measurement")
Systematic Reviews and Meta-Analyses	(“systematic review” OR “systematic literature review” OR metaanalysis OR "meta analysis" OR metanalyses OR "meta analyses" OR "pooled analysis" OR “pooled analyses” OR "pooled data")
Limits	2006–present English language Peer reviewed Exclude Medline records Human

Search Strategy: Cochrane (Systematic Reviews, Meta-Analyses, Pooled Analyses, and High-Quality Reports)

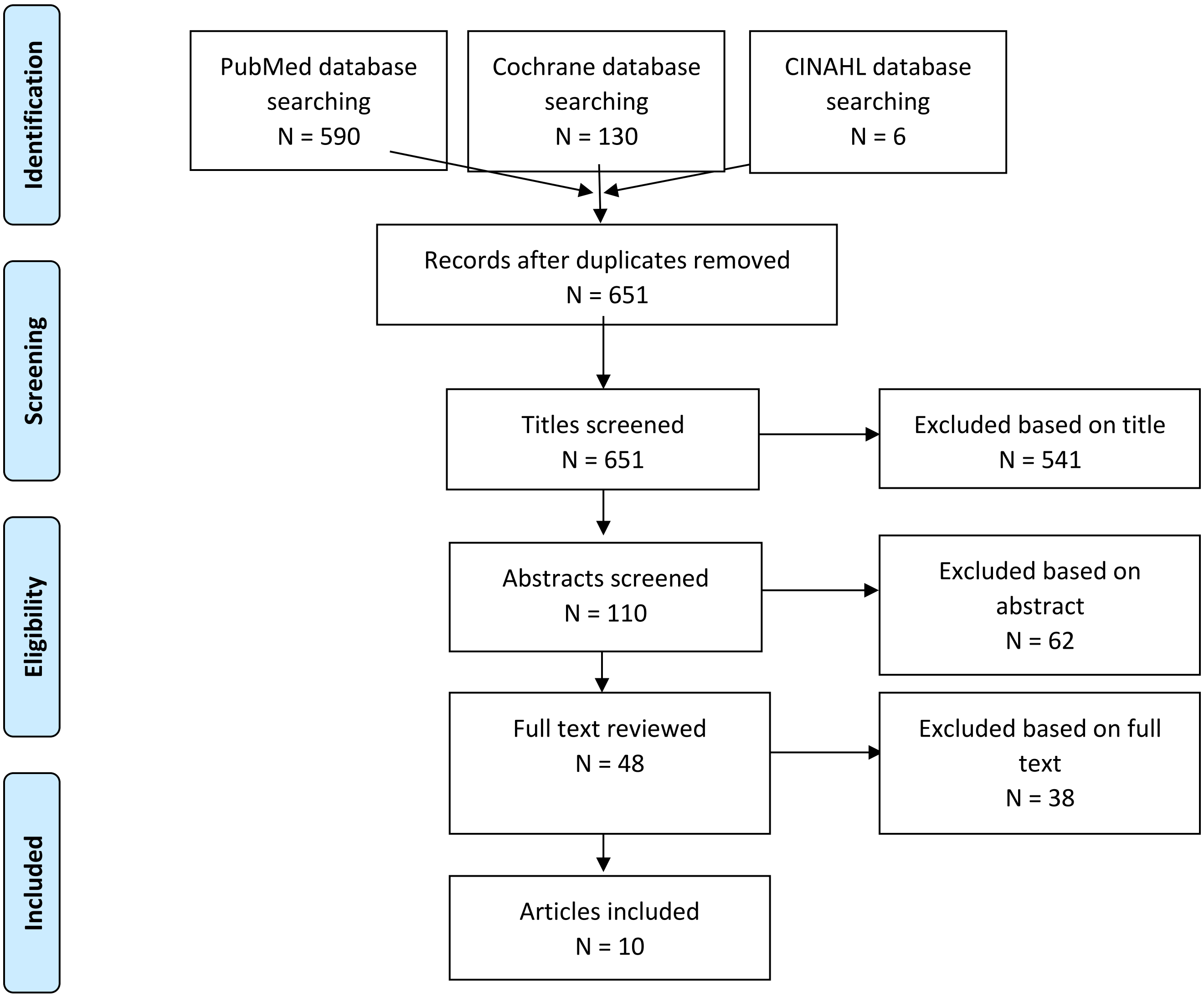
Database: Cochrane; Date of Search: 4/7/17; 130 results

