**Role of exercise in hypertension and hypertensive heart disease**

Epidemiological studies have demonstrated the beneficial impact of exercise on hypertension control.1 Even modest levels of physical activity have been associated with a decrease in the incidence of hypertension.2,3 On the other hand, there is evidence that adults with hypertension are less physically active than those without hypertension, and high cardiorespiratory fitness (VO2 max) has been shown to protect against progression from prehypertension to hypertension.4,5

A meta-analysis of 93 randomized controlled trials lasting ≥4 weeks in healthy adults has shown that aerobic endurance training, dynamic resistance training and isometric training reduce resting SBP and DBP by 3.5/2.5, 1.8/3.2 and 10.9/6.2 mmHg, respectively, in the general population.6 The EXERDIET-HTA study compared different aerobic exercise programs in sedentary adults with hypertension who were overweight or obese.7 Interval training was associated with a significantly greater improvement in cardiorespiratory fitness than moderate-intensity continuous training, but BP reduction was similar in both groups.8

Few studies have examined the effects of chronic exercise on BP in patients with resistant hypertension and have shown a reduction of BP (approximately 7 mmHg for SBP and 3 mmHg for DBP) with a further decrease in combination with lifestyle modifications.9,10 Patients with hypertension who are at risk for HFpEF seem to benefit most from aerobic exercise, with a significant reported reduction in systolic (-10 mmHg) and diastolic (-5.5 mmHg) BP in subjects following aerobic training programs.11 The reductions in BP were similar (no statistical difference between groups) for aerobic exercise performed as walking/running or combined training modalities, and for continuous and interval methods.11 Vigorous aerobic exercise, however, tends to produce the largest effects on 24-hour ambulatory BP, while resistance or combined (aerobic and resistance) exercise show no strong effects.12 A limitation of the vast majority of randomized control trials is the use of a single resting office BP measurement as standard. More evidence is necessary to determine the BP-lowering effects of combined exercise as the primary outcome in patients with hypertension.

HIIT showed a significant BP reduction in older patients (≥60 years), with an efficacy in terms of BP reduction comparable to that of moderate intensity continuous training in this population.13 In people with a susceptible heart there is the potential for a plateau or even a decline in benefit at more extreme levels of exercise (i.e. a reverse J-curve or U-curve pattern), and possibly an increased risk of deterioration in cardiovascular function in some individuals; it is therefore important to address the risks associated with vigorous to high-intensity endurance training and competition.14 To avoid overtraining and ensure sufficient recovery periods, training intensity, frequency and duration should be tailored to each patient’s clinical status, stress tolerance and comorbidities. For example, patients should be advised to perform HIIT periodically (mainly in more fit patients) in conjunction with moderate continuous training at lower intensities.

Essential hypertension is characterized by pressure overload that may lead to LVH, myocardial fibrosis, impaired diastolic filling, and diastolic dysfunction, which is a common cause of HFpEF. Exercise training affects all of these factors, but there are insufficient data from randomized trials to prove the benefits of exercise in patients with diastolic dysfunction, even though a number of clinical studies have suggested it.15,16 Endurance-type exercise presented promising outcomes in patients with symptomatic diastolic dysfunction, due to better oxygen utilization in peripheral muscles and in the myocardium; however, this benefit still remains unproven. Initially, it is clear that endurance-type exercise should be performed under professional supervision. In the case of resistance training no data are yet available. A specific group of patients, who have aortic stenosis with hemodynamic alterations and diastolic dysfunction, should avoid any type of exercise until the stenosis is repaired. Another trial in obese patients with HFpEF, concluded that, through exercise and diet, an increased peak VO2 was achieved, as well as an improvement in cardiac function.17

Whether exercise training is effective in elderly patients with diastolic dysfunction remains debatable, as many trials cannot reach a common endpoint to indicate whether endurance-type exercise can improve the early diastolic filling and atrial filling rates in this population.18,19 Another trial, however, concluded that age-associated left ventricle diastolic dysfunction in trained patients was less profound compared to the untrained patients.20,21 Heart rate values, cardiac function time intervals, left ventricular dimensions, stress and wall thickness are affected by exercise, mostly with beneficial results. However, none of these studies performed exercise training in symptomatic patients with diastolic dysfunction, so whether exercise could be considered a therapeutic approach in this group of patients remains unknown.

