EFFECTS OF HIGH-INTENSITY INTERVAL TRAINING ON FUNCTIONAL CAPACITY AND ECHOCARDIOGRAPHIC PARAMETERS AFTER MYOCARDIAL INFARCTION: A CASE REPORT

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Abstract: The purpose of this case report is to describe the impact of high-intensity interval training implemented within a structured cardiac rehabilitation program and its clinical effects in a patient following a recent myocardial infarction. Cardiac rehabilitation represents a key component of secondary prevention after myocardial infarction, combining supervised exercise training with patient education, risk factor modification, and lifestyle interventions to improve functional capacity, reduce the risk of recurrent cardiovascular events, and enhance long-term quality of life. Interval-based exercise has gained increasing interest as a training approach that may lead to meaningful improvements in exercise tolerance and cardiac performance in selected post-myocardial infarction patients compared with traditional continuous training. A 59-year-old woman with type 2 diabetes mellitus, dyslipidemia, and diabetic polyneuropathy experienced an acute myocardial infarction and underwent selective coronary angiography followed by percutaneous coronary intervention with implantation of two stents in the right coronary artery. Given her metabolic comorbidities, the patient was considered at increased risk for impaired recovery and reduced functional capacity in the early post-event period. Early follow-up included routine clinical evaluation and baseline functional assessment using echocardiography and exercise testing, demonstrating mildly impaired left ventricular performance and markedly reduced exercise capacity. These findings supported the need for early initiation of structured rehabilitation aimed at restoring functional capacity and optimizing cardiovascular recovery. Pharmacological therapy was optimized as part of secondary prevention, and the patient was enrolled in a supervised cardiac rehabilitation program with an individualized exercise prescription. The training protocol consisted of repeated high-intensity exercise intervals guided by peak heart rate targets, interspersed with active recovery periods, and progressed according to tolerance and clinical response under professional supervision. Two months after completion of the intervention, follow-up evaluation demonstrated improvements, including better echocardiographic markers of left ventricular performance and substantially enhanced functional capacity compared with baseline assessment. The observed improvements suggest enhanced cardiovascular efficiency and exercise tolerance following structured interval-based training during post-myocardial infarction recovery. Interval-based exercise may be considered within formal cardiac rehabilitation programs for carefully selected patients after myocardial infarction, in combination with guideline-directed medical therapy, risk factor control, and gradual progression of intensity under appropriate monitoring to optimize safety and outcomes. Further studies are warranted to clarify optimal interval protocols, progression strategies, and patient selection criteria in the early post-myocardial infarction phase.
Keywords: myocardial infarction; cardiac rehabilitation; interval training; exercise tolerance; echocardiography; secondary prevention

1. INTRODUCTION

Cardiovascular diseases remain the most common cause of death worldwide. According to the World Health Organization (WHO) an estimated 19.8 million people died from CVDs in 2022, representing approximately 32% of all global deaths. Of these deaths, 85% were due to heart attacks and stroke. (World Health Organization [WHO], 2025) However, with the advancements in medicine and adequate hospital treatment, more and more people manage to survive the acute myocardial infarction (AMI). As survival after AMI improves, the burden of post-infarction complications such as heart failure, arrhythmias, recurrent hospital admissions, reduced functional capacity, and impaired quality of life (QoL) becomes increasingly relevant. These complications are managed through several strategies which include medication plans, risk factor management, lifestyle changes and inclusion in cardiac rehabilitation programs. Evidence grows stronger in favor of cardiac rehabilitation, showing that people who undergo a systematized cardiac rehabilitation program reduce CV hospitalizations, MI, CV mortality and, in some studies, all-cause mortality. (Byrne et al., 2023; Brown et al., 2024) Rehabilitation strategies can range across a wide spectrum depending on the clinical context. Exercise prescription varies depending on whether the underlying cardiac condition is chronic (ischemia, heart failure) or following an acute event (myocardial infarction). Common strategies applied are continuous low intensity, moderate intensity continuous, interval-based protocols such as HIIT and combined aerobic–resistance. Recent studies indicate that interval-based exercise, most notably HIIT, can have advantages in terms of greater improvements in post-MI patients such as enhancement in peak oxygen uptake (VO_2 peak), enhancement of left ventricular systolic function (e.g., ejection fraction), and increased myocardial deformation parameters (global and regional longitudinal strain). (Eser et al., 2022) (D'Andrea et al., 2022)

