

The Role of Aerobic Exercise in Managing Type 2 Diabetes, Obesity, and Hypertension

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Abstract. In modern society, the fast pace of life and sedentary work habits have led to a growing prevalence of chronic diseases such as type 2 diabetes (T2DM), obesity, and hypertension. These conditions pose serious health risks and place a significant burden on public healthcare systems. This review explores the positive impact of aerobic exercise on managing and alleviating symptoms of these chronic diseases. By analyzing a wide range of studies, it was found that aerobic exercise can significantly improve key physiological indicators, including blood glucose, blood pressure, and body weight. These benefits not only reduce disease symptoms but also decrease patients' reliance on medication and enhance their quality of life. The review also compiles exercise recommendations from authoritative guidelines, addressing factors such as frequency, intensity, and duration to help individuals tailor their exercise plans. Understanding the crucial role that aerobic exercise plays in preventing and managing chronic diseases is key to promoting healthier lifestyles and forms a basis for further research in chronic disease treatment.

Keywords: Aerobic exercise, Chronic disease, Type 2 diabetes, Obesity, Hypertension.

1. Introduction

The emergence of chronic diseases is a major challenge for global health, and the high cost of treatment places a financial burden on the national healthcare system and on many families. In fact, obesity, diabetes, and hypertension are now even commonplace in human. Unhealthy lifestyle habits and the lack of regular physical exercise often lead to the emergence of these chronic diseases. There is evidence that chronic diseases are associated with aging and accelerate the onset of disability and functional decline in older people, while chronic diseases cause inflammation in the body [1-3]. Relatively, regular physical exercise seems to be able to produce positive improvements on the numerous inflammatory or immunological mechanisms involved in these diseases [4].

Since 1980, the prevalence of diabetes mellitus in China has seen a dramatic increase, rising from less than 1% to 10.9% among adults by 2013 [5]. This trend is part of a broader global rise in type II diabetes, often associated with obesity and hypertension. As of 2022, approximately 16% of Chinese adults are obese, mirroring a global trend where obesity prevalence more than doubled between 1990 and 2022 [6]. Similar alarming trends are observed in the Asia-Pacific and Southeast Asia regions,

particularly in the prevalence of hypertension, which has doubled in the Western Pacific region from 144 million in 1990 to 346 million in 2019 [7].

Physical inactivity is closely associated with a higher likelihood of developing chronic conditions such as T2DM, obesity, and hypertension. Engaging in regular aerobic exercise has been demonstrated to enhance cardiorespiratory fitness and lower the chances of negative health outcomes [4, 8]. The Physical Activity Guidelines for Americans recommend that adults engage in 150 to 300 minutes of moderate-intensity aerobic exercise, 75 to 150 minutes of vigorous-intensity aerobic activity, or a comparable combination each week [9]. This article seeks to review the current knowledge on the therapeutic benefits, treatment approaches, and limitations of aerobic exercise in managing these chronic diseases. By synthesizing existing research, it offers guidance for creating more effective exercise programs tailored to chronic disease management.

2. Aerobic exercise and T2DM

Diabetes has reached epidemic proportions, primarily fueled by the growing prevalence and incidence of T2DM. In 2013, the national prevalence of diabetes in China was estimated at 10.9%, and this figure continues to climb [10]. Significant differences in the prevalence exist between different genders and age groups, especially in the elderly population over 60 years old, where the prevalence has remained at a high level and increased rapidly. The prevalence is higher in males compared to females, with variations observed across different regions and ethnic groups [11].

2.1. Advantages of aerobic exercise for T2DM

Aerobic exercise has shown significant health benefits in patients with T2DM. Recent studies highlight that exercise, combined with dietary modifications and behavioral changes, is a preferred management strategy for individuals with T2DM. It plays a key role in diabetes and obesity prevention as well as lifestyle intervention programs. Additionally, supervised aerobic and resistance exercises have been shown to enhance glycemic control, reduce body weight, and improve blood pressure and lipid profiles compared to no exercise [12]. Most resistance exercises are high-load and instantaneous exercises, which are not the best choice for young people with busy work or elderly people with declining physical function.

2.1.1. Blood glucose control. Aerobic exercise has been proven to enhance, increase insulin sensitivity, improve cardiopulmonary function, and reduce cardiovascular and overall mortality risk through continuous, rhythmic large muscle group movements like walking, jogging, and cycling. In one study, participants demonstrated significant improvements in HbA1c and cardiorespiratory fitness after 20 weeks of regular exercise [12]. Moreover, a systematic review and network meta-analysis of randomized trials revealed that, with moderate evidence certainty, none of the six exercise types significantly reduced HbA1c except for unsupervised aerobic or resistance exercise [13].

