Exercise Training after Cardiac Surgery

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Abstract: Exercise training is one important part of cardiac rehabilitation after cardiac surgery. This training is aimed at improving exercise capacity and optimizing daily physical functioning concerning individual physical activity limitations and participation restrictions. Exercise training should be started as early as possible after cardiac surgery, which must be prescribed and supervised under medical guidance. In the case of rehabilitation after cardiac surgery exercise training should be individually tailored according to the clinical condition. Exercise training for patients after cardiac surgery has benefits in improving exercise capacity, increasing muscular strength, improving graft patency and recovery of cardiac function after surgery. Exercise training is a major component in cardiac rehabilitation programs has been proven to be safe and effective in improving cardiac surgery patients' outcomes. Each cardiac rehabilitation programs are tailored individually according to the clinical condition.

1 INTRODUCTION

Exercise training is one important part of Cardiac Rehabilitation after Cardiac Surgery. This training is aimed at improving exercise capacity and optimizing daily physical functioning concerning individual physical activity limitations and participation restrictions and also can induce inactive patients to develop and maintain an active lifestyle, and consequently lower their future cardiovascular risk. (Lavie CJ et.al, 2009; Taylor et al, 2004) Cardiac rehabilitation (CR) itself usually beginning during hospitalization (phase I, inpatient), followed by a supervised outpatient program lasting 3-6 months (phase II), and continuing in a lifetime maintenance stage in minimally supervised or unsupervised setting (phase III). Physical activity counseling and individually prescribed and supervised exercise training are core components of a comprehensive cardiac rehabilitation program, compromising 30–50% (up to >70%) of all cardiac rehabilitation activities. This applies to phase II as well as to phase III cardiac rehabilitation for patients post-acute coronary syndrome (ACS) and post-primary coronary angioplasty (PCI), post-cardiac surgery (coronary artery bypass, valve heart surgery, cardiac transplantation), as well as in chronic heart failure patients. Within large meta-analysis of the Cochrane database, exercise training interventions have been shown to reduce overall mortality rate of patients with coronary artery disease by 27% (risk reduction 0.73; con dence interval 0.54–0.98) and mortality rate due to cardiovascular disease by 31% (risk reduction 0.87, con dence interval 0.71–1.05). (Jolliffe JA et al, 2001; Taylor RS et al, 2004)

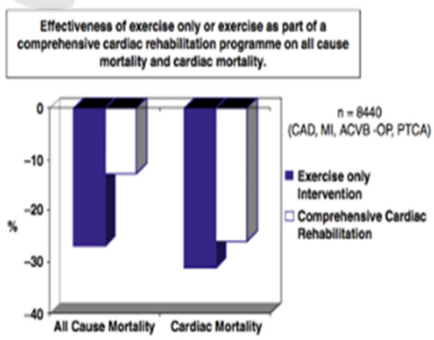

Figure.1: Effectiveness of exercise only or exercise as part of a comprehensive cardiac rehabilitation program on all-cause mortality and cardiac mortality (according to Jolliffe et al).

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There are some benefits of exercise training for patients after cardiac surgery. They improve exercise capacity, increase muscular strength, improves ventilatory efficiency, and also can improve graft patency and recovery of cardiac function. For example, inpatient after CABG, exercise training can improve exercise capacity, without significant complications or other adverse effects. Kavanagh et al reported exercise test data for 12,169 male rehabilitation candidates and found the most powerful predictor of cardiac and all-cause mortality was VO2peak. Values of <15, 15 to 22, and >22 mL·kg-1·min-1 yielded respective hazard ratios of 1.00, 0.62, and 0.39 for cardiac deaths and 1.00, 0.66, and 0.45 for all-cause deaths. Additionally, the mortality rate might decrease by 9% for each 1 mL·kg-1·min-1 increase of VO2peak. (Kavanagh T et al, 2002)

Furthermore, exercise training also improves cardiac function after surgery. Nakai et al. reported the effects of exercise training on the recovery of cardiac function and graft patency in 115 patients after CABG. The patients were divided into Group I (n = 60) and Group II (n = 55) without a CR program. The rate of graft patency was 98% in Group I and 80% in Group II. After training, the exercise stroke index increased significantly in Group I, but not in Group II. The result suggested that physical exercise training should be started as early as possible after CABG to improve graft patency and recovery of cardiac function. Study by Brügemann et al.also showed physical training improves quality of life of patients, by comparing two types of cardiac rehabilitation: physical training plus information ('Fit' program) during 6 weeks or comprehensive CR which, on top of the Fit-program, included weekly psycho-education sessions and relaxation therapy ('Fit-Plus' program) for 8 weeks. The results showed that quality of life improved in both treatment groups with time up to 9 months after training, and there was no difference between the two types of CR. (Brugemann J et al., 2007) Based on many studies in multicentre of cardiology, cardiac rehabilitation programs have evolved to be an integral part of the standard of care in modern cardiology. (Brugemann J et al., 2007; Eagle KA et al., 2004)

