Exercise in the Management of Coronary Artery Disease

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Abstract

Disability adjusted life years (DALYs) lost can be thought of as “healthy years of life lost”. DALYs combine years of potential life lost due to premature death with years of productive life lost due to disability. They indicate the total burden of a disease, as opposed to the resulting deaths. Cardiovascular diseases are responsible for 10 % of DALYs lost in low and middle income and 18 % in high income countries. The incidence of coronary artery disease (CAD) is increasing in developing countries, partly as a result of increasing longevity, urbanization, and lifestyle changes. CAD burden is projected to rise from 47 million DALYs globally in 1990 to 82 million DALYs in 2020, of which 60 % would be from developing countries. DALYs lost per thousand population; age standardized estimates for 2002 for India is 20-29 and is amongst the highest in the world. A report by World Health Organisation (WHO) says that by the end of this century, India would account for more than half of the total heart patients in the world and majority of them would be in the younger age group. This highlights the need for early diagnosis and prevention.

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Introduction

Since 1990, more people have died from coronary artery disease (CAD) than from any other cause. While genetic factors play a part, 80-90% of people dying from CAD have one or more major risk factors that are influenced by lifestyle.

Death rates from CAD have decreased in Europe and North America due to improved diagnosis, treatment and prevention. It is expected that 82% of the future increase in CAD mortality will occur in developing countries. According to ‘The Atlas of Heart Disease and Stroke’ by the World Health Organisation (WHO) and the US Centres for Disease Control and Prevention (CDC), 3.8 million men and 3.4 million women worldwide die each year from CAD. Of these, India accounts for the highest number of deaths at 15,31,534, followed by China with 7,02,925 and Russian Federation with 6,74,881 deaths.

According to WHO, India would account for more than half of the total heart patients in the world by the end of this century [1] and majority would be from the younger age group. In India about 16% of the CAD patients are under 40 years of age, while similar incidence in western countries is only 4%. According to the US National Institute of Health, CAD is a disease of lifestyle the burden of which rests on the least active [2]. Many epidemiological studies have examined the association between physical activities and CAD risk.

Their findings have consistently shown that physically active men and women have half the risk of CAD as compared to sedentary patients. The benefit of exercise for CAD patients continues to be rediscovered and its utility has been extended to other heart diseases such as congestive heart failure.

A look at the risk factors for CAD (Fig.1) shows that acute interventions, including drug therapy, coronary artery bypass graft surgery and angioplasty do not modify the underlying causes of the disease. Unless patients make important lifestyle changes, these are palliative measures for treating CAD [3]. A lifestyle change and exercise is a cornerstone of a multifaceted plan for preventing and reversing CAD.

However exercise as therapy remains under utilised in patients with CAD. No data is available from India, but in western countries only 15% of the CAD patients are referred for exercise based cardiac rehabilitation programs [4], which rarely exceeds three months.

The major barriers to participation in exercise program are lack of physician referral, patient resistance and lack of access [5]. The reasons for these low referral rates are unclear, but it is felt that many physicians are uncomfortable recommending exercise.

Goals of Cardiac Rehabilitation Program

Exercise training for patients with CAD is generally referred to as cardiac rehabilitation, but exercise is really

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Fig. 1: Prevalence of risk factors for coronary heart disease and stroke. Sedentary lifestyle means no or irregular physical activity (fewer than three times a week or less than 20 minutes per session)

only one component of what is referred to as “post discharge intensive cardiac care”. This program aims at returning the patients with cardiac disease to their optimal physical, psychological, social, emotional, vocational, and economic status. The short term objectives include physical reconditioning, education on the disease process, and psychological support during the early recovery phase. The long term objectives include managing risk factors and teaching healthy life style that improves prognosis and physical conditioning for an early return to occupational activities.

