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CASE REPORT

Implementation of Super-circuit Training Protocol to Improve Functional Capacity in a Patient with Coronary Artery Disease: A Case Report

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ABSTRACT

Introduction: Phase II cardiac rehabilitation (CR) was the primary intervention used to improve functional capacity (FC) and facilitate patients with coronary artery disease (CAD) in returning to their pre-illness functional activities. This case report described the implementation of super-circuit training (SCT) as a novel exercise modality to assess its efficacy and safety.

Case Description: A 37-year-old man underwent phase II CR eight weeks after percutaneous coronary intervention with an FC of 5.4 metabolic equivalents, which limited his activities. Fear of recurrent heart attacks further contributed to these limitations. The patient participated in a six-week SCT program aimed at improving FC as the primary cause of functional impairment. After completing the program, improvements in FC, muscular fitness, and psychological well-being were observed, leading to enhanced daily, vocational, and sexual activities. No adverse events occurred during the CR program.

Discussion: The SCT protocol was a novel form of circuit training combining high-intensity aerobic exercise (AE) and resistance training (RT), specifically designed for CAD and heart failure patients with reduced ejection fraction. In this case, the protocol was adapted with modified RT intensity and type. AE was performed at 75%-85% of heart rate reserve, while RT included calisthenic exercises at 50% of repetition to failure. Physiologically, this regimen effectively increased metabolic and hemodynamic demand, improving muscular endurance, strength, and cardiorespiratory fitness. SCT was found to be safe and beneficial, consistent with previous studies.

Conclusion: The implementation of SCT in a CAD patient undergoing phase II CR resulted in significant FC improvement and was considered safe.

Keywords: Cardiac Rehabilitation, Circuit-Based Exercise, Coronary Artery Disease, Percutaneous Coronary Intervention, Resistance Training

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INTRODUCTION

Coronary artery disease (CAD) can lead to various levels of functional impairment, one of which is a decline in functional capacity, which can be assessed through metabolic equivalent (MET) values. Compared to the healthy population, men with CAD have a lower average MET (10.9 vs. 12) and are at moderate to high risk of developing CAD within the next 10 years.[1] Additionally, functional capacity is also used as an indicator of mortality risk due to cardiovascular disease (CVD). A decline in FC of more than 2.0 METs is associated with a 74% increase in mortality risk.[2]

Cardiac rehabilitation (CR) programs are structured efforts aimed at addressing the underlying causes of CVD and supporting the achievement of optimal physical, mental, and social conditions. This program is designed to help patients regain their optimal function in society independently by adopting a healthy lifestyle and slowing or even reversing disease progression.[3]

One of the exercise methods used in CR is aerobic exercise (AE). Super-circuit Training (SCT) is an innovative form of circuit training that combines high-intensity AE and resistance training (RT) done simultaneously. This type of exercise is considered safe and has been shown to improve left ventricular ejection fraction (LVEF), functional capacity, and the physical component of quality of life in men after myocardial infarction.[4]

To evaluate the feasibility of SCT in phase II CR, this method was implemented in a post-percutaneous coronary intervention (PCI) patient undergoing phase II CR. The combination of high-intensity AE and RT has been proven in previous studies to effectively improve functional capacity.[5,6] However, implementing this method remains a challenge in CAD management within our institution. As an initial step, this case report will assess the effects of SCT on functional capacity and its safety for a CAD patient undergoing PCI.

CASE DESCRIPTION

A 37-year-old man is undergoing a phase II CR program following PCI due to CAD affecting two vessels. He experienced a heart attack 9 months ago, during sexual intercourse with his wife and was admitted to Dr. Hasan Sadikin Hospital. Angiography revealed two obstructed vessels, and the cardiologist recommended PCI. He underwent the first procedure on the same day and was hospitalized for two days. However, he did not participate in the first phase of the CR program. Upon discharge, he was in good condition, with the only complaint being mild pain at the intervention site.

Subsequently, he underwent a second PCI on June 20, 2022 (6 weeks ago), was hospitalized for two days, and discharged without complications. His prescribed medications included aspilet (80 mg once daily), clopidogrel (once daily), bisoprolol (2.5 mg once daily), atorvastatin (40 mg once daily), and ramipril (20 mg once daily). He takes these medications regularly. His risk factors include dyslipidemia, smoking, and low physical activity. Before undergoing PCI, he was able to perform daily activities independently, working on 6-8 graphic design projects per month, engaging in sports, and actively participating in social activities. He was also sexually active. However, after the procedure, he reduced his workload to 1-2 projects per month due to fatigue, ceased sports activities, and limited social interactions. He resumed sexual activity three weeks post-procedure, occurring once per month, without experiencing symptoms. However, he still harbored fear related to his previous cardiac event.