2. CASE PRESENTATION

This case report describes the effects of a two-month HIIT-based cardiac rehabilitation program in a patient following recent myocardial infarction. A 59-year-old woman with a medical history significant for type 2 diabetes mellitus, dyslipidemia, and diabetic polyneuropathy presented to the hospital with complaints of dry mouth, paresthesia, and numbness of the upper and lower limbs, according to the available medical documentation. The electrocardiogram demonstrated sinus rhythm with ST-segment elevation in the inferior leads, consistent with an acute inferior ST-elevation myocardial infarction (STEMI). Selective coronary angiography revealed a critical stenosis with a high thrombotic burden in the distal right coronary artery (RCA). Percutaneous coronary intervention (PCI) was subsequently performed, with placement of two stents in the RCA. Fifteen days later, the patient presented for routine follow-up. Physical examination was in normal state, except for elevated blood pressure (BP) (~140/90 mmHg). ECG showed sinus rhythm with persisting pathological Q-waves in leads II, III and aVF.
Echocardiography shows ischemic remodeling of ventricle (LV), without hypertrophy and hypokinesis on basal and middle segments of the inferior and inferolateral wall. Reduced myocardial deformation parameters were displayed along the inferior and inferolateral wall and global peak longitudinal strain of -15.7%. Ejection fraction was also mildly reduced – 48%.
The patient underwent a symptom-limited cycle ergometer exercise test demonstrating reduced functional capacity. There were no ST-segment changes throughout the test; however, it should be noted that the test was terminated at a relatively low workload due to limited tolerance. (Table 1) Normal chronotropic response was observed with double product (DP/RPP) of 24 480. Medication therapy was optimized and the patient was assigned to cardiac rehabilitation program.

Table 1 Baseline symptom-limited cycle ergometer test results prior to cardiac rehabilitation

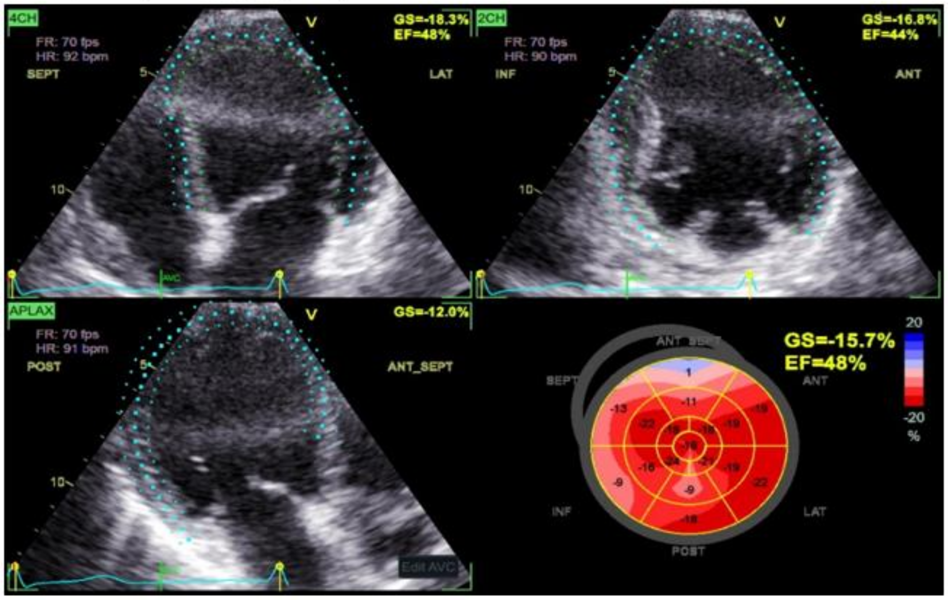
Stage	Time	Load			HR	BP	SpO2
		W/kg	W	MET	bpm	mmHg	%
Reference	P 02:21	0,00	0	1,0	**101**	140/80	96
E1 stage	E 02:00	0,50	25	3,6	**124**	150/80	-
E2 stage	E 04:01	1,00	50	5,1	**132**	170/80	-
E3 peak	E 05:38	1,50	75	6,7	**144**	170/80	-
Recovery	R 00:20	0,00	0	1,0	**142**	170/80	-
Recovery	R 01:05	0,00	0	1,0	**126**	170/80	-
Recovery	R 03:05	0,00	0	1,0	**110**	140/80	-
Recovery	R 05:06	0,00	0	1,0	**107**	130/80	96

Source: Authors' own clinical data collected during routine care at the Medical Center for Cardiovascular Diseases (Cardio Center), Sofia, Bulgaria; anonymized for publication.

