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High-Intensity Interval Training - health benefits and risks - literature review

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1. Abstract

High-Intensity Interval Training (HIIT) has become a prominent exercise modality known for its efficiency and effectiveness in improving various health outcomes. This review critically examines the positive and negative health aspects of HIIT, focusing on its impact on cardiovascular health, metabolic function, weight management, psychological well-being, and life expectancy. Evidence suggests that HIIT significantly enhances cardiovascular health by improving VO2 max, reducing blood pressure, and enhancing endothelial function. Metabolically, HIIT improves insulin sensitivity, glucose metabolism, and lipid profiles, while effectively reducing visceral fat and enhancing mitochondrial function. In terms of weight management, HIIT promotes fat loss and muscle maintenance, contributing to favorable body composition. Psychologically, HIIT has been shown to reduce symptoms of

anxiety and depression, improve cognitive function, and enhance overall mental health. It has also a positive effect on chronic pain conditions.

Emerging studies indicate that HIIT may reduce mortality risk and extend life expectancy by improving cardiovascular and metabolic health. Despite these benefits, HIIT also presents risks such as a higher incidence of musculoskeletal injuries, potential adverse cardiac events in high-risk individuals, and the risk of overtraining and burnout. Special populations, including older adults, children, adolescents, and individuals with chronic conditions, can benefit from HIIT, but modifications and precautions are necessary to ensure safety and effectiveness. The review underscores the importance of individualized HIIT program design, thorough assessment, and continuous monitoring to maximize benefits while minimizing risks. Future research should focus on long-term effects, optimal protocols for diverse populations, and personalized HIIT approaches to enhance safety and efficacy.

2. Introduction

Background Information

High-Intensity Interval Training (HIIT) is a form of exercise that involves short bursts of intense activity alternated with periods of low-intensity exercise or rest. It can also be referred to as high-intensity interval exercise (HIIE). However, HIIE is sometimes used to specifically emphasize the exercise aspect rather than a training program. The HIIT method has garnered significant attention for its efficiency and effectiveness in improving various health parameters. The concept of HIIT dates back to the early 20th century when it was initially used to enhance athletic performance. It gained popularity in the mid to late 20th century, especially for its application in training Olympic athletes (1, 2).

Definition and History of High-Intensity Interval Training (HIIT)

HIIT is defined as a training regimen that alternates short periods of intense anaerobic exercise with less-intense recovery periods. A typical HIIT session involves repeated bouts of high-intensity efforts, generally lasting from 20 seconds to several minutes, interspersed with recovery phases of similar or shorter duration (3). This method contrasts with traditional moderate-intensity continuous training (MICT), where exercise is performed at a constant, moderate pace.

The roots of HIIT can be traced back to the early 1900s, but its scientific basis and widespread adoption emerged later. Swedish coach Gösta Holmer developed a systematic approach known as "Fartlek" or "speed play" in the 1930s, which laid the groundwork for modern HIIT protocols. This approach was further refined and popularized by Dr. Izumi Tabata and colleagues in the 1990s through studies demonstrating significant aerobic and anaerobic benefits from short, high-intensity workouts (4).

Overview of HIIT's Popularity in Modern Fitness Regimes

In recent years, HIIT has surged in popularity, becoming a staple in many fitness programs and regimes. Its appeal lies in its time efficiency and versatility, allowing individuals to achieve significant health benefits in a shorter time compared to traditional exercise methods. HIIT has been shown to improve cardiovascular fitness, metabolic health, and body composition, making it an attractive option for both athletes and the general population (5, 6).

The fitness industry has embraced HIIT due to its adaptable nature. It can be customized for various fitness levels and performed with minimal equipment, making it accessible for home workouts, gym classes, and even outdoor sessions. Furthermore, the rise of digital fitness platforms has contributed to HIIT's widespread adoption, offering guided sessions that can be easily followed by users globally (7).

Despite its benefits, HIIT is not without drawbacks. Concerns about the potential for increased injury risk and overtraining highlight the importance of appropriate program design and individualization. Additionally, while HIIT can be highly effective, it may not be suitable for everyone, particularly individuals with certain medical conditions or low baseline fitness levels (8).

Purpose of the Review

The purpose of this review is to critically analyze and summarize the positive and negative health aspects of HIIT. By examining both the benefits and potential risks, this review aims to provide a comprehensive understanding of HIIT's impact on health.