Terms searched in title, abstract, or keywords

Set	Search Terms
Physical activity	("Aerobic endurance" OR "Bicycl*" OR "Endurance training" OR "Exercise" OR "Exercises" OR "Free living activities" OR "Free living activity" OR "Functional training" OR "Leisure-time physical activity" OR "Lifestyle activities" OR "Lifestyle activity" OR "Muscle stretching exercises" OR "Physical activity" OR "Qi gong" OR "Recreational activities" OR "Recreational activity" OR "Resistance training" OR "Running" OR "Sedentary lifestyle" OR "Speed training" OR "Strength training" OR "Tai chi" OR "Tai ji" OR "Tai ji" OR "Training duration" OR "Training frequency" OR "Training intensity" OR "Treadmill" OR "Walking" OR "Weight lifting" OR "Weight training" OR "Yoga" OR "Aerobic activities" OR "Aerobic activity" OR "Cardiovascular activities" OR "Cardiovascular activity" OR "Endurance activities" OR "Endurance activity" OR "Physical activities" OR "Physical conditioning" OR "Sedentary”)
Outcomes	AND ("mean arterial" OR "blood pressure" OR "blood pressure" OR "blood pressures" OR "arterial pressure" OR "arterial pressures" OR “hypertension” OR “hypotension” OR “normotension” OR “hypertensive” OR “hypotensive” OR “normotensive” OR "systolic pressure" OR "diastolic pressure" OR "pulse pressure" OR "venous pressure" OR "pressure monitor" OR "pre hypertension" OR "bp response" OR "bp decrease" OR "bp reduction" OR "bp monitor" OR "bp monitors" OR "bp measurement")
Limits	2006–present Word variations not searched Cochrane Reviews and Other Reviews

Appendix C: Literature Tree

Existing Systematic Reviews, Meta-Analyses, Pooled Analyses, and Reports Literature Tree



Appendix D: Inclusion/Exclusion Criteria

Cardiometabolic Health and Weight Management Subcommittee

Systematic Review Question: In people with normal blood pressure or pre-hypertension, what is the relationship between physical activity and blood pressure?

a. Is there a dose-response relationship? If yes, what is the shape of the relationship?
b. Does the relationship vary by age, sex, race/ethnicity, socio-economic status, weight status, or resting blood pressure level?
c. Does the relationship vary based on frequency, duration, intensity, type (mode), or how physical activity is measured?

Category	Inclusion/Exclusion Criteria	Notes/Rationale
Publication Language	**Include:** • Studies published with full text in English	
Publication Status	**Include:** • Studies published in peer-reviewed journals • Reports determined to have appropriate suitability and quality by PAGAC **Exclude:** • Grey literature, including unpublished data, manuscripts, abstracts, conference proceedings	
Research Type	**Include:** • Original research: Prospective (concurrent; longitudinal) cohort studies; Randomized controlled trials • Meta-analyses • Systematic reviews • Pooled analyses • Reports determined to have appropriate suitability and quality by PAGAC	
Study Subjects	**Include:** • Human subjects	
Age of Study Subjects	**Include:** • Adults, ages 18 and older • When data are analyzed by age groups, only data with lower age range of 18 may be included (e.g., in a study with individuals 13–21 where data are presented for multiple age groups, only data for 18 and older may be included)	
Health Status of Study Subjects	**Include:** • Healthy adults with normal blood pressure or pre-hypertension • Overweight or obese adults	

	Exclude: • Adults with chronic conditions (obesity is ok) • Hospitalized patients • Smokers	
Comparison	**Include:** • Adults who participate in varying levels of physical activity, including acute or chronic exercise or no reported physical activity • Recreational athletes (marathons ok as long as the study looks at a diverse group of runners—not just the elites) **Exclude:** • High performance athletes • Studies comparing athletes to non-athletes • Studies comparing athlete types (e.g., comparing runners to soccer players)	
Date of Publication	**Include:** • Original research published 2006–2017 • Systematic reviews and meta-analyses published from 2006–2017	
Study Design	**Include:** • Randomized trials • Prospective cohort studies • Systematic reviews • Meta-analyses • Pooled analyses • PAGAC approved reports **Exclude:** • Non-randomized trials • Retrospective cohort studies • Case-control studies • Before-after studies • Narrative reviews • Commentaries • Editorials • Cross-sectional studies • Time series	
Intervention/ Exposure	**Include studies in which the exposure or intervention is:** • All types and intensities of physical activity including lifestyle activities, leisure activities, and sedentary behavior • Acute or chronic exercise	

