Evidence for exercise training in the management of hypertension in adults

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Abstract

Objective To provide recommendations on exercise training as part of the management of hypertension in adults.

Quality of evidence Evidence was found through a systematic search of PubMed, MEDLINE, EMBASE, Agency for Healthcare Research and Quality evidence-based reports, *Bandolier*, *Clinical Evidence*, the Institute for Clinical Systems Improvement guidelines, the National Guideline Clearinghouse database, UpToDate, and the Cochrane Database of Systematic Reviews (part of Ovid Evidence Based Medicine Reviews) for articles published from January 1973 to September 2013. Study types were limited to meta-analyses, randomized controlled trials, clinical trials, and reviews.

Main message Exercise exerts an anti-inflammatory action through the sympathetic nervous system and the hypothalamic-pituitary-adrenal axis, and has direct effects on blood pressure. The resulting physiologic effects are classified as acute, postexercise, and chronic. Current treatment guidelines emphasize the role of nonpharmacologic interventions, including physical activity, in the management of mild to moderate hypertension.

Conclusion Moderate intensity aerobic exercise has been proven to prevent hypertension and to help in the management of stage 1 hypertension. Dynamic resistance exercises, if done properly, contribute to lowering both systolic and diastolic blood pressures. There is insufficient evidence about the safety and efficacy of isometric resistance training to recommend it.

Données probantes en faveur de l'entraînement physique dans la prise en charge de l'hypertension chez l'adulte

Résumé

Objectif Présenter des recommandations concernant l'entraînement physique dans le contexte de la prise en charge de l'hypertension chez les adultes.

EDITOR'S KEY POINTS

- Substantial evidence emphasizes the role of moderate-intensity aerobic exercise in preventing hypertension and managing stage 1 hypertension. Dynamic resistance training, if done properly, contributes to lowering both systolic and diastolic blood pressure. However, there is insufficient evidence about the safety and efficacy of isometric resistance training.

- Before starting an exercise program, patients with stage 2 hypertension, especially those with systolic blood pressure greater than 180 mm Hg and those with cardiovascular disease or diabetes, should have a pre-participation examination.

- When prescribing exercise, it is important to consider monitoring training programs and to account for the individual's preferences, as this will affect long-term adherence.

POINTS DE REPÈRE DU RÉDACTEUR

- De nombreuses données probantes mettent en évidence le rôle des exercices aérobiques d'intensité modérée dans la prévention de l'hypertension et la prise en charge de l'hypertension de stade 1. L'entraînement dynamique contre résistance, s'il est fait de manière appropriée, contribue à faire baisser à la fois la tension systolique et diastolique. Toutefois, les données probantes sont insuffisantes concernant la sécurité et l'efficacité de l'entraînement contre résistance isométrique.

- Avant de commencer un programme d'exercices, les patients souffrant d'hypertension de stade 2, surtout ceux dont la tension systolique est supérieure à 180 mm Hg et ceux atteints de maladies cardiovasculaires ou de diabète, devraient subir un examen préalable à leur participation.

- Quand on prescrit des exercices, il est important d'envisager la surveillance des programmes d'entraînement et de tenir compte des préférences de la personne, car ces éléments influent sur la conformité à long terme.

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Cet article a fait l'objet d'une révision par des pairs.
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Qualité des données Les données probantes ont été cernées à la suite d'une recension systématique dans PubMed, MEDLINE, EMBASE, les rapports fondés sur des données probantes de l'Agency for Healthcare Research and Quality, *Bandolier*, *Clinical Evidence*, les lignes directrices de l'Institute for Clinical Systems Improvement, la base de données du National Guideline Clearinghouse, UpToDate et la base de données des révisions systématiques Cochrane (faisant partie des révisions en médecine factuelle Ovid) pour trouver des articles publiés de janvier 1973 à septembre 2013. Seuls les méta-analyses, les études contrôlées randomisées, les essais cliniques et les révisions ont été inclus.

Message principal Les exercices déclenchent une action anti-inflammatoire par l'intermédiaire du système nerveux sympathique et de l'axe hypothalamo-hypophyso-surrénalien et ont des effets directs sur la tension artérielle. Les effets physiologiques qui en résultent sont classés comme étant aigus, post-exercices et chroniques. Les lignes directrices actuelles sur les traitements insistent sur le rôle des interventions non pharmacologiques, y compris l'activité physique, dans la prise en charge de l'hypertension de légère à modérée.