Scope

This review focuses on adult populations, including both healthy individuals and those with certain health conditions. It examines the short-term and long-term effects of HIIT on various health outcomes, providing insights into its applicability and effectiveness across different demographics.

3. Methods

Literature Search Strategy

To compile a comprehensive review of the positive and negative health aspects of High-Intensity Interval Training (HIIT), a literature search was conducted using several key databases. These databases include:

- **PubMed**
- **NCBI**
- **Cochrane Library**
- **Google Scholar**

The search was performed using a combination of the following keywords: "High-Intensity Interval Training," "HIIT," "health benefits," "health risks," and "exercise physiology."

Inclusion and Exclusion Criteria

Inclusion Criteria:

- Peer-reviewed articles
- Clinical trials
- Meta-analyses
- Systematic reviews

Exclusion Criteria:

- Non-peer-reviewed sources
- Case reports

Studies with small sample sizes

Data Extraction

The data extraction process involved summarizing key findings related to the health benefits and risks associated with HIIT. The following aspects of each study were taken into account:

Study Design: The type of study conducted (e.g., randomized controlled trial, observational study).
Population: The characteristics of the study population, including age, health status, and sample size.
Duration: The length of the intervention or follow-up period.
Outcomes: The primary and secondary outcomes measured, focusing on health benefits and risks.

Only the most relevant articles to this topic were included.

4. Positive Health Aspects of HIIT

Cardiovascular Health

High-Intensity Interval Training (HIIT) has been shown to significantly improve cardiovascular health. Studies have documented notable enhancements in VO2 max, an important marker of cardiovascular endurance, indicating improved aerobic capacity and overall cardiovascular function (3, 8). Additionally, HIIT has been associated with reductions in both systolic and diastolic blood pressure, as well as lower resting heart rates, contributing to better heart health and reduced cardiovascular risk (2, 9). It improved ejection fraction in individuals with heart failure. In patients with metabolic syndrome it enhanced stroke volume, mitral annular excursion, ejection velocity, and systolic mitral annular velocity (10). Furthermore, research indicates that HIIT can significantly improve endothelial function, which is crucial for maintaining vascular health. Improved endothelial function leads to better vasodilation and reduced arterial stiffness, contributing to overall cardiovascular health (9).

Metabolic Benefits

HIIT has also demonstrated significant metabolic benefits, particularly in enhancing insulin sensitivity and glucose metabolism. This type of training can improve the body's ability to regulate blood sugar levels, which is crucial for preventing and managing conditions like type 2 diabetes (11). Furthermore, HIIT positively impacts lipid profiles by increasing HDL (good cholesterol) and reducing LDL (bad cholesterol) and triglycerides, which are critical factors in preventing metabolic syndrome and cardiovascular diseases (12). Additional studies have found that HIIT can reduce visceral fat, which is more metabolically active and associated with higher risks of metabolic diseases compared to subcutaneous fat. These reductions in visceral fat are particularly beneficial in lowering the risk of metabolic syndrome and improving insulin sensitivity (8). Studies also show that HIIT can enhance mitochondrial function, thereby improving cellular energy production and metabolic efficiency. Finally, this training method was shown to reduce the liver inflammation (13).

Weight Management

One of the most well-recognized benefits of HIIT is its efficacy in reducing body fat percentage and improving muscle mass. Studies have shown that HIIT can effectively promote fat loss while preserving lean muscle, making it an efficient exercise regimen for weight management (14, 15). This combination of fat reduction and muscle maintenance contributes to a more favorable body composition and overall metabolic health. Additionally, HIIT's impact on appetite-regulating hormones such as ghrelin and leptin suggests potential benefits in appetite control and long-term weight management. The combination of HIIT and intermittent fasting nutritional intervention (IF) may have even more pronounced, enhanced benefits on weight loss, hormones, glucose tolerance/insulin resistance, liver steatosis/inflammation, FA oxidation, and lipogenesis (16). However, more future studies are needed.

Psychological and Neurological Benefits

The psychological benefits of HIIT are equally significant. Research indicates that HIIT can positively impact mental health by reducing symptoms of anxiety and depression (12, 17). Furthermore, improvements in overall mood and cognitive function have been reported, highlighting the mental health advantages of incorporating HIIT into regular exercise routines (18). Evidence suggests that HIIT can also enhance executive function and reduce psychiatric symptoms in older adults, making it beneficial for maintaining mental acuity throughout the lifespan. Buzdagli et al. (19) compared the effect of moderate-intensity continuous exercise (MICE) and HIIT on improving cognitive performance and neuroprotection in a healthy, athlete population. They concluded that HIIE is considered more effective than MICE for improving neuroprotection and cognitive performance. Additionally, some studies demonstrated improvements in motor learning in healthy individuals and the retention of motor skills after a stroke. It may be explained by the increases in cortico-spinal excitability and brain-derived neurotrophic factor (10, 20).

