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The use of high-intensity interval training (HIIT) in cardiac rehabilitation - a review

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Abstract

Background. Cardiac rehabilitation plays a crucial role in reducing mortality and improving the quality of life in patients after cardiovascular events. High-intensity interval training (HIIT) is gaining attention as a time-efficient and potentially more effective alternative to moderate-intensity continuous training (MICT).
Aim. The aim of this review is to assess the effectiveness and the safety of high-intensity interval training in cardiac rehabilitation.
Material and methods. A literature search was performed using PubMed database, narrowing it down to studies published between 2015 and 2025. The inclusion criteria focused on the use of high-intensity interval training in patients with coronary artery disease, after myocardial infarction, and with heart failure.
Results. The analyzed studies demonstrated that high-intensity interval training significantly improves cardiorespiratory fitness, endothelial function, and metabolic parameters. Recent meta-analyses confirm the effectiveness of HIIT showing a significantly greater increase in peak oxygen uptake (VO_2 peak), with an average difference of approximately 1.42 mL/kg/min, compared to MICT. When patients are properly selected and monitored, HIIT is safe and well tolerated in cardiac rehabilitation programs.
Conclusions. HIIT is an effective and safe form of exercise for cardiac patients and may complement or even replace traditional training approaches. However, it requires individualized programming and supervision by a specialized medical team. Further research is necessary to confirm its long-term outcomes.

Key words: high-intensity interval training, cardiac rehabilitation, coronary artery disease, myocardial infarction, heart failure, exercise therapy

1. Introduction

Cardiovascular diseases (CVD) are the leading cause of death worldwide, accounting for approximately 17.9 million deaths per year, according to WHO data [1], [2]. One of the key components in the treatment and prevention of recurrence is cardiac rehabilitation (CR), specifically a comprehensive program including health education, optimization of pharmacological treatment, and physical exercise [3]. Traditionally, the mainstay of exercise rehabilitation has been moderate-intensity continuous training (MICT), which has good tolerance and well-documented effectiveness [4]. High-intensity interval training (HIIT) has become increasingly popular in recent years. HIIT involves alternating short rounds of intense exercise with periods of rest. Considering the growing number of studies on the efficacy and

safety of HIIT in the rehabilitation of patients with coronary artery disease (CAD), post-myocardial infarction (post-MI), and heart failure (HF), the purpose of this review is to analyze the current state of knowledge in this field.

2. Research materials and methods.

PubMed database was searched to identify studies on the use of HIIT in CR. Searches were conducted using combinations of the following keywords: "high-intensity interval training" AND "cardiac rehabilitation", “HIIT” AND “coronary artery disease", "HIIT" AND "myocardial infarction", "HIIT" AND "heart failure". Studies published between 2015 and 2025, written in English, were considered. The review included randomized controlled trials (RCTs), meta-analyses, and systematic reviews involving adult patients undergoing CR. Experimental studies on animal models and purely theoretical articles were excluded.

3. Characteristics of HIIT

HIIT is a structured form of exercise that involves alternating short but high-intensity periods of exercise, usually ≥85% maximum heart rate (HRmax) or ≥80% of peak oxygen uptake (VO_2 peak), and phases of active or passive recovery, performed at low intensity [5], [6]. That training maximally stimulates the cardiovascular and respiratory systems in a shorter time than traditional forms of continuous exercise. A key feature of HIIT is the contrast between intensity and recovery: short periods of work, but very intense, interspersed with longer or equal phases of rest. This pattern of activity allows for an intensity that would be impossible to maintain with continuous exercise [7]. As a result, HIIT induces significant aerobic and anaerobic adaptations while improving cardiovascular capacity, glucose metabolism, and endothelial function [8]. The types of exercises used in HIIT depend on the training goal, level of training, and place of implementation e.g. hospital, home, gym. Bodyweight exercises such as burpees, jump squats, boxing runs, mountain climbers, skipping, interval sprints are used. The advantage of HIIT is its modularity - it is easy to adapt to the patient's capabilities, e.g., from 15 seconds to several minutes, intensity, type of exercise, and the work- to- rest ratio. The total duration of an exercise session, including warm-up and cool-down, is usually between 20 and 40 minutes [9]. The following figure illustrates an example of HIIT protocol [Figure 1].

