



(RESEARCH ARTICLE)



## The safety of exercise-based cardiac rehabilitation program in patients after Myocardial Infarction

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### Abstract

**Objective:** The aim of the present review is to identify the safety of an exercise-based cardiac rehabilitation program in patients after myocardial infarction.

**Materials and Methods:** The PubMed/Medline and Scopus/Elsevier electronic databases were searched. A search strategy was developed based on the intersection of 2 search themes: cardiac rehabilitation program and exercise safety.

**Results:** The articles that finally met all the inclusion criteria and were analyzed, after the screening of the title, the summary and the whole text, were 4. A total of 180.946 patients who received cardiac rehabilitation were examined in this review and 124 complications were occurred: 71 cardiac arrests (11 fatal), 15 myocardial infarctions (2 fatal), and 31 non-life-threatening patients: angina, ventricular tachycardia, 1 orthopedic injury and 4 deaths from cardiorespiratory disorder.

**Discussion:** The present review has demonstrated that individualized and prescribed exercise-based cardiac rehabilitation is safe and recommended. The complications of these programs appear to be of low risk and with no statistical importance. The exercise-based cardiac rehabilitation when combined with patient participation, proper equipment and educated physicians present a very safe clinical approach to cardiovascular patients.

**Keywords:** Cardiac Rehabilitation Program; Exercise Safety; Myocardium Infrastructure; Patients

### 1. Introduction

Initially complete exercise-based cardiac rehabilitation (exCR) was applied to patients recovering from acute myocardial infarction and are now applied to a wide range of cardiovascular diseases [1]. The effectiveness of structured exercise as a therapeutic intervention has been proven in the literature and is considered fundamental in the management of coronary heart disease [2-4].

Researchers have been arguing that exercise in the exCR "has similar effects in reducing risk for patients and competes with or exceeds the effectiveness of the common medication patients receive" [5] "was not found to make any difference compared to medication in relation to mortality after a myocardial infarction "is equally important as much as medication" [6]. In 2004 Hambrecht et al. published a study which showed that the participation of selected patients with stable coronary heart disease in a 12-month regular exercise program resulted in a higher survival rate without

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new cardiac events (88%) compared to patients who underwent in percutaneous coronary intervention (PCI) (70%) [7].

The use of exercise as a treatment for survivors of acute myocardial infarction began to gain ground in the late 1970s, when the decades-long practice of immobilization and reduced activity was overturned. Since then, a series of studies have been conducted to examine the effectiveness of these programs in cardiologic patients. It is crucial to be evaluated the safety of exCR for patients participating in the various phases of rehabilitation. The aim of the present review is to identify the exercise safety of an exCR program in patients after myocardial infarction.

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## 2. Material and methods

### 2.1. Review design

The results are presented as per the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) reporting guideline (supporting checklist/diagram) [8].

### 2.2. Data Sources and Search Strategy

A search strategy was developed based on the intersection of 2 search themes: cardiac rehabilitation program and exercise safety. The following databases were searched: Medline databases (via PubMed), and Scopus /Elsevier. Additional relevant research was also identified by direct search in scientific journals available online. Prisma methodology was used, and 4 unique studies were included in the review.

### 2.3. Inclusion Criteria

The review included studies designed to evaluate the safety of an exCR program with no limitation about the publication date. Case reports and case series were excluded.

### 2.4. Study selection

Eligibility screening of the studies was conducted in a blinded standardized way by two independent reviewers (E.T. and G.X.). Titles and abstracts were screened using and duplicate articles were excluded. After screening titles and abstracts, full paper copies were retrieved. Full text screening was also performed blinded by the same reviewers (E.T. and G.X.). Disagreements between authors during any stage of the screening process were resolved by consulting a third reviewer (E.T.).

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## 3. Results

The articles that finally met all the inclusion criteria and were analyzed, after the screening of the title, the summary, and the whole text, were 4. (Table 1)

In 1978 Haskell [9] collected questionnaires from 30 exCR programs in North America from 1960 to 1974. These were conducted under medical supervision in 103 areas and reported 13,750 patients who underwent a total of 1,629,234 hours of supervised exercise. The results showed 50 cardiac arrests (8 fatal), 7 myocardial infarctions (2 fatal), and 4 deaths from cardiorespiratory disorder. The mean complication rate was 1 non-fatal event per 34,673 hours of exercise and 1 fatal per 116,402 hours of exercise. Complication rates were lower in programs with continuous electrocardiographic monitoring of patients during exercise.

In 1986 Van Camp & Peterson [10] collected data from 167 randomly selected outpatient of exeCR programs with questionnaires sent by mail and telephone interviews. The study included 51,303 patients who collected 2,351,916 hours from 1/1980 to 12/1984. A total of 21 cardiac arrests (3 fatal) and 8 non-fatal myocardial infarctions were presented. The complication rate was 1 cardiac arrest per 111,996 hours of exercise, 1 heart attack per 293,990 hours of exercise and 1 death per 783,972 hours of exercise. There was no statistically significant difference in the frequency of these events between programs of different sizes or the extent of electrocardiographic monitoring.

