Review Article

Exercise and Cardiovascular Disease

'Physical exercise should be taken everyday' Susruta; 600 BCE Indian Physician

Shashi K Agarwal1,*

1 Center for Contemporary and Complementary Cardiology, North Brunswick, USA

ARTICLE INFO

Article history:
Received 18-12-2020
Accepted 22-12-2020
Available online 02-02-2021

Keywords:
Cardiovascular
Erectile dysfunction
Coronary heart disease

ABSTRACT

Cardiovascular diseases are the leading cause of global mortality. Besides imparting a tremendous amount of human suffering, they also inflict huge direct and indirect financial costs on the worldwide society. With the ready availability of affordable therapeutics, and the lack of newer innovations, non-invasive strategies are being developed to halt their worldwide spread. The major emphasis has been on implementing lifestyle changes. Physical exercise is one such prescription. This manuscript briefly discusses the benefits of exercise in the prevention and management of cardiovascular diseases.

© This is an open access article distributed under the terms of the Creative Commons Attribution License (https://creativecommons.org/licenses/by/4.0/) which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

1. Introduction

The American College of Sports Medicine defines cardiovascular exercise as ‘any sport or activity that works large groups of muscles, is continually maintained and performed rhythmically’.1 It is a subcategory of physical activity, which is defined as any bodily movement produced by skeletal muscles that results in energy expenditure.2 Although lack of physical activity or sedentary behavior is deleteriously linked to cardiovascular disease (CVD),3 this communication is aimed at highlighting the benefits of exercise on CVD. Regular physical exercise provides a multitude of physical and psychological health benefits,4 including a decrease in premature mortality5 and an increase in life expectancy.6 A curvilinear relationship exists between CVD and exercise, and a dose-dependent reduction in CVD is associated with increasing exercise.7 In a meta-analysis of 33 studies, Wahid and group noted an 11% CVD risk reduction with low physical activity (0.1–11.5 METs h/week), a 21% risk reduction with medium physical activity (11.5–29.5 METs h/week) and a 25% risk reduction with high physical activity (29.5+ METs h/week).8 Exercise also reduces the risk of CVD mortality, both in healthy individuals9 and in cardiac patients.10 It also improves life expectancy.11 Its importance as a modifiable lifestyle behavior in cardiovascular diseases is being increasingly recognized.12,13

2. Exercise and Hypertension

Hypertension (HTN) is a major public health problem in the United States.14 Due to the revision of the threshold for the diagnosis of hypertension to <130/89 mmHg by the ACC/AHA in 2017, there are now 105 million hypertensives in the US (representing 45.4% of the population).15 HTN is an independent predisposing factor for several other CVDs including, CAD, stroke, HF, and PAD.16 It is estimated that for every 20 mmHg systolic and 10 mmHg diastolic blood pressure (BP) increase above the threshold the risk of mortality from ischemic heart disease and stroke doubles.17 Exercise has BP-lowering effects,18 and is often prescribed as the first step in high BP management.19 A meta-analyses calculated that aerobic exercise training lowers systolic BP by 5–7 mmHg, which in turn reduces the risk of CVD by 20-30%.20 Dynamic resistance exercise is also beneficial and lowers the systolic BP by 2–3 mmHg.21 These reductions are similar to the reductions seen with many first-line antihypertensive medications.22

*Corresponding author.
E-mail address: usacardiologist@gmail.com (S. K. Agarwal).
Exercising as little as 1 day per week also reduces all-cause mortality among those with hypertension.23

3. Exercise and Coronary Heart Disease

Coronary heart disease (CHD), due to atherosclerosis, is present in 15.5 million Americans.24 It is characterized by a diseased endothelium, low-grade inflammation, lipid accumulation, and plaque formation within the intima of the vessel wall.25 This can progress into flow-limiting stenosis of large epicardial coronary arteries, resulting in angina.26 Plaque rupture or erosion can provoke superimposed atherothrombosis and subsequent vessel occlusion, leading to a myocardial infarction, or even death.27 Exercise helps protect the coronary arteries28 and the relationship is inverse.29 Sofo and group did a meta-analysis of 26 studies and found that moderate level of leisure-time physical activity was associated with a decreased CHD risk of 0.88 while those engaging in higher levels demonstrated a decreased risk of 0.73.30 In a subsequent meta-analysis of 33 studies, Satelmaier and associates reported that involvement in leisure-time physical activity of 150 min/week resulted in a 14% lower CHD risk while those who reached 300 min/week had a 20% lower risk.31 Secondary cardiovascular protection (re-infarction and cardiac mortality) with cardiac rehabilitation following a myocardial infarction has been repeatedly demonstrated.32,33 Exercise induces a significant improvement in post-CABG outcomes.34 It also exerts a major salutary effect on CHD mortality.35

