GSC Biological and Pharmaceutical Sciences, 2020, 12(03), 090-097

Available online at GSC Online Press Directory

GSC Biological and Pharmaceutical Sciences

e-ISSN: 2581-3250, CODEN (USA): GBPSC2

Journal homepage: https://www.gsconlinepress.com/journals/gscbps

(REVIEW ARTICLE)

Role of exercise and physical activity in prevention and management of chronic diseases

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Publication history: Received on 26 August 2020; revised on 09 September 2020; accepted on 12 September 2020

Article DOI: https://doi.org/10.30574/gscbps.2020.12.3.0277

Abstract

The burden of chronic disease and the cost of treatment and management has skyrocketed. According to the World Health Organization (WHO), an estimated 17.9 million people died from cardiovascular diseases (CVDs) in 2016 making it the leading cause of death. Cancer is the second leading cause of death globally and was responsible for an estimated 9.6 million deaths in 2018, there are other chronic diseases which include obesity, diabetes, chronic obstructive pulmonary diseases (COPD), dementia and Alzheimer's disease. Most chronic diseases can be caused and aggravated by physical inactivity amongst other factors. However, physical activity and exercise when properly implemented demonstrate tremendous effect in the prevention and management of several chronic diseases and health related conditions. This review focuses on the role of exercise in prevention and management of chronic diseases and the biochemical mechanism underlying it.

Keywords: Chronic disease; Physical activity; Exercise; Prevention; Management; Treatment

1. Introduction

Chronic diseases are diseases that are not infectious, slowly progressing, prolonged and usually caused by genetics, environmental factors and poor lifestyle [1]. In recent years there has been an astronomical rise in the incidence of chronic diseases due to the adoption of sedentary lifestyle (physical inactivity) coupled with excessive caloric intake. Epidemiological, experimental and clinical evidence abounds to prove that behavioural risk factors such as sedentary lifestyle, unhealthy diets, tobacco and alcohol initiates dysfunctions that cause chronic diseases [2,3,4]. Physical inactivity is a modifiable risk factor that increases the risk of developing chronic diseases [5]. Hence physical activity and exercise will both help to ameliorate and prevent chronic disease conditions.

2. Exercise and Physical Activity

Exercise and physical activity though often used interchangeably, have somewhat different definitions. According to Zanuso *et al* (2010): Physical activity involves movement of the parts of the body produced by the contraction of skeletal muscle that expend energy higher than the resting energy [6]. It can include activities related to work, leisure or daily routine. On the other hand, exercise is a subset of physical activity that is organised and executed in order to improve or sustain physical fitness [7].

Exercise is categorized based on the type, ferocity and time span of activity. Exercise can be classified into three: Aerobic, anaerobic and flexibility exercise. Aerobic or endurance exercise is an exercise that causes the body to use more oxygen thus improving cardiovascular endurance, examples include running, swimming, brisk walking, skipping rope, dancing

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etc[8]. Anaerobic, strength or resistance training can increase body mass and improve bone density and balance, examples include push-ups, pull-ups, squats, weightlifting and sprinting. Flexibility exercises involves stretching of muscles to improve flexibility and movements around the joints [8].

Endurance exercise involves protracted periods of muscle contraction activity against low resistance, while resistance exercise involves brief periods of muscle contraction activity against a high resistance. Conversely, sprint exercise occurs during short periods of intense and recurrent muscle contraction activity against a low resistance, such as running a 100m sprint race [9]. Regular exercise prevents condition like diabetes, cardiovascular diseases and obesity, though humans exhibit varying degree of responses to exercises due to genetic differences [10]. Junk diet and physical inactivity causes more than 300,000 deaths per year [10] and physical inactivity is an independent risk factor for cardiovascular diseases [11,12].

Researchers have proven that there is a prevalence of chronic metabolic diseases like diabetes, obesity, and coronary heart diseases among individuals with low intrinsic exercise capacity [13,14,15], thus linking aerobic capacity to several chronic diseases. Endurance exercise like running, cycling, swimming, and other aerobic exercises can be referred to as cardiovascular exercise [16]. Endurance exercise educes both muscular and systemic responses as a result of its physiological and biochemical requirements [10]. Endurance exercise has been proven to cause major adaptations like: change in the mechanical, metabolic and contractile role in muscle; reduced glycogen reserve [17]; equilibrated electrolytes [18] and enhanced mitochondrial biogenesis [19].