3. MATERIALS AND METHODS

As described in the Case presentation, the patient underwent baseline clinical evaluation and functional assessment prior to initiation of the rehabilitation program; therefore, the present section specifies the methodological approach used for exercise prescription, monitoring, and follow-up. Baseline functional capacity was assessed using a symptom-limited incremental cycle ergometer test, which was later used to guide individualized exercise prescription and progression. (Brown et al., 2024) Heart rate, blood pressure, electrocardiographic activity, and patient-reported symptoms were monitored continuously. The test was terminated according to clinical tolerance and established safety criteria. (Gibbons et al., 2002) Transthoracic echocardiography (TTE) was performed at the beginning and repeated after completion of the rehabilitation period for comparison over time. Left ventricular systolic function was assessed, with left ventricular ejection fraction calculated using the biplane Simpson method. Also, the myocardial deformation was evaluated using two-dimensional speckle-tracking echocardiography with calculation of global and regional longitudinal strain from standard apical 3, 4 and 2 chamber views. (Fig. 1)

Figure 1 Two-dimensional speckle-tracking echocardiography workflow for global longitudinal strain (GLS) assessment, based on analysis of three apical views (4-chamber, 2-chamber, and apical long-axis) with display of segmental strain curves and a polar ("bull's-eye") map.

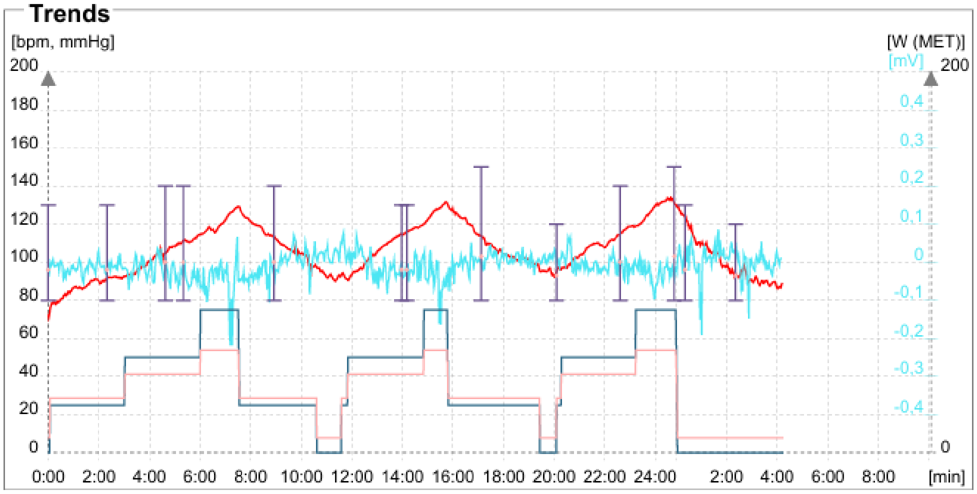


Source: Authors' own clinical data collected during routine care at the Medical Center for Cardiovascular Diseases (Cardio Center), Sofia, Bulgaria; anonymized for publication.

Echocardiographic measurements were acquired by the same protocol/workflow, ensuring comparability between assessments. (Mihos et al., 2025) The rehabilitation was delivered over a two-month period. It combined supervised sessions with a structured home-based program. During the first month, the patient attended monitored exercise sessions twice per week, whereas during the second month supervised sessions were performed once per week. Home-based rehabilitation was prescribed for the remaining days. The weekly structure during the first month followed a repeating pattern consisting of one light resistance-strengthening session combined with stretching - supervised interval-based training - rest day - second light resistance-strengthening session - supervised interval-based session - rest day - light stretching/mobility day. During the second month the rest intervals between higher-demand training days were increased, while maintaining the same home-based program. Supervised aerobic training sessions were delivered as high-intensity interval training (HIIT) on a cycle ergometer. The software enabled interval programming and continuous heart rate recording, allowing objective documentation of peak–recovery patterns. Each supervised HIIT session followed a standardized workload progression, consisting of 3 minutes at 25 W, followed by 2 minutes at 50 W, and subsequent progression toward the patient's previously established peak workload. Workload increased up to a maximum of 75 W, corresponding to the peak workload achieved during baseline testing, and the patient maintained 75 W for approximately 4 minutes with the aim of reaching the predefined submaximal heart rate target zone. (Fig. 2) Exercise intensity targets were prescribed using an age-predicted maximal heart rate (APMHR) approach. Calculating HRmax = 220 – age, for this 59-year-old patient, estimated HRmax was 161 bpm, and the target range for high-intensity peaks during HIIT was set as 80–85% of HRmax (approximately 129–137 bpm).