4. Exercise and Stroke

Stroke is also a major cardiovascular disease in the US.36 It is projected that by 2030, there will be a 20.5% increase in stroke prevalence compared to its prevalence in 2012.37 Stroke is the leading cause of serious long-term disability in US adults,38 and one of the leading causes of death.39 A large percentage of the stroke burden is attributable to modifiable risk factors, including physical activity.40 In one study, Harvard alumni with a history of athletic involvement in college, demonstrated less than half the risk of fatal stroke when compared with non-athletes.41 Research data indicates that physical activity is inversely related to the incidence of stroke.42 Approximately two-thirds of stroke survivors experience long-term impairments in physical, psychosocial, and cognitive function.43 Regular exercise in stroke patients helps ameliorate these symptoms, with improvements in aerobic fitness, maximal walking speed, balance, and walking endurance.44 It also helps improve cognitive function and mood, as well as the quality of life, while reducing subsequent cardiovascular events.45

5. Exercise and Heart Failure

Heart failure (HF) affects more than 37 million individuals in the world.46 It is also pervasive in the USA.47 Projections show that the prevalence of HF will increase by 46% from 2012 to 2030, and this will result in more than 8 million Americans being diagnosed with this disease.48 HF patients are notorious for frequent hospitalizations, with 25% of patients being re-hospitalized within 30 days, and 50% being re-hospitalized within six months.49 Several studies have demonstrated that exercise reduces the risk of future heart failure.50–52 Benefits have been demonstrated in both systolic HF and HF with preserved left ventricular ejection fraction.53 Exercise reduces HF hospitalizations,54 improves quality of life,55 and reduces mortality56 in these patients. Cardiac rehabilitation is approved by the Center for Medicaid and Medicare Services for HF patients.57

6. Exercise and Cardiac Arrhythmias

Atrial fibrillation (AF) is the most common cardiac arrhythmia in the world and affects about 34 million individuals.58 It affects about 1% of the US population and is related to severe prognostic implications and high mortality.59 Moderate physical exercise reduces the risk of developing AF.60 However, more strenuous endurance exercise, often practiced by elite athletes and marathon runners, may increase the risk of AF in healthy athletes without organic heart disease.61 Sudden cardiac death (SCD) is an unexpected death that usually occurs within one hour of symptoms onset,62 Ventricular arrhythmias are a major cause of SCD and are noted occasionally in healthy elite athletes performing strenuous activity.63 A recent study by Aune and group suggests that moderate physical activity may reduce the risk of SCD by almost 50% in the general population.64 Moderate exercise is safe and beneficial in preventing cardiac arrhythmias.64,65

7. Exercise and Peripheral Artery Disease

It is estimated that more than 8.5 million men and women in the US suffer from lower extremity peripheral artery disease (PAD).66 Worldwide, it is present in more than 200 million people.67 It is seen in 7–14% of the general population68 and this increases to approximately 20% in individuals over seventy years of age.69 Ankle-brachial index (ABI) is obtained by Doppler measurements of the systolic pressures in the lower and upper extremities.70 An ABI < 0.90 is considered highly sensitive and specific for a diagnosis of PAD.71 PAD is an atherosclerotic disease.72 In a meta-analysis of sixteen population cohort studies, Fowkes and group noted an approximately 2-fold increased risk of 10-year all-cause mortality, cardiovascular mortality, and coronary event rate, in individuals with an ABI of <0.90 when compared to those with normal ABI values.73 People with PAD also have a greater and faster decline in
functional capacity and have a poorer quality of life than people without PAD. Morbidity and mortality rates from this disease, unfortunately, continue to rise. Exercise helps prevent PAD. Several exercise programs, including supervised treadmill exercise, significantly improve pain-free and maximal walking distance in people with PAD. Upper body exercises are also beneficial in these patients. Exercise improves the quality of life. Supervised treadmill exercise therapy in patients with PAD is covered in the US by the Center for Medicaid and Medicare Services.

8. Exercise and Erectile Dysfunction

Erectile dysfunction (ED) is a common male sexual disorder. It causes persistent inability to attain and/or maintain an erection sufficient for sexual performance. Epidemiological studies indicate that it affects approximately 37% of men over 70 years old and 11% of men over 30 years. Atherosclerosis of the pelvic and penile vasculature is a major underlying cause. Erectile dysfunction is a strong predictor for other cardiovascular diseases, including coronary artery disease. Aerobic exercise training has been used successfully to treat patients with atherogenic ED. In patients on PDE-5 inhibitors, exercise further improves ED and increases functional capacity.

9. Exercise and DVT

Deep vein thrombosis (DVT) of the lower extremities is a common venous disease and is associated with significant morbidity and a high rate of recurrence. Immobilization is an important risk factor for DVT. Ankle exercises help prevent DVT following hospital immobilization or following a long duration air travel. Physical exercises aimed at the leg musculature also help reduce post-thrombotic syndrome and venous ulceration.

10. Exercise and General Health

Exercise also exerts an important ameliorating effect on major cardiovascular risk factors such as smoking, obesity, diabetes mellitus, hyperlipidemia, metabolic syndrome, alcohol abuse, chronic kidney disease, psychosomatic stress, and depression. Besides the significant benefits in CVD and CVD risk factors, physical exercise also plays a therapeutic role in several non-cardiovascular disorders, including chronic back pain, osteoporosis, several cancers, constipation, anxiety, dementia, inflammatory bowel disease, gall bladder disease, osteoarthritis, rheumatoid arthritis, Parkinson’s disease, and multiple sclerosis. Exercise can also provide help in cognition impairment, and drug addiction. The quality of life is improved with exercise, even in healthy individuals. Moderate to vigorous physical activity also helps reduce all-cause mortality and increases life expectancy.