The patient began phase II CR one month after PCI, starting on July 2022. An initial assessment indicated low functional capacity (METs: 5.4). Following hospital discharge, he was advised to engage in walking exercises for 15-30 minutes, 3-5 times per week; however, he was inconsistent in following this recommendation and was only able to walk 1.5 km. He continued to limit his workload to 1-2 projects per month but did not report any significant complaints.

For phase II CR, he was initially prescribed moderate-intensity continuous AE twice weekly at the hospital, with a 5-minute warm-up and cool-down sessions. Additionally, he was advised to perform ground walking exercises three times per week, using the talk test (ability to complete a full sentence) as an intensity indicator for his home-based program. He now adheres to this regimen regularly.
After completing four exercise sessions at the hospital, a mid-program assessment revealed an improvement in functional capacity, with METs increasing to 11.47

(classified as fair fitness). Consequently, SCT was incorporated into the remainder of his CR program.

Physical examination findings were unremarkable, except for slightly elevated systolic blood pressure (140/79 mmHg). His weight was 60 kg (previously 69.5 kg), with a height of 165 cm, resulting in a BMI of 22.2 (classified as normal weight). A neuromusculoskeletal examination yielded normal results. A cardiac catheterization report from June 20, 2022, confirmed CAD 2 vessels at left and right anterior descending post-stenting. Bioelectrical impedance analysis indicated low skeletal muscle mass (24.7%), normal subcutaneous fat (14.1%), and normal visceral fat (2.5%). Muscular fitness assessment using a hand grip strength dynamometer showed a grip strength of 26 kg in each hand (total 52 kg), indicating poor muscular fitness. Functional assessments revealed mild fatigue (based on the Fatigue Severity Scale), no signs of depression, anxiety, or stress (based on the Depression, Anxiety, and Stress Scale), and normal instrumental activities of daily living (based on the Lawton-IADL scale). However, the patient expressed ongoing fear regarding sexual activity, as he remained psychologically affected by his initial heart attack, which occurred during intercourse. An exercise test using the Bruce protocol demonstrated an appropriate hemodynamic response, no symptoms during testing, a functional capacity of 11.47 METs (classified as fair fitness), and a low-risk stratification.

The primary rehabilitation concerns include cardiorespiratory fitness (CRF), respiratory function, muscular fitness, and psychological fear related to sexual activity. In the short term (0-3 months), the CR program aims to improve functional capacity, respiratory function, and muscular fitness to achieve a normal fitness classification while enhancing the patient's understanding of the impact of CAD and the revascularization procedure on daily activities. In the long term (>3 months), the goal is to encourage adherence to a lifelong healthy lifestyle and prevent the recurrence of CVD or the development of additional risk factors. To address these rehabilitation concerns and achieve the set objectives, an exercise-based CR program has been prescribed, as detailed in Table 1. SCT session is visualized in Figure 1.

Table 1. The prescription for exercise

Component of the Prescription	**Hospital-based Super-circuit Training**	**Flexibility Exercise**	**Breathing Exercise**	**Home Program**
Frequency	Twice a week	Once daily, every day	3 times a day, every day	3 times a week
Intensity	• One set of RT followed by 5-min AE (treadmill, leg, or arm ergocycle) at 75%-85% HRR and 3-min rest • This circuit was repeated eight times • One set of RT consisted of 7-rep calisthenic (push-up, sit-ups, and lunges) • The RT intensity increased by 10% every 2 weeks • Each session of SCT was precede and followed by 5-min of warm up/cool down	Stretch to the point of discomfort	50% of MIV	Moderate
Time (set, repetition)		1 set, 4-rep	1 set, 10-rep	30-min per session
Type			Sustained-maximal breathing using incentive spirometry	Ground walking
Progression			volume adjusted every week as MIV increased	

AE, aerobic exercise; HRR, heart rate reserve; MIV, maximum inspiratory volume; RT, resistance training; SCT, super-circuit training

