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Phase II Cardiac Rehabilitation Using Treadmill and Cycle Ergometer: A Case Report

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Abstract
Background: Congestive heart failure (CHF) is characterized by impaired cardiac output, leading to reduced aerobic capacity and functional limitation. Phase II cardiac rehabilitation is recommended to improve cardiopulmonary function after coronary artery bypass grafting (CABG).
Objective: To evaluate the effects of a Phase II cardiac rehabilitation program using treadmill and cycle ergometer exercise on aerobic capacity in a patient with CHF due to three-vessel coronary artery disease (CAD) after CABG.
Methods: This case report involved a 52-year-old male with CHF et causa CAD three-vessel disease following CABG. The patient participated in a supervised Phase II cardiac rehabilitation program consisting of treadmill walking and cycle ergometer training, performed 3–5 sessions per week over five sessions, with each session lasting 20–60 minutes. Aerobic capacity was assessed using the 6-Minute Walk Test (6MWT), metabolic equivalents (METs), Borg Rating of Perceived Exertion, and vital signs measured before and after the intervention.
Results: Aerobic capacity improved, with METs increasing from 4.13 to 4.90 (+18.6%) and 6MWT distance increasing from 350 m to 441 m (+26.0%). Hemodynamic parameters remained stable throughout the intervention, and no adverse events or exercise intolerance were observed.
Conclusion: Phase II cardiac rehabilitation using treadmill and cycle ergometer exercise was safe and effective in improving aerobic capacity and functional tolerance in a patient with CHF after CABG.

Keywords
Heart Failure; Cardiac Rehabilitation; Treadmill Exercise; Cycling; Aerobic Capacity

Introduction

Congestive heart failure (CHF) is a complex clinical syndrome characterized by the inability of the heart to pump sufficient blood to meet the metabolic demands of peripheral tissues. This condition is commonly associated with symptoms such as dyspnea, early fatigue, and reduced exercise tolerance, which substantially impair functional capacity and quality of life. CHF represents the advanced or terminal stage of many cardiovascular disorders and remains a major contributor to morbidity and mortality worldwide.[1]

Cardiovascular disease continues to be the leading cause of death globally, accounting for approximately 17.9 million deaths each year.[2] Heart failure contributes significantly to this burden, particularly among patients with underlying coronary artery disease (CAD). In Indonesia, national health data indicate that the prevalence of physician-diagnosed heart failure reaches approximately 1.5% of the population, corresponding to more than one million affected individuals.[3] This epidemiological profile highlights the urgent need for effective secondary prevention and rehabilitation strategies to reduce disability and improve long-term outcomes.

Coronary artery disease is a primary etiological factor in the development of CHF. Progressive atherosclerotic narrowing or occlusion of the coronary arteries results in myocardial ischemia, impaired ventricular function, and reduced cardiac output. In patients with multivessel CAD, especially those involving three-vessel disease (3VD), myocardial perfusion deficits are often severe and diffuse, leading to pronounced functional limitation. Coronary artery bypass grafting (CABG) is a well-established revascularization procedure aimed at restoring myocardial blood flow, alleviating ischemic symptoms, and improving survival.[4] However, despite successful surgical intervention, many patients continue to experience persistent exercise intolerance, reduced aerobic capacity, and fear of physical activity during the post-operative period.

Cardiac rehabilitation is a comprehensive, multidisciplinary intervention designed to optimize physical, psychological, and social recovery following cardiovascular events or procedures.[5] It integrates structured exercise training, patient education, risk factor modification, and psychosocial support to facilitate long-term cardiovascular health. Cardiac rehabilitation is commonly divided into phases, with Phase II—also referred to as the early outpatient or conditioning phase—beginning shortly after hospital discharge and typically lasting between 2 and 12 weeks.[6] The primary objectives of Phase II cardiac rehabilitation include improving functional capacity, enhancing cardiopulmonary fitness, restoring confidence in physical activity, and promoting adherence to healthy lifestyle behaviors.