11. Discussion

CVD includes coronary heart disease (CHD) high blood pressure (HTN), stroke, heart failure (HF), cardiac arrhythmias, peripheral arterial disease (PAD), and deep vein thrombosis (DVT). Erectile dysfunction is often due to atherosclerosis and may be included under the umbrella of CVD.

CVDs impart the greatest non-communicable diseases burden globally. They account for 17.9 million global deaths annually. These deaths represent 31% of the total global mortality and make CVDs the leading factor in worldwide mortality. It is anticipated that in the year 2035, nearly one in four individuals will be over the age of 65. Age is a major non-modifiable risk factor for CVD and as the world ages, the incidence of CVD is expected to rise globally in the coming years. CVDs cause considerable loss of productivity and health care spending, which results in a huge financial burden worldwide. CVD is also a leading cause of loss of disability-adjusted life years globally. Healthy lifestyles, including recommended physical exercise, are estimated to be able to prevent 80% of premature CVD mortality in the world. In the USA, CVD is not only common but also its leading cause of death. CVDs are responsible for about 655,000 American deaths each year—that is 1 in every 4 deaths. Despite advances in CVD management and treatment, CVDs still claim more lives than the combination of all cancer forms. Health-related direct and indirect costs of CVDs during the years 2013 to 2014, were estimated at $329.7 billion and are expected to reach $1.1 trillion in 2035. CVDs are also associated with a significant reduction in the quality of life.

In recent years there has been a major push to reduce the CVD burden by encouraging healthy lifestyles. Physical exercise, is a major modifiable CVD lifestyle risk factor and generates significant cardiovascular benefits. Regular exercise can help decrease weight, reduce blood pressure, and improve lipid disorders, including raising HDL, decreasing LDL, and lowering triglycerides. It also reduces systemic inflammation, improves glucose tolerance, decreases insulin resistance, and lowers blood coagulation. Exercise also helps increase nitric oxide bioavailability, improve endothelial function, reduce heart rate, increase myocardial oxygen supply, improve myocardial contraction and stroke volume, establish electrical stability and increase physiological cardiac hypertrophy. The American Heart Association recommends that individuals perform ≥150 min/week moderate or ≥75 min/week vigorous or ≥150 min/week moderate + vigorous-intensity exercise for optimal
cardiovascular health. The duration of physical activity appears to be more important than the intensity, and 40 minutes of moderate to vigorous-intensity aerobic activity, 3 or 4 times a week, also delivers cardioprotection. Lower degrees of physical activity also generate CVD benefits.

12. Conclusion

Physical activity is now regarded as a major lifestyle intervention in the primary and secondary prevention of cardiovascular diseases. According to the World Health Organization, 1 in 4 adults are non-compliant with the recommended levels of physical activity and experience a 20% -30% higher risk of death when compared to people who are sufficiently active. In the USA, the numbers are not much different. Approximately 80% of US adolescents and adults are not active enough. Approximately 80% of US adolescents and adults are not active enough. Despite 60.9 million U.S. citizens joining a gym or starting an exercise program every year, 50% drop out or stop exercising after 6 months. 149,150 Given the significant benefits of exercise in cardiovascular diseases, healthcare workers should strongly incorporate exercise counseling in their CVD preventive and therapeutic armamentarium.

13. Source of Funding

None.

14. Conflict of Interest

The authors declare that there is no conflict of interest.