Heart rate response was monitored continuously, and recovery phases were used to modulate heart rate decline before subsequent workload increases. Training intensity was individualized based on clinical tolerance and perceived exertion to ensure safe progression. (Robergs & Landwehr, 2002) Although the above protocol reflects the intended session structure, interval durations and workload transitions were adjusted, when necessary, based on symptoms, hemodynamic response, and overall perceived well-being. Minor modifications typically within approximately ±20 seconds were included to ensure patient compliance and safety. Other than continuous electrocardiographic monitoring, repeated blood pressure measurements and ongoing symptom supervision, myocardial workload was evaluated using the rate–pressure product (RPP; double product). Suppose exertion was assessed using the Borg Rating of Perceived Exertion scale (6–20) and utilize to guide exercise intensity regulation and progression over time. (Pack et al., 2022) Home-based low-intensity resistance-strengthening sessions focused

Figure 2 Example supervised HIIT cycling session showing workload progression and corresponding heart-rate peak–recovery dynamics recorded using rehabilitation



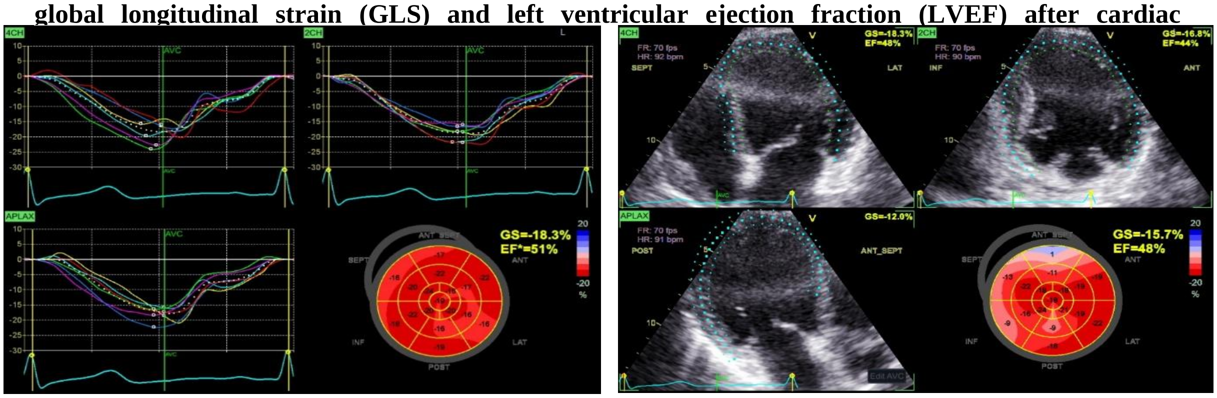
Source: Authors' own clinical data collected during routine care at the Medical Center for Cardiovascular Diseases (Cardio Center), Sofia, Bulgaria; anonymized for publication.

on major muscle groups, with attention to breathing to avoid Valsalva maneuvers, and supplemented by stretching and mobility exercises on designated days. Outcome measures evaluated in this report included changes in echocardiographic parameters (left ventricular ejection fraction and global longitudinal strain), as well as changes in exertion, myocardial workload indices, and clinical exercise tolerance during supervised sessions across the two-month rehabilitation period.

4. RESULTS

After completing the two months cardiac rehabilitation program, the patient showed significant improvements in cardiac function, exercise tolerance, and hemodynamic efficiency. Follow-up echocardiography revealed improvement in LV systolic function, with LVEF increasing from 48% to 51% post-rehabilitation /p< 0,0001/ Meanwhile, myocardial deformation parameters improved, as reflected by global longitudinal strain (GLS)increasing from −15.7% to −18.3% /p< 0,0001 / (Fig. 3).

Figure 3 Baseline and follow-up speckle-tracking echocardiography demonstrating improvement in global longitudinal strain (GLS) and left ventricular ejection fraction (LVEF) after cardiac



Source: Authors' own clinical data collected during routine care at the Medical Center for Cardiovascular Diseases (Cardio Center), Sofia, Bulgaria; anonymized for publication.

Functional and hemodynamic responses during monitored exercise improved relative to initial cycle ergometer evaluation. During the symptom-limited exercise testing, the patient achieved a peak workload of 75 W, heart rate of 144 beats per minute (bpm) and BP of 170/80 mmHg, corresponding to RPP of 24,480. In the following supervised HIIT cycling sessions, the patient repeatedly reached the same maximal workload level of 75 W within an interval structure, while demonstrating a lower hemodynamic burden. At peak intensity during supervised sessions, heart rate reached 132 bpm with peak blood pressure of 150/80 mmHg, calculating a peak RPP of 19,800 (Table 2).

Table 2 Workload stages and corresponding cardiovascular responses during supervised HIIT cycling, including heart rate (HR), blood pressure (BP), and oxygen saturation (SpO_2).