Conclusion Il a été démontré que des exercices aérobiques d'intensité modérée préviennent l'hypertension et sont utiles dans la prise en charge de l'hypertension de stade 1. Les exercices dynamiques contre résistance, s'ils sont faits de manière appropriée, contribuent à faire baisser à la fois la tension systolique et diastolique. Les données probantes sur la sécurité et l'efficacité des exercices contre résistance isométriques sont insuffisantes pour les recommander.

Hypertension, defined as systolic blood pressure (SBP) of 140 mm Hg or greater or diastolic blood pressure (DBP) of 90 mm Hg or greater, affects more than 1 in 5 people in Canada.[1] It is anticipated that it will affect up to one-third of the adult population worldwide by 2025.[2] Hypertension is the leading chronic risk factor for mortality, accounting for 13.5% of all deaths.[3] The prevalence is approximately 15%, 30%, and 55% in men aged 18 to 39 years, 40 to 59 years, and 60 years or older, respectively, and about 5%, 30%, and 65% in women in the same age groups.[4] Progressive arterial stiffening leads to a continuous increase in SBP throughout adult life, whereas DBP plateaus in the sixth decade of life and decreases thereafter, which explains the high prevalence of isolated systolic hypertension in the elderly.[5]

High blood pressure (BP) is an important risk factor for end-stage renal disease, coronary artery disease, congestive heart failure, and stroke. Across the BP range from 115/75 mm Hg to 185/115 mm Hg, the risk of cardiovascular events doubles with each 20 mm Hg increment of SBP.[6] Despite pharmacologic advances, only one-third of American adult patients with hypertension in 2000 had adequate BP control, far below the Healthy People 2010 goal of 50%.[7]

With concerns about the cost, effectiveness, and potential for deleterious side effects of antihypertensive drugs, there is an increased interest in behavioural interventions, including exercise for the treatment and prevention of hypertension.[8] Unfortunately, exercise prescription is underused among clinicians, mainly owing to uncertainty regarding its effectiveness and ambiguity about exercise prescription determinants (duration, intensity, and frequency).[9]

The National Heart Foundation; the World Health Organization and International Society of Hypertension; the United States Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure; and the American College of Sports Medicine advocate increased physical activity as a first-line intervention for preventing and treating patients with prehypertension (SBP of 120 to 139 mm Hg or DBP of 80 to 89 mm Hg) and as a treatment strategy for patients with stage 1 (SBP of 140 to 159 mm Hg or DBP of 80 to 99 mm Hg) or stage 2 (SBP of ≥160 mm Hg or DBP of ≥100 mm Hg) hypertension.[10] Consequently, prehypertension can be prevented from progressing and medications prescribed to treat stage 1 hypertension can be reduced or stopped.[11]

Quality of evidence

A PubMed search was completed in Clinical Queries using the terms *hypertension*, *blood pressure*, *exercise,* and *physical activity*. The search included meta-analyses, randomized controlled trials, clinical trials, and reviews. Also searched were the Agency for Healthcare Research and Quality evidence-based reports, *Bandolier*, *Clinical Evidence*, the Cochrane Database of Systematic Reviews (part of Ovid Evidence Based Medicine Reviews), EMBASE, MEDLINE, the Institute for Clinical Systems Improvement guidelines, the National Guideline Clearinghouse database, and UpToDate. Evidence was found through a systematic search for articles published from January 1973 to September 2013.

Main message

Exercise and mechanism of BP lowering

Acute physiologic response to exercise: Aerobic exercise increases and redistributes cardiac output to maintain perfusion of active muscles. This response is triggered by neurohormonal and hydrostatic mechanisms, initially by increasing systolic volume and then by increasing the heart rate. Systolic BP rises as cardiac output increases, while DBP falls as a result of decreased peripheral vascular resistance (PVR), facilitating perfusion of large muscle groups.