Aerobic exercise constitutes the core component of Phase II cardiac rehabilitation. Exercise training has been shown to induce beneficial central and peripheral physiological adaptations, including improved myocardial efficiency, enhanced endothelial function, increased skeletal muscle oxidative capacity, and improved oxygen utilization.[7] Exercise modalities commonly used in cardiac rehabilitation include treadmill walking and cycle ergometer training, both of which allow precise control of exercise intensity and continuous monitoring of cardiovascular responses. Treadmill exercise closely simulates daily ambulation and has been associated with significant improvements in peak oxygen uptake (VO_2peak) and walking capacity.[8] In contrast, cycle ergometer training reduces weight-bearing stress on the lower extremities and is particularly advantageous for post-operative patients, as it enables safe cardiovascular conditioning with minimal orthopedic risk.[9]

Current international guidelines recommend at least 150 minutes per week of moderate-intensity aerobic physical activity for individuals with cardiovascular disease, complemented by resistance training to enhance muscular strength and endurance. Nevertheless, the optimal combination of exercise modalities and training parameters for patients with CHF following CABG—particularly those with complex conditions such as three-vessel CAD—remains an area of ongoing investigation. Clinical decision-making is often influenced by patient-specific factors, including left ventricular function, comorbidities, post-surgical recovery status, and exercise tolerance.

Despite growing evidence supporting the benefits of cardiac rehabilitation, data specifically addressing the safety and effectiveness of Phase II rehabilitation programs combining treadmill and cycle ergometer exercise in patients with CHF due to three-vessel CAD after CABG remain limited, particularly in low- and middle-income countries such as Indonesia. Most existing studies focus on broader heart failure populations or evaluate single exercise modalities, leaving a gap in evidence regarding combined aerobic training approaches in high-risk post-CABG patients.

Therefore, this case report aims to describe the effects of a Phase II cardiac rehabilitation program incorporating treadmill and cycle ergometer exercise on aerobic capacity in a patient with CHF due to three-vessel CAD following CABG. By presenting detailed clinical outcomes and exercise responses, this report seeks to contribute practical clinical insights for physiotherapists and multidisciplinary cardiac rehabilitation teams and to support evidence-based exercise prescription in post-CABG patients with heart failure.

Methods

Study Design

This study employed a single-case report design to describe the clinical effects of a Phase II cardiac rehabilitation program using treadmill and cycle ergometer exercise in a patient with congestive heart failure (CHF) following coronary artery bypass grafting (CABG). A case report design was selected to allow in-depth documentation of clinical presentation, intervention characteristics, physiological responses, and functional outcomes in a patient with a complex cardiovascular condition. Although this design does not permit causal inference or statistical generalization, it is appropriate for generating clinically relevant insights and supporting hypothesis development for future controlled studies.

Study Setting

The study was conducted at the Integrated Cardiac Care Unit (Pelayanan Jantung Terpadu, PJT) of Prof. dr. I.G.N.G. Ngoerah General Hospital, Denpasar, Bali, Indonesia. This tertiary referral hospital provides comprehensive cardiovascular services, including cardiac surgery, cardiology care, and supervised cardiac rehabilitation delivered by a multidisciplinary team consisting of cardiologists, physiotherapists, nurses, and exercise specialists. The rehabilitation program followed institutional clinical protocols aligned with international cardiac rehabilitation guidelines.

Participant Characteristics

The participant was a 52-year-old male diagnosed with CHF secondary to three-vessel coronary artery disease (CAD) following CABG surgery. The patient had undergone CABG two months prior to enrollment and was clinically stable at the time of referral to Phase II cardiac rehabilitation. Left ventricular systolic function was preserved, with a left ventricular ejection fraction of 57.8% as measured by transthoracic echocardiography.

The patient had a medical history of hypertension and type 2 diabetes mellitus, both of which were medically controlled. Pharmacological therapy at the time of rehabilitation included antihypertensive agents, antiplatelet therapy, beta-blockers, nitrates, statins, and angiotensin receptor blockers, prescribed and monitored by a cardiologist. From a psychosocial perspective, the patient demonstrated adequate motivation and adherence to the rehabilitation program, which is an important determinant of successful cardiac rehabilitation outcomes.

