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Effectiveness of high-intensity interval training on cardiovascular rehabilitation: A systematic review

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ABSTRACT

This systematic review evaluated the effectiveness of high-intensity interval training (HIIT) in cardiovascular rehabilitation, analyzing its impact on cardiorespiratory capacity and quality of life in patients with heart disease. Searches were conducted in PubMed and Web of Science up to 01/08/2024 using MeSH terms related to “heart disease” and “physical exercise” (“High-Intensity Interval Training” AND “Heart Diseases” OR “Heart Failure”). The results showed that HIIT significantly improves VO2max and cardiac function, outperforming moderate-intensity continuous training (MICT). Additionally, it enhances patients' autonomy and well-being without increasing adverse event risk. In conclusion, HIIT is established as a key strategy in cardiac rehabilitation, providing significant improvements in cardiorespiratory fitness and quality of life for patients with heart disease. Its implementation optimizes resources in rehabilitation programs, offering an efficient alternative to MICT. However, it is crucial to continue conducting long-term studies to validate its efficacy and safety across different populations and clinical settings.

KEYWORDS

HIIT; Heart Disease; Coronary Disease; Cardiorespiratory Capacity; Quality of Life

1. INTRODUCTION

Cardiovascular diseases are among the leading causes of morbidity and mortality worldwide, with heart failure (HF) standing out as a significant clinical challenge (Malakar et al., 2019). This chronic condition affects patients’ quality of life, causing debilitating symptoms and high hospitalization rates (Campo et al., 2020; Cannon et al., 2017). To improve prognosis, more comprehensive therapeutic strategies have been developed, incorporating physical exercise as a fundamental pillar of cardiac rehabilitation (Vega et al., 2017; Cornish et al., 2011; McGregor et al., 2023). Among these strategies, High-Intensity Interval Training (HIIT) has shown positive effects on cardiac function and physical endurance (Du et al., 2021; Liou et al., 2016; Valentino et al., 2022).

HIIT alternates periods of high-intensity exercise with recovery phases, making it an efficient method to improve cardiorespiratory fitness, a key marker in HF (Pattyn et al., 2018). Compared to moderate-intensity continuous training, HIIT has demonstrated superiority in optimizing ventricular function and autonomic regulation (Calverley et al., 2020; Gill et al., 2021; Nobrega et al., 2014). Furthermore, its benefits go beyond physical health, positively impacting quality of life by reducing fatigue and enhancing autonomy in daily activities (Mueller et al., 2021; Yu et al., 2023).

However, although studies support HIIT as a safe and effective option, further research is needed to assess its long-term impact and to establish protocols tailored to the heterogeneity of HF patients (Wen et al., 2019; Karlsen et al., 2017).

The present study aims to evaluate the efficacy of HIIT on cardiac function and quality of life in patients with heart disease, analyzing parameters such as VO2 max, ventricular ejection fraction, and functional capacity. Additionally, it will examine its influence on perceived well-being and patients' autonomy in daily life.

2. METHODS

This systematic review involved a search conducted in PubMed and Web of Science up to 01/08/2024, using MeSH terms related to "heart disease" and "physical exercise" ("High-Intensity Interval Training" AND "Heart Diseases" OR "Heart Failure"). The inclusion and exclusion criteria are presented in Table 1, and the search flow is illustrated in Figure 1. Data were extracted on the following aspects:

- **Study characteristics**: Design, year, country, and population.
  Intervention: Type, duration, frequency, and intensity of HIIT.
  Participants: Age, sex, type of heart disease, and baseline variables.
  Outcomes: Measurement of cardiac function (LVEF, VO_2max, HR), quality of life, and cardiovascular events.

To assess methodological quality, the Cochrane risk of bias tool was used, analyzing randomization, allocation concealment, blinding, data completeness, and outcome reporting (Table 2). Most studies showed low risk in randomization and data reporting, although due to the nature of the exercise, participant blinding was considered high risk. However, assessor blinding was generally adequate, ensuring objectivity in outcome evaluation.