References

1. 2020. Available from: https://healthyliving.azcentral.com/acsm-definition-cardiovascular-exercise-18723.
2. Caspersen CJ, Powell KE, Christenson GM. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. Public Health Rep. 1985;100:126–31.
3. Pandey A, Salahuddin U, Garg S, Ayers C, Kulinski J, Anand V, et al. Continuous Dose-Response Association Between Sedentary Time and Risk for Cardiovascular Disease. JAMA Cardiol. 2016;1(5):575–83. doi:10.1001/jamacardio.2016.1567.
4. Ruessegger GN, Booth FW. Health Benefits of Exercise. Cold Spring Harbor Perspect Med. 2018;8(7):a029694. doi:10.1101/cshperspect.a029694.
5. Jeong SW, Kim SH, Kang SH, Kim HJ, Yoon CH, Youn TJ, et al. Mortality reduction with physical activity in patients with and without cardiovascular disease. Eur Heart J. 2019;40(43):3547–55. doi:10.1093/eurheartj/ehz200.
6. Mokdad AH, Ballestros K, Echko M. The state of US health, 1990-2016: burden of diseases, injuries, and risk factors among US states. JAMA. 2018;319:1444–72.
7. Powell KE, Paluch AE, Blair SN. Physical Activity for Health: What Kind? How Much? How Intense? On Top of What? Ann Rev Public Health. 2011;32(1):349–65. doi:10.1146/annurev-publichealth-131410-101131.
8. Wahid A. Quantifying the Association Between Physical Activity and Cardiovascular Disease and Diabetes: A Systematic Review and Meta-Analysis. J Am Heart Assoc. 2016;5:2495. doi:10.1161/JAHA.115.003299.
9. Wen CP, Wai JP, Tsai MK. Minimum amount of physical activity for reduced mortality and extended life expectancy: a prospective cohort study. Lancet. 2011;378:1244–53.
10. Thijs MH, Eijsvogels S, Molossi, Lee MS, Emery PD, Thompson. Exercise at the Extremes: The Amount of Exercise to Reduce Cardiovascular Events. Am J Cardiol. 2016;67(3):316–29.
11. Franco OH, Laet CD, Peeters A, Jonker J, Mackenbach J, Nusselder W. Effects of physical activity on life expectancy with cardiovascular disease. Arch Intern Med. 2005;165:2555–60.
12. Hansen D, Niebauer J, Cornelissen V. Exercise Prescription in Patients with Different Combinations of Cardiovascular Disease Risk Factors: A Consensus Statement from the EXPERT Working Group. Sports Med. 2018;48(8):1781–97.
13. Li G, Li J, Gao F. Exercise and Cardiovascular Protection. Adv Exp Med Biol. 2020;1228:205–16.
14. Iqbal AM, Jamal SF. Essential Hypertension; 2020.
15. Bundy JD, Mills KT, Chen J, Li C, Greenland P, He J. Estimating the Association of the 2017 and 2014 Hypertension Guidelines With Cardiovascular Events and Deaths in US Adults. JAMA Cardiol. 2018;3(7):572. doi:10.1001/jamacardio.2018.1334.
16. Sawicka K, Szczyrek M, Jastrzebska I, Prasał M, Zwolak A, Daniluk J. Hypertension - The Silent Killer. J Pre Clin Clin Res. 2011;5(2):43–46.
17. Lee JH, Kim SH, Kang SH, Cho JH. Blood pressure control and cardiovascular outcomes: real-world implications of the 2017 ACC/AHA Hypertension Guideline. Sci Rep. 2018;8(1):13155. doi:10.1038/s41598-018-31598-3.
18. Cornelissen VA, Smart NA. Exercise Training for Blood Pressure: A Systematic Review and Meta-analysis. J Am Heart Assoc. 2013;2(1). doi:10.1161/jaha.112.001573.
19. Chobanian AV. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure<SUBTITLE>The JNC 7 Report</SUBTITLE>. JAMA. 2003;289(19):2500. doi:10.1001/jama.289.19.2504.
20. Pescatello LS, Franklin BA, Fagard R, Farquhar WB, Kelley GA, Ray CA. American college of sports medicine position stand: exercise and hypertension. Med Sci Sports Exerc. 2004;36:533–53.
21. Cornelissen VA, Fagard RH. Effect of resistance training on resting blood pressure: a meta-analysis of randomized controlled trials. J Hypertens. 2005;23(2):251–9. doi:10.1097/01.jhy.0000163805.00429.10.
22. ALLHAT Officers and Coordinators for the ALLHAT Collaborative Research Group Major outcomes in high-risk hypertensive patients randomized to angiotensin-converting enzyme inhibitor or calcium channel blocker vs diuretic: The Antihypertensive and Lipid-Lowering Treatment to Prevent Heart Attack Trial (ALLHAT). JAMA. 2002;288:2981–97.
23. Brown RE, Riddell MC, Macpherson AK, Canning KL, Kuk JL. The Association of the 2017 and 2014 Hypertension Guidelines With Joint Association of Physical Activity, Blood-Pressure Control, and Pharmacologic Treatment of Hypertension for All-Cause Mortality Risk. Am J Hypertens. 2013;26(8):1005–10. doi:10.1038/ajh.2013.73.
24. Mozaffarian D, Benjamin EJ, Go AS, Arnett DK, Blaha MJ, Cushman M. Heart Disease and Stroke Statistics-2016 Update: A Report from the American Heart Association. Circ. 2016;133(4):38–360.
25. Libby P. Ridker PM, Hansson GK. Progress and challenges in translating the biology of atherosclerosis. N Engl J Med. 2005;457(7347):1685–95.
26. Ganz P, Abben RP, Barry WH. Dynamic variations in resistance of atherosclerotic coronary artery segments in resting. Am J Cardiol. 1987;59(1):66–70. doi:10.1016/0002-9149(87)90071-7.
27. Bentzon JF, Otsuka F, Virmani R, Falk E. Mechanisms of Plaque Formation and Rupture. Circ Res. 2014;114(12):1852–66. doi:10.1161/circresaha.114.307724.
28. Thompson PD, Buchner D, Pina IL. Exercise and physical activity in the prevention and treatment of atherosclerotic cardiovascular disease: a statement from the council on clinical cardiology (subcommittee on exercise, rehabilitation, and prevention) and the council on nutrition, physical activity, and metabolism.
(subcommittee on physical activity). *Arterioscler Thromb Vasc Biol.* 2000;20(2):342–9.