Eligibility Criteria

The patient was included in this study based on several predefined inclusion criteria. The participant had been diagnosed with congestive heart failure secondary to three-vessel coronary artery disease and had previously undergone coronary artery bypass grafting with a stable post-operative recovery. At the time of enrollment, the patient was classified as eligible for Phase II cardiac rehabilitation and demonstrated hemodynamic stability, as indicated by resting vital signs within acceptable clinical limits. In addition, the patient was physically capable of performing structured aerobic exercise under professional supervision and provided written informed consent for participation in the rehabilitation program as well as for publication of clinical data.

Exclusion criteria were applied to ensure patient safety and to minimize clinical risk during exercise training. These criteria included the presence of acute decompensated heart failure, unstable angina, or a recent acute coronary syndrome. Patients with severe or uncontrolled arrhythmias or uncontrolled hypertension, defined as a resting blood pressure of ≥180/110 mmHg, were also excluded. Furthermore, individuals with severe comorbid conditions that could limit exercise participation were not eligible. The occurrence of adverse events, clinical deterioration, or any condition requiring premature termination of exercise during the rehabilitation program also constituted grounds for exclusion.

Intervention Protocol

The intervention consisted of a structured Phase II cardiac rehabilitation exercise program incorporating treadmill walking and cycle ergometer training. The program was implemented over five supervised sessions, performed at a frequency of 3–5 sessions per week. Each session lasted approximately 20–60 minutes and included warm-up, main aerobic exercise, and cool-down phases.[10]

Exercise Prescription

Exercise prescription followed the Frequency, Intensity, Time, and Type (FITT) principle. Exercise intensity was prescribed at a moderate level, corresponding to 40–59% of heart rate reserve and a Borg Rating of Perceived Exertion (RPE) score of 12–13 on the 6–20 scale.[11] This intensity range aligns with recommendations from international cardiac rehabilitation guidelines for patients with heart failure and post-CABG status.

Treadmill exercise was initiated at a comfortable walking speed and gradually progressed based on patient tolerance and physiological response. Cycle ergometer training began at a low workload (approximately 25 W) with a cadence of 50–60 revolutions per minute and was incrementally increased toward a target workload of 30 W as tolerated. Exercise progression was individualized and guided by continuous monitoring of vital signs and subjective symptoms.

Safety Monitoring

Patient safety was prioritized throughout the rehabilitation program. Vital signs—including blood pressure, heart rate, respiratory rate, and peripheral oxygen saturation—were monitored before, during, and after each exercise session. Subjective exercise tolerance was assessed using the Borg RPE scale. Exercise sessions were immediately modified or terminated if the patient exhibited warning signs such as excessive dyspnea, chest discomfort, dizziness, abnormal blood pressure responses, or arrhythmias. Absolute contraindications (red flags) and relative contraindications (yellow flags) to exercise were strictly observed in accordance with established clinical guidelines. No adverse events or signs of hemodynamic instability were recorded during the intervention period.

Outcome Measures

Primary Outcome: Aerobic Capacity

Aerobic capacity was assessed using the 6-Minute Walk Test (6MWT), a widely used and validated functional exercise test in cardiac rehabilitation populations. The test was conducted according to standardized procedures, and the total walking distance was recorded in meters. Metabolic equivalents (METs) were calculated to quantify functional aerobic capacity.

Secondary Outcomes

Secondary outcomes included the Borg Rating of Perceived Exertion, resting and post-exercise vital signs, and the heart rate walking speed index as an indicator of cardiovascular efficiency. These outcome measures were selected to provide a comprehensive assessment of the patient’s physiological responses to exercise and to capture functional adaptations to the cardiac rehabilitation program.Assessment Procedures

Baseline assessments were performed prior to initiation of the rehabilitation program. Follow-up assessments were conducted after completion of the five-session intervention. All assessments were performed by a licensed physiotherapist trained in cardiac rehabilitation protocols to ensure consistency and reliability.

Data Analysis

Data were analyzed descriptively by comparing pre-intervention and post-intervention values. Due to the single-case design, no inferential statistical analysis was performed. Changes in outcome measures were interpreted based on absolute differences, percentage change, and established thresholds for minimal clinically important difference where applicable.