Impact on Life Expectancy and Mortality

Emerging evidence suggests that HIIT may play a role in reducing mortality risk and potentially extending life expectancy. By improving cardiovascular and metabolic health, HIIT can lower the risk of premature death from various chronic diseases (21). Jaureguizar et al. found that HIIT significantly improved functional capacity and quality of life in patients with coronary artery disease compared to moderate continuous training (MCT), with no increase in cardiovascular risk. Improved functional capacity is closely linked to lower mortality rates (22). Another study found that HIIT resulted in substantial clinical improvements in patients with coronary artery disease and heart failure, including better peak oxygen uptake and ventricular function, both of which are important prognostic factors for survival (2). Stensvold et al. (23) found that HIIT did not significantly differ from moderate-intensity continuous training (MICT) in reducing all-cause mortality among older adults. However, there was a trend towards lower mortality with HIIT, suggesting potential benefits for life expectancy. Moreover, HIIT improved long-term survival in heart failure patients by increasing VO2 peak and decreasing left ventricular end-systolic diameter, both critical factors for reducing mortality (24).

The combination of enhanced heart health, better metabolic control, and improved physical and mental well-being contributes to the overall longevity benefits of HIIT.

5. Negative Health Aspects of HIIT

While HIIT is popular for its efficiency and health benefits, there are potential negative health aspects associated with this type of training. Findings from various studies demonstrate the negative impacts of HIIT.

Risk of Injury

High-Intensity Interval Training (HIIT) is associated with a higher incidence of musculoskeletal injuries compared to moderate-intensity exercise. This increased risk is due to the intense and rapid movements required during HIIT sessions, which can strain muscles and joints, leading to injuries such as sprains, strains, and tendonitis (12). Common types of injuries include muscle pulls, joint sprains, and stress fractures. To mitigate these risks, it is essential to employ proper warm-up routines, ensure correct technique, and incorporate adequate rest and recovery periods between sessions (5). Additionally, tailoring HIIT programs to individual fitness levels can help reduce the likelihood of injuries.

Cardiovascular Risks

While HIIT can provide significant cardiovascular benefits, it also carries potential risks, particularly for individuals with pre-existing heart conditions. There is a potential for adverse cardiac events such as arrhythmias, myocardial infarction, or sudden cardiac arrest, especially in high-risk individuals (25). Therefore, it is crucial to conduct thorough screening and monitoring before and during HIIT programs. Recommendations include pre-exercise cardiovascular evaluations, continuous monitoring during exercise, and gradual progression of intensity to ensure safety (26). Recent studies advocate for the use of wearable technology to monitor heart rate and detect any abnormalities during HIIT sessions.

Overtraining and Burnout

HIIT can lead to overtraining, psychological stress, and burnout if not appropriately balanced with recovery periods (27). Signs and symptoms of overtraining syndrome include persistent fatigue, decreased performance, mood disturbances, and increased susceptibility to infections due to a compromised immune system (18, 28). HIIT can lead to detrimental effects on metabolic health, such as impaired glucose metabolism and increased oxidative stress, when the intensity and volume of training exceed optimal levels (29). To prevent burnout, it is important to incorporate adequate recovery time, ensure varied training intensities, and listen to the body's signals. Balancing high-intensity sessions with lower-intensity or rest days can help maintain long-term adherence and prevent the negative effects of overtraining (17). Implementing periodized training plans can also aid in optimizing performance and recovery. Ultimately, not all individuals respond positively to HIIT. Factors such as age, fitness level, and genetic predisposition can lead to variable responses, with some individuals experiencing adverse metabolic and cardiovascular responses (30).