29. Williams PT. Physical fitness and activity as separate heart disease risk factors: a meta-analysis. *Med Sci Sports Exerc.* 2001;33(5):754–61.

30. Sofi F, Capalbo A, Cesari F, Abbate R, Gensini GF. Physical activity during leisure time and primary prevention of coronary heart disease: an updated meta-analysis of cohort studies. *Eur J Cardiovasc Prev Rehabil.* 2008;15(3):247–57. doi:10.1097/HJH.0b013e3282772c3c

31. Sattelmair J, Pertman J, Ding EL, Kohl HW, Haskell W, Lee IM. The Dose Response Between Physical Activity and Risk of Coronary Heart Disease. *Circ.* 2011;124(7):789–95. doi:10.1161/circulationaha.110.010710

32. Lawler PR, Filion KB, Eisenberg MJ. Efficacy of exercise-based cardiac rehabilitation post-myocardial infarction: A systematic review and meta-analysis of randomized controlled trials. *Am Heart J.* 2011;162(4):571–84.e2. doi:10.1016/j.ahj.2011.07.013

33. Rauch B, Davos CH, Doherty F, Saure D, Metzendorf M, Salzwedel A. The prognostic effect of cardiac rehabilitation in the era of acute revascularisation and statin therapy: a systematic review and meta-analysis of randomized and non-randomized studies - the Cardiac Rehabilitation Outcome Study (CROS). *Eur J Prev Cardiol.* 2016;23:1914–39.

34. Coyan GN, Reeder KM, Vacek JL. Diet and Exercise Interventions Following Coronary Artery Bypass Graft Surgery: A Review and Call to Action. *Phys Sportsmed.* 2014;42(2):119–29. doi:10.3810/psm.2014.03.2064

35. Keterian SJ, Brawner CA, Savage PD, Ehrman JK, Schaier J, Divine G, et al. Peak aerobic capacity predicts prognosis in patients with coronary heart disease. *Am Heart J.* 2008;156(2):292–300. doi:10.1016/j.ahj.2008.03.017

36. Go AS, Mozaffarian D, Roger VL. Heart disease and stroke statistics American Heart Association. *Circ.* 2014;129(3):28–29.

37. Oviabiele B, Goldstein LB, Higashida RT. Forecasting the future of stroke in the United States. *Stroke.* 2013;44:2361–75.

38. Roger VL, Go AS, Lloyd-Jones DM, Benjamin EJ, Berry JD, Borden WB. Heart disease and stroke statistics-2012 update: A report from the American Heart Association. *Circ.* 2012;125(1).

39. Kochanek KD, Xu JQ, Murphy SL, Minino AM, Kung HC. Deaths: Final data for 2009 National vital statistics reports. Hyattsville, MD: National Center for Health Statistics. National Center for Health Statistics. National Health and Nutrition Examination Survey (NHANES) public use data files. Centers for Disease Control and Prevention website; 2019. Available from: https://www.cdc.gov/nchs/nhanes/Accesed.

40. Heidenreich PA, Albert NM, Allen LA, Blumenke DA, Butler J, Fonarow GC, et al. On behalf of the American Heart Association Advocacy Coordinating Committee; Council on Arteriosclerosis, Thrombosis and Vascular Biology; Council on Cardiovascular Radiology and Intervention; Council on Clinical Cardiology; Council on Epidemiology and Prevention; Stroke Council. Forecasting the impact of heart failure in the United States: a policy statement from the American Heart Association. *Circ Heart Fail.* 2013;6:606–19.

41. Dharmarajan K, Rich MW. Epidemiology, Pathophysiology, and Prognosis of Heart Failure in Older Adults. *Heart Fail Clin.* 2013;13(3):417–26. doi:10.1016/j.hfc.2013.07.001

42. Wang Y, Tuomilehto J, Josuailah P, Antikainen R, Mahonen M, Katzungyak PT, et al. Occupational, Commuting, and Leisure-Time Physical Activity in Relation to Heart Failure Among Finnish Men and Women. *J Am Coll Cardiol.* 2010;56(14):1140–8. doi:10.1016/j.jacc.2010.05.025

43. Djuosse L, Driver JA, Gaziano JM. Relation between modifiable lifestyle factors and lifetime risk of heart failure. *JAMA.* 2009;302(394–400.

44. Kenchiaa S, Sesso HD, Gaziano JM. Body Mass Index and Vigorous Physical Activity and the Risk of Heart Failure Among Men. *Circ.* 2009;119(1):44–52. doi:10.1161/circulationaha.108.807289

45. Guazzi M, Myers J, Peberdy MA, Bensimhon D, PChase, Pinkstaff S, et al. Echocardiography with Tissue Doppler Imaging and cardiopulmonary exercise testing in patients with heart failure: A correlative and prognostic analysis. *Int J Cardiol.* 2010;143(3):323–9. doi:10.1016/j.ijcard.2009.03.053

46. Pandey A, Patel M, Gao A, Wills BL, Das SR, Leonard D, et al. Changes in mid-life fitness predicts heart failure risk at a later age independent of interval development of cardiac and noncardiac risk factors: The Cooper Center Longitudinal Study. *Am Heart J.* 2015;169(2):290–7. doi:10.1016/j.amjheart.2014.10.014

47. Sagar VA, Davies EJ, Briscoe S, Coats AJ, Dalal HM, Lough F, et al. Exercise-based rehabilitation for heart failure: systematic review and meta-analysis. *Open Heart.* 2015;2:e000163.