During aerobic exercise, a rise in SBP of more than 7 to 10 mm Hg for every 1 metabolic equivalent task unit (MET), or failure of DBP to drop more than 15 mm Hg, is a strong predictor of developing hypertension; patients with this characteristic have a higher rate of fatal cardiovascular events.[12]

In resistance exercise both SBP and DBP rise owing to the exercise pressor reflex to the cardiovascular centre in the medulla from proprioceptors (mechanoreceptors and metaboreceptors) in active muscles; arterial pressure rises to overcome the resistance to muscle perfusion caused by elevated intramuscular pressure interrupting arterial blood flow. Improperly performed resistance exercise can cause SBP and DBP to rise up to 320 mm Hg and 250 mm Hg, respectively, during a single repetition at maximum load.[12]

Postexercise physiologic response: A hypotensive response lasting up to 22 hours after exercise is caused by reduced norepinephrine levels and thus by inhibition of sympathetic activity and reduction in circulating angiotensin II, adenosine, and endothelin levels and their receptors in the central nervous system, leading to decreased PVR and increased baroreflex sensitivity. Hypotension is also triggered by the vasodilator effect of prostaglandins and nitric oxide.[13]

Various factors influence the hypotensive response, including duration and type of exercise (but not the intensity), and the individual's clinical status, age, ethnicity, and physical fitness.[13]

Chronic physiologic response to exercise: Physical activity leads to neuroendocrine, immune, and vascular changes. The vascular changes include increased vascular length, increased lumen diameter, increased number of precapillary sphincters, and neoangiogenesis. Decreased levels of C-reactive protein, inflammatory cytokines, and soluble adhesion molecules, which are predictive of morbidity and mortality, are also observed. The antihypertensive effects of exercise are mediated through enhanced baroreceptor sensitivity, decreased norepinephrine level, reduced PVR, improved insulin sensitivity, and alterations in the expression of vasodilator and vasoconstrictor factors (eg, expression of endothelin 1, triggered by exercise, promotes vasoconstriction; expression of prostaglandins and nitric oxide during exercise causes vasodilation; use of calcium channel blockers also causes vasodilation). Moreover, aerobic exercise decreases left ventricular mass and wall thickness, upregulates central antioxidant concentrations, reduces pro-oxidant levels and arterial stiffness, and increases central nitric oxide synthase activity, thus improving endothelial function.[12]

Therefore, while medications reduce BP with limited effectiveness in reducing inflammation and its associated morbidity and mortality, aerobic exercise exerts an anti-inflammatory action through the sympathetic nervous system and the hypothalamic-pituitary-adrenal axis, and directly lowers BP. In addition, repeated isometric exercise was shown to reset the baroreceptors and thus lower BP in the long term and enhance the action of antihypertensive drugs.[14] In contrast, the complex mechanisms linking dynamic resistance training to a small reduction in BP are not fully elucidated.

Aerobic exercise and hypertension. Aerobic exercise, when not contraindicated, is almost completely free of secondary effects. This type of exercise consists of regular, purposeful movement of joints and large muscle groups. Regular aerobic exercise has been shown to reduce resting BP and BP reactivity to stressors (**Table 1**).[5,15-17]

Table 1. Effects of aerobic exercise training on hypertension

META-ANALYSIS	INTERVENTION	OUTCOME AND COMMENTS
Fagard and Cornelissen,[5] 2007	• 72 trials with an average of 40 participants per trial • 40-min sessions 3 times per wk for 16 wk at an average intensity of 65% of HR reserve*	• Reduction in SBP of 6.9 mm Hg and in DBP of 4.9 mm Hg
Lee et al,[15] 2010	• 27 RCTs with 1842 participants • Walking for a mean of 19 wk (range 4 d to 26 wk), 4.4 d/wk, and 36.5 min/d	• Effect larger with more intense and frequent exercise regimens for longer durations • Mean reduction in SBP of 5.2 to 11.0 mm Hg and in DBP of 3.8 to 7.7 mm Hg
Cornelissen et al,[16] 2013	• 15 trials with 633 participants • Study duration: 6-52 wk; 30-60 min sessions, 2-5 times per wk, at 50%-75% HR reserve*	• Daytime reduction in SBP of 3.2 mm Hg and in DBP of 2.7 mm Hg • No BP reduction at night
Cornelissen and Smart,[17] 2013	• 105 trials with 3957 participants • Moderate aerobic exercise (walking and jogging) 3-5 times per wk, 30-60 min per session for 4-52 wk	• Reduction in SBP of 3.5 mm Hg and in DBP of 2.5 mm Hg

BP—blood pressure, DBP—diastolic BP, HR—heart rate, RCT—randomized controlled trial, SBP—systolic BP.
*HR reserve is the difference between a person's maximum HR and resting HR.

Examples of aerobic exercise include speed walking, jogging, running, dancing, cycling, and swimming.

The magnitude of postexercise hypotension correlates highly with long-term BP reductions produced by aerobic exercise training in patients with prehypertension. Therefore, the magnitude of postexercise hypotension can be used to predict the longer-term benefits of exercise training.