Exercise training is a critical part of such a rehabilitative and secondary prevention program. Other components are aggressive dietary and pharmacologic treatment of serum lipids, smoking cessation, routine use of antiplatelet agents, selective use of anticoagulants, β blocking agents, angiotensin converting enzyme (ACE) inhibitors and health education. The American Heart Association have published comprehensive risk reduction strategies, which have been endorsed by the American College of Cardiology. These can be easily remembered as the ABCDEs of tertiary prevention [6].

‘A’ – Alpha tocopherol, antiplatelet agents, anticoagulants and ACE inhibitors.

‘B’ – β blockers, B vitamins and blood pressure control.

‘C’ – Cholesterol management

‘D’ – Diabetes mellitus and diet.

‘E’ – Exercise and estrogen replacement.

‘S’ – Social support, smoking cessation and stress management

Mechanisms for Decreased Risk of CAD through Physical Activity

Physical activity may reduce the risk of CAD through different mechanisms [7]. The direct action of physical activity on heart results in decreased myocardial oxygen

demand through improved myocardial contraction, electrical stability, increase in the diameter and dilating capacity of coronary arteries, increased collateral artery formation and reduced rate of progression of coronary artery atherosclerosis [8,9]. In addition high levels of activity are associated with low blood pressure [10], high levels of high density lipoproteins and lower levels of low density lipoproteins [11,12] and increased insulin sensitivity and glucose tolerance [13]. Other likely mechanisms are reduced tendency for platelet aggregation and increased fibrinolytic activity, possibly as a consequence of lower levels of plasminogen activator inhibitor-1 (PAI-1) [14]. Increased physical activity is also associated with decreased levels of homocysteine [15] and these individuals are less likely to be overweight.

The physiological basis of these beneficial mechanisms [16] would involve the understanding of the following concepts:

- Maximal O_2 uptake or VO_2 max:** The maximum capacity to utilize oxygen is defined as the person’s maximal oxygen uptake or VO_2 max. It is the product of maximal cardiac output and the maximal arterio-venous (AV) O_2 difference.
- External work rate:** The O_2 consumed by a physical task is referred to as the “external work rate”. It is also referred to as the absolute work rate or the absolute VO_2 . Identical external work rates require roughly similar oxygen uptakes among different individuals, despite clear differences in their exercise skills and efficiency. The external work rate determines the cardiac output response to the exercise task.
- Relative work rate:** The “relative work rate” refers to the percent of an individual’s VO_2 max that is required to perform a certain physical task. Despite differences in individual exercise capacity, the same physical task usually requires approximately the same absolute work rate for different individuals, but often requires markedly different relative work rates.
- Internal work rate - Myocardial O_2 demand** is referred as the “internal work rate”.

The various physiological mechanisms responsible for decreased risk of CAD through physical activity are illustrated diagrammatically (Figs. 2,3). Possibly some of the benefits of exercise in patients with CAD are mediated by ischaemic preconditioning. Ischaemic preconditioning refers to the observation primarily in animal models that brief periods of ischaemia before coronary occlusion reduces subsequent infarct size. Ischaemic preconditioning is important in cardiology since it is widely recognized as second only to early reperfusion

Fig. 2: Effects of exercise training on exercise performance in coronary artery disease patients

as a mechanism to protect the myocardium against ischaemic injury [16]. Exercise training also improves submaximal working capacity in patients with CAD. Many of these adaptations are related to changes in the exercised skeletal muscle. These changes include increased capillary density, increased muscle strength and increased mitochondrial size and function.

Studies have shown that exercise training can reduce the coronary artery vasoconstrictor response to exercise, thereby increasing the coronary blood flow but there is no evidence to show that exercise training can increase coronary collateral flow in patients with CAD or reduce the severity of stenotic lesions [16].

Cost Effectiveness of Exercise Based Cardiac Rehabilitation

Ades et al [17], compared medical expenses in 589 patients after myocardial infarction (MI) or bypass surgery who were ($n = 234$) or were not ($n = 355$) referred to a cardiac exercise program. Patients participating in rehabilitation programs had fewer hospital admissions and shorter hospital stays than those who did not, resulting in a savings of \$739 per patient per year. These benefits compare favourably with other accepted interventions such as thrombolytic therapy, coronary bypass surgery, and lipid lowering medications.

