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Cardiac rehabilitation secondary prevention programs

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Contemporary trends

There has been considerable evolution in the 40-plus years since the first cardiac rehabilitation programs. Historically, cardiac patients were restricted to bed rest for up to 6 weeks. Eventually, it was noted that after myocardial infarction, in-hospital ambulation was not associated with an increase in adverse events, and was in fact beneficial. Formal outpatient programs were initiated in the 1960s, and consisted primarily of exercise therapy with continuous electrocardiograph (ECG) monitoring and intensive physician supervision [1]. More contemporary programs include risk factor modification, provide only limited exercise telemetry, and are overseen primarily by nonphysicians, including registered nurses, clinical exercise physiologists, and physical therapists.

Recent analysis of patient characteristics and trends demonstrates that more patients are participating in outpatient cardiac rehabilitation programs [2,3]. This increase is particularly significant for women and the elderly. The absolute number of patients entering rehabilitation after coronary artery bypass grafting (CABG) or percutaneous coronary intervention (PCI) has increased, with a particularly dramatic increase in the post-PCI subset [3]. There is a trend for increase in referral and participation of "high-risk" patients with significant comorbidities.

The increase in cardiac rehabilitation participation is likely related to a heightened awareness by physicians and patients of the importance of secondary prevention. The American Heart Association (AHA) and the American College of Cardiology (ACC) recently released secondary prevention guidelines to help physicians and clinicians in their efforts towards this end [4]. Exercise and other therapies (eg, nutrition) typically offered by cardiac rehabilitation programs play

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key roles in these recommendations. Whereas rehabilitation programs of the past focused primarily on exercise therapy, contemporary programs focus on all aspects of secondary prevention. A comprehensive cardiac rehabilitation program will offer clinical assessment and monitoring, supervised exercise, nutritional counseling, smoking cessation support, stress management, and attention to all important health behaviors of the patient [1,5–8]. Cardiac rehabilitation programs are increasingly recognized as an important adjunct to standard medical care, and are considered a cost-effective use of medical care resources [6].

Cardiac rehabilitation program design

Program personnel

Specific recommendations regarding cardiac rehabilitation program personnel can be found in the American Association of Cardiovascular and Pulmonary Rehabilitation (AACVPR) Guidelines for Cardiac Rehabilitation Programs [1]. In general, the following personnel are essential in the operation of a cardiac rehabilitation program:

Medical director

The medical director should be a cardiologist, internist, or other physician with interest and experience in the program; current licensure; experience in exercise testing, prescription, and counseling; and advanced cardiac life support (ACLS) or comparable emergency experience.

The medical director is responsible for assisting with establishing and approving all clinical practice guidelines. The medical director's role may vary in terms of physical presence and direct supervision. Ideally, the medical director will serve as an important consultant for the rehabilitation staff regarding patient care issues. For example, the medical director may provide the final word as to whether a complex patient can safely participate in the program. She may also provide input toward the clinical management of patients, including exercise progression and secondary prevention efforts. She may play the role of contacting the patient's referring physician if significant clinical issues arise.

Program director

Per the AACVPR [1], the program director is responsible for the overall development, planning, and operation of the program, and for ensuring that all policies and processes are appropriately implemented. Qualifications recommended by AACVPR include a bachelor's degree in an allied health field such as exercise physiology, or licensure (such as registered nurse or physical therapist), along with advanced knowledge of exercise physiology, risk-factor modification strategies, and other related areas, and a minimum of basic life support (with ACLS preferred). In addition, advanced certification (eg, American College of Sports Medicine Exercise Specialist) or specialty is desirable.

Core clinical staff

The core clinical staff usually includes registered nurses, clinical exercise physiologists, or physical therapists, all with appropriate education, experience, and licensure. Ideally, all clinical staff should hold current ACLS training and have the skills to meet the competencies recommended by the AACVPR [61].