Dynamic resistance exercise and hypertension. In dynamic resistance training, effort is performed against an opposing force accompanied by purposeful movement of joints and large muscle groups with a goal of progressively increasing muscle strength. It involves concentric or eccentric contraction of muscles. Examples of dynamic resistance exercise are weight lifting and circuit training with equipment such as resistance-training machines.

Training regimens consist of 2 to 3 sessions per week of 8 to 10 weight-lifting exercises working the important muscle groups at a resistance (weight) of 30% to 40% of the 1-repetition maximum (ie, the heaviest weight that can be lifted once) for upper-body exercises and 50% to 60% of the 1-repetition maximum for lower-body exercises. Exercises should comprise 3 sets of 10 to 15 repetitions. Patients should avoid prolonged breath holding while performing dynamic resistance training.[12] If the resistance training program increases the DBP more than 20 mm Hg over baseline or the DBP rises above 120 mm Hg, the program should be reviewed.

Overall, evidence suggests that dynamic resistance exercises can lower BP by a modest degree, especially in stage 1 hypertension, with no evidence of harm, acute triggering of cardiovascular events during exercise, or chronic worsening of BP (**Table 2**).[17,18] Dynamic resistance training has the same contraindications as aerobic exercise. Patients with stage 2 hypertension should be treated pharmacologically before beginning training.

Isometric resistance exercise and hypertension. Isometric resistance exercise involves sustained static contraction of muscles with no change in the length of the involved muscle groups and without joint movement. Most of the studies on isometric resistance were of short duration and enrolled relatively few participants. Nonetheless, a clear yet relatively small cardiovascular benefit of isometric resistance training has emerged, including modest improvements in BP (**Table 3**).[17-20] However, the cardiovascular health risks associated with the transient elevation in BP that occurs during muscle contractions need to be more clearly established. Isometric exercises have not been studied in very high-risk or unstable cardiovascular patients or individuals with more severe stages of hypertension.

Isometric hand-grip training regimens consist of several intermittent bouts of hand-grip contractions at 30% maximal strength lasting 2 minutes each, for a total of 12 to 15 minutes per session performed at least 3 times per week over 8 to 12 weeks. Thus, it needs less time commitment to produce effective reduction in BP (33 minutes per week in total) compared with other exercise types (typically 150 minutes per week with aerobic or dynamic resistance exercise).[18] In fact, a new hand-held dynamometer has been approved by the US Food and Drug Administration that can be used at home by both ambulatory and nonambulatory patients. Using the dynamometer improves endothelial function secondary to increased production of nitric oxide and vagal function (decreased sympathetic activity).[19]

Choosing the appropriate type of exercise. In a 2013 meta-analysis by Cornelissen and Smart,[17] 93 trials accounting for a total of 5223 participants compared the various types of exercise and concluded the following:

- Endurance training ($P<.001$), dynamic resistance training ($P<.001$), isometric resistance training ($P=.003$), and combined training ($P=.012$) significantly reduce DBP.

Table 2. Effects of dynamic resistance exercise training on hypertension

META-ANALYSIS	INTERVENTION	OUTCOME AND COMMENTS
Cornelissen et al,[18] 2011	• 25 trials with 1043 adults • Interventions were supervised • Median duration 8 wk (range 6-52 wk) and frequency 3 sessions per wk • Weight- or resistance-training machines were used to train the muscles of the upper or lower body • 1-6 (median 3) sets per exercise session for each individual muscle • 6-30 repetitions for each set	• Mean net reduction in SBP of 2.7 mm Hg and in DBP of 2.9 mm Hg • No relationship between training intensity (proportion of RM) and amount of BP reduction • Resistance training was found to be safe • Dynamic resistance exercise provided improved peak oxygen consumption, reduced body fat, and reduced blood triglyceride levels
Cornelissen and Smart,[17] 2013	• 29 trials with 750 participants • 8-52 wk, 3 sessions per wk at 60%-80% of 1 RM using weight-lifting and resistance machines, 3 sets per session for each muscle and 10-14 repetitions per set	• Reduction in SBP of 1.8 mm Hg and in DBP of 3.2 mm Hg

BP—blood pressure, DBP—diastolic BP, RM—repetition maximum, SBP—systolic BP.