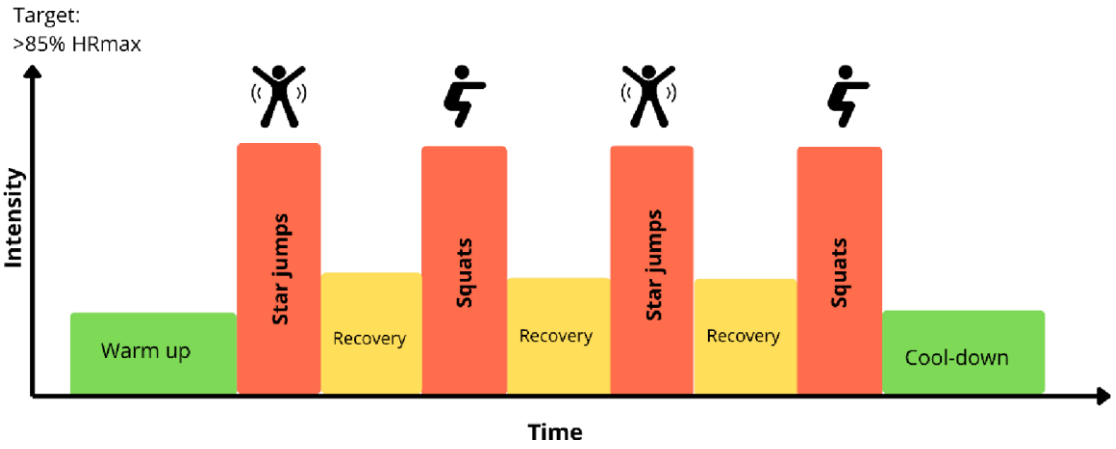

Figure 1. An example of HIIT protocol. (source: author’s own work)

The protocol includes a warm-up phase, alternating series of high-intensity exercises, eg., jumping jacks, squats, designed to achieve >85% HRmax and recovery periods, followed by a cool-down phase.

4. Effectiveness of HIIT in Cardiac Patients

HIIT represents a modern and promising form of physical exercise in the rehabilitation of CVD patients. Physiologically, HIIT leads to a significant increase in metabolic demand over a short period of time, which stimulates adaptations in the myocardium, increases cardiac stroke volume, and improves oxygen transport mechanisms [10], [11]. In addition, improvements in insulin sensitivity, blood pressure, and lipid profile reduction have been reported in patients with CVD and metabolic syndrome [6], [8].

4.1 The improvement of aerobic capacity

VO_2 peak is considered one of the most crucial prognostic indicators in CVD patients, as its improvement is significantly correlated with a reduced risk of mortality and rehospitalization [12]. In recent years, numerous studies have confirmed the superiority of

HIIT over MICT in increasing VO_2 peak [13]. A meta-analysis by Gao et al., which included 22 randomized controlled trials involving 1,364 patients with coronary artery disease (CAD), found that HIIT led to a statistically significant increase in VO_2 peak by an average of 1.42 mL/kg/min compared with MICT (95% CI: 0.90-1.95 mL/kg/min). Moreover, the largest increases were observed in interventions lasting more than 40 minutes, VO_2 peak increased by as much as 2.31 mL/kg/min, suggesting a dependence of the effect on the duration of training sessions [14]. Similarly, a systematic review by Weston et al. confirmed that HIIT interventions resulted in greater improvements in VO_2 peak than MICT [15]. Furthermore, an analysis by Hannan et al. showed that even in the home-based HIIT setting, patients with CAD achieved an average increase in VO_2 peak of 1.40 mL/kg/min (95% CI: 0.50-2.30) compared to MICT [16]. These results suggest that HIIT is a more effective approach to improving cardiorespiratory fitness, which has important clinical implications, especially in post-MI and HF patients [17] [18].