Ethical Considerations

This study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval was obtained from the Health Research Ethics Committee of Universitas Muhammadiyah Surakarta (Ethical Approval No. 1693/KEPK-FIK/XI/2025). Written informed consent was obtained from the patient for participation and publication of clinical data.

Results

Participant Follow-up and Intervention Adherence

The patient completed the entire Phase II cardiac rehabilitation program consisting of five supervised exercise sessions without interruption. Attendance adherence was 100%, and no sessions were missed. Throughout the intervention period, the patient did not report new symptoms or adverse events related to exercise participation. All exercise sessions were conducted under direct supervision by a physiotherapist, with continuous monitoring of vital signs and subjective exertion.

During the intervention period, the patient tolerated progressive increases in exercise workload on both the treadmill and cycle ergometer. No clinical deterioration, exercise intolerance, or hemodynamic instability was observed that required modification or termination of the rehabilitation program.

Physiological Responses During Rehabilitation Sessions

Vital signs and perceived exertion were recorded before and after each rehabilitation session to monitor safety and physiological response. Across the five sessions, systolic blood pressure ranged from 101 to 126 mmHg, while diastolic blood pressure ranged from 63 to 70 mmHg. Heart rate values increased during exercise sessions, with post-exercise heart rate ranging from 73 to 83 beats per minute. Peripheral oxygen saturation remained within normal limits throughout the intervention, ranging from 98% to 100%.

The Borg Rating of Perceived Exertion demonstrated a gradual increase across sessions, with values ranging from 6 to 8 on the 6–20 scale. These data indicate that the patient was able to perform aerobic exercise within the prescribed intensity range during all sessions.

Changes in Aerobic Capacity and Functional Performance

Aerobic capacity was assessed before and after completion of the rehabilitation program using metabolic equivalents (METs) and the 6-Minute Walk Test (6MWT). Post-intervention assessment demonstrated an increase in METs from 4.13 to 4.90, corresponding to an absolute change of +0.77 METs and a relative increase of 18.6%. The distance covered during the 6MWT increased from 350 m at baseline to 441 m after the intervention, representing an absolute increase of 91 m and a relative improvement of 26.0%.

Resting physiological parameters assessed at baseline and post-intervention showed stable values. Systolic blood pressure increased from 106 mmHg to 111 mmHg, while diastolic blood pressure remained unchanged at 67 mmHg. Resting heart rate increased from 63 beats per minute to 77 beats per minute. Peripheral oxygen saturation remained at 100% at both assessments. Borg scale values recorded during functional testing remained unchanged at 6/20.

Table 1. Timeline of Study Procedures

Time Point	Event	Findings / Actions
Pre-intervention	Medical history	Diagnosis of CHF secondary to three-vessel CAD following CABG
Baseline (Week 0)	Initial assessment	Evaluation of vital signs, Borg scale, METs, and 6MWT
Week 1	Exercise intervention	Phase II cardiac rehabilitation using treadmill and cycle ergometer with warm-up and cool-down
During intervention	Safety monitoring	Gradual workload progression; no exercise intolerance or hemodynamic instability
Post-intervention	Final assessment	Re-evaluation of METs, 6MWT, Borg scale, and vital signs
Follow-up	Clinical outcome	Completion of rehabilitation program without adverse events

Table 2. Baseline Clinical and Instrumental Assessment

Variable	Result
Blood pressure	106/67 mmHg
Heart rate	63 bpm
Respiratory rate	18 breaths/min
Oxygen saturation	100%
Cardiac auscultation	No murmur
Pulmonary auscultation	No rales or wheezing
Left ventricular ejection fraction	57.8%
Aerobic capacity (METs)	4.13
Borg scale	6/20
Heart rate walking speed index	1.32

Table 3. Comparison of Physiological and Functional Outcomes Before and After Intervention

