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The Impact of Running on Cardiovascular Health: A Comprehensive Review of Benefits and Risks

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Abstract

In recent years, running has become a very prevalent form of physical activity. Numerous studies indicate that it can have a beneficial effect on reducing the occurrence of cardiovascular

disease (CVD). In this review, we look at the benefits and possible risks to the heart associated with running. Regular running can reduce the risk of all-cause death and improve heart and vascular function. The benefits from running are obtained by optimizing the dose of running to moderate levels. Running at high intensity or for long periods can cause problems such as heart tissue damage, arrhythmias, and exercise-induced hypertension (EIH), especially in middle-aged and older people. Marathons and ultra-endurance running (UER) are also associated with the risk of sudden cardiac death (SCD). This review discusses the latest information on the benefits and risks of running and examines the research on recreational running, marathons and, UER. This article aims to help people understand how running affects heart health and discusses the best amount of running to get the most health benefits while avoiding the negative effects. Information was collected from PubMed and Google Scholar.

Keywords: Running, Cardiovascular diseases (CVD), Exercise-induced hypertension (EIH), Arrhythmias, Ultra-endurance running (UER), Sudden cardiac death (SCD)

1. Introduction

Cardiovascular diseases (CVD) are the leading cause of mortality worldwide. They are responsible for a significant number of deaths and disabilities. In 2021, CVD caused 20.5 million deaths, which is about one-third of all deaths in the world [1]. Regular physical activity, especially running, may lower the risk of death from all causes [2].

Running is a widely available and popular form of physical activity that has been repeatedly studied for its effects on cardiovascular health. Numerous studies have shown that running significantly reduces cardiovascular risk [3][4]. Even short periods of running, such as 5–10 minutes per day, can lead to significant health benefits, including improved lipid profile, weight control, and increased cardiovascular fitness [3]. These benefits are observed at a variety of running doses and intensities, making it an effective exercise for everyone [5].

However, while moderate running is beneficial, high-intensity and prolonged running may be associated with certain cardiovascular risks. Potential risks include myocardial fibrosis,

arrhythmias, and exercise-induced hypertension (EIH), particularly in middle-aged and older adults [6]. Understanding these risks is crucial to developing balanced training programs that maximize health benefits and minimize potential side effects. The aim of this review is to summarize the current evidence on the benefits and risks of running for cardiovascular health based on a wide range of studies, including studies on recreational running, marathon running, and ultra-endurance running (UER). The review will also examine the optimal dose of running to maximize health benefits and discuss the potential side effects of endurance exercise.

2. Benefits associated with running

2.1. General health benefits

Running is a popular and easy form of exercise that is becoming increasingly common. The health benefits of physical activity are well-known. According to the World Health Organization, all adults should do 150–300 minutes of moderate exercise per week or 75–150 minutes of vigorous exercise per week, or a combination of both [7, 8]. Even short sessions, such as 5–10 minutes of easy running daily, can significantly reduce the risk of cardiovascular diseases (CVD) or death [2, 8].

Running has a beneficial effect on the heart, especially at moderate intensity. It helps increase oxygen flow to the heart and endurance, improving overall heart function [4]. A study of 55,137 adults aged 18 to 100 years found that running significantly reduced the risk of all-cause and heart disease death. Over an average follow-up period of 15 years, 24% of participants were runners. Compared to non-runners, runners had a 30% lower risk of all-cause death and a 45% lower risk of heart disease death. Even running less than 51 minutes per week or at a speed of less than 9,5 km per hour was enough to achieve these positive results. The greatest improvements were seen in people who ran consistently over a longer period. This finding may motivate healthy but inactive people to start and continue running to gain significant health benefits [2].

In addition to reducing mortality risks, running has many other health benefits. It improves cholesterol levels, helps control weight, and enhances cardiovascular fitness. These benefits are seen even at relatively low running amounts, well below the current minimum guidelines for physical activity. This suggests that any physical activity, even in small amounts, is much better than none [3]. Exercise like running has been shown to protect against atrial

arrhythmias, reduce atrial fibrillation, and is recommended in cardiac rehabilitation to improve quality of life and reduce illness in heart patients [10].