The primary risk of exercise training in patients with CAD are few. Cardiac arrest (1 event for every 1,12,000 patient hours of participation), myocardial infarction (MI) (1 event for every 2,94,000 patient hours) and death (1 event for every 7,84,000 patient hours) have been reported [18]. In supervised programs approximately 85% of patients suffering a cardiac arrest have been successfully resuscitated [18]. The increased risk is generally seen in exercise done at an intensity of $\geq 60\%$ of heart rate reserve and is higher in subjects with sedentary habits.

Fig. 3: Effects of exercise training on coronary artery vasodilatory capacity, coronary artery collaterals and stenosis.

The key to success is setting short term attainable goals for patients, such as small improvements in exercise tolerance, reduced angina, weight loss, smoking cessation, lowered blood lipids, improved blood pressure control, psychological well being and return to work.

Phases of Cardiac Rehabilitation

Phase 1 refers to an inpatient rehabilitation, which is mainly utilised for assessment of risk factors, the ability to carry out daily activities, activity counselling and education of the patient and the family. Phase 2 refers to the first 12 weeks of rehabilitation after a cardiac event or interventional procedure. Phase 3 refers to patients who have completed the initial 12 - 24 weeks but elect to remain in a supervised setting and Phase 4 refers to cardiac rehabilitation done at other places away from an organised rehabilitation centre.

Inpatient Program

During the first 48 hours, following MI and/or cardiac surgery, physical activity should be restricted to self care activities, arm and leg range of motion exercises and postural change. Simple exposure to orthostatic or gravitational stress, such as intermittent sitting or standing, may help in preventing deterioration in exercise performance that follows an acute cardiac event. The patient gradually starts walking for 50 to 100 feet, three times a day which can be increased to 250 to 500 feet, 3 to 4 times per day.

Outpatient Program

The outpatient program aims to return the patient to his vocational activity. The patient is helped in developing an exercise program that can be safely implemented at home. Patients should be encouraged to engage in multiple activities, including flexibility exercises and strength training in addition to the aerobic exercises, with a view to promote total physical conditioning.

Exercise for Aerobic/Cardio Respiratory Fitness

The exercise can be prescribed on the basis of the 'FITT' factors:

Frequency : In the early weeks of phase II cardiac rehabilitation, two exercise sessions in a week may be effective. This can be increased upto five times weekly.

Intensity : For most deconditioned cardiac patients, the threshold intensity for exercise training lies between 40-50% of heart rate reserve (HRR) (Table 1). For higher levels of training (phase III and IV) intensity is gradually increased to 80% of HRR under supervision. The rating of perceived exertion (RPE) (Table 2) provides a useful adjunct to heart rate as an intensity guide for exercise training. In the phase II of cardiac rehabilitation, exercise rated as 11-13 on the RPE scale is prescribed, which can be gradually be increased to rating of 15.

Time : The duration of exercise varies inversely with the degree of desired improvement in aerobic fitness. The recommended duration is 20 to 60 minutes of continuous or intermittent activity. The exercise duration can be broken into shorter periods of activity.

Type : The primary aerobic exercises are running, jogging, brisk walking, swimming, cycling etc. The endurance sports like racquetball (singles), tennis,

basketball etc constitute secondary exercises.