The above staff working with patients on a day-to-day basis may have specific responsibilities based on their areas of expertise. Traditionally, program nurses provided clinical assessment, and exercise physiologists or physical therapists provided exercise prescription and supervision. With the trend toward more clinical training and certification for non-nurse personnel, exercise physiologists and physical therapists play a larger role in non exercise-related care of the patient. In addition, with the newer certifications for nurses that include specific training in exercise physiology, nurses are increasingly playing a larger role in aspects of care related to exercise. This blurring of roles can work very well for cardiac rehabilitation programs, provided emphasis is placed on appropriate education and training.

Because of issues related to emergency care, AACVPR recommends that at least two staff members with basic life support (BLS) be available at all times, and that at least one of these two have ACLS training [1].

Other staff

Other professional staff members may include registered dietitians, social workers, and psychologists to provide additional patient education and individualized therapeutic intervention. Operation of the program will also require clerical support staff to perform duties such as billing and insurance preauthorization.

Phases of cardiac rehabilitation

Most cardiac rehabilitation programs are designed to offer three or four phases:

Phase 1: inpatient

Phase 1 cardiac rehabilitation begins in the hospital, generally within 48 hours of bypass surgery or an acute myocardial infarction (MI), or within 24 hours of an admission for angina or percutaneous intervention [1,9–11]. Patients ready to begin in-patient therapy are stable, with no new or recurrent chest pain for the past 8 hours; no new signs of uncompensated heart failure; and no new significant ECG abnormalities in the past 8 hours [1]. Indications and contraindications for inpatient and outpatient cardiac rehabilitation are listed in Box 1 [9]:

The primary purposes of inpatient cardiac rehabilitation include: (1) activity progression; (2) education; (3) psychosocial support; and (4) discharge planning and referral. Progression of activity has important physiological benefits and also allows for assessment of the patient's tolerance to activities of daily living (ADLs) and light exercise. The physiological purposes include the prevention of orthostatic intolerance, prevention of thrombus formation due to blood stasis

Box 1. Clinical indications and contraindications for inpatient and outpatient cardiac rehabilitation

Indications

- Medically stable post-myocardial infarction
- Stable angina
- Coronary artery bypass graft surgery
- Percutaneous transluminal coronary angioplasty
- Compensated heart failure
- Cardiomyopathy
- Heart or other organ transplant
- Other cardiac surgery, including valvular and pacemaker insertion (including implantable cardioverter/defibrillator)
- Peripheral vascular disease
- High-risk cardiovascular disease ineligible for surgical intervention
- Sudden cardiac death syndrome
- End-stage renal disease
- At risk for coronary artery disease, with diagnoses of diabetes mellitus, hyperlipidemia, hypertension, etc.
- Other patients who may benefit from structured exercise or patient education (based on physician referral and consensus of the rehabilitation team)

Contraindications

- Unstable angina
- Resting systolic blood pressure of >200 mmHg or resting diastolic blood pressure >110 mmHg should be evaluated on a case-by-case basis.
- Orthostatic blood pressure drop of >20 mmHg with symptoms
- Critical aortic stenosis (peak systolic pressure gradient of >50 mmHg with an aortic valve orifice area of $<.75$ cm^2 in an average-sized adult)
- Acute systemic illness or fever
- Uncontrolled sinus tachycardia (>120 bpm)
- Uncompensated heart failure
- Third degree AV block (without pacemaker)
- Active pericarditis or myocarditis
- Recent embolism
- Thrombophlebitis

- Resting ST segment displacement (> 2mm)
- Uncontrolled diabetes (fasting blood glucose > 400 mg/dl)
- Severe orthopedic conditions that would prohibit exercise
- Other metabolic conditions such as acute thyroiditis, hypokalemia, hyperkalemia, hypovolemia, etc.