	Exclude: • Studies that do not include physical activity (or the lack thereof) as the primary exposure variable or used solely as a confounding variable • Studies missing physical activity (mental games such as Sudoku instead of physical activities)	

Outcome	**Include studies in which the outcome is:**
	• Blood pressure
	  ○ Systolic
	  ○ Diastolic
	  ○ Mean
	• Disease progression to hypertension	

Study Duration (Original Research)	• Minimum 1 year for observational studies	

Appendix E: Rationale for Exclusion at Abstract or Full-Text Triage for Existing Systematic Reviews, Meta-Analyses, Pooled Analyses, and Reports

The table below lists the excluded articles with at least one reason for exclusion, but may not reflect all possible reasons.

Citation	Outcome	Population	Study Design	Exposure	Not ideal fit for replacement of de novo search
Ahmad S, Shanmugasegaram S, Walker KL, Prince SA. Examining sedentary time as a risk factor for cardiometabolic diseases and their markers in South Asian adults: a systematic review. *Int J Public Health*. 2017;62(4):503-515. doi:10.1007/s00038-017-0947-8.	X				
Ashor AW, Lara J, Siervo M, Celis-Morales C, Mathers JC. Effects of exercise modalities on arterial stiffness and wave reflection: a systematic review and meta-analysis of randomized controlled trials. *PLoS One*. 2014;9(10):e110034. doi:10.1371/journal.pone.0110034.	X				
Baena CP, Olandoski M, Younge JO, et al. Effects of lifestyle-related interventions on blood pressure in low and middle-income countries: systematic review and meta-analysis. *J Hypertens*. 2014;32(5):961-973. doi:10.1097/HJH.0000000000000136.				X	
Barrows JL, Fleury J. Systematic review of yoga interventions to promote cardiovascular health in older adults. *West J Nurs Res*. 2016;38(6):753-781. doi:10.1177/0193945915618610.			X		
Batacan RB, Duncan MJ, Dalbo VJ, et al. Effects of high-intensity interval training on cardiometabolic health: a systematic review and meta-analysis of intervention studies. *Br J Sports Med*. 2017;51(6):494-503.		X			
Batacan RB, Duncan MJ, Dalbo VJ, et al. Effects of light intensity activity on CVD risk factors: a systematic review of intervention studies. *Biomed Res Int*. 2015;2015:596367. doi:10.1155/2015/596367.			X		
Bento VF, Albino FB, de Moura KF, et al. Impact of physical activity interventions on blood pressure in Brazilian populations. *Arq Bras Cardiol*. 2015;105(3):301-308. doi:10.5935/abc.20150048.		X			
Chandrasekaran B, Arumugam A, Davis F, et al. Resistance exercise training for hypertension. *Cochrane Database Syst Rev*. 2010;(11):CD008822. doi:10.1002/14651858.CD008822.			X		
Chiang CE, Wang TD, Li YH, et al; Hypertension Committee of the Taiwan Society of Cardiology. 2010 guidelines of the Taiwan Society of Cardiology for the management of hypertension. *J Formos Med Assoc*.					X