Exercise for Strength Training

Strength training improves muscular strength and endurance. The increased muscle mass leads to an increased basal metabolic rate (BMR), thus strength training complements aerobic exercise for weight control. It also attenuates the rate-pressure product when lifting any load, thus strength training appears to decrease cardiac demands during daily activities. Low and moderate risk patients should be encouraged to include resistance training into their physical conditioning program. During the inpatient phase most of the cardiac patients should begin with range-of-motion i.e. flexibility or stretching exercises for the upper and lower extremities. Low-level resistance training using elastic bands (exer-tubes or thera-bands) or very light (1 to 5 pounds) hand weights can begin in two to three weeks post MI phase. Once patients complete the convalescence stage, regular barbell, dumbbell and/or weight machines may be initiated. Surgical patients are encouraged to use range-of-motion i.e. stretching or flexibility exercises and very light (1 to 3 pounds) hand weights during convalescence and recovery. However, these patients should avoid traditional resistance training exercises, which may cause pulling on the sternum, within three months of sternotomy. Guidelines for sedentary adults, elderly people, and cardiac patients are given in Table 3.

Once the patient is able to perform more than the prescribed number of repetitions of an exercise comfortably, the weight should be increased by 5-10%. Once the patient has reached a stage where weight can not be increased any further, patient can add another set to his training program, depending on patient tolerance, if he intends to further improve his strength levels. Light aerobic exercises and stretching exercises can be performed during the warm-up and cool-down.

Flexibility exercises must be carried out with upto four repetitions per muscle group two to three days per week. It includes stretching the muscle beyond its normal length to the point of tension or slight discomfort, not pain. Hold the stretch for 30 seconds or longer (10-15 seconds stretch for warm up). The dynamic and static range-of-motion stretching should be assumed slowly and gradually. Flexibility exercises are best carried out as part of cooling down process.

The absolute contraindications for entry into inpatient and outpatient exercise training are unstable angina, resting systolic blood pressure >200 mm Hg, resting diastolic pressure >100 mm Hg, significant drop (≥ 20 mm Hg) in resting systolic blood pressure from average level, moderate to severe aortic stenosis, acute

Table 1

Determination of training heart rate (THR) using heart rate reserve method

Step 1

- Determine your age related 'maximum heart rate' or HRmax
 $HR_{max} = 220 - \text{Age}$

Step 2

- Determine the resting heart rate (HRrest)
- Determine the 'heart rate reserve' or HRR
 $HRR = HR_{max} - HR_{rest}$

Step 3

- Calculate 'training heart rate' or THR. Say at 60% of HRR
 $HRR_{60\%} = 60\% \text{ of } HRR + HR_{rest}$

Table 2

Borg category scale for rating of perceived exertion (RPE)

6	
7	Very, very light
8	
9	Very light
10	
11	Fairly light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very hard
18	
19	Very, very hard
20	

Table 3**Strength training guidelines for sedentary adults, elderly people, and cardiac patients**

Guideline	Sets	Repetitions*	Number of exercises	Frequency (days/week)
Healthy sedentary adults				
1990 ACSM position stand	1	8-12	8-10**	2
1995 ACSM guidelines***	1	8-12	8-10	2
1996 Surgeon general's report	1-2	8-12	8-10	2
Elderly people				
Pollock et al, 1994	1	10-15	8-10	2
Cardiac patients				
1995 AHA exercise standards	1	10-15	8-10	2-3
1995 AACVPR guidelines	1	10-15	8-10	2-3

ACSM = American College of Sports Medicine; AHA = American Heart Association; AACVPR = American Association of Cardiovascular and Pulmonary Rehabilitation

* For healthy people under age 50, weight should be sufficient to induce moderate fatigue with the number of repetitions listed. For older people, lighter loads may be used.

** Minimum one exercise per major muscle group (eg, chest press, shoulder press, triceps extension, biceps curl, pull-down [upper back], lower back extension, abdominal crunch/curl-up, quadriceps extension, leg curls [hamstrings], calf raise).

***1995 ACSM guidelines also included low-risk diseased populations.

systemic illness or fever, uncontrolled tachycardia (>100 bpm), symptomatic congestive heart failure, third degree heart block without pacemaker, active pericarditis or myocarditis, recent embolism, thrombophlebitis, resting ST segment displacement (>3mm), uncontrolled diabetes and orthopaedic problems that would prohibit exercise [19].

Conflicts of Interest

None identified

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