- Endurance training ($P<.001$), dynamic resistance training ($P=.049$), and isometric resistance training ($P<.001$) significantly reduce SBP.
- Aerobic training might be superior to dynamic resistance training in men with hypertension only.
- Larger BP reductions were seen after moderate- to high-intensity aerobic training for less than 210 minutes per week versus 210 minutes per week or longer. Longer unsupervised exercise programs are correlated with decreased adherence and therefore less reduction in BP. Thus, primary care physicians should follow their patients closely to ensure compliance.
- Aerobic exercise, dynamic resistance training, and combined training are equivalent in lowering BP in normotensive and prehypertensive persons.

The 2004 American College of Sports Medicine review concluded the following[21,22]:

- Aerobic exercise results in an average reduction of 5 to 7 mm Hg in both SBP and DBP for up to 22 hours regardless of the exercise intensity.
- Aerobic exercise results in an average chronic reduction in BP of 7.4/5.8 mm Hg for patients with hypertension that does not respond to drugs and of 2.6/1.8 mm Hg for patients with normalized BP irrespective of drug type.
- Resistance training has a favourable but less meaningful chronic effect on BP than aerobic exercise does.
- Reductions of 2 mm Hg in SBP and DBP lower the risk of stroke by 14% and 17%, respectively, and the risk of coronary artery disease by 9% and 6%, respectively.[23]

Exercise prescription. Exercise prescription in patients with hypertension should be individualized. The prescription should include frequency, intensity, time, and type.[13] The exercise should be done 3 to 5 days per week. The intensity should be moderate—the maximum oxygen consumption (VO_{2max}) should be 40% to 70%, equivalent to 3 to 6 METs (**Table 4**).[24] Each patient should do at least 30 minutes of continuous or accumulated (eg, 3 intervals of 10 minutes) exercise per day. It should include aerobic exercise supplemented by resistance training.

As part of the initial treatment, aerobic exercise is recommended in patients with stage 1 hypertension with no other coronary risk factors and no evidence of cardiovascular disease (CVD), as well as in patients with other risk factors, but not diabetes. In patients with diabetes, CVD, or stage 2 or 3 hypertension, drug therapy should be initiated before starting an exercise program.[6]

Pre-participation screening depends on the intensity of the planned exercise and the patient's global cardiovascular risk.[6] The points below highlight recommendations related to pre-participation screening:

- For asymptomatic patients with BP less than 180/110 mm Hg intending to participate in light to moderate exercise (<60% VO_{2max} or <6 METs), there is no need for evaluation.
- Preliminary peak or symptom-limited exercise testing might be warranted when planning a vigorous exercise program (≥60% VO_{2max} or ≥6 METs).[22]
- Patients with cardiovascular risk factors or stage 2 hypertension but without CVD or BP greater than 180/110 mm Hg need to be screened before engaging in moderate-intensity exercise (40% to 60% VO_{2max} or 3 to 6 METs), but not for light activity (<40% VO_{2max} or MET <3).
- Exercise testing is essential for all patients with documented CVD, whatever the level of exercise intensity. Vigorous exercise (≥60% VO_{2max} or ≥6 METs) should only be performed in dedicated cardiac rehabilitation centres.
- Absolute contraindications to aerobic and resistance training programs include recent myocardial infarction or electrocardiography changes, complete heart block, acute congestive heart failure, unstable angina, and uncontrolled severe hypertension (BP ≥180/110 mm Hg).

Table 3. Effects of isometric resistance exercise training on hypertension

META-ANALYSIS	INTERVENTION	OUTCOME AND COMMENTS
Kelley and Kelley,[20] 2010	• 3 trials with 81 participants • IHG exercise training lasting at least 4 wk	• Decrease in SBP of 13.4 mm Hg and in DBP of 7.8 mm Hg • Limitation in sample size • Resistance training was found to be safe
Cornelissen et al,[18] 2011	• 82 participants in 3 trials • Subgroup analysis of IHG exercise • 3 bilateral or unilateral contractions, 2 min long, with a rest period of 1 min between contractions • For 8-10 wk, 3 sessions per wk, intensity 30%-40% of 1 MVC	• IHG showed larger decreases in BP (decrease in SBP of 13.5 mm Hg and in DBP of 7.8 mm Hg) than other modes of training • Limitation in sample size
Owen et al,[19] 2010	• 5 trials with 122 subjects • IHG in bouts of 20 min 3 times per wk for 10 wk	• Reduction in SBP of 10 mm Hg and in DBP of 7 mm Hg
Cornelissen and Smart,[17] 2013	• 5 trials with 150 participants • 8-14 wk, 3 sessions per wk at 30%-40% MVC using IHG or leg extension exercise; 4 isometric contractions 2 min in length	• Reduction in SBP of 10.9 mm Hg and in DBP of 6.2 mm Hg

BP—blood pressure, DBP—diastolic BP, IHG—isometric hand grip, MVC—maximal voluntary contraction, SBP—systolic BP.