Stage	Time	Load			HR	BP	SpO2
		W/kg	W	MET	bpm	mmHg	%
Reference	P 01:52	0,00	0	1,0	**72**	130/80	98
E1 stage	E 03:00	0,50	25	3,6	**91**	130/80	98
E2 stage	E 06:00	1,00	50	5,1	**114**	140/80	98
E3 stage	E 07:30	1,50	75	6,7	**129**	-	98
E4 stage	E 11:50	0,50	25	3,6	**92**	-	98
E5 stage	E 14:50	1,00	50	5,1	**119**	130/80	98
E6 stage	E 15:46	1,50	75	6,7	**131**	-	98
E7 stage	E 20:17	0,50	25	3,6	**97**	120/80	98
E8 stage	E 23:13	1,00	50	5,1	**119**	140/80	98
E9 peak	E 24:49	1,50	75	6,7	**132**	150/80	98
Recovery	R 00:20	0,00	0	1,0	**125**	130/80	98
Recovery	R 01:05	0,00	0	1,0	**110**	130/80	98
Recovery	R 03:05	0,00	0	1,0	**90**	120/80	98

Source: Authors' own clinical data collected during routine care at the Medical Center for Cardiovascular Diseases (Cardio Center), Sofia, Bulgaria; anonymized for publication.

At an equivalent external workload of 75 W, peak RPP decreased from 24,480 (initial testing) to 19,800 during HIIT sessions (Δ = −4,680). Furthermore, lower peak systolic blood pressure (−20 mmHg) as well as lower peak heart rate (−12 bpm) were recorded. Tolerance to repeated exposure at 75 W within a single session improved over time. Oxygen saturation remained stable (approximately 96–98%). The patient displayed a preserved chronotropic reserve and efficient heart rate recovery, characterized by predictable heart rate acceleration during intervals and appropriate reduction during recovery phases.

Continuous ECG monitoring demonstrated no clinically relevant ST-segment changes during exercise or recovery, and no electrical disturbances were documented during supervised sessions. Hemodynamic tolerance was preserved. No hypotensive responses or symptomatic hypertension were recorded. The patient did not report dizziness, syncope/presyncope, disproportionate dyspnea, or abnormal fatigue requiring premature termination. No adverse events occurred during the rehabilitation period.

Subjective training intensity perception also improved. Using the RPE scale (6–20), the patient's effort during comparable training exposure decreased from 17 early in rehabilitation to 13 by the end of the program.

5. DISCUSSION

HIIT has gained increasing attention as an alternative to moderate-intensity continuous training (MICT) within cardiac rehabilitation, due to its potential for greater improvements. Available evidence indicates that HIIT can maintain a safety profile when applied in appropriately selected patients under clinical supervision (Hannan et al., 2018). Beyond functional tolerance, strain-based imaging offers valuable insight into recovery after ischemic injury, since GLS may detect subclinical changes in left ventricular performance that are not always fully captured by LVEF alone (Mihos et al., 2025). Previous studies in post-acute coronary syndrome populations have reported that structured HIIT rehabilitation can improve left ventricular remodeling and deformation-related indices, supporting the credibility of the observed echocardiographic changes in this case (Eser et al., 2022; D'Andrea et al., 2022). What's more, the followed reduction in DP may suggest improved cardiovascular efficiency, as RPP is commonly used as a practical index of myocardial oxygen demand during exercise (Gobel et al., 1978).

Several limitations should be acknowledged. This report describes a single patient and therefore cannot be generalized. Exercise intensity targets were prescribed using an age-predicted maximal heart rate method, and alternative equations have been proposed, which may yield different HRmax estimates (Tanaka et al., 2001). In addition, while the findings are encouraging, they rely on routine clinical metrics and session-obtained parameters rather than a structured post-rehabilitation testing protocol. Finally, the absence of longer-term follow-up prevents conclusions about sustained benefit. From a broader perspective, cardiac rehabilitation has value beyond physiological parameters. Improvements in functional capacity often translate into greater independence and confidence in routine activities. For many patients, regaining control over the symptoms supports a return to normal social roles and improves overall quality of life. This recovery process is particularly important after a major cardiac event, when fear of exertion can become a barrier to living.

6. CONCLUSSION

This case report supports the practicability of supervised HIIT-based rehabilitation early after myocardial infarction. When implemented with individualized pacing and continuous clinical monitoring its safety and tolerability appear favorable. These observations may help inform clinical decision-making when tailoring exercise strategies to patient tolerance and response. Future studies with larger cohorts and standardized follow-up testing are warranted to confirm these findings and better define optimal interval prescription.

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