48. Taylor RS, Sagar VA, Davies EJ, Briscoe S, Coats AJ, Dalal HM, et al. Exercise-based rehabilitation for heart failure. *Cochrane Database Syst Rev.* 2014;2014.10.10.100163.

49. Forman DE, Sanderson BK, Josephson RA, Raikhelkar J, Bittner V. American College of Cardiology’s Prevention of Cardiovascular Disease Section . Heart failure as a newly approved diagnosis for cardiac rehabilitation. Challenges and opportunities. *J Am Coll Cardiol.* 2015;65:2652–9.

50. Go AS, Hylek EM, Phillips KA, Chang Y, Henault LE, Selby JV, et al. Prevalence of diagnosed atrial fibrillation in adults: national implications for rhythm management and stroke prevention: the Anticoagulation and Risk Factors in Atrial Fibrillation (ATRIA) Study. *JAMA.* 2001;285(18):2370–5.

51. Malmo V, Nes BM, Amundsen BH, Tjonna AE, Stoylen A, Rossvoll O, et al. Aerobic Interval Training Reduces the Burden of Atrial Fibrillation in the Short Term. *Circ.* 2016;133(5):466–73. doi:10.1161/circulationaha.113.154181

52. Forman DE, Sanderson BK, Josephson RA, Raikhelkar J, Bittner V. American College of Cardiology’s Prevention of Cardiovascular Disease Section . Heart failure as a newly approved diagnosis for cardiac rehabilitation. Challenges and opportunities. *J Am Coll Cardiol.* 2015;65:2652–9.

53. Go AS, Hylek EM, Phillips KA, Chang Y, Henault LE, Selby JV, et al. Prevalence of diagnosed atrial fibrillation in adults: national implications for rhythm management and stroke prevention: the Anticoagulation and Risk Factors in Atrial Fibrillation (ATRIA) Study. *JAMA.* 2001;285(18):2370–5.

54. Malmo V, Nes BM, Amundsen BH, Tjonna AE, Stoylen A, Rossvoll O, et al. Aerobic Interval Training Reduces the Burden of Atrial Fibrillation in the Short Term. *Circ.* 2016;133(5):466–73. doi:10.1161/circulationaha.113.154181

55. Forman DE, Sanderson BK, Josephson RA, Raikhelkar J, Bittner V. American College of Cardiology’s Prevention of Cardiovascular Disease Section . Heart failure as a newly approved diagnosis for cardiac rehabilitation. Challenges and opportunities. *J Am Coll Cardiol.* 2015;65:2652–9.

56. Abdulla J, Nielsen JR. Is the risk of atrial fibrillation higher in athletes than in the general population? A systematic review and meta-analysis. *European.* 2009;11(9):1156–9. doi:10.1016/j.eurheartj.2009.05.002

57. Kuriachan VP, Sunner GL, Mitchell LB. Sudden Cardiac Death. *Curr Problem Cardiol.* 2015;40(4):133–200. doi:10.1016/j.cpcardiol.2015.01.002