2 DISCUSSION

Based on recommendation EACPR Committee 2010, in post-cardiac surgery, cardiac rehabilitation in patients after coronary artery and valve heart surgery should be consist of: (recommendation class I, level evidence C)(Eagle KA et al., 2004; Vahanian A et al., 2007; Butchart EG et al., 2005)

- Physical activity counseling:
  - Assess exercise capacity to guide exercise prescription.
  - Submaximal exercise stress test as soon as after surgery. A maximal exercise test after surgical wound stabilization.
  - Recommended physical activity counseling according to wound healing and exercise capacity.
- Exercise training recommendation
  - Exercise training can be started early in-hospital.
  - Programs should last 2 – 4 weeks for in-patient or up to 12 weeks for out-patient settings.
  - Upper-body training can begin when the sternal wound is stable.
  - Exercise training should be individually tailored according to the clinical condition, baseline exercise capacity, ventricular function, and different valve surgery (after mitral valve replacement exercise tolerance is much lower than that after aortic valve replacement, particularly if there is residual pulmonary hypertension).

The following points are established/general agreed on issues in exercise training applicable to all clinical conditions : (Piepoli MF et al., 2010)

- Assess exercise capacity by symptom-limited stress testing, either on bicycle ergometer or on a treadmill. In the routine clinical setting, this is not always applicable, particularly in the presence of left ventricular dysfunction (ejection fraction 40%) or after recent surgical intervention (because of the surgical wounds) and therefore sub-maximal exercise evaluation and/ or 6 min walk test should be considered.
- Advise individualized exercise training after careful clinical evaluation, including risk stratification.
- Recommend as general advice sub-maximal endurance aerobic.
- Educate on the recognition of symptoms induced by effort. Appropriate behavior and re-definition of exercise training target should be discussed for the individual patient.
- Expected outcomes: increased cardiorespiratory fitness and enhanced flexibility, muscular endurance, and strength; reduction of symptoms, attenuated physiologic

responses to physical challenges, and improved psychosocial well-being.

- Program settings. During the initial phases supervised in-patient or hospital-based exercise training programs may be recommended in high-risk cardiovascular patients, i.e. those with impaired systolic left ventricular function, those with severe co-morbidities, leading to significant disability, and in those with recent (1 week) clinical destabilization. This will verify individual responses and tolerability in a safe clinical setting and will promptly identify signs and symptoms indicating to modify or terminate the program. The supervision should include physical examination, assessment of exercise-related symptoms or arrhythmias, and monitoring of heart rate and blood pressure before, during, and after exercise training. The supervised period should be prolonged in patients with new symptoms, clinical signs of decompensation, blood pressure abnormalities, and increased supraventricular or ventricular arrhythmia during exercise.

There are a recommendation of exercise training that generally applicable for secondary prevention in patients with heart disease: (Piepoli MF et al., 2010)

- Mode: Continuous endurance: walking, jogging, cycling, swimming, rowing, stair climbing, elliptical trainers, and aerobic dancing.
- Duration: At least 20–30 min (preferably 45–60 min).
- Most days (at least 3 days/week and preferably 6 – 7 days/ week.
- Intensity: 50–80% of peak oxygen consumption (close to the anaerobic threshold) or peak heart rate or 40 – 60% of heart rate reserve; 10/20–14/20 of the Borg Rating of Perceived Exertion.

There are some differences in prescription in patients after cardiac surgery. The following general criteria should be considered in planning exercise testing modality for exercise prescription in patients after cardiac surgery: (Piepoli MF et al., 2010)

- Safety
- Co-morbidities: hemoglobin concentration (Hb) values; muscular-skeletal discomfort, healing issues at the incision sites
- Associated factors: deconditioning due to prolonged hospitalization, sedentary habits, orthopedic limitations, occupational and recreational needs.
- Incomplete revascularization after CABG surgery.

