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Review Article

Exercise and Cardiovascular Disease

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

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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.

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 mortality[5] 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 individuals[9] 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]

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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 arteries[28] and the relationship is inverse.[29] Sofi 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, Satelmair 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 mortality[56] 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 population[68] 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.[74] Morbidity and mortality rates from this disease, unfortunately, continue to rise.[75,76] Exercise helps prevent PAD.[77] Several exercise programs, including supervised treadmill exercise, significantly improve pain-free and maximal walking distance in people with PAD.[78–80] Upper body exercises are also beneficial in these patients.[81] Exercise improves the quality of life.[82] Supervised treadmill exercise therapy in patients with PAD is covered in the US by the Center for Medicaid and Medicare Services.[83]

8. Exercise and Erectile Dysfunction

Erectile dysfunction (ED) is a common male sexual disorder.[84] It causes persistent inability to attain and/or maintain an erection sufficient for sexual performance.[85] Epidemiological studies indicate that it affects approximately 37% of men over 70 years old and 11% of men over 30 years.[86] Atherosclerosis of the pelvic and penile vasculature is a major underlying cause.[87] Erectile dysfunction is a strong predictor for other cardiovascular diseases, including coronary artery disease.[88] Aerobic exercise training has been used successfully to treat patients with atherogenic ED.[89] In patients on PDE-5 inhibitors, exercise further improves ED and increases functional capacity.[90]

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.[91,92] Immobilization is an important risk factor for DVT.[93] Ankle exercises help prevent DVT following hospital immobilization or following a long duration air travel.[94] Physical exercises aimed at the leg musculature also help reduce post-thrombotic syndrome and venous ulceration.[95,96]

10. Exercise and General Health

Exercise also exerts an important ameliorating effect on major cardiovascular risk factors such as smoking,[97] obesity,[98] diabetes mellitus,[99] hyperlipidemia,[100] metabolic syndrome,[101] alcohol abuse,[102] chronic kidney disease,[103] psychosomatic stress,[104] and depression.[105] 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,[106] osteoporosis,[107] several cancers,[108] constipation,[109] anxiety,[110] dementia,[111] inflammatory bowel disease,[112] gall bladder disease,[113] osteoarthritis,[114] rheumatoid arthritis,[115] Parkinson's disease,[116] and multiple sclerosis.[117] Exercise can also provide help in cognition impairment,[118] and drug addiction.[119] The quality of life is improved with exercise, even in healthy individuals.[120] Moderate to vigorous physical activity also helps reduce all-cause mortality and increases life expectancy.[9]

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).[121] Erectile dysfunction is often due to atherosclerosis and may be included under the umbrella of CVD.[122]

CVDs impart the greatest non-communicable diseases burden globally.[123] They account for 17.9 million global deaths annually.[124] These deaths represent 31% of the total global mortality[124] and make CVDs the leading factor in worldwide mortality.[125] It is anticipated that in the year 2035, nearly one in four individuals will be over the age of 65.[126] Age is a major non-modifiable risk factor for CVD[127] and as the world ages, the incidence of CVD is expected to rise globally in the coming years.[128] CVDs cause considerable loss of productivity and health care spending, which results in a huge financial burden worldwide.[129] CVD is also a leading cause of loss of disability-adjusted life years globally.[130] Healthy lifestyles, including recommended physical exercise, are estimated to be able to prevent 80% of premature CVD mortality in the world.[131] In the USA, CVD is not only common but also its leading cause of death.[132] CVDs are responsible for about 655,000 American deaths each year—that is 1 in every 4 deaths.[133] Despite advances in CVD management and treatment, CVDs still claim more lives than the combination of all cancer forms.[134] 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.[135] CVDs are also associated with a significant reduction in the quality of life.[136]

In recent years there has been a major push to reduce the CVD burden by encouraging healthy lifestyles.[137] Physical exercise, is a major modifiable CVD lifestyle risk factor and generates significant cardiovascular benefits.[8,10–12] Regular exercise can help decrease weight, reduce blood pressure, and improve lipid disorders, including raising HDL, decreasing LDL, and lowering triglycerides.[138–142] It also reduces systemic inflammation, improves glucose tolerance, decreases insulin resistance, and lowers blood coagulation.[138–142] 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.[138–142] The American Heart Association recommends that individuals perform $\geq$150 min/week moderate or $\geq$75 min/week vigorous or $\geq$150 min/week moderate + vigorous-intensity exercise for optimal

cardiovascular health.[143] The duration of physical activity appears to be more important than the intensity,[144] and 40 minutes of moderate to vigorous-intensity aerobic activity, 3 or 4 times a week, also delivers cardioprotection.[145] Lower degrees of physical activity also generate CVD benefits.[131]

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.[146] In the USA, the numbers are not much different. Approximately 80% of US adolescents and adults are not active enough.[147,148] 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, health care workers should strongly incorporate exercise counseling in their CVD preventive and therapeutic armamentarium.

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14. Conflict of Interest

The authors declare that there is no conflict of interest.

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