In China, running is widely practiced by university students because it is convenient, simple and low-risk. A study of 60 university students without previous regular physical activity showed that after 12 weeks of running, the cardiovascular health indicators of both male and female students showed positive changes. Measurements of cardiac function indicators in the experimental group showed significant improvement compared with the control group. It has been shown that running can effectively improve endothelial function, lower blood pressure and prevent atherosclerosis, thereby reducing the risk of CVD [9].

Overall, the evidence strongly supports that running is a highly beneficial form of physical activity that can lead to significant improvements in health and longevity, especially in preventing heart diseases. The benefits of running are seen across various amounts and intensities, making it an accessible and effective exercise for many people.

2.2. Benefits associated with different running doses

The cardiovascular benefits of regular exercise, particularly running, are well documented. Even short runs, such as 5-10 minutes per day at a slow pace, can significantly reduce the risk of cardiovascular diseases (CVD) [2,8]. Running helps the heart get more oxygen and improves its overall function [4]. However, it is important to pay attention to the optimal dose of physical activity. The amount of running is significant for health benefits and exceeding the recommended dose could even increase cardiovascular risk.

As mentioned earlier, even short runs can have major health advantages. A study conducted in Taiwan involving 416,175 participants found that those who did about 92 minutes of aerobic exercise per week, including running (about 15 minutes per day), had a 14% lower risk of death and lived 3 years longer than inactive individuals. Each additional 15 minutes of daily exercise further reduced the risk of death by 4%. These benefits were observed across all age groups, both sexes and in people at risk for heart disease [11].

For people who want to get heart health benefits from running, the standard guideline of 150 minutes of moderate exercise or 75 minutes of vigorous exercise per week is recommended. Research suggests that the greatest benefits in terms of mortality rates are achieved with moderate levels of weekly aerobic activity. Specifically, running 1 to 2.5 hours per week at a slow or moderate pace provides significant health benefits [8]. The Copenhagen

City Heart Study of 1,098 healthy runners and 3,950 healthy non-runners showed a U-shaped relationship between running and mortality rates. The lowest mortality rates were observed in light runners, followed by moderate runners, while high-paced runners had similar mortality rates to non-runners. This suggests that moderate amounts of running are best for health benefits [12].

However, it should be noted that running longer than recommended or participating in ultra-endurance events (UER) – such as marathons and ultramarathons – may have potential long-term health problems. While dangerous acute cardiovascular events are rare and UER is generally a safe form of physical activity for healthy individuals, it can lead to long-term adverse effects such as right ventricular dysfunction, arrhythmias, and increased arterial stiffness. These risks emphasize the importance of balanced training and appropriate medical supervision, especially for those engaging in high-intensity running [6].

To summarize, the best amount of running for health benefits is moderate running, specifically 1 to 2.5 hours per week at a slow to moderate pace. Higher amounts of running may not provide additional benefits and may pose health risks. Therefore, it is important to balance the intensity and duration of running to positively impact cardiovascular risk.

2.3. Improvements in vascular function and arterial health

Heart disease is a leading cause of morbidity and mortality in both men and women in developed countries. As we age, our risk of arterial stiffening and endothelial dysfunction increases, which can lead to the development of hypertension. Regular aerobic exercise, such as running, is the best way to reduce our risk of CVD as we age [1,13].

Running helps reduce arterial stiffness and improve arterial health in middle-aged and older people who have not previously been physically active. This is associated with reducing oxidative stress, maintaining stable nitric oxide (NO) levels, and improving arterial function. Aerobic exercise also increases the production of antioxidant enzymes and NO. However, these benefits are less consistent in postmenopausal women, whose estrogen levels decrease significantly. In these women, estrogen therapy can restore the positive effects of exercise on arterial function. More research is needed to understand the differences between men and women in how their arteries adapt to regular exercise, including the role of estrogen [13].