Citation	Outcome	Population	Study Design	Exposure	Not ideal fit for replacement of de novo search
2010;109(10):740-773. doi:10.1016/S0929-6646(10)60120-9.					
Chrysant SG. Current evidence on the hemodynamic and blood pressure effects of isometric exercise in normotensive and hypertensive persons. *J Clin Hypertens* (Greenwich). 2010;12(9):721-726. doi:10.1111/j.1751-7176.2010.00328.			X		
Collins P, Rosano G, Casey C, et al. Management of cardiovascular risk in the peri-menopausal woman: a consensus statement of European cardiologists and gynaecologists. *Eur Heart J*. 2007;28(16):2028-2040.			X		
Conceição LS, Neto MG, do Amaral MA, Martins-Filho PR, Carvalho O. Effect of dance therapy on blood pressure and exercise capacity of individuals with hypertension: a systematic review and meta-analysis. *Int J Cardiol*. 2016;220:553-557. doi:10.1016/j.ijcard.2016.06.182.		X			
Cornelissen VA, Buys R, Smart NA. Endurance exercise beneficially affects ambulatory blood pressure: a systematic review and meta-analysis. *J Hypertens*. 2013;31(4):639-648. doi:10.1097/HJH.0b013e32835ca964.					X
Cornelissen VA, Goetschalckx K, Verheyden B, et al. Effect of endurance training on blood pressure regulation, biomarkers and the heart in subjects at a higher age. *Scand J Med Sci Sports*. 2011;21(4):526-534. doi:10.1111/j.1600-0838.2010.01094.x.			X		
Cramer H, Haller H, Lauche R, et al. A systematic review and meta-analysis of yoga for hypertension. *Am J Hypertens*. 2014;27(9):1146-1151. doi:10.1093/ajh/hpu078.		X			
Cramer H, Langhorst J, Dobos G, Lauche R. Yoga for metabolic syndrome: a systematic review and meta-analysis. *Eur J Prev Cardiol*. 2016;23(18).		X			
de Rezende LF, Rodrigues Lopes M, Rey-Lopez JP, Matsudo VK, Luiz Odo C. Sedentary behavior and health outcomes: an overview of systematic reviews. *PLoS One*. 2014;9(8):e105620. doi:10.1371/journal.pone.0105620.			X		
Dickinson HO, Mason JM, Nicolson DJ, et al. Lifestyle interventions to reduce raised blood pressure: a systematic review of randomized controlled trials. *J Hypertens*. 2006;24(2):215-233.		X			
Ebireri J, Aderemi AV, Omoregbe N, Adeloye D. Interventions addressing risk factors of ischaemic heart disease in sub-Saharan Africa:			X		

Citation	Outcome	Population	Study Design	Exposure	Not ideal fit for replacement of de novo search
a systematic review. *BMJ Open*. 2016;6(7):e011881. doi:10.1136/bmjopen-2016-011881.					
Ebrahim S, Taylor F, Ward K, Beswick A, Burke M, Davey Smith G. Multiple risk factor interventions for primary prevention of coronary heart disease. *Cochrane Database Syst Rev*. 2011;1:CD001561. doi:10.1002/14651858.CD001561.pub3.				X	
Eckel RH, Jakicic JM, Ard JD, et al. 2013 AHA/ACC guideline on lifestyle management to reduce cardiovascular risk: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *Circulation*. 2014;129(25 suppl 2):S76-S99. doi:10.1161/01.cir.0000437740.48606.d1.					X
Erdine S, Ari O, Zanchetti A, et al. ESH-ESC guidelines for the management of hypertension. *Herz*. 2006;31(4):331-338.		X			
Fagard RH. Exercise is good for your blood pressure: effects of endurance training and resistance training. *Clin Exp Pharmacol Physiol*. 2006;33(9):853-856.		X			
Fazzi C, Saunders DH, Linton K, Norman JE, Reynolds RM. Sedentary behaviours during pregnancy: a systematic review. *Int J Behav Nutr Phys Act*. 2017;14(1):32. doi:10.1186/s12966-017-0485-z.	X				
Ghadieh AS, Saab B. Evidence for exercise training in the management of hypertension in adults. *Can Fam Physician*. 2015;61(3):233-239.			X		
Gilbert JS. From apelin to exercise: emerging therapies for management of hypertension in pregnancy. *Hypertens Res*. 2017. doi:10.1038/hr.2017.40.		X			
Goessler K, Polito M, Cornelissen VA. Effect of exercise training on the renin-angiotensin-aldosterone system in healthy individuals: a systematic review and meta-analysis. *Hypertens Res*. 2016;39(3):119-126. doi:10.1038/hr.2015.100.		X			
Gomes Anunciacao P, Doederlein Polito M. A review on post-exercise hypotension in hypertensive individuals. *Arq Bras Cardiol*. 2011;96(5):e100-e109.		X			
Groeneveld IF, Proper KI, van der Beek AJ, Hildebrandt VH, van Mechelen W. Lifestyle-focused interventions at the workplace to reduce the risk of cardiovascular disease–a systematic review. *Scand J Work Environ Health*. 2010;36(3):202-215.				X	
Guo X, Zhou B, Nishimura T, Teramukai S, Fukushima M. Clinical effect of qigong practice		X			