3. Exercise and Physical Activity in Prevention and Management of Chronic Diseases

Studies have shown the efficacy of physical activities and a lifestyle of continuous exercise. It has been observed that physical activities play a beneficial role in the health of both the young and the old [20]. Lack of physical activity and poor dietary routine is associated to development of conditions such as obesity [21] and progressiveness of several life-threatening chronic diseases such as cancer, cardiovascular diseases, neurological diseases, metabolic diseases and immune related disorders [22]. It has also been shown that regular physical activity is associated with improve cellular functions and tissue processes resulting in a healthier biological system [1]. The inclusion of physical activities to prevent sicknesses showed a highly significant decreased susceptibility to type 2 diabetes [23], an 80% decreased vulnerability to CVD [24], and a 33% decreased susceptibility to cancer [25], and sometimes there is a decrease in risk of early death due to chronic illness [26], aging or both.

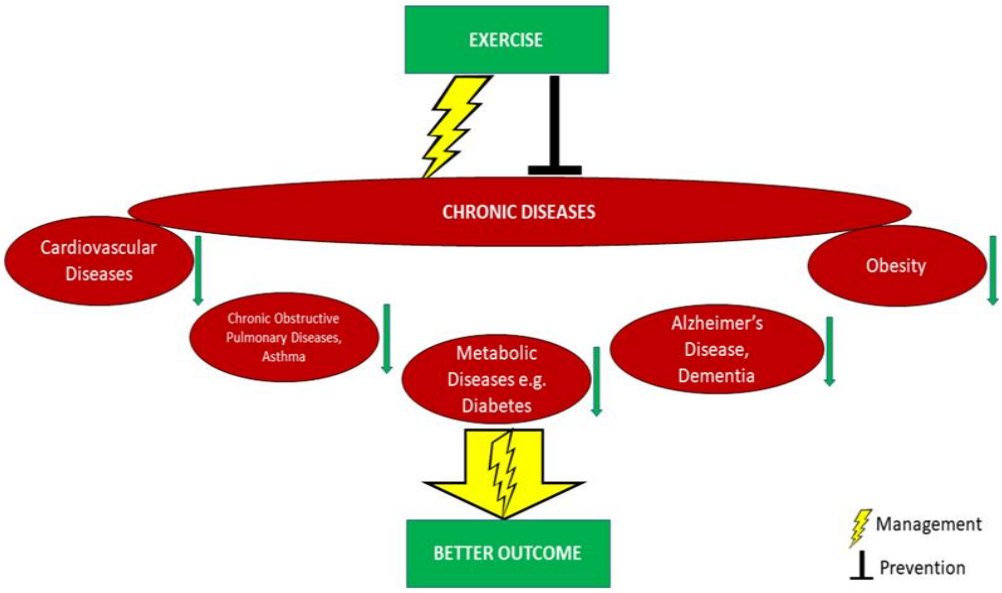

Figure 1 Dual effect of exercise in prevention and management of chronic diseases

Most scientific research has shown that exercise impacts positively on the human body system and it would be safe to say exercise may serve as a form of treatment and management for different disease conditions. This literature focuses on some prevalent chronic disease conditions and how exercise prevents, improves and modulates the condition. Recently, Doctors have started seeing the efficacy of targeted exercise in many medical conditions. Diabetes and obesity

experts have now emphasized regular exercise as a confirmed therapy [27], while geriatricians have included exercise in the regime of older patients to improve their well-being [28]. Some common diseases and the effect of exercise in their prevention and management are highlighted as follows.

3.1. Obesity

A study by Laskowsi (2018) revealed that high intensity interval training is an effectual and therapeutic exercise relevant for combating obesity [29]. Another review showed that lack of physical activities and exercise increased the risk of morbidity in inactive obese patients [30]. Booth *et al* (2017) showed that lack of physical activities increased the weight of rats within just 2-7 days and revealed that inactivity increases risk of obesity and causes reduced insulin sensitivity [22]. Research has shown a relationship between the intensity and amount of exercise and the level of weight loss in total body fat and visceral adipose tissue. Friedenreich *et al* (2010) concluded from their research on postmenopausal women that a minimum dose of exercise is needed to reduce body fat with greater result observed with individuals engaging in a higher volume of training [31].

3.2. Diabetes

Aune *et al* (2015) showed that inactivity groups showed over 26% increased susceptibility to type 2 diabetes than in high activity groups in meta-analyses when total activity was determined in 14 cohort studies and inactivity was reported in a different 55 cohort studies, respectively [32]. Hu *et al* (2004) made findings showing that although obesity is a risk factor for type 2 diabetes, increased physical activity reduced the risk [33]. Obese individuals with high levels of physical activities had less than half the relative risk of type 2 diabetes compared to obese individuals who had low levels of physical activities [33]. In addition, Meta-analysis by Kelly and Kelly demonstrated that exercise decreased the amount of body fat in obese and overweight children and teenagers [34], thereby decreasing their chances of developing diabetes.