2.1.2. Weight reduction. Aerobic exercise can help T2DM patients effectively lose weight. Research has demonstrated that aerobic exercise training leads to significant reductions in body weight, fat mass, and visceral fat, although it does not have a substantial impact on long-term weight maintenance [14]. In a systematic 8-week aerobic exercise program, positive effects were observed on fasting blood glucose (FBG), HbA1c, body mass index, blood pressure, and resting heart rate (RHR) in patients with T2DM. The findings demonstrated a significant decrease in FBG and HbA1c, along with a reduction in RHR and an increase in VO₂ max, indicating improved cardiorespiratory fitness [15]. Further research is required to determine specific aerobic exercise patterns that effectively support long-term weight maintenance as part of a comprehensive T2DM management strategy.

For people with T2DM, it is best to maintain 150 minutes of aerobic activity per week. The National Health Commission recommended that aerobic exercise, such as brisk walking, jogging, and swimming, is recommended for patients with diabetes, 3~7 days per week, and each exercise lasted more than 30 minutes. People who had no exercise habit started with moderate intensity exercise and gradually

stepped up to high intensity exercise. And can start from 20 minutes each time and gradually increase to 60 minutes.

3. Aerobic exercise and obesity

3.1. Obesity and health

Obesity is a serious and widespread health issue, with a high probability of resulting in mortality. It is primarily caused by lifestyle factors, which can contribute to the development of numerous chronic diseases such as T2DM, hypertension, cardiovascular diseases, and certain types of cancer. According to the WHO, by 2030, the proportion of deaths due to lifestyle-related diseases could reach 30% [16].

3.2. Benefits of aerobic exercise in obesity management

3.2.1. Reduction in body weight and fat. Aerobic exercise is effective in burning calories, leading to significant reductions in body weight and fat. Aerobic exercise, can notably improve weight management in overweight or obese individuals. Obesity frequently results in the accumulation of visceral fat, which poses significant health risks. Both aerobic exercise and resistance training are effective in reducing visceral fat, with aerobic exercise playing a key role in minimizing visceral fat deposition [17]. However, weight loss is just the beginning; the critical challenge lies in managing and maintaining this weight loss over time. The METPOWeR trial indicates that weight gain can occur even when adhering to either high or low levels of exercise post-weight loss. Nevertheless, maintaining at least the minimum exercise recommendation (150 minutes/week) may help in weight maintenance [14]. Thus, creating an effective strategy to maintain individuals' engagement in physical activity is essential, as it significantly influences the long-term effectiveness of aerobic exercise in weight management.

3.2.2. Enhancement of cardiopulmonary function. Obesity can have significant adverse effects on the respiratory system, exacerbating existing respiratory diseases. For instance, conditions like asthma and obstructive sleep apnea are more prevalent in obese children compared to their peers [18]. Studies by Kong and Gao have shown that aerobic exercise combined with strength training can effectively increase maximal oxygen consumption (VO₂ max) and peak oxygen uptake [19]. Peak oxygen uptake is a critical predictor of cardiovascular disease prognosis and mortality. Low peak oxygen uptake is also associated with cardiotoxicity, cancer-related mortality, and decreased quality of life. Therefore, aerobic exercise training is essential for improving cardiopulmonary function. And peak oxygen uptake increased by 16% following exercise training [20].

3.2.3. Enhancement of metabolic health. Aerobic metabolism, which initially depends on glycogen and later shifts increasingly to fat, is the primary pathway for ATP resynthesis during activities lasting longer than two minutes. However, it can only support work rates that are about one-fourth of those achievable during short bursts of high-intensity activity. As aerobic work rates increase, blood lactate levels also rise. In the absence of sufficient oxygen, glucose undergoes glycolysis, resulting in lactic acid production. After more than two minutes of intense exercise, lactic acid can accumulate, contributing to fatigue [21]. Aerobic training can raise the lactate threshold (LT: approximately 2 mmol/l), thereby improving endurance. Additionally, aerobic training improves visceral lipid metabolism, increases ApoB content and the ApoB/ApoA1 ratio, and raises HDL levels, thus reducing the risk of coronary heart disease [22].

3.2.4. Boosting microcirculation. Aerobic exercise training enhances the structure of blood vessels, not only in major arteries but also in peripheral circulation. It also increases the production of angiopoietin, which stimulates capillary growth and normalizes capillary density. Furthermore, it improves the balance between prostacyclin and thrombin levels, contributing to better vascular health [23].

3.2.5. Reduction in mortality and complications. When combined with a healthy diet, aerobic exercise is more effective in reducing weight and fat than diet alone. Weight loss not only lowers the incidence of cardiovascular diseases, myocardial infarction, stroke, and cancer but also reduces premature all-cause mortality by nearly 18% [24].