Citation	Outcome	Population	Study Design	Exposure	Not ideal fit for replacement of de novo search
on essential hypertension: a meta-analysis of randomized controlled trials. *J Altern Complement Med*. 2008;14(1):27-37. doi:10.1089/acm.2007.7213.					
Hackam DG, Khan NA, Hemmelgarn BR, et al; Canadian Hypertension Education Program. The 2010 Canadian Hypertension Education Program recommendations for the management of hypertension: Part 2 – therapy. *Can J Cardiol*. 2010;26(5):249-258.					X
Hackam DG, Quinn RR, Ravani P, et al; Canadian Hypertension Education Program. The 2013 Canadian Hypertension Education Program recommendations for blood pressure measurement, diagnosis, assessment of risk, prevention, and treatment of hypertension. *Can J Cardiol*. 2013;29(5):528-542. doi:10.1016/j.cjca.2013.01.005.					X
Hagins M, States R, Selfe T, Innes K. Effectiveness of yoga for hypertension: systematic review and meta-analysis. *Evid Based Complement Alternat Med*. 2013;2013:649836. doi:10.1155/2013/649836.		X			
Hamer M, Taylor A, Steptoe A. The effect of acute aerobic exercise on stress related blood pressure responses: a systematic review and meta-analysis. *Biol Psychol*. 2006;71(2):183-190.				X	
Hammami A, Chamari K, Slimani M, et al. Effects of recreational soccer on physical fitness and health indices in sedentary healthy and unhealthy subjects. *Biol Sport*. 2016;33(2):127-137. doi:10.5604/20831862.1198209.					X
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.		X			
Hartley L, Flowers N, Lee MS, Ernst E, Rees K. Tai chi for primary prevention of cardiovascular disease. *Cochrane Database Syst Rev*. 2014;(4):Cd010366. doi:10.1002/14651858.CD010366.pub2.		X			
Huang G, Shi X, Gibson CA, Huang SC, Coudret NA, Ehlman MC. Controlled aerobic exercise training reduces resting blood pressure in sedentary older adults. *Blood Press*. 2013;22(6):386-394. doi:10.3109/08037051.2013.778003.		X			
Inder JD, Carlson DJ, Dieberg G, McFarlane JR, Hess NC, Smart NA. Isometric exercise training for blood pressure management: a systematic review and meta-analysis to optimize benefit.					X

Citation	Outcome	Population	Study Design	Exposure	Not ideal fit for replacement of de novo search
Hypertens Res. 2016;39(2):88-94. doi:10.1038/hr.2015.111.					
Johnson BT, MacDonald HV, Bruneau ML, et al. Methodological quality of meta-analyses on the blood pressure response to exercise: a review. *J Hypertens*. 2014;32(4):706-723. doi:10.1097/HJH.0000000000000097.					X
Katzmarzyk PT, Lear SA. Physical activity for obese individuals: a systematic review of effects on chronic disease risk factors. *Obes Rev*. 2012;13(2):95-105. doi:10.1111/j.1467-789X.2011.00933.x.					X
Kelley GA, Kelley KS. Efficacy of aerobic exercise on coronary heart disease risk factors. *Prev Cardiol*. 2008;11(2):71-75.					X
Kelley GA, Kelley KS. Isometric handgrip exercise and resting blood pressure: a meta-analysis of randomized controlled trials. *J Hypertens*. 2010;28(3):411-418. doi:10.1097/HJH.0b013e3283357d16.		X			
Kingsley JD, Figueroa A. Acute and training effects of resistance exercise on heart rate variability. *Clin Physiol Funct Imaging*. 2016;36(3):179-187. doi:10.1111/cpf.12223.	X				
Le VV, Mitiku T, Sungar G, Myers J, Froelicher V. The blood pressure response to dynamic exercise testing: a systematic review. *Prog Cardiovasc Dis*. 2008;51(2):135-160. doi:10.1016/j.pcad.2008.07.001.	X				
Lee LL, Watson MC, Mulvaney CA, Tsai CC, Lo SF. The effect of walking intervention on blood pressure control: a systematic review. *Int J Nurs Stud*. 2010;47(12):1545-1561. doi:10.1016/j.ijnurstu.2010.08.008.					X
Lee LL, Watson M, Mulvaney C, Salzwedel DM, Chan ES. Walking for hypertension. *Cochrane Database Syst Rev*. 2010;(11). doi:10.1002/14651858.CD008823.			X		
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