3.3. Cancer

According to WHO, around 31% of adults worldwide are physically inactive [35]. The panel concluded that regular, sustained physical activities protects against several types of cancer independent of body fat [36]. Physical activities have been shown to cause a 20% decreased susceptibility to colon cancer [37]. A cohort of more than 40,000 men in the USA showed that aerobic exercise and physical activities seems to be more effective and that all-round physical activity is more effective than the intensity of the exercise [38]. Most studies show a protective effect with a 13% decreased risk in high versus low physical activity groups [39].

Cancer risk is associated with body weight and inactivity, and the prevention of adiposity may be the link between physical activity and cancer. A 20% decrease in susceptibility to cancer in high versus low physical activity groups was shown using a meta-analysis [40]. This inverse association was only observed in overweight/obese women [40]. A 27% decrease in lung cancer incidence in the high versus low physical activity group was also seen among smokers [41]. It is crucial to understand the efficacy of exercise as a safe and effective therapy in patients fighting cancer. However, the precaution varies for different prognosis of the disease, and exercise routines should be under supervision of a specialist.

3.4. Cardiovascular Diseases

Exercise has the ability to decrease susceptibility to cardiovascular diseases (CVD) such as coronary artery disease, atherosclerosis and more via several methods [42]. Some of the different mechanisms on the heart includes improved myocardial contraction, electrical stability, increased dilation capacity of coronary arteries, decreased rate of coronary artery atherosclerosis. In addition, high levels of activity are associated with low blood pressure, high levels of high-density lipoproteins and lower levels of low-density lipoproteins and increased insulin sensitivity and glucose tolerance [43]. It was observed that individuals who were moderately inactive had a substantially lower CVD risk than those who were completely inactive, suggesting that even modest engagement in physical activity may be associated with a substantially lower risk of CVD [44].

3.5. Chronic Respiratory Diseases

Chronic obstructive pulmonary disease (COPD) and asthma (most prevalent chronic respiratory disorder), constitute health burden for health workers, inhaled therapeutics has been the main treatment for asthma [45] and COPD however exercise can improve health conditions of patients [46]. Exercise triggers off asthmatic symptoms like wheezing and/or shortness of breath in most asthmatics and this is because during vigorous physical activities there is loss of heat and water causing the lungs to be dry and leading to constriction of the bronchi [47]. Hence, asthmatics may need to take

their medications (mostly aerosols) before exercise to prevent asthmatic symptoms due to exercise. Walking and other aerobic exercises are recommended for asthmatic individuals, although other vigorous exercises such as basketball and running are not encouraged as they have higher probability of causing symptoms [48].

There is no confirmation of a general degree of exercise required however, the level that is tolerated without any symptom is recommended. Patients that are just starting may need to start from a minimum level and then increase the exercise as much as their condition permits [49]. Exercise and physical activities are usually for up to 30 minutes at a stretch and it is advisable that the patient rests before the next one. Daily physical activity like walking has protective effects and walking in patients with asthma can improve quality of life and control asthma [48].

Physical activities and exercise should be encouraged at the early diagnosis of COPD and being able to maintain a level of physical activity (as their condition can permit without symptom) in individuals with COPD such as bronchitis and emphysema, is associated with a better prognosis in their conditions [50].

3.6. Cognitive Function and Mental Health

Benefits of exercise and physical activity also includes: increase in cerebral blood flow and maximal oxygen consumption, delivery of oxygen to cerebral tissue, reduction in muscle tension and increased serum concentrations of endocannabinoid receptors [51]. Physical activities and exercise have been found to increase the levels of neurotransmitters like serotonin and endorphins [52]. Studies have consistently proven the benefits of exercise and physical activities in reducing depression [53]. It has also been seen that people that practice exercise frequently are not often depressed and do not suffer anxiety [54]. Therefore, physical activity can act as a cheap therapy for these conditions.

Exercise and constant physical activities have also been shown to foster the release of peripheral Brain Derived Neurotrophic Factor (BDNF) [55], improve cerebrovascular health, increase blood flow, and facilitates easier transport of nutrient and energy to the brain [56]. Several studies revealed that exercise enhances cognitive functions in adolescents and aged adults [57,58]. Physical activities also prevent cognitive deterioration associated with aging [59]. Exercise and frequent physical activity also decrease the risk of having dementia [56], prevents deterioration of other mental abilities [60] and it also enhances the quality of life [61].