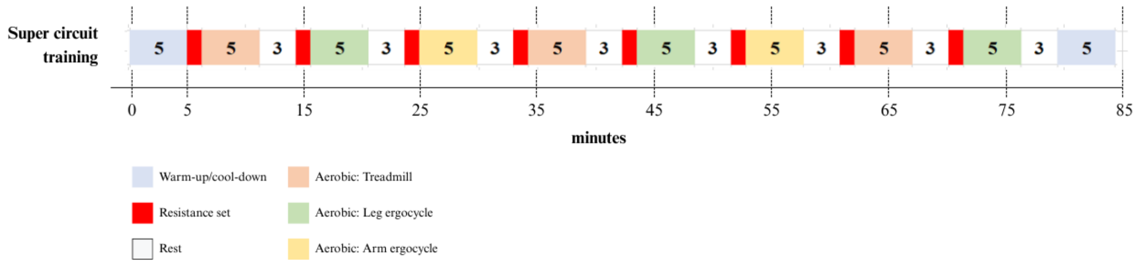

Figure 1. Super-circuit training protocols

NB: numbers appear inside the boxes mark the number of minutes engaged in the designated set

Evaluation after four weeks of SCT and a home exercise program demonstrated improvement in fatigue levels during daily activities and work. The patient showed increased capacity for work projects, completing 3-4 projects per month, and resumed sexual activity with a frequency of once per week. The 6-minute walk test (6MWT) indicated an improvement in MET to 8.1.

A follow-up assessment was conducted after the patient completed 12 sessions of SCT and underwent the final evaluation. The patient reported feeling fitter than in the previous assessment and experienced less fatigue during daily activities and work. Additionally, the frequency of sexual activity increased to twice per week. Further improvement was observed in MET, which increased to 13.18. As a result, the hospital-based CR program was concluded, and the patient transitioned to a home-based program consisting of overground walking, calisthenics, flexibility exercises, and deep breathing exercises.

DISCUSSION

This case report presented a relatively young adult with a history of CAD affecting two vessels who underwent a staged PCI. The patient experienced sudden-onset chest pain without any prior symptoms related to cardiac conditions. As part of his rehabilitation, he was introduced to the SCT protocol adapted from Dor-Haim et al., which was originally designed for post-myocardial infarction patients with reduced LVEF and a New York Heart Association classification of class III or lower.[4]

SCT is a novel form of circuit training that integrates high-intensity AE and RT.[4] Physiologically, a combination of these exercises increases global metabolic and hemodynamic demands, pushing the body toward the anaerobic phase. As a result, it creates a favorable physiological environment during RT, leading to improvements in muscular endurance, strength, and CRF. [7,8] A previous study demonstrated that SCT significantly enhances ventricular mechanical function (e.g., LVEF), strength performance (as measured by a hand grip dynamometer), quality of life, and functional capacity compared to conventional continuous AE. [4] In this patient, after undergoing four weeks of this training protocol, there was a notable improvement in functional capacity, as assessed by the 6MWT, along with an overall enhancement in well-being, allowing the patient to increase his workload.

Previous studies on SCT reported no exercise-related adverse events, such as cardiovascular complications or musculoskeletal injuries, even though such risks exist in exercise programs.[4,9] A systematic review analyzed eleven clinical trials that reported adverse events. Among these, ten trials documented incidents such as knee pain and significant exercise-induced ST-segment depression without chest pain, though none required readmission. Three trials noted cases of rehospitalization. A pooled analysis of six trials involving 333 participants found no significant difference in the occurrence of adverse events between combined AE and RT versus AE alone. The review concluded that RT may be more appropriate during the stable period of CAD.[9]

RT has numerous benefits for cardiovascular health. It can involve weighted dumbbells, elastic bands, resistance machines, or body-weight exercises. Research has shown that resistance training reduces cardiovascular mortality, prevents obesity, lowers blood pressure, improves insulin resistance, and enhances psychosocial well-being in CAD patients.[9-12] The primary goal of incorporating RT in programs is to improve muscle strength, endurance, and physical function.[13]

Guidelines from the American College of Sports Medicine recommend initiating resistance training 4-6 weeks after AE, while the American Association of Cardiovascular and Pulmonary Rehabilitation suggests starting RT in the ninth week following a myocardial infarction or four weeks after beginning AE.[14,15] The American Heart Association also recognizes the combination of AE and RT as the foundation of an effective exercise-based CR program.[13] One systematic review further supports this approach, highlighting improvements in exercise capacity (peak oxygen volume and exercise time), blood pressure, muscle strength and endurance, body composition, sleep quality, depression, and health-related quality of life in stable CAD patients following combined AE and RT.[16]

In this case, RT was introduced early due to the absence of contraindications and the patient's poor muscular endurance. Improvements in CRF are influenced by multiple factors, including respiratory function, cardiac and vascular health, and skeletal muscle performance.[17] Therefore, RT was incorporated alongside AE to optimize the patient's overall rehabilitation outcomes.