Studies have shown that running significantly reduces the risk of high blood pressure and improves artery function. In a study of 33,060 runners and 15,945 walkers, both running

and walking were associated with a lower risk of high blood pressure. Running reduced the risk by 4.2% per MET (metabolic equivalent task) hour per day while walking reduced it by 7.2% [3,14]. In another study of 25,552 men and 29,148 women, running at higher intensities (e.g., faster running) was associated with a lower risk of high blood pressure, regardless of the amount of exercise or fitness level [3]. Recent studies also show that running can significantly reduce arterial stiffness in even amateur marathon runners, improving arterial elasticity and overall heart health. Reduced arterial stiffness can improve marathon performance by increasing blood flow and oxygen to active muscles [15].

In summary, regular running not only helps maintain healthy blood pressure, but also significantly improves the elasticity and function of arteries. These benefits are especially important for older people, who have increased arterial stiffness and CVD risk. Therefore, running may be a key element in preventing and maintaining arterial health, offering long-term benefits for the heart and circulatory system.

3. Risks associated with running

3.1. Risks of long-distance running and marathons

Marathon running originated at the 1896 Athens Olympics and has become a popular activity worldwide. It attracts both young professional athletes and millions of middle-aged amateur runners. Marathon participants often believe that endurance exercise will provide significant health benefits. While regular moderate-intensity exercise is generally good for heart health, the extreme exertion of marathon running may pose specific cardiovascular risks [16][17][18].

Marathon running can significantly impact the workload of the heart muscle. Increases in heart-related biomarkers such as troponin and brain natriuretic peptide (BNP) have been observed in middle-aged amateur runners. These biomarkers, along with temporary changes in heart function, may indicate potential heart damage. In addition, this group is at increased risk for developing atrial fibrillation (AF), a condition with irregular heartbeats that can lead to serious problems [16][17]. A review from the past decade found that marathon running has little effect on the heart's systolic function, but may negatively affect its diastolic function in recreational runners. These problems are often associated with temporary damage to the heart muscle [18]. However, studies show that these heart changes usually return to normal quickly, suggesting that they may be temporary responses to intense exercise, often called "cardiac

fatigue” [16][17]. In addition, the type of troponin released after a marathon is different from that released during a heart attack. [19]

The Berlin Beat of Running study looked at exercise-induced heart rhythm problems in marathon runners. Continuous ECG monitoring during the marathon showed that 16.8% of the athletes had abnormal results, including brief episodes of rapid heartbeat and temporary changes in heart rate. These problems were more common in older athletes and were associated with higher levels of high-sensitivity troponin T (hsTnT), a marker of myocardial damage [20].

Although rare, sudden cardiac death (SCD) during marathons has attracted considerable attention and concern about the safety of this physical activity. The risk of SCD is low and is usually associated with underlying heart disease. The incidence of SCD is lower in women and is not significantly affected by marathon experience or preexisting symptoms. Appropriate preparation and the availability of automated external defibrillators (AEDs) are key to improving survival rates from cardiac arrest during marathons [17].

In conclusion, although marathon running has many health benefits, it also carries specific cardiovascular risks, especially for middle-aged amateur runners. The extent of exercise-induced cardiac changes and potential damage is still a matter of debate, and more research is needed to develop guidelines for screening athletes and to design optimal marathon training plans.

3.2. Risk of Exercise-Induced Hypertension

Exercise-induced hypertension (EIH) occurs when blood pressure increases to dangerous levels during or after intense exercise. EIH is diagnosed when resting blood pressure is $<140/80$ mmHg and systolic blood pressure (SBP) is ≥ 210 mmHg during exercise [21]. This can lead to increased risk of CVD.

Research shows that high blood pressure during exercise can disrupt the balance between oxygen demand and delivery to the heart, potentially causing heart disease even in the absence of coronary artery disease (CAD) [22]. Long-term excessive exercise can damage blood vessels and stiffen arteries, which further increases blood pressure during exercise [21]. EIH is more common in middle-aged distance runners and increases the risk of serious arrhythmias such as atrial fibrillation or ventricular arrhythmias [23]. EIH is associated with angiotensin II activity, so angiotensin II receptor blockers may help middle-aged runners [21]. Improving guidelines for limiting participation in running events and exercise intensity may

positively impact health safety [22]. Understanding these factors is key to recognizing EIH as a risk for heart disease and sudden cardiac death (SCD).