To collect updated data in 2006, Pavy et al. [11] (Working Group of the French Cardiac Society for Functional Assessment and Cardiac Rehabilitation) conducted an original registry complication survey during exCR. For this prospective study, data were collected over a 1-year period (January-December 2003) from 65 cardiac rehabilitation centers that reported severe episodes that occurred during or 1 hour after a fatigue test or exercise session. The study included 25,420 patients (78% men) with a mean age of 61.3 years with recent (1 month) coronary artery bypass graft

surgery (34.3%), with recent valve surgery (18.4%), with recent transdermal coronary artery bypass graft surgery revascularization (21.6%), not recent revascularization (13.2%) and non-coronary patients (12.5%).

In France, patients after an acute heart attack are referred early to exCR programs in phase 2 and are usually short-term [11]. They are performed either in the hospital for 3 to 4 weeks, or outpatient involving 20 exercise sessions in 4 to 8 weeks. Patients before their participation had all the necessary tests to assess their condition. All fatigue tests were performed under the medical supervision of a cardiologist to assess heart rate for subsequent exercise sessions. The exercise program had differences between the different CR centers, but all had to include fine gymnastics (gentle exercises with body weight), endurance exercise on a stationary bike or electric treadmill for at least 1 hour a day. Exercise sessions were supervised by physiotherapists in 93% of the centers, by cardiologists in 35.4% and by nurses in 41.5%. According to the French exCR guidelines, electrocardiographic monitoring of patients is recommended for exercise sessions, but is not mandatory.

The study population underwent 42,419 fatigue tests (at the beginning and often at the end of the program) and collected 743,471 hours of exercise. Twenty serious cardiac events were reported, 18 of which required immediate transfer of the patient to an emergency department. All 5 occurred during the initial fatigue test, all in patients who had recently had a stent implanted. In three cases, patients developed angina pectoris with ischemic heart disease, one with cardiac arrest due to a parasympathetic reflex during post-test recovery, but met with immediate cardiopulmonary resuscitation, and drug-induced acute pulmonary edema. Other events (angina, ventricular arrhythmias, cardiac arrest, acute myocardial infarction, cardiac arrest) occurred during different types of exercise, at centers of different sizes and operating times, regardless of whether or not electrocardiographic follow-up was followed. The instructions given to them for the intensity of the exercise. Of these patients 3 belonged to the high-risk category, 4 to the medium risk and 6 to the low-risk category. Thus, the frequency of severe episodes was 1 per 8,484 fatigue tests (1.2 per 10,000 tests) and 1 per 49,565 hours of exercise. Cardiac arrest (not fatal) was 1.3 per million hours of exercise. No fatal complications or defibrillation were reported. The incidence of serious heart complications during supervised exercise in France is quite low.

The same data were investigated in 2010 in another national study conducted in Japan by Saito et al. [12], on behalf of the Cardiovascular Disease Research Department of the Ministry of Health, Welfare and Labor. It was a multicenter retrospective study on data collected from 1059 hospitals in the country over a period of 3 years (2001-2003) for patients who participated in exCR after acute myocardial infarction and percutaneous coronary artery surgery. In Japan the regulations for approving an institution as an official CR provider are very strict. They require a cardiology and cardiac surgery department and at least 1 cardiologist/cardiac surgeon and 1 experienced CR physiotherapist 24 hours a day. Patients were divided into those who participated in formal (formal) and informal (non-formal) programs depending on whether the program was prescribed to them after individual evaluation with an exercise test or not.

In CR-approved hospitals, for patients with myocardial infarction, the 'acute phase' of exCR begins immediately in bed a few days after admission, followed by the in-hospital phase in an exCR-specific area for 1 to 2 weeks and continued after discharge from the hospital for 3-5 months with exercise sessions that take place again at the hospital and are supervised by medical staff (at least 1 nurse or a physiotherapist and 1 cardiologist) and with electrocardiographic monitoring.

The study population underwent 469,215 fatigue tests (433,269 on a treadmill and 35,946 on a treadmill), of which 91.7% in CR-approved hospitals. A total of 34 cardiac complications were reported during the test or 1 hour later, all on the treadmill and none on the cyclometer. A total of 3 life-threatening patients: heart attacks, 31 non-life-threatening patients: angina, ventricular tachycardia and 1 orthopedic injury. In the present study, the rate of non-life-threatening complications during the fatigue test was approximately 6.61 per 100,000 tests, while that of life-threatening complications was 0.64 per 100,000 tests.