58. Priori SG, Blomström-Lundqvist C, Mazzanti A. Scientific Document Group . 2015 ESC Guidelines for the management of a systemic analysis for the Global Burden of Disease Study. *Nat Rev Cardiol.* 2010;8:263–96.
patients with ventricular arrhythmias and the prevention of sudden cardiac death. *Eur Heart J*. 2015;36:2793–67.
63. Aune D, Schlesinger S, Hamer M, Norat T, Riboli E. Physical activity and the risk of sudden cardiac death: a systematic review and meta-analysis of prospective studies. *BMC Cardiovasc Disord*. 2020;20(1):318.
64. Antonio CO, José CC, Karina SE, Laura GB, Judith TM, Marcelo ML. The Association Between Atrial Fibrillation and Endurance Physical Activity: How Much is too Much? *J Att Fibrillation*. 2019;12(3):2167.
65. Benjamin EJ, Buechel CC, Chiuve SE, Heart Disease and stroke statistics American Heart Association. *Circ*. 2017;127(1):143–52.
66. Fowkes FG, Rudan D, Rudan I. Comparison of global estimates of prevalence and risk factors for peripheral artery disease in 2000 and 2010: a systematic review and analysis. *Lancet*. 2013;382(9901):1329–40.
67. Alzamora MT, Forés R, Baena-Diez JM, Pera G, Toran P, Reina MD. The Peripheral Arterial Disease study (PERART/ARTPER): prevalence and risk factors in the general population. *BMJ Public Health*. 2010;10(1):38.
68. Peach G, Griffin M, Jones KG, Thompson MM, Hinchcliffe RJ. Diagnosis and management of peripheral arterial disease. *BMJ*. 2012;345:e5208. doi:10.1136/bmj.e5208
69. Aboynas V, Criqui MH, Abraham P. American Heart Association Council on Peripheral Vascular Disease; Council on Epidemiology and Prevention; Council on Clinical Cardiology; Council on Cardiovascular Nursing; Council on Cardiovascular Radiology and Intervention, and Council on Cardiovascular Surgery and Anesthesia. Measurement and interpretation of the ankle-brachial index: A scientific statement from the American Heart Association. *Circ*. 2012;126:2890–9.
70. Gerhard-Herman MD, Gornik HL, Barrett C, Bashes NR, Corriere MA, Drachman DE, et al. 2016 AHA/ACC Guideline on the Management of Patients With Lower Extremity Peripheral Artery Disease: Executive Summary: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *Circ*. 2017;135(12).
71. Aboynas V, Ricco JB, Bartelink M. ESC Guidelines on the Diagnosis and Treatment of Peripheral Arterial Diseases, in collaboration with the European Society for Vascular Surgery (ESVS): document covering atherosclerotic disease of extracranial carotid and vertebral, mesenteric, renal, upper and lower extremity arteriesEndorsed by: the European Stroke Organization (ESO)The Task Force for the Diagnosis and Treatment of Peripheral Arterial Diseases of the European Society of Cardiology (ESC) and of the European Society for Vascular Surgery (ESVS). *Eur Heart J*. 2017;38:763–816.
72. Fowkes FG, Murray GD, Butcher I. Ankle brachial index combined with Framingham Risk Score to predict cardiovascular events and mortality: a meta-analysis. *JAMA*. 2008;300(2):197–208.
73. McDermott MM, Ferrucci L, Liu K, Guralnik JM, Tian K, Liao Y, et al. Leg Symptom Categories and Rates of Mobility Decline in Peripheral Arterial Disease. *J Am Geriatr Soc*. 2010;58(7):1256–62.
74. McDermott MM, Ferrucci L, Liu K, Guralnik JM, Tian K, Liao Y, et al. Leg Symptom Categories and Rates of Mobility Decline in Peripheral Arterial Disease. *J Am Geriatr Soc*. 2010;58(7):1256–62.
75. Peach G, Griffin M, Jones KG, Thompson MM, Hinchcliffe RJ. Diagnosis and management of peripheral arterial disease. *BMJ*. 2012;345:e5208. doi:10.1136/bmj.e5208
76. Layden J, Michaels J, Berriming S, Higgins B. Diagnosis and management of lower limb peripheral arterial disease: summary of NICE guidance. *BMJ*. 2012;345:e2497.
77. Hiatt WR, Regensteiner JG, Hargarten ME, Wolfel EE, Brass EP. Benefit of exercise conditioning for patients with peripheral arterial disease. *Circ*. 1999;100(5):1202–9. doi:10.1161/01.CIR.100.5.1202
78. Fakhry F, van de Luitjegaarden K, Bax L, den Hoed P, Hunink MGM, Rouwet EV, et al. Supervised walking therapy in patients with intermittent claudication. *J Vasc Surg*. 2012;56(4):1132–42. doi:10.1016/j.jvs.2012.03.051
79. McDermott MM. Exercise training for intermittent claudication. *J Vasc Surg*. 2017;66(5):1612–20. doi:10.1016/j.jvs.2017.05.111
80. Zwierska I, Walker RD, Choksy SA, Male JS, Pockley AG, Saxton JM. Upper- vs lower-limb aerobic exercise rehabilitation in patients with symptomatic peripheral arterial disease: A randomized controlled trial. *J Vasc Surg*. 2005;42(6):1122–30.
81. Lane R, Harwood A, Watson L, Leng GC. Exercise for intermittent claudication Cochrane Database Syst Rev. 2017;12(12).
82. Jensen TS, Chin J, Ashby L, Scharf J, Dolan D. Proposed national coverage determination for supervised exercise therapy (SET) for symptomatic peripheral artery disease (PAD) Centers for Medicare and Medicaid Services; 2017.
83. Muneer A, Kalsi J, Nazareth I, Arya M. Erectile dysfunction. *BMJ*. 2014;348jan27 71:g129. doi:10.1136/bmj.g129
84. Najarri BB, Kashanian JA. Erectile Dysfunction. *JAMA*. 2016;316(17):1833.
85. Rosen RC, Fisher WA, Eardley I, Niederberger C, Nadel A, Sand M. The multinational Men’s Attitudes to Life Events and Sexuality (MALES) study: I. Prevalence of erectile dysfunction and related health concerns in the general population. *Curr Med Res Opin*. 2004;20(5):607–17. doi:10.1185/030079904200003467
86. Richardson D, Vink A. Etiology and treatment of erectile failure in diabetes mellitus. *Curr Diabetes Rep*. 2002;2(6):501–9.
87. Maresca L, D’Agostino M, Castaldo L. Exercise training improves erectile dysfunction (ED) in patients with metabolic syndrome on phosphodiesterase-5 (PDE-5) inhibitors. *Monaldi Arch Chest Dis*. 2013;80(4):177–83.
88. Heit JA. Epidemiology of venous thromboembolism. *Nat Rev Cardiol*. 2015;12(8):464–74. doi:10.1038/nrrevcardio.2015.67
89. Brandjes DPM, Böller HR, Heijboer H, Huismans MV, de Rijk M, Jagt H, et al. Randomised trial of effect of compression stockings in patients with symptomatic proximal-vein thrombosis. *Lancet*. 1997;349(9054):762–7.
90. Sayegh FA, Almalmood W, Humood S, Marashi B, Ahrari M, Mahdi HA. Global Risk Profile Verification in Patients with Venous Thromboembolism (GRIP VTE) in 5 Gulf Countries. *Clin Appl Thromb*. 2009;15(3):289–96. doi:10.1097/WAC.0b013e3181bc25a1
91. Padberg FT, Johnston MV, Sisto SA. Structured exercise in the management of erectile dysfunction: a meta-analysis study on randomized controlled trials. *Eihpog J Health Sci*. 2011;21(3):195–201.
92. Maresca L, D’Agostino M, Castaldo L. Exercise training improves erectile dysfunction (ED) in patients with metabolic syndrome on phosphodiesterase-5 (PDE-5) inhibitors. *Monaldi Arch Chest Dis*. 2013;80(4):177–83.
136. Arija V, Villalobos F, Pedret R, Vinuesa A, Jovani D, Pascual G, et al. Physical activity, cardiovascular health, quality of life and blood pressure control in hypertensive subjects: randomized clinical trial. *Health Qual Life Outcomes*. 2018;16(1):184. doi:10.1186/s12955-018-1054-1.