6. HIIT in Special Populations

Older Adults

HIIT offers numerous benefits to older adults, but it must be approached with caution. HIIT has been shown to improve functional capacity, muscle power, and physical performance in healthy older adults. It can enhance cardiovascular health, muscle strength, and overall physical function, which are critical in reducing fall risk and improving quality of life (31). However, older adults are at a higher risk of injuries and adverse events. Therefore, HIIT protocols should be modified to ensure safety, including longer warm-up and cool-down periods, lower intensity intervals, and close monitoring during exercise sessions (5). Recent research suggests that supervised HIIT programs specifically designed for older populations can maximize benefits while minimizing risks. In relation to neurogenesis and cognitive enhancement, a Cochrane review found that aerobic physical activities that enhance cardiorespiratory fitness do not appear to confer any significant cognitive benefit in healthy older adults (32).

Children and adolescents

Overall, training in child populations focuses on promoting physical activity and skill development in a way that is effective and enjoyable. Research highlights the importance of incorporating age-appropriate exercises that enhance motor skills, strength, and endurance while considering the developmental stages of children. Programs should emphasize variety to keep children engaged and motivated, ensuring a positive attitude toward lifelong fitness and introducing good routines. To prevent injuries and foster a supportive environment for growth and development, proper supervision and guidance from trained professionals should be applied (33). Long-term HIIT can enhance cardiorespiratory fitness in children and adolescents with overweight or obesity (34). Furthermore, HIIT positively influences cardiometabolic risk factors in obese children and adolescents. Compared to MICT, HIIT is more effective in improving cardiorespiratory fitness and systolic blood pressure. Studies exhibit that the specific components of the HIIT protocol play a crucial role in its effectiveness for managing childhood obesity (35). In summary, children and adolescents benefit significantly from HIIT; however, it is important to remember to take appropriate breaks for regeneration (36).

Individuals with Chronic Conditions

HIIT has proven effective for individuals with various chronic conditions, such as diabetes, obesity, and cardiovascular diseases. For patients with type 2 diabetes, HIIT has been shown to improve insulin sensitivity, glucose metabolism, and cardiovascular fitness, making it a valuable component of diabetes management (37). In individuals with obesity, HIIT can significantly reduce body fat and improve metabolic health (38). For those with cardiovascular diseases, HIIT has demonstrated superior benefits compared to moderate-intensity continuous training, improving cardiorespiratory fitness, endothelial function, and overall cardiovascular health (26).

Given the increased risk associated with high-intensity exercise, HIIT programs for individuals with chronic conditions should be tailored to their specific health status and conducted under medical supervision. This ensures that the exercise intensity is appropriate and that any potential adverse effects are promptly managed.

Regular monitoring and adjustments to the HIIT protocol can help maximize benefits while minimizing risks (39).

Emerging evidence suggests that HIIT can be beneficial for patients with chronic diseases. For instance, individuals with cardiovascular disease have shown improved functional capacity and quality of life through HIIT, without increasing medical risks. Compared to moderate continuous training (MCT), HIIT has been found to significantly enhance left ventricular ejection fraction while reducing left ventricular end-diastolic and end-systolic volumes. Although research on HIIT in patients with pulmonary disease and Type 2 Diabetes (T2D) is limited, HIIT appears to be at least as effective as MCT in improving functional capacity and quality of life in pulmonary disease patients. Additionally, HIIT may offer advantages such as peripheral muscle changes leading to reduced negative training symptoms like dyspnea and leg discomfort. In the case of T2D patients, HIIT programming is equally effective as MCT in reducing body fat percentage and enhancing peak power output. HIIT should be considered either in combination with or as a supplement to MCT in the treatment plan for patients with chronic diseases, particularly for those who cannot tolerate high-intensity continuous exercise. Patient preference for the exercise protocol is crucial, as it can impact adherence to the intervention. Future studies with larger sample sizes are needed to determine the most effective HIIT protocols for optimal exercise responses and training adaptations in patients with various chronic diseases. While using HIIT with chronic disease patients raises concerns about safety, following prescribed exercise protocols can mitigate risks. Overall, the literature reviewed here underscores the growing scientific support for the safety and efficacy of HIIT in stable patients with chronic diseases (3).