In general, the included studies provide robust evidence on the effectiveness of HIIT in cardiac rehabilitation, although the lack of participant blinding should be considered when interpreting the results. The inclusion and exclusion criteria are presented in Table 1, and the subsequent search flow is shown in Figure 1.

Table 1. Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
It is a Randomized Controlled Trial (RCT)	It is not a randomized controlled trial
The presence of heart disease in participants is specified	The presence of heart disease is not specified or the population does not have this condition
HIIT is included in the exercise intervention (the presence of additional exercise interventions besides HIIT is not a reason for exclusion, but those data will not be considered)	HIIT is not included in the intervention
A cardiac function variable is reported (VO_2max, heart rate, or Left Ventricular Ejection Fraction)	No cardiac function variable is reported

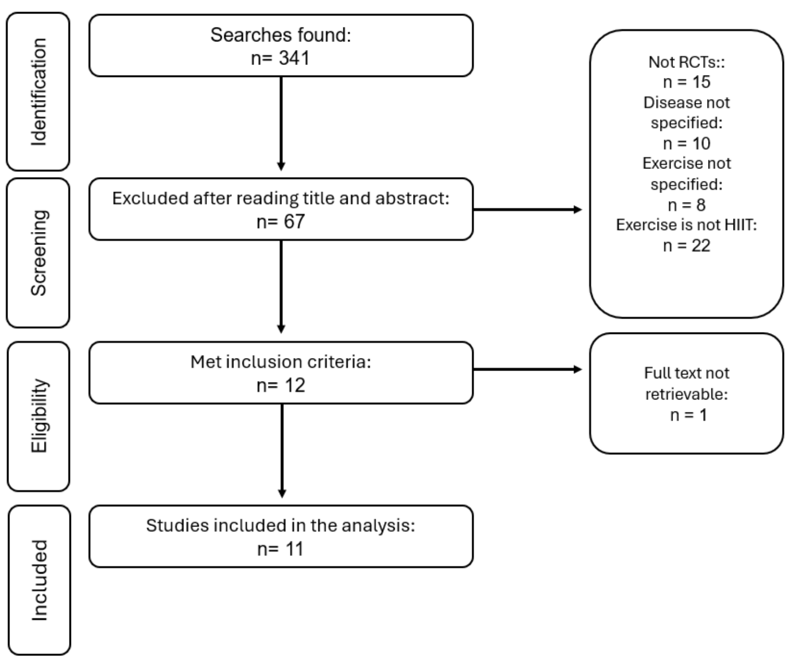

Figure 1. Flowchart of the search process

Table 2 presents a risk of bias assessment for the studies included in your review. It evaluates the methodological quality of each study across several domains.

Table 2. Risk of bias assessment of included studies using the Cochrane tool

Study	Randomization	Allocation Concealment	Participant Blinding	Assessor Blinding	Complete Data	Outcome Reporting	Other Bias
Reed et al. (2022)	Low risk	Unclear risk	High risk	Low risk	Low risk	Low risk	Low risk
Besnier et al. (2019)	Low risk	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
Papathanasiou et al. (2022)	Low risk	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
Kristiansen et al. (2022)	Low risk	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
Villelabeitia-Jaureguizar et al. (2019)	Low risk	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
Ellingsen et al. (2017)	Low risk	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
Silveira et al. (2020)	Low risk	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
Mueller et al. (2021)	Low risk	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
Taylor et al. (2020)	Low risk	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
Valentino et al. (2022)	Low risk	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
McGregor et al. (2023)	Low risk	Low risk	High risk	Low risk	Low risk	Low risk	Low risk

Note. *Studies are rated as 'Low risk', 'High risk', or 'Unclear risk' for each evaluated domain*

The risk of bias assessment for the studies included in this systematic review shows that most present a low risk in the domains of randomization, allocation concealment, and outcome reporting, indicating a strong methodological design. However, as is common in exercise intervention studies, participant and personnel blinding consistently shows a high risk, reflecting the nature of interventions that do not allow complete blinding. On the other hand, outcome assessors are generally blinded, ensuring objective evaluation of the data. Most studies also demonstrate low risk regarding the completeness of outcome data and absence of other potential biases. Overall, these findings suggest that the studies provide a reasonably robust evidential basis, although limitations in blinding should be taken into account when interpreting the results. The strength of the evidence, combined with the consistency of findings across studies, supports the validity of the overall conclusions about the effectiveness of the interventions studied.