3.3. Recommended aerobic exercises

Current guidelines recommend at least 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity aerobic activity each week, along with resistance or muscle-strengthening exercises for all major muscle groups at least twice a week [25]. Additionally, higher levels of moderate-intensity exercise (225-420 minutes per week) have been associated with better weight management in individuals aiming to sustain weight loss, compared to lower levels (<150 minutes per week).

3.4. Strategies for preventing obesity

Preventing obesity should start early in life, beginning with creating a supportive family environment and fostering healthy parent-child relationships. In a nurturing family setting, parents who prioritize a healthy diet and active physical exercise can effectively prevent obesity in their children. Conversely, exposure to factors such as family stress, absence of a father figure, maternal depression, confinement, and an unclean home environment can increase the likelihood of obesity [26].

4. Aerobic exercise and hypertension

4.1. Hypertension

Hypertension can be influenced by a variety of factors, including a sedentary lifestyle, high-sodium diet, obesity, smoking, and excessive alcohol consumption [27]. Yet managing blood pressure adequately often proves challenging. Although medications and adjunct therapies are typically prescribed to manage hypertension, they are frequently insufficient on their own. As a result, incorporating exercise training has become a necessary intervention for effective blood pressure control.

4.2. Benefits of Aerobic exercise for hypertension

4.2.1. Improvement in heart function. The healthy heart relies primarily on mitochondrial oxidative phosphorylation (OXPHOS) of fatty acids (~70%) for its energy needs. In cases of hypertension, an excess of substrates can lead to fatty acid overload, oxidative stress, and mitochondrial dysfunction. Aerobic exercise helps to metabolize this excess substrate, mitigating these negative effects [28]. Research shows that just 30 minutes of aerobic exercise can reduce mean arterial pressure by 1.37 mmHg and lower resting heart rate by 1.08 bpm [29]. Additionally, aerobic exercise improves vagal tone and baroreflex sensitivity, both of which contribute to reductions in arterial pressure and overall blood pressure [30].

4.2.2. Increase in vascular elasticity. Intermittent high-intensity aerobic exercise, particularly when performed at intensities greater than 70% of maximal oxygen consumption, this is a threshold that determines whether it is efficient or not. This form of exercise enhances aerobic fitness in a relatively short period, improving arterial stiffness, endothelial function, and insulin resistance [31]. The impact of aerobic exercise on blood pressure reduction is dose-dependent. Engaging in 150 minutes of aerobic exercise per week, divided into 30-minute sessions, resulted in a reduction of systolic blood pressure by 1.78 mmHg and diastolic blood pressure by 1.23 mmHg [29].

4.2.3. Reduction in oxidative stress. Oxidative stress, a REDOX imbalance, is a significant contributor to hypertension. Aerobic exercise can increase nitric oxide bioavailability in the endothelial lining of blood vessels, thereby reducing oxidative stress and improving blood pressure regulation. It also

enhances endothelium-dependent vasodilation, meaning that regular aerobic exercise is an effective method to combat oxidative stress—a key aspect of hypertension treatment [30].

4.2.4. Anti-fibrosis and prevention of adverse cardiac remodeling. Chronic high blood pressure puts too much strain on the heart, leading to fibrosis, adverse cardiac remodeling, and hypertrophy. These changes, especially the pathological thickening and enlargement of the heart wall due to collagen deposition, can ultimately result in heart failure. Aerobic exercise benefits cardiovascular function by reducing collagen deposition and myocardial hypertrophy, thereby reducing the risk of heart failure and mitigating the effects of cardiac remodeling [30].

4.3. Exercise recommendations

Daily step accumulation can effectively lower blood pressure. Research suggests that taking at least 10,000 steps per day significantly reduces systolic blood pressure by 3.8 mmHg, although diastolic blood pressure only decreases by 0.3 mmHg [32]. These findings highlight the importance of daily aerobic activity in blood pressure management.

4.4. Prevention

With approximately one-quarter of the world's adult population affected by hypertension—equivalent to nearly a billion individuals—and the global prevalence expected to rise by 60% by 2025, preventing hypertension has emerged as a critical global public health challenge [33]. Aerobic exercise can help prevent hypertension through multiple mechanisms, including reducing vascular resistance, lowering arterial stiffness and improving angiogenesis [32].

5. Conclusion

In summary, aerobic exercise holds a significant and irreplaceable role in managing obesity, diabetes, and hypertension compared to drug-based treatments and resistance training. Its key mechanisms include reducing body fat and weight, lowering blood pressure and blood sugar levels, and enhancing various physiological markers. The benefits of aerobic exercise in mitigating these chronic diseases are highly dependent on maintaining the right frequency, duration, and intensity of exercise, underscoring the importance of establishing consistent training programs. Additionally, aerobic exercise not only aids in disease management but also offers key preventive and prognostic advantages, making it an essential component of chronic disease intervention strategies.

Authors contribution

All the authors contributed equally and their names were listed in alphabetical order.

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