2.1 Exercise Prescription in Patients After CABG.

Exercise prescription methodology is generally the same as that used with CAD patients. Initially, some patients may need lower-intensity or modified exercise because of musculoskeletal discomfort or healing issues at their incision sites, including not only the chest but possibly also legs and arms. Specifically, patients should completely refrain from upper-extremity aerobic exercise training, for example, arm ergometry and resistance training, for 4–6 weeks post-surgery to ensure the stability of the sternum and sternal wound healing. The exception is appropriate upper and lower body stretching and flexibility exercises to promote mobility. In patients with previous CABG, several aerobic training intensities have proven effective the choice of which will depend on both the level of exercise-related risk and the patient's clinical condition. In this regard, it must be borne in mind that, among patients entering a rehabilitation program after a recent acute cardiac event, those with recent CABG have been found to have the lowest peak VO2. (Ades PA et al., 2006)

Because of the possibility of graft closure, program staff should be alert for new patient complaints of angina pectoris or angina-equivalent symptoms or signs, such as exercise intolerance or new ECG signs of myocardial ischemia. Patients should also be educated regarding these possibilities. Recognizing whether the revascularization was complete or incomplete is valuable in this regard as the latter may increase the likelihood of postsurgical signs and symptoms of residual myocardial ischemia during exercise, which may significantly affect the results of the rehabilitation process.

2.2 Exercise Prescription in Patients After Valve Repair/ Replacement

The exercise prescription and training of patients with recent valve replacement or repair is very similar to that used with CABG surgery patients. However, the physical activity of some valvular heart disease patients may have been very restricted for an extended period before the surgical intervention. Consequently, the resulting low functional capacity may require these patients to initiate, and proceed with, an exercise in a conservative fashion, especially during the early stages of the exercise training program. Exercise intensities in the light to moderate and moderate to high domains have been used in patients with recent heart valve replacement or repair and balloon valvuloplasty, demonstrating significant effects on exercise capacity and quality of life. Preliminary data also indicate a possible reverse left ventricular remodeling effect of prolonged aerobic training in patients with previous aortic valve replacement. Anticoagulation therapy is very common in patients who have undergone valve surgery; consequently, this necessitates caution for exercise-related injuries and subsequent bleeding. Staff should frequently remind patients undergoing exercise training of the increased risk of such events.

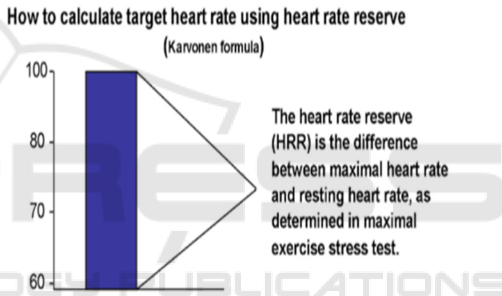
2.3 How to Define Exercise Intensity

Training intensity can be defined based on the results of an exercise stress test. This should yield maximal heart rate, maximal exercise load in watts, possible ischemic threshold, and blood pressure response to exercise. These data will form the basis for determining the individual training load and training heart rate. A complete cardiovascular examination or more specific therapy has to take place if cardiac complaints and/or symptoms arise during the exercise stress test.

If complaints or symptom limitations persist, despite maximal therapeutic efforts, it is crucial to keep the exercise load at a level free of symptoms and ischemia. It is generally recommended that the training intensity should be clearly below the ischemic threshold

The heart rate is an objective, easily determined parameter used to regulate and control exercise load in cardiac rehabilitation. The maximal heart rate (HRmax) is the highest heart rate achieved before the termination of an incremental exercise tolerance test due to subjective exhaustion or objective indications. In cardiac rehabilitation, a training heart rate of 60–75% HFmax (maximal heart rate) is recommended. It is important to keep in mind that only the heart rate response to an exercise stress test performed under the patient's actual medication can be used for exercise prescription. This applies especially to the use of ß-receptor blockers The training heart rate can also be determined mathematically by using the Karvonen formula, in which the heart rate reserve (HRR) is calculated. In cardiac patients, training heart rate of 40–60% of heart rate reserve is recommended. The heart rate reserve method should especially be used in patients with chronotropic incompetence. The training heart rate should always be determined clearly below the ischemic threshold (i.e., 10 beats/min).

Maximal exercise capacity measured in watt is a reliable and reproducible parameter to regulate exercise training performed on a bicycle ergometer. In cardiac rehabilitation, exercise intensity at 40–60% (if tolerated up to 70–80%) of maximal load (watt) achieved in a symptom-limited exercise test is recommended. In patients with very low exercise tolerance, very low heart rate reserve as well as with the inability of the sinus node to react adequately to exercise stress by increasing heart rate (patients with chronotropic incompetence, atrial fibrillation, pacemakers, and post-heart transplant) training intensity should be controlled according to exercise load in watts and by using the Borg scale.