3. RESULTS

Table 3 presents a structured summary based on the PICO framework (Population, Intervention, Comparison, Outcomes), which is essential for analyzing evidence in systematic reviews. This structure helps clarify the focus of each reviewed study by detailing the population studied, the interventions applied, the comparisons made, and the outcomes obtained. This approach ensures a consistent and systematic comparison across studies, facilitating the synthesis of their findings. It provides a clear overview of how high-intensity interval training (HIIT) has been implemented in various clinical settings and populations, showing consistent improvements in cardiorespiratory fitness and quality of life. The structured presentation of information according to the PICO framework allows for the identification of patterns and differences in study outcomes, contributing to deeper and more grounded understanding of HIIT's effectiveness in cardiac rehabilitation.

Table 3. Summary of studies based on the PICO framework, highlighting the population, intervention, comparison, and outcomes of each study

Study	Population	% Women	Mean Age	Intervention	Comparison	Outcomes
Reed et al. (2022) n = 150	Patients with coronary artery disease	11%	61 years	HIIT, NW, MICT	MICT	Improvement in functional capacity, reduced depression, better quality of life
Besnier et al. (2019) n = 90	Patients with coronary artery disease	20%	58 years	HIIT	MICT	Improvement in heart rate variability and VO_2max
Papathanasiou et al. (2022) n = 80	Patients with stable coronary artery disease	30%	64 years	Group-based HIIT, MICT	MICT	Reduction in inflammatory biomarkers, improvement in functional capacity
Kristiansen et al. (2022) n = 100	Patients with stable coronary artery disease	25%	62 years	HIIT	Standard care	Increase in VO_2max, improved quality of life
Villelabeitia-Jaureguizar et al. (2019) n = 112	Patients with coronary artery disease	46%	57.6 years	HIIT vs MCT	MICT	Improvements in mechanical efficiency and aerobic capacity

Ellingsen et al. (2017) n = 75	Patients with heart failure and reduced ejection fraction	19%	68 years	HIIT	MICT and guideline-recommended regular exercise	Improvements in VO_2max, no changes in ventricular structure
Silveira et al. (2020) n = 60	Patients with heart failure with preserved ejection fraction	35%	67 years	HIIT	MICT	Significant improvements in VO_2max and diastolic function
Mueller et al. (2021) n = 85	Sedentary patients with HFpEF	67%	70 years	HIIT, MCT	Physical activity counseling based on guidelines	Modest increases in VO_2max, no significant long-term differences
Taylor et al. (2020) n = 95	Patients with angiographically proven coronary disease	16%	65 years	HIIT	MICT	Short- and long-term improvements in VO_2peak, good safety profile
Valentino et al. (2022) n = 120	Patients with coronary artery disease	23%	64 years	Stair-climbing HIIT	TRAD (traditional training)	Improvement in apical rotation of the left ventricle
McGregor et al. (2023) n = 138	Patients in cardiac rehabilitation programs	7%	59 years	HIIT	MICT	Improvements in cardiorespiratory fitness and quality of life, exercise safety

The selected studies analyzed the impact of HIIT in cardiac rehabilitation across different populations of patients with heart disease. A total of 11 randomized controlled trials were evaluated, encompassing patients with heart failure with either a reduced or preserved ejection fraction, as well as those with stable coronary artery disease. The mean age of participants ranged from 57 to 70 years, with a predominance of male participants in most studies.