Chronic pain is a debilitating condition that can co-occur with various chronic diseases and results in worse quality of life in patients. Drug therapy remains the primary treatment for chronic pain. However, a review by Stefano Palermi et al. suggests that HIIT offers significant benefits for several chronic pain conditions. Consequently, HIIT could serve as a valuable adjunct to conventional pharmacological therapies and may enhance the quality of life for patients suffering from these diseases. Chronic pain conditions such as fibromyalgia (FM), low-back pain, and diabetes are prevalent examples (40). HIIT may also reduce disease symptoms like pain, fatigue and also has been proved to reduce inflammation in patients with axial spondyloarthritis. (41). Due to the complex nature of these conditions, a multidisciplinary treatment approach is often the most effective strategy, with physical activity being a cornerstone of complementary therapies. Physical activity offers significant advantages for patients with chronic pain, as it does not interact with the multiple medications they commonly use. Moreover, exercise can specifically reduce the severity of chronic pain and provide broader benefits, such as improvements in overall physical and mental health, including alleviation of depression and physical deconditioning which are frequently observed in these patients. The positive effects of exercise on chronic pain can be understood at a microscopic level. For instance, exercise increases the production of endogenous opioids, which can lead to transient antinociception and has probably a antihyperalgesic effect. In conclusion, HIIT has demonstrated promising results as a therapeutic exercise for patients with chronic pain conditions.

However, the current quality of evidence is low, and further high-quality studies, such as randomized controlled trials are needed to confirm the encouraging results (40).

7. Discussion

Summary of Key Findings

High-Intensity Interval Training (HIIT) has been shown to offer numerous health benefits, including improvements in cardiovascular health, metabolic benefits, weight management, psychological health, and even potential increases in life expectancy. However, it also presents certain risks, such as a higher incidence of musculoskeletal injuries, potential cardiovascular risks for high-risk individuals, and the possibility of overtraining and burnout (2, 5, 8, 26, 38).

Comparison with Other Forms of Exercise

When compared to moderate-intensity continuous training (MICT) and resistance training (RT), HIIT demonstrates several distinct advantages. HIIT often provides greater improvements in aerobic capacity, cardiovascular health, and metabolic function in a shorter amount of time (25, 42). Studies show that HIIT is at least as effective as MICT in improving cardiovascular health, with some research indicating superior benefits in terms of VO2 max, insulin sensitivity, and overall fitness (43, 44). Moreover, HIIT can lead to similar or even greater reductions in body fat and improvements in body composition compared to MICT (45). Resistance training complements HIIT by improving muscle strength and endurance, which can further enhance overall physical fitness (46).

Limitations of Current Research

Despite the promising findings, there are several limitations in the current research on HIIT. Many studies have small sample sizes and short durations, limiting the generalizability of their results. Additionally, there is a lack of long-term studies examining the sustained benefits and risks of HIIT over extended periods. Furthermore, variations in HIIT protocols (e.g., duration, intensity, frequency) make it difficult to standardize recommendations (39). More research is needed to establish optimal HIIT protocols for different populations, particularly older adults and individuals with chronic conditions.

Practical Implications

To safely incorporate HIIT into exercise routines, it is important to tailor the program to individual fitness levels and health conditions. Beginners should start with lower intensity and gradually increase the intensity and duration of their workouts. Incorporating adequate warm-up and cool-down periods is essential to prevent injuries. Health professionals should conduct thorough assessments and provide personalized guidance to ensure the safety and effectiveness of HIIT programs for their patients. Regular monitoring and adjustments to the HIIT protocol can help maximize benefits while minimizing risks (8, 26). The use of technology such as heart rate monitors and fitness trackers can aid in optimizing training and ensuring safety.

Future Directions

While the current body of research underscores the efficacy of HIIT, there is a pressing need for more comprehensive and long-term studies to better understand its sustained effects and safety profiles.

Future research should focus on addressing the gaps in the literature, such as the long-term impacts of HIIT on diverse populations, the optimal protocols for different age groups and health conditions, and the mechanisms underlying the observed benefits and risks (47, 48). Additionally, there is a need for developing personalized HIIT protocols that consider individual health status, fitness levels, and specific needs to maximize benefits while minimizing risks. Health professionals should also be equipped with clear guidelines and tools to advise patients on incorporating HIIT into their exercise routines safely and effectively (6). Future research should also focus on the molecular mechanisms underlying HIIT's benefits to provide deeper insights into its physiological effects.

Conclusions

High-Intensity Interval Training has emerged as a highly effective exercise modality that offers numerous health benefits across various populations. The key positive aspects of HIIT include significant improvements in cardiovascular health, metabolic function, weight management, psychological well-being, and potential reductions in mortality risk. However, HIIT is also associated with risks such as higher incidences of musculoskeletal injuries, potential adverse cardiac events in high-risk individuals, and the risk of overtraining and burnout. These benefits and risks highlight the importance of individualized program design and careful monitoring, especially for special populations like older adults and those with chronic conditions.

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