Table 4. Metabolic equivalents of selected common physical activities

PHYSICAL ACTIVITY	MET
Light intensity	< 3.0
• Watching television	1.0
• Walking 2.7 km/h on level ground, strolling very slowly	2.3
Moderate intensity	3.0 to 6.0
• Stationary bicycling, very light effort, 50 W	3.0
• Walking 4.8 km/h, dancing, gardening, housework	3.3
• Stationary bicycling, light effort, 100 W	5.5
High intensity	> 6.0
• Jogging	7.0
• Calisthenics (push-ups, sit-ups, pull-ups, jumping jacks), vigorous effort	8.0
• Running in place	8.0
• Rope jumping, competitive sports	10.0

MET—metabolic equivalent task unit.
Data from Manfredini et al.[24]

For patients who exercise, calcium channel blockers and blockers of the renin-angiotensin system are currently the drugs of choice, whereas β-blockers, with their negative chronotropic and inotropic effects, are contraindicated.[6] Diuretics and β-blockers in the first week of treatment can affect thermoregulation and increase the risk of hypoglycemia. Additionally, loop diuretics cause volume depletion and β-blockers reduce maximal heart rate, thus compromising exercise capacity.[6]

Variations in genetic background, hypertension pathogenesis, pharmacodynamics, and pharmacokinetics might explain the different BP responses to exercise among patients with hypertension.[12]

Conclusion

A summary of clinical recommendations is presented in **Table 5**.[3,5,10,23,25] Substantial evidence emphasizes the role of moderate-intensity aerobic exercise in preventing hypertension and managing stage 1 hypertension. There is sufficient evidence that dynamic resistance training, if done properly, contributes to lowering both SBP and DBP. However, there is insufficient evidence

Table 5. Clinical recommendations

CLINICAL RECOMMENDATIONS	GRADE EVIDENCE RATING[25]	REFERENCE	RECOMMENDED BY ...
Increased physical activity is considered a first-line intervention for preventing progression in patients with prehypertension, as well as a treatment strategy for patients with stage 1 or 2 hypertension	A	Baster and Baster-Brooks,[10] 2005	National Heart Foundation; WHO; International Society of Hypertension; US Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure; and ACSM
AHA 2013 recommendations support exercise regimens, including aerobic exercise, in the treatment of hypertension	A	Brook et al,[3] 2013	AHA
AHA advocates dynamic resistance training in the management of hypertension	B	Brook et al,[3] 2013	AHA
AHA suggests isometric hand-grip exercises in the treatment of hypertension	C	Brook et al,[3] 2013	AHA
Decreases of 2 mm Hg in SBP and DBP reduce the risk of stroke by 14% and 17%, and the risk of coronary artery disease by 9% and 6%, respectively	A	Cardoso et al,[23] 2010	ACSM
Pre-participation screening depends on the intensity of the planned exercise and the patient's global cardiovascular risk	A	Fagard and Cornelissen,[5] 2007	ACSM, AHA, and ACC
Absolute contraindications to aerobic and resistance training include recent myocardial infarction or electrocardiography changes, complete heart block, acute congestive heart failure, unstable angina, and uncontrolled severe hypertension (blood pressure ≥ 180/110 mm Hg)	A	Fagard and Cornelissen,[5] 2007	ACSM, AHA, and ACC

ACC—American College of Cardiology, ACSM—American College of Sports Medicine, AHA—American Heart Association, DBP—diastolic blood pressure, SBP—systolic blood pressure, US—United States, WHO—World Health Organization.

about the safety and efficacy of isometric resistance training. Additionally, before starting an exercise program, patients with stage 2 hypertension, especially those with SBP greater than 180 mm Hg and those with CVD or diabetes, should have a pre-participation examination. When prescribing exercise, it is important to consider monitoring training programs and to account for the individual's preferences, as this will affect long-term adherence. Further research should focus on assessment of resistance training, especially isometric exercise.

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Contributors

Drs Ghadieh and **Saab** contributed to the literature review and interpretation, and to preparing the manuscript for submission.

Competing interests

None declared

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