There is also evidence that physical exercise can reduce left ventricular mass, thus leading to LVH regression.22,23 In a study by Kokkinos et al, the investigators demonstrated that patients with arterial hypertension who exercise on a daily basis for 16 weeks experienced not only a drop in BP, but also a quite significant (12%) reduction in LV mass index.54 Physical activity-driven regression of LVH was associated with a statistically significant reduction of stroke risk in hypertensive individuals.24

Despite the beneficial effects of chronic physical activity, the acute effects of exercise may entail some risk in specific patient groups. In the case of highly intensive resistance exercise, if improperly performed (e.g. with the Valsalva maneuver), there can be an increase of SBP and DBP up to 320 mm Hg and 250 mm Hg, respectively, during a single repetition at maximum load.25 In the hypertensive patient, the BP response may be exaggerated during both aerobic and anaerobic activity.26 There is a post-exercise hypotensive response (up to 10-20 mmHg), which lasts up to 22 hours. This is caused by a drop in norepinephrine levels, with inhibition of sympathetic activity and reduction in circulating angiotensin II, adenosine and endothelin levels and their receptors in the central nervous system, and an increase in the vasodilator effect of prostaglandins and nitric oxide, leading to decreased peripheral vascular resistance and increased baroreflex sensitivity.27 This hypotensive response is influenced by a variety of factors, such as the type and duration of exercise, and the individual’s characteristics (age, ethnicity, physical fitness). To minimalize the post-exercise effect on the hemodynamic load estimation, the recommended procedure for routine office and home BP measurement requires no exercise for at least 30 minutes before BP measurement.28