4.2 Impact on Cardiac Function

The benefits of HIIT include potential improvements in left ventricular function, including ejection fraction (LVEF) and diastolic parameters. Data in this regard are less clear in post-MI patients. Meta-analysis, found no significant differences between HIIT and MICT in terms of changes in LVEF and left ventricular end-diastolic volume (LVEDV), mainly due to the limited number of studies considering these indicators [14]. In the SMARTEX-HF multicenter trial, which included heart failure patients with reduced ejection fraction, both HIIT and MICT, led to reductions in systolic and diastolic pressures, but without a notable advantage for either training method [19]. This indicates that although HIIT has significant benefits in terms of aerobic capacity, its effects on systolic function and blood pressure may be comparable to MICT.

4.3 Reduction of Cardiovascular Risk Factors

HIIT has a beneficial effect on traditional cardiovascular risk factors. Studies show that interval training programs effectively lower blood pressure, low-density lipoprotein (LDL) cholesterol, and fasting blood glucose [20], [21]. In addition, improvements in insulin

sensitivity have been observed, as well as reductions in body weight and waist circumference [5]. These benefits are particularly important in patients with metabolic syndrome and type 2 diabetes. A narrative review published in 2023 also reported improved endothelial function and decreased arterial stiffness, indicating the comprehensive impact of HIIT on the cardiovascular system [8], [18]. These metabolic effects not only support the treatment of CVD but also help prevent its progression and related complications.

4.4 Quality of Life and Patient Well-Being

An important aspect of HIIT's effectiveness is its effect on patients' quality of life. RCTs in individuals with chronic HF have demonstrated that HIIT significantly improves scores on the Minnesota Living with Heart Failure Questionnaire (MLHFQ) [22], [23]. Moreover, patients often report greater satisfaction with shorter, more intense training sessions, which may translate into greater motivation and better adherence to rehabilitation programs [24], [25]. By improving subjective well-being, HIIT implementation supports comprehensive patient care and may enhance the long-term effectiveness of therapeutic strategies.

4.5 Differences in Effectiveness Depending on the Underlying Condition

The effectiveness of HIIT varies depending on the specific cardiovascular condition. The greatest benefits – both in terms of VO_2 peak improvement and cardiac function parameters - are observed in heart failure patients with reduced ejection fraction (HFrEF) and in post-MI. In contrast, results in heart failure patients with preserved ejection fraction (HFpEF) are more heterogeneous [26]. Some studies report significant improvements in physical performance, while others show no clear advantage of HIIT over MICT [23], [27]. This inconsistency may result from the heterogeneity of the HFpEF population and highlights the need for further research that takes into account different heart failure phenotypes and supports the individualization of rehabilitation programs [26].

5. Safety and Tolerability of HIIT

The implementation of HIIT in the rehabilitation of patients with CVD initially raised concerns regarding its safety, especially in relation to the risk of complications such as cardiac arrhythmia, myocardial ischemia, or sudden cardiac arrest. However, scientific evidence and clinical practice suggest that, under appropriate supervision, HIIT is a safe and well-tolerated intervention [28], [29], [30], [31]. A meta-analysis by Wewege et al. found no significant differences in adverse event rates between HIIT and MICT [32]. However, the safety of HIIT depends on proper workout design and close monitoring of vital signs during exercise, especially in high-risk patients, such as those with recent MI, significant arrhythmia, and advanced HF. In RCTs, HIIT sessions are typically conducted under supervised conditions, allowing for continuous monitoring of ECG, heart rate, and blood pressure [9], [28]. This approach minimizes the risk of complications and enables prompt intervention in the event of adverse symptoms. Another important factor is the structure of HIIT. It involves short intervals of high intensity interspersed with periods of rest. This format allows even patients with limited exercise capacity to perform high-intensity efforts while maintaining good tolerance [29]. Studies have shown CVD patients generally tolerate HIIT well, and the rate of session interruption due to symptoms such as dyspnea or fatigue remains low [33]. Patient compliance and motivation are critical for the long-term effectiveness of rehabilitation. Some patients report greater satisfaction with shorter, more intense HIIT sessions compared to traditional training, which may lead to better adherence and sustained physical activity after completing

the clinical program [29], [30]. It should be emphasized that not all patients feel comfortable exercising at high intensity [34], [35]. Therefore, individualization of the training program and appropriate patient education are essential.