HIIT interventions varied in duration and frequency, with programs ranging from 4 to 12 weeks, involving 2 to 5 sessions per week. In most studies, HIIT intensity was defined as exertion between 80–95% of maximum heart rate, interspersed with active recovery or rest periods.

Regarding the observed effects, VO_2max—the main indicator of cardiorespiratory fitness—showed significant improvements in most of the studies evaluated. Increases ranged from 8% to 20% following HIIT interventions, with superior effects compared to moderate-intensity continuous training. Additionally, some studies reported improvements in left ventricular ejection fraction and ventilatory efficiency, suggesting a positive impact of HIIT on overall cardiac function.

Several studies also assessed the impact of HIIT on perceived well-being and quality of life, using validated scales such as the SF-36 and the Minnesota Living with Heart Failure Questionnaire. Improvements in quality of life were evident among participants who performed HIIT, including reduced fatigue, greater independence in daily activities, and lower prevalence of depressive and anxiety symptoms.

None of the studies reported serious adverse events related to the intervention, indicating that HIIT is safe for clinically stable patients. Adherence to HIIT programs was high, with rates exceeding 80% in most studies, suggesting that HIIT is a well-tolerated and accepted intervention among patients.

4. DISCUSSION

Cardiovascular diseases remain one of the leading causes of morbidity and mortality worldwide. Traditional cardiac rehabilitation has emphasized moderate-intensity exercise, but recent research suggests that high-intensity interval training (HIIT) may be a more effective alternative for improving cardiorespiratory fitness and quality of life in patients with heart disease (Weston et al., 2014; Gomes-Neto et al., 2017).

The results of this systematic review confirm that HIIT significantly improves VO_2max, with increases ranging from 8% to 20%, surpassing moderate-intensity continuous training (MICT) in most of the included studies. This supports previous evidence suggesting that HIIT optimizes ventricular function and autonomic regulation (Pattyn et al., 2018*)*. Additionally, a positive impact was observed on left ventricular ejection fraction and ventilatory efficiency, indicating improvements in overall cardiac function (Calverley et al., 2020; Ellingsen et al., 2017).

In terms of quality of life, HIIT also demonstrated benefits by reducing fatigue and improving autonomy in daily activities, as assessed by validated scales such as the SF-36 and the Minnesota Living with Heart Failure Questionnaire. However, some previous reviews, such as that by Yu et al. (2023), did not find significant differences in quality of life between HIIT and MICT, which could be attributed to the heterogeneity in protocols and characteristics of the studied populations.

A notable finding of this review is the high adherence to HIIT programs, with rates above 80%, suggesting favorable acceptance of this exercise modality by patients. Furthermore, none of the included studies reported serious adverse events, reinforcing the safety of HIIT when applied under proper clinical supervision (McGregor et al., 2023).

Despite these positive findings, this review presents certain limitations. The heterogeneity in study designs, durations, and intensities of HIIT protocols hinders the comparability of results. Additionally, selection bias may have contributed to an overestimation of HIIT's impact, as studies with negative findings may not have been included. To enhance the robustness of these findings, future studies should include meta-analyses with greater methodological homogeneity and long-term follow-up (Wen et al., 2019*)*.

From a clinical perspective, the reviewed evidence supports the inclusion of HIIT in cardiac rehabilitation programs, given its positive impact on cardiovascular health indicators and well-being. However, it is recommended to individualize protocols based on each patient's condition and functional capacity. Future research should explore the applicability of HIIT in less controlled environments, such as home-based rehabilitation or gyms, aiming to improve its accessibility and adherence (Karlsen et al., 2017).

5. CONCLUSIONS

In conclusion, HIIT is established as a key strategy in cardiac rehabilitation, providing significant improvements in cardiorespiratory fitness and quality of life for patients with heart disease. Its implementation optimizes resources in rehabilitation programs, offering an efficient alternative to MICT. However, it is crucial to continue conducting long-term studies to validate its efficacy and safety across different populations and clinical settings.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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