Example calculation – target intensity 60% of heart rate reserve	
Resting heart rate	= 60 beats/min
Maximal heart rate in exercise test	= 100 beats/min
Target heart rate for exercise training = 60 + (100 -60) x 0,6 = 84/min.	

Figure 2: How to determine the target heart rate for exercise training in cardiac rehabilitation using the Karvonen formula.

The Borg Scale (rate of perceived exertion, RPE) is used to subjectively assess how the individual perceives the intensity of the performed exercise on a scale from 6 to 20. It is not advisable, however, to solely rely on the Borg scale to regulate training load as it contains too many influencing factors from the patient's perspective (i.e., unfamiliar method, poor body awareness, over motivation, and peer pressure). The Borg scale can be used as a supplement to other training regulation options, as well as to facilitate developing body awareness to the exercise load. Target values are RPE 11–14, comparable to light to moderate exercise intensity.

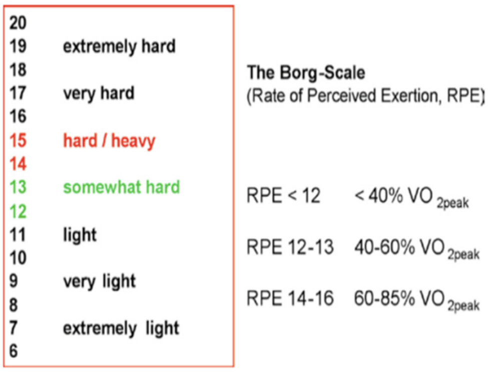


Figure 3: The Borg- Scale

Maximal oxygen consumption (VO2peak) reached during an exercise stress test and the oxygen consumption at the anaerobic threshold (VO2-AT) are meaningful parameters in regulating exercise load during training. The latter can also be determined during submaximal exercise testing, independent of the individual's motivation level. If a cardiopulmonary exercise test is used to determine aerobic training intensity, then 40–70% of VO2peak (up to 80% if tolerated) should be targeted, close to the individual's anaerobic threshold.

Before doing exercise training in cardiac patients, there are some contraindications for aerobic endurance training that should be aware of some conditions listed in table 1.

Table 1: Exercise Contraindication in Cardiac Patients.

Acute coronary syndrome (ACS)
Malignant hypertension with systolic blood pressure >190 mmHg during exercise training despite exhaustive antihypertensive medication therapy
Drop-in systolic blood pressure by 320 mmHg during exercise, in particular in patients with coronary heart disease (CHD)
Severe secondary mitral valve insufficiency or more specifically moderate mitral valve insufficiency with evidence of increased regurgitation during exercise
Heart failure NYHA IV
Supraventricular and ventricular arrhythmias causing symptoms or hemodynamic compromise, continual ventricular tachycardia
Frequent ventricular extra-systoles, known continual ventricular tachycardia in advanced left ventricular dysfunction or more specifically after myocardial infarct as well as in response to exercise or during the post-exercise regeneration phase
Cardiovascular diseases that have not been risk evaluated according to 4.1.3, and that have not been treated according to guideline requirements in terms of best possible prognosis outcome (i.e., Beta-blocker in patients with CHD, angiotensin-converting enzyme-inhibitor in patients with heart failure), or more specifically, hemodynamic control (i.e., maximal medication therapy for blood pressure regulation in severe arterial hypertension). Patients with contraindications to exercise training due to malignant arrhythmias, on the other hand, can be introduced to a training program after antiarrhythmic measures have been taken (i.e., implantable cardio de brillator (ICD), proven efficacy of medication therapy)

3 CONCLUSION

Based on many studies, the clinical effect of exercise training for patients after cardiac surgery has benefits in improving exercise capacity, increasing muscular strength, improving graft patency and recovery of cardiac function after surgery. Thus cardiac rehabilitation programs must be given in advanced to patients who underwent cardiac surgery. The programs are generally exercised based and prescribed individually according to the patient's special condition which varies one another. According to that the cardiac rehabilitation programs exercise’s prescription which determined by exercise testing particularly is safe.

Cardiac rehabilitation programs have become an integral part of the standard of care in modern cardiology. Their scope has shifted from the emphasis on exercise therapy to a comprehensive exercise measured approach that has many benefits in supporting cardiac surgery patient outcomes. Each cardiac rehabilitation programs are tailored individually according to the clinical condition. In most current guidelines of cardiovascular societies worldwide cardiac rehabilitation is a class I recommendation.

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