4. Protective Mechanism of Exercise

The therapeutic role of exercise is due to the various protective biochemical mechanisms underlying it, these mechanisms include activation of insulin-like growth factor (IGF-1), brain derived neurotrophic factor (BDNF) and two major pathways: Peroxisome proliferator-activated receptor-γ coactivator 1α (PGC-1α) and Nuclear factor erythroid 2-related factor 2 (Nrf2) signaling pathways [62]. PGC-1α and Nrf2 pathways both lead to the activation of nuclear respiratory factor 1 (NRF1) and subsequent transcription of genes involved in mitochondrial biogenesis [62].

PGC-1α is a member of a family of transcription coactivators that plays a central role in the regulation of cellular energy metabolism, PGC-1α is linked to alleviation of disorders such as obesity, diabetes, and heart diseases [63]. PGC-1α activates mitochondrial biogenesis which is required for the continuous generation of mitochondria and mitochondria DNA which plays a major role in disease prevention and act as an anti-aging therapy [62]. PGC-1α also activates fatty acid oxidation [64] and increased fatty acid oxidation improves insulin sensitivity [65]. PGC-1α modulates signaling pathways such as Ca^{2+}/calmodulin-dependent signaling, AMPK signaling, p38 MAPK signaling, reactive nitrogen and oxygen species-dependent signaling in exerting therapeutic effects due to exercise [66].

Nrf2 is the master regulator of the antioxidant defense system, it is a transcription factor that regulates the expression of many cytoprotective genes. Studies reveal that Nrf2 signaling plays a major role in how oxidative stress due to exercise can trigger mitochondrial biogenesis and nitric oxide (NO) and hydrogen peroxide (H_2O_2) released during exercise can activate antioxidant defenses such as heme oxygenase 1 (HO-1), NAD(P)H quinone dehydrogenase 1 (NQO1) and superoxide dismutase (SOD) by inhibiting Keap1 (cytosolic repressor of NrF2) from binding to form NrF2-Keap1 complex, thus allowing NrF2 to bind and subsequently activate antioxidant response elements (AREs) in the nucleus [67].

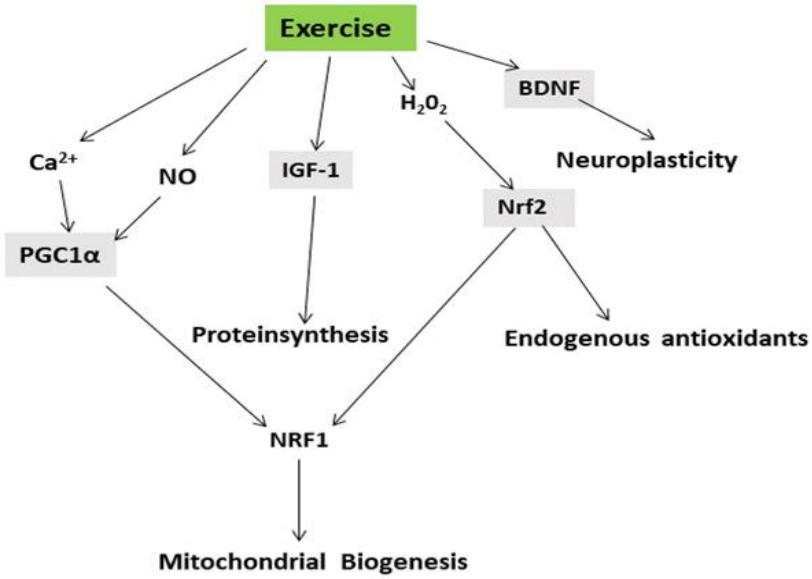

Figure 2 Protective Mechanism of Exercise

Research also shows a link between exercise, IGF-1, and BDNF. BDNF promotes neuroplasticity and neurogenesis, thereby improving cognitive function, mood and neuroprotection [68]. Physical exercise can upregulate growth factor signaling by decreasing proinflammatory signaling [69]. Exercise also induces noradrenalin and serotonin [70] which affect and improves mood. IGF-1, known for its role in child growth and increased body mass shows increased expression as a result of exercise, IGF-1 and vascular endothelial growth factor (VEGF) have also been shown to upregulate BDNF [69,71] thereby improving brain health.

5. Conclusion

Physical inactivity is the primary cause of many chronic diseases. Exercise and Physical activity have been shown to have dual functions: effective in the treatment of chronic diseases, and more importantly help in the primary prevention of chronic diseases. The inclusion of exercise and physical activities in one's daily routine will reduce the risk of chronic diseases and its associated mortality. Thus, exercise and physical activity provides a healthy and cost-effective alternative to other treatment methods for chronic diseases especially because both are involved in primary disease prevention.

Compliance with ethical standards

Acknowledgments

The authors appreciate the support and contribution of Superminds Research Team.

Disclosure of conflict of interest

The authors declare no conflict of interest.

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