In contemporary clinical practice, RT intensity is typically prescribed using either the individual's repetition maximum for a given exercise or a percentage of their one-repetition maximum (1RM). The 1RM test is widely accepted for determining maximal strength in a specific exercise. However, when the 1RM test is not feasible, alternative methods estimate 1RM indirectly by performing sets to exhaustion with submaximal loads. A previous study suggested that this predictive approach reduces the risk of injury during training while maintaining a strong correlation with actual 1RM values.[18]

Calisthenics was chosen for this patient due to the lack of resistance machines at our rehabilitation facility. A previous study demonstrated that calisthenics effectively improves postural control, strength, endurance, and body composition by reducing fat mass.[19] Additionally, it is suitable for untrained individuals, ensuring all participants can complete the training program.[20] Since quantifying 1RM in calisthenics is challenging, the exercise intensity was determined using a repetition-to-failure approach.

Beyond cardiovascular disease, the patient was also found to have mild restrictive lung disease, as identified through spirometry. The etiology remains uncertain. Various factors can affect pulmonary function, including loss of consciousness, ventilation mode (spontaneous vs. mechanical), patient posture, and the influence of anesthetic agents and medications on respiratory muscles and secretions. A previous study found that PCI procedures may contribute to restrictive lung function, potentially due to sedative medication used during the intervention. However, further investigations are needed to confirm this hypothesis.[21]

A previous study indicated a significant decline in pulmonary function test values after PCI, with smokers experiencing more pronounced deterioration than non-smokers.[22] Tobacco smoke is a well-known risk factor for multiple respiratory diseases, including smoking-related interstitial lung disease, a type of restrictive lung disease.[23] Physical inactivity following the procedure may also contribute to decreased pulmonary function. Existing literature supports a positive association between physical activity and lung function, demonstrating that active individuals generally exhibit better respiratory performance than their sedentary counterparts. [24] Consequently, the patient was referred to an internist for further evaluation and management of his pulmonary impairment.

Patients with impaired pulmonary function who participate in CR programs often experience more severe functional limitations, which can negatively impact work efficiency due to impaired lung mechanics, inspiratory muscle fatigue, ineffective gas exchange, right ventricular dysfunction, altered peripheral muscle metabolism, acute exacerbations, and malnutrition. These additional challenges may place patients with respiratory comorbidities at a disadvantage compared to those without airflow limitations.[25] Based on these findings, the patient's respiratory condition was addressed with incentive spirometry (IS). incentive spirometry is a widely used and cost-effective modality for post-operative and hospitalized patients with respiratory conditions. The patient was instructed to perform slow, deep breathing exercises with visual feedback from the IS device, promoting airway expansion and improved lung function. Research has demonstrated that IS effectively prevents pulmonary function deterioration in post-coronary artery bypass graft surgery patients.[26-28]

The final concern in this patient was anxiety regarding sexual activity. A guided interview was conducted to assess the issue, as no standardized tool exists for evaluating post-PCI sexual activity concerns. Education was provided to address the patient's fear, which was likely influenced by a lack of knowledge and psychological distress related to his initial cardiac event. Future research should focus on developing a standardized assessment tool to evaluate and manage post-procedural anxiety related to sexual activity, as this is a common concern among cardiovascular patients.

Based on this case report, SCT could be used as an alternative method for delivering AE and RT in post-PCI CAD patients, as the primary goal of CR to improve functional capacity was achieved. The combination of SCT with other exercises, such as flexibility and breathing exercises, could also be provided according to the patient's needs, as this combination showed no difference in effect compared to the conventional exercise program that we typically administered. High-intensity AE combined with RT, flexibility, and breathing exercises were performed by the patient without any adverse events.

CONCLUSION

The implementation of SCT in the CAD patient who underwent phase II CR was considered safe and led to significant improvement in functional capacity and other rehabilitation problems.

CONFLICT OF INTEREST

The authors have none to declare.

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