Variable	Pre-intervention	Post-intervention	Absolute Change	Percentage Change
Systolic blood pressure (mmHg)	106	111	+5	+4.7%
Diastolic blood pressure (mmHg)	67	67	0	0%
Heart rate (bpm)	63	77	+14	+22.2%
Oxygen saturation (%)	100	100	0	0%
Borg scale	6/20	6/20	0	0%
METs	4.13	4.90	+0.77	+18.6%
6MWT distance (m)	350	441	+91	+26.0%

Discussion

This case report demonstrated that a Phase II cardiac rehabilitation program incorporating treadmill and cycle ergometer exercise was associated with improvements in aerobic capacity and functional performance in a patient with congestive heart failure (CHF) secondary to three-vessel coronary artery disease (CAD) following coronary artery bypass grafting (CABG). The observed increases in metabolic equivalents (METs) and 6-Minute Walk Test (6MWT) distance, alongside stable hemodynamic responses throughout the intervention, support the feasibility and safety of structured aerobic training during the early outpatient rehabilitation phase in post-CABG patients with heart failure.[12,13]

The improvement in aerobic capacity observed in this case is consistent with previous evidence demonstrating the benefits of supervised aerobic exercise in patients with heart failure. Systematic reviews and meta-analyses have reported that regular aerobic training during cardiac rehabilitation significantly improves functional capacity, exercise tolerance, and health-related quality of life in individuals with CHF.[12,14] These benefits have been observed across different heart failure phenotypes, including patients with preserved left ventricular ejection fraction, as demonstrated in the present case.[12]

The increase in METs following the rehabilitation program reflects enhanced cardiopulmonary efficiency and improved functional reserve. Similar magnitudes of improvement in METs following structured cardiac rehabilitation programs have been reported in patients with heart failure undergoing aerobic training.[13] Improvements in METs are clinically relevant, as they are associated with increased independence in daily activities and reduced cardiovascular risk.[13]

Functional capacity, as assessed by the 6MWT, also improved substantially in this case. The increase in walking distance exceeded the minimal clinically important difference (MCID) thresholds previously reported for patients with heart failure. Studies have suggested that MCID values for the 6MWT range from approximately 14–15 meters in patients with reduced ejection fraction to 30–45 meters in broader heart failure populations.14,15 Exceeding these thresholds indicates that the observed improvement was clinically meaningful and likely reflects enhanced tolerance to daily physical activities such as walking and stair climbing.[16]

The combined use of treadmill and cycle ergometer exercise may have contributed to the favorable outcomes observed. Treadmill walking closely resembles functional ambulation and has been shown to produce greater improvements in peak oxygen uptake compared with cycle ergometer exercise in some cardiac rehabilitation populations.[9] Conversely, cycle ergometer training offers advantages in terms of safety, load control, and reduced orthopedic stress, particularly in post-operative patients.[7,17] The integration of both modalities within a single rehabilitation program may therefore provide complementary physiological stimuli that optimize aerobic adaptation while maintaining patient safety.[9,17]

From a physiological perspective, improvements in aerobic capacity following aerobic exercise training are mediated by both central and peripheral adaptations. Central adaptations include improved stroke volume, enhanced myocardial contractility, and more efficient ventricular filling, which collectively improve cardiac output during exercise.[18] Peripheral adaptations involve increased skeletal muscle capillary density, improved endothelial function, enhanced mitochondrial oxidative capacity, and improved oxygen extraction by working muscles.[18] These adaptations are particularly relevant in patients with CHF, in whom peripheral muscle dysfunction plays a significant role in exercise intolerance.

The safety profile observed in this case is consistent with existing evidence indicating that supervised moderate-intensity aerobic exercise is safe for patients with CHF when appropriate screening, monitoring, and individualized exercise prescription are applied.[19] Throughout the rehabilitation program, the patient demonstrated stable blood pressure, heart rate, and oxygen saturation responses, with no adverse events or signs of exercise intolerance. Adherence to established safety criteria, including continuous monitoring of vital signs and perceived exertion, is essential to minimize cardiovascular risk during rehabilitation.[19]