137. Ž Reiner, Laufs U, Cosentino F, Landmesser U. The year in cardiology 2018: prevention. *Eur Heart J*. 2019;40(4):336–44. doi:10.1093/eurheartj/ehy899.

138. Mora S, Cook N, Buring JE, Ridker PM, Lee IM. Physical Activity and Reduced Risk of Cardiovascular Events. *Circulation*. 2007;116(19):2110–2118. Available from: https://dx.doi.org/10.1161/circulationaha.107.729939. doi:10.1161/circulationaha.107.729939.

139. Myers J. The new AHA/ACC guidelines on cardiovascular risk: When will fitness get the recognition it deserves? *Mayo Clin Proc*. 2014;89:722–726.

140. Ellison GM, Waring CD, Vicinanza C, Torella D. Physiological cardiac remodelling in response to endurance exercise training: cellular and molecular mechanisms. *Heart*. 2012;98(1):5–10. doi:10.1136/heartjnl-2011-300639.

141. Slentz CA, Bateman LA, Willis LH, Granville EO, Piner LW, Samsa GP, et al. Effects of exercise training alone vs a combined exercise and nutritional lifestyle intervention on glucose homeostasis in prediabetic individuals: a randomised controlled trial. *Diabetol*. 2016;59(10):2088–98. doi:10.1007/s00117-016-4011-5.

142. Wilson MG, Ellison GM, Cable NT. Basic science behind the cardiovascular benefits of exercise. *Heart*. 2015;101(10):758–65. doi:10.1136/heartjnl-2014-306590.

143. Han L, You D, Ma W. National Trends in American Heart Association Revised Life’s Simple 7 Metrics Associated With Risk of Mortality Among US Adults. *JAMA Netw Open*. 2019;2(10).

144. Cortez MY, Togan CE, Brozinick JT, Ivy JL. Insulin resistance of obese Zucker rats exercise trained at two different intensities. *Am J Physiol Endocrinol Metab*. 1991;261(5):E613–9. doi:10.1152/ajpendo.1991.261.5.e613.

145. Lobelo F, Young D, Sallis R. Routine assessment and promotion of physical activity in healthcare settings: a scientific statement from the American Heart Association. *Circ*. 2018;137(18):495–522.

146. Piercy KL, Troiano RP, Ballard RM, Carlson SA, Fulton JE, Galuska DA, et al. The Physical Activity Guidelines for Americans. *JAMA*. 2018;320(19). doi:10.1001/jama.2018.14823.

147. Lobelo F, Young R, Sallis D, Garber MD, Billinger SA, Duperly J, et al. Routine Assessment and Promotion of Physical Activity in Healthcare Settings: A Scientific Statement From the American Heart Association. *Circ*. 2018;137(18):495–522.

148. The 2018 IHRSA Health Club Consumer Report. International Health, Racquet & Sportsclub Association; Web. 25 October 2019.

149. Wilson K, Brookfield D. Effect of Goal Setting on Motivation and Adherence in a Six-Week Exercise Program. *Int J Sport Exer Psychol*. 2009;7(1):89–100. doi:10.1080/1612197x.2009.957140.

150. Berra K, Rippe J, Manson JE. Making Physical Activity Counseling a Priority in Clinical Practice. *JAMA*. 2015;314(24):2617–8. doi:10.1001/jama.2015.162549.

**Author biography**

**Shashi K Agarwal**, Medical Director

---

**Cite this article:** Agarwal SK. Exercise and Cardiovascular Disease. *J Prev Med Holistic Health* 2020;6(2):54–61.