6. Practical Application and Recommendations

Although the efficacy and safety of HIIT in the rehabilitation of cardiac patients is well documented, its implementation into routine clinical practice remains a challenge. A key element is the appropriate patient qualification before starting a HIIT program. It should include an assessment of physical capacity using an exercise stress test as well as a cardiovascular risk score, including rest and exercise ECG, echocardiography, and arrhythmia assessment. It should also involve a thorough analysis of comorbidities, such as diabetes, chronic obstructive pulmonary disease, or musculoskeletal disorders [9]. HIIT is recommended for clinically stable patients, such as those post-MI, after coronary revascularization, with chronic HFrEF and HFpEF, provided there are no contraindications to high-intensity exercise. In clinical practice, three HIIT protocols are mostly used [Table 1.].

Table 1. The most popular HIIT protocols used in CR. (source: author's own work)

HIIT Protocol	Interval Duration and Intensity	Recovery period between intervals	Total Duration	Additional elements
4x4	4 intervals x 4 minutes at 85-95% HRmax	3 minutes at 60-70% HRmax	~ 40 minutes	5 minutes warm up and 5 minutes cool-down
10x1	10 intervals x 1 minute at >90% HRmax	1 minute low intensity	~ 30 minutes	5 minutes warm up and 5 minutes cool-down, suitable for shorter intense sessions
30:30	alternating 30 seconds at 90-100% HRmax	30 seconds recovery	15-20 minutes	can be adapted for different fitness levels

The choice of a specific protocol should be tailored to the patient's baseline physical capacity, individual preferences, and the capabilities of the rehabilitation center [28]. HIIT sessions should be conducted under the supervision of qualified healthcare professionals, such as doctors or physiotherapists, to ensure safety. Exercise sessions should include monitoring of heart rate (ideally via a heart rate monitor), perceived exertion (e.g., using the Borg scale),

blood pressure before and after the session, and observation for potential clinical symptoms such as chest pain, dyspnea, dizziness, or arrhythmia [9]. In many outpatient programs, initial HIIT sessions are conducted in clinical settings. In recent years, several international scientific societies, including the European Society of Cardiology (ESC), have endorsed the use of HIIT as an alternative to MICT in patients with CAD and HF, subject to appropriate surveillance [12]. The American Heart Association (AHA) also recommends HIIT as an adjunct to conventional training, emphasizing its effectiveness in improving VO_2 peak and cardiac function [9]. The Polish Society of Cardiology also acknowledges the growing body of evidence supporting the effectiveness of HIIT while emphasizing the importance of individualized therapy [4]. However, the implementation of HIIT in a clinical setting comes with some limitations, such as the need for increased staff involvement and more intensive monitoring compared to MICT, patient reluctance to engage in high-intensity exercises, and the need to standardize protocols and adapt them to the conditions of specific rehabilitation centers [36]. Despite these challenges, with proper preparation by the medical team and appropriate patient education, HIIT can serve as a valuable and effective component of an individualized CR plan.

7. Conclusions

The use of HIIT in CR shows high efficacy in improving physical capacity, hemodynamic parameters, and quality of life in patients with CVD. Compared to traditional MICT, HIIT often provides faster and more pronounced physiological effects with shorter session durations. Results from meta-analyses and RCTs confirm the safety of HIIT in patients with HF, CAD, and post-MI, provided the program is conducted under appropriate supervision. Scientific societies such as the ESC and AHA are increasingly willing to recognize HIIT as an equivalent alternative to MICT. Given the growing evidence base and the need for individualized exercise therapy, HIIT should be considered an integral part of modern CR programs, particularly among active, motivated patients who tolerate exercise well. However, further studies are required to optimize the safety and maximize the therapeutic benefits of HIIT in CVD patients.

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Writing- rough preparation: MB, DB, ZB, DAŚ, KK, BR, DK
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