The presence of comorbid conditions, such as hypertension and type 2 diabetes mellitus, may influence exercise tolerance and cardiovascular risk in patients with CHF. Aerobic exercise has been shown to exert beneficial effects on blood pressure regulation and glycemic control through improvements in insulin sensitivity and endothelial function.[20] Although metabolic parameters were not directly measured in this case, the stable physiological responses observed during exercise suggest that the rehabilitation program was well tolerated despite these comorbidities.[20]

Patient adherence is a critical determinant of successful cardiac rehabilitation outcomes. In this case, the patient completed all scheduled sessions and demonstrated consistent participation. Supervised exercise, individualized progression, and continuous monitoring likely contributed to adherence by enhancing patient confidence and reducing fear associated with physical activity following cardiac surgery.[12,21] High adherence to cardiac rehabilitation programs has been associated with greater improvements in functional capacity and reduced cardiovascular events.[12]

This case also highlights the important role of physiotherapists within the multidisciplinary cardiac rehabilitation team. Physiotherapists are responsible for functional assessment, exercise prescription, progression, and safety monitoring during rehabilitation. Their expertise enables the delivery of individualized, evidence-based interventions that optimize functional recovery while minimizing risk.[21] The findings of this case reinforce the contribution of physiotherapy-led exercise programs to the effectiveness of cardiac rehabilitation.

Several limitations should be acknowledged. The single-patient design limits generalizability, and the short intervention duration precludes conclusions regarding long-term outcomes. The absence of cardiopulmonary exercise testing (CPET) prevented direct assessment of peak oxygen uptake, which is considered the gold standard for evaluating aerobic capacity.[18] Additionally, the lack of a control condition limits causal inference. Future studies should employ randomized controlled designs with larger samples, longer follow-up, and objective physiological measurements to strengthen the evidence base.[9,12]

Conclusion

This case report demonstrated that a Phase II cardiac rehabilitation program incorporating treadmill and cycle ergometer exercise was feasible, safe, and associated with meaningful improvements in aerobic capacity and functional tolerance in a patient with congestive heart failure (CHF) secondary to three-vessel coronary artery disease following coronary artery bypass grafting (CABG). The structured and supervised aerobic training program resulted in improvements in metabolic equivalents and 6-Minute Walk Test distance, indicating enhanced functional capacity and exercise tolerance without adverse events or hemodynamic instability.

The findings of this case highlight the potential clinical value of combining treadmill and cycle ergometer modalities during Phase II cardiac rehabilitation, particularly in post-CABG patients with complex cardiovascular conditions. The use of moderate-intensity aerobic exercise prescribed according to established guidelines, combined with close monitoring of physiological responses and perceived exertion, supported patient safety and adherence throughout the rehabilitation process. These elements are essential in the early outpatient phase, during which patients may experience residual physical limitations and anxiety related to physical activity.

Although the results are derived from a single case and therefore cannot be generalized to all patients with CHF, the observed functional improvements exceeded commonly reported thresholds for clinically meaningful change. This suggests that individualized, physiotherapist-led cardiac rehabilitation programs may play a critical role in optimizing recovery, restoring confidence in physical activity, and supporting functional independence after CABG.

Future research employing larger sample sizes, longer follow-up periods, and more robust study designs is needed to confirm these findings and to further define optimal exercise prescription strategies for patients with CHF after surgical revascularization. Nonetheless, this case report provides practical clinical insight and supports the integration of combined aerobic exercise modalities within Phase II cardiac rehabilitation programs for patients with heart failure following CABG.

Author Contribution

Fauzia Alya Putri: Conceptualization, Methodology, Data curation, Formal analysis, Writing—original draft, Writing—review & editing.
Farid Rahman: Conceptualization, Methodology, Writing—review & editing, Supervision.
Kadek Agustini Aryani: Conceptualization, Data curation.
All authors have read and approved the final version of the manuscript.

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Conflict of Interest Statement

The authors declare that there is no conflict of interest related to this study.

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Ethics Statement

This study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Health Research Ethics Committee of Universitas Muhammadiyah Surakarta (Ethical Approval No. 1693/KEPK-FIK/XI/2025). Written informed consent was obtained from the patient for participation in the study and for the publication of clinical information and anonymized data.

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