Participating patients collected 383,096 hours of exercise and reported 50 complications, of which 12 during exercise and 38 within 24 hours. Of these 12 only 1 was deemed life-threatening (heart attack). The percentage of life-threatening complications during exercise was 1 per 383,096 hours of exercise. No fatalities were reported. It should be noted that the non-life-threatening episodes that occurred in patients who participated in a formal exCR program were significantly less than those reported in patients who participated in an informal program. No dangerous cases were reported in patients who participated in a formal exCR program in 277,721 hours of exercise, while 2 cases were reported in 105,375 hours of exercise in patients who participated in an informal exCR program.

**Table 1** Studies included in the review

Authors (year)	Methods	Sample (n)		Intervention		Conclusion
		Size	Age	(Follow up)	Type	
Haskell 1978	Retrospective polycentric observational study	3.750		1.629.234 hours of exercise	CR & exercise in supervised programs	Supervised exercise, prescribed by a doctor can be performed safely
Van Camp & Peterson 1986	Retrospective polycentric observational study	51.303		2.351.916 hours of exercise	CR & exercise in outpatient supervised programs	Outpatient supervised exercise programs have a low risk of cardiovascular complications
Pavy et al 2006	National perspective observational study of a register of complications France CR programs	25.420	Mean 61,3	42.419 fatigue test 743.471 hours of exercise	CR & training inpatient and outpatient programs, which should include calisthenics & endurance	Low incidence of serious cardiac complications during supervised exercise and fatigue testing (no fatal complication)
Saito et al 2010	National retrospective polycentric observational study	-	-	469.215 fatigue test 383.096 hours of exercise	CR & exercise in hospital centers	Exercise-based CR programs and fatigue tests are safe (no fatal complications)

**Table 2** Mean complication rate of the studies included in the review

Author (year)	Size	Mean complication rate (cases per hour of exercises)		Cardiac complications
		Non-fatal	Fatal	
Haskell 1978	13.750	1 per 34,673	1 fatal per 116,402	61 complications: 50 cardiac arrests (8 fatal), 7 myocardial infarctions (2 fatal) and 4 deaths from cardiorespiratory disorder
Van Camp & Peterson 1986	51.303	1 cardiac arrest per 111,996, 1 heart attack per 293,990	1 per 783,972	29 complications: 21 cardiac arrests (3 fatal) and 8 non-fatal myocardial infarctions
Pavy et al 2006	25.420	1.3 per 1,000,000	1 per 49,565	No fatal complications or defibrillation were reported
Saito et al 2010	83,096 patient-hours of exercise training	6.61 per 100,000 tests	0.64 per 100,000	34 complications: 3 life-threatening patients: heart attacks, 31 non-life-threatening patients: angina, ventricular tachycardia and 1 orthopedic injury.

#### 4. Discussion

A total of 180.946 patients who received exCR were examined in this review and 124 complications were occurred: 71 cardiac arrests (11 fatal), 15 myocardial infarctions (2 fatal), 31 non-life-threatening patients: angina, ventricular tachycardia, 1 orthopedic injury and 4 deaths from cardiorespiratory disorder. (Table 2)

The results of Haskell [9] and Van Camp & Peterson [10] studies suggest that outpatient supervised exercise programs, prescribed by a physical therapist, have a low risk of serious cardiovascular complications. However, these pre-2000 complication rates do not need to be generalized to modern heart patients as they receive more aggressive treatments, percutaneous coronary artery bypass grafting, pharmacotherapy has changed, patients are generally older and more cohabiting. The procedures followed to determine an individual's risk of participating in an exCR program have changed [13].

According to the Pavy et al. [11] and Saito et al. [12] data, the rates of complications during exercise or fatigue test have decreased while no fatal complications are observed. The modern medical and invasive treatment of patients, in combination with the correct assessment of the risk of each patient's condition before his participation in a program for prescribing an appropriate protocol, the equipment of the rehabilitation centers, the training and the cooperation of the staff implementing the exercise in rehabilitation, as well as patient compliance with the instructions may be possible interpretations. This first national survey in Japan showed that both exCR programs and fatigue tests are generally safe [12]. Even the participation of patients in official exercise-based CR programs, after first being evaluated with a test, their individual condition is very safe [12].

There are absolute contraindications to participating in exercise programs in the exercise-based CR as well as situations that may be considered temporary contraindications, but the safety of exercise in supervised exercise-based CR programs that follow the current guidelines is well documented [14].

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#### 5. Conclusion

The present review has demonstrated that that individualized and prescribed exCR are generally safe and recommended. The complications of these programs appear to be of low risk and with no statistical importance. The exCR when combined with patient participation, proper equipment and educated physicians present a very safe clinical approach to cardiovascular patients.

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#### Compliance with ethical standards

##### *Disclosure of conflict of interest*

The authors declare no conflict of interest.

##### *Statement of informed consent*

Informed consent was obtained from all individual participants included in the studies of the review.

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