The increased oxygen demand of the heart during exercise due to EIH leads to inflammation and higher levels of substances that narrow blood vessels. This can cause the formation of atherosclerotic plaque in the coronary arteries, lead to fatal arrhythmias, and affect the enlargement of the heart muscle. This condition can cause an imbalance in oxygen delivery to the heart, acting as a new risk factor for SCD [22]. Studies have shown that EIH is associated with higher levels of cardiac markers such as troponin I and N-terminal pro-brain natriuretic peptide, which indicate heart damage [21]. Long-distance runners with EIH have been shown to have chronic vascular damage, reduced heart function, and increased arterial stiffness. These factors increase the risk of SCD during exercise or competition [22,24]. EIH increases the risk of future resting hypertension and is an independent risk factor for cardiovascular disease of the brain [21].

In summary, although regular exercise is good for heart health, excessive exercise leading to EIH is risky. Middle-aged long-distance runners should be aware of these risks and take preventive measures, such as regular monitoring of blood pressure and possibly the use of angiotensin II receptor blockers. Middle-aged marathon runners are also advised to undergo annual exercise testing to monitor heart health and adjust training accordingly [21,23].

3.3. Long-term health risks

Although running offers many benefits for the heart, prolonged and intense running can pose serious health risks. The previously mentioned Copenhagen City Heart Study showed that moderate running reduces the risk of death, but intense running training may be associated with similar cardiovascular risks as a sedentary lifestyle [12].

One of the main long-term risks of intense running is atrial fibrillation (AF). Studies show that prolonged endurance running can cause changes in the heart, such as myocardial fibrosis and right ventricular dysfunction, which increase the risk of arrhythmia. These changes are more common in people participating in ultra-endurance events (UER), where the heart is subjected to prolonged exertion, which can lead to potential long-term damage. Therefore, runners should be aware of these risks and get regular tests to monitor their heart health [6].

Exercise-induced hypertension (EIH) is another serious risk for distance runners. EIH can cause chronic vascular damage, reduced heart function, and increased arterial stiffness,

increasing the risk of serious arrhythmias and sudden cardiac death (SCD) [21, 22, 24]. Prolonged overexertion can increase the risk of these conditions, so runners should monitor their blood pressure and adjust their training intensity. Incorporating rest days and mixed exercise (cross-training) can help reduce these risks and reduce CVD [21, 22, 23]. Runners should also consult with their healthcare providers to develop a balanced training plan that includes adequate rest and recovery periods.

Balancing training intensity and duration is essential to maximize health benefits and minimize risks. Excessive and intense running can lead to long-term health problems, including atrial fibrillation, myocardial fibrosis, right ventricular dysfunction, exercise-induced hypertension, and transient heart abnormalities. It is important for runners to approach training sensibly, with attention to adequate rest and medical care, to enjoy the benefits of their sport while taking care of their long-term health.

4. Conclusions

Running is a popular and easily accessible form of physical activity that has a beneficial effect on maintaining health, especially the heart. Particular benefits are gained during training at a moderate pace and in accordance with the guidelines. Regular, moderate running, even in small amounts, can significantly reduce the risk of death from any cause, including the risk of cardiovascular disease (CVD). Physical activity in the form of moderate running affects better heart function and prevents arrhythmia. Running at the right intensity also improves the functioning of blood vessels, makes arteries more elastic, and lowers blood pressure, which is especially important for older people.

However, attention must be paid to the intensity of running training. Very intensive and long-distance running, such as marathons and ultramarathons (UER), can be risky, especially for middle-aged and older people. These activities can put a lot of strain on the heart, causing temporary changes in the heart, heart fibrosis, and therefore a higher risk of arrhythmia. Exercise-induced hypertension (EIH) is another risk for distance runners, which can damage blood vessels and stiffen arteries. There is also a risk of sudden cardiac death (SCD) in ultra-endurance (UER) exercise.

It is important for runners to balance the intensity and duration of their training to maximize the health benefits while avoiding the potential negative effects. The optimal amount of running is the most important factor in determining the benefits and risks of CVD. Regular

check-ups with a doctor, taking care of your heart health, and taking rest days can help reduce these risks. A mindful approach to running, training, and race preparation can allow runners to enjoy the many benefits of their sport, reduce their risk of CVD, and protect against long-term negative effects.

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