References

1. van Baak MA: Exercise and hypertension: facts and uncertainties. Br J Sport Med 1998, 32:6–10
2. Haapanen N, Miilunpalo S, Vuori I, Oja P, Pasanen M. Association of leisure time physical activity with the risk of coronary heart disease, hypertension and diabetes in middle-aged men and women. *Int J Epidemiol.* 1997;26(4):739-747.
3. Hayashi T, Tsumura K, Suematsu C, Okada K, Fujii S, Endo G. Walking to work and the risk for hypertension in men: the Osaka Health Survey. *Ann Intern Med.* 1999;131(1):21-26.
4. Churilla JR, Ford ES. Comparing physical activity patterns of hypertensive and nonhypertensive US adults. *Am J Hypertens.* 2010; 23:987–993.
5. Faselis C, Doumas M, Kokkinos JP, et al. Exercise capacity and progression from prehypertension to hypertension. *Hypertension.* 2012; 60:333–338.
6. Cornelissen VA, Buys R, Smart NA. [Endurance exercise beneficially affects ambulatory blood pressure: a systematic review and meta-analysis.](https://pubmed.ncbi.nlm.nih.gov/23325392/) *J Hypertens.* 2013;31(4):639-648.
7. Gorostegi-Anduaga I, Corres P, MartinezAguirre-Betolaza A, et al. Effects of different aerobic exercise programmes with nutritional intervention in sedentary adults with overweight/obesity and hypertension: EXERDIET-HTA study. *Eur J Prev Cardiol.* 2018;25(4):343-353
8. Pedralli ML, Marschner RA, Kollet DP, et al. Different exercise training modalities produce similar endothelial function improvements in individuals with prehypertension or hypertension: a randomized clinical trial Exercise, endothelium and BP. *Sci Rep.* 2020;10(1):7628
9. Dimeo F, Pagonas N, Seibert F, Arndt R, Zidek W, Westhoff TH. Aerobic exercise reduces BP in resistant hypertension. Hypertension. 2012 Sep;60(3):653-658
10. Blumenthal JA, Hinderliter AL, Smith PJ, et al. Effects of lifestyle modification on patients with resistant hypertension: Results of the TRIUMPH Randomized Clinical Trial. *Circulation.* 2021;144(15):1212-1226
11. de Barcelos GT, Heberle I, Coneglian JC, Vieira BA, Delevatti RS, Gerage AM. Effects of aerobic training progression on BP in individuals with hypertension: A systematic review with meta-analysis and meta-regression. *Front Sports Act Living.* 2022;4:719063.
12. Saco-Ledo G, Valenzuela PL, Ramírez-Jiménez M, et al. Acute aerobic exercise induces short-term reductions in ambulatory BP in patients with hypertension: A systematic review and meta-analysis. Hypertension. 2021; 78:1844-58.
13. Carpes L, Costa R, Schaarschmidt B, Reichert T, Ferrari R. High-intensity interval training reduces BP in older adults: A systematic review and meta-analysis. *Exp Gerontol.* 2022; 158:111657.
14. Franklin BA, Thompson PD, Al-Zaiti SS, et al. Exercise-related acute cardiovascular events and potential deleterious adaptations following long-term exercise training: Placing the risks into perspective-an update: A Scientific Statement from the American Heart Association. *Circulation.* 2020; 141(13):e705-e736.
15. Brinker SK, Pandey A, Ayers CR, et al. Association of cardiorespiratory fitness with left ventricular remodeling and diastolic function: the Cooper Center Longitudinal Study. *JACC Heart Fail.* 2014;2(3):238-246.
16. Pandey A, Allen NB, Ayers C, et al. Fitness in young adulthood and long-term cardiac structure and function: The CARDIA Study. *JACC Heart Fail.* 2017;5(5):347-355.
17. Kitzman DW, Brubaker P, Morgan T, et al. Effect of caloric restriction or aerobic exercise training on peak oxygen consumption and quality of life in obese older patients with heart failure with preserved ejection fraction: A randomized clinical trial. *JAMA.* 2016;315(1):36-46.
18. Fleg JL, Shapiro EP, O’Connor F, et al. Left ventricular diastolic filling performance in older male athletes. *JAMA.* 1995;273:1371–1375.
19. Cattadori G, Segurini C, Picozzi A, Padeletti L, Anzà C. Exercise and heart failure: an update. *ESC Heart Fail.* 2018;5(2):222-232.
20. Hietanen E. Cardiovascular responses to static exercise. *Scand J Work Environ Health.* 1984;10(6 Spec No):397-402.
21. Keul J, Dickhuth HH, Simon G, Lehmann M. Effect of static and dynamic exercise on heart volume, contractility, and left ventricular dimensions. *Circ Res.* 1981;48(6 Pt 2):I162-I170.
22. Kokkinos PF, Giannelou A, Manolis A, Pittaras A. Physical activity in the prevention and management of high BP. *Hellenic J Cardiol.* 2009;50(1):52-59.
23. Kokkinos PF, Narayan P, Colleran JA, et al. Effects of regular exercise on BP and left ventricular hypertrophy in African-American men with severe hypertension. *N Engl J Med.* 1995; 333:1462-1467.
24. Rodriguez CJ, Sacco RL, Sciacca RR, et al. Physical activity attenuates the effect of increased left ventricular mass on the risk of ischemic stroke: The Northern Manhattan Stroke Study. *J Am Coll Cardiol.* 2002;39:1482-1488.
25. Ghadieh AS, Saab B. Evidence for exercise training in the management of hypertension in adults. *Can Fam Physician.* 2015 Mar;61(3):233-239.
26. Gordon NF. Hypertension. In: Durstine JL, ed. ACSM’s exercise management for persons with chronic diseases and disabilities. Champaign, IL: Human Kinetics, 2009;107–113.
27. Eicher JD, Maresh CM, Tsongalis GJ, Thompson PD, Pescatello LS. The additive BP lowering effects of exercise intensity on post-exercise hypotension. *Am Heart J*. 2010;160(3):513-520.
28. Stergiou GS, Palatini P, Parati G, O'Brien E, Januszewicz A, Lurbe E, Persu A, Mancia G, Kreutz R; European Society of Hypertension Council and the European Society of Hypertension Working Group on BP Monitoring and Cardiovascular Variability. 2021 European Society of Hypertension practice guidelines for office and out-of-office BP measurement. *J Hypertens.* 2021;39(7):1293-1302.