Adapted from Balady G, Berra K, Golding L, et al. In Franklin B, editor: ACSM's Guidelines for Exercise Testing and Prescription, 6th edition. Philadelphia, PA: Lippincott, Williams & Wilkins 2000; p. 166–7; with permission.

associated with bed rest, prevention of decline in physical fitness, and reduction in overall musculoskeletal stiffness and complaints. Activity is progressed from bed rest immediately to chair and self-care activities after 24 hours, to ambulation and even stair climbing before discharge. Orthostatic blood pressure should be checked with the first time out of bed. Patients may be considered for activity progression when activity responses include: a normal heart rate response (increase of 5–20 beats per minute from standing rest); adequate systolic blood pressure rise to within 10 to 40 mmHg from rest; no new rhythm or ECG changes; and no cardiac symptoms with activity [1]. Thus the cardiac rehabilitation staff will monitor heart rate, rhythm, and blood pressure response, and will carefully assess the patient for symptoms of angina, breathlessness, lightheadedness, or activity intolerance. Any signs or symptoms are reported to the medical team. If the patient tolerates supervised ambulation without abnormal signs or symptoms or an unsteady gait, he should be encouraged to exercise as he wishes two to four times per day until discharge.

The focus of inpatient education should vary as needed with the patient's immediate questions and concerns, but in general is comprised of: (1) a layman's definition of the development of coronary artery disease (CAD) and myocardial infarction; (2) proper response to cardiac symptoms; (3) risk factor modification strategies, including smoking cessation and nutritional counseling; (4) information regarding any tests and procedures the patient will undergo; and (5) discharge instructions for home activities, including resumption of sexual activity, return to work, and home exercise.

It can be argued that in-patients retain very little of the teaching they receive because of being overwhelmed by their experience and the sheer numbers of professionals with whom they come into contact. An equally compelling counterargument, however, takes the stance that inpatient teaching provides a unique window of opportunity to influence patients, as they are more likely to be motivated to change (the "scare factor") [1].

The psychosocial component of inpatient cardiac rehabilitation may include emotional support by the rehabilitation staff, referral to other disciplines (eg, social work), or consultation with the patient's immediate family members.

Phase 1 cardiac rehabilitation plays a large role in discharge planning and referral issues. The rehabilitation staff should provide education and information about outpatient cardiac rehabilitation programs, including the process for enrolling, and may also help to facilitate outpatient follow-up appointments.

If phase 1 cardiac rehabilitation has been successful, the patient should be discharged with an enhanced understanding of all issues related to his heart condition and should be able to tolerate activities of daily living without signs or symptoms of cardiac compromise.

Phase 2: outpatient—monitored cardiac rehabilitation

Patients are encouraged to begin phase 2 cardiac rehabilitation as soon as possible postdischarge, largely because of the clinical assessment, cardiac teaching, and emotional support they will receive. Participation may be delayed due to insurance preauthorization or postdischarge medical complications (eg, recurrent angina or heart failure), but otherwise the goal should be early entry. This philosophy represents a shift from previous thinking, in which patients did not begin rehabilitation until 6 weeks after their event or surgery. This shift is due to increased awareness of the safety of cardiac rehabilitation[1,9,12–15], and is partly related to enhanced services provided by rehabilitation programs regarding secondary prevention, and partly related to the fact that many cardiac patients return to work within 2 to 6 weeks of hospital discharge.

Patients entering phase 2 should have a referral from their cardiologist or primary care physician. The referral includes diagnoses and other relevant history and indicates the need for phase 2 services. The referral may also include orders for pre-entry stress testing or other measurements. The physician referral is required for insurance reimbursement [16]. Medicare will reimburse physician-supervised monitored cardiac rehabilitation services for the following diagnoses: (1) acute MI within the preceding 12 months; (2) coronary artery bypass grafting; or (3) stable angina [16]. Insurance reimbursement for other providers varies considerably; pre-authorization is usually required.

Phase 2 cardiac rehabilitation includes continuous ECG monitoring by telemetry. A physician is readily available in the event of an emergency, but may not be actually present in the exercise room (ie, it is acceptable that the physician be down the hall, but not out of the building) [16]. The maximum recommended patient-to-staff ratio is 5:1, secondary to the greater acuity of these patients [1]. Education is provided as an important component of the phase 2 program. Patients typically remain in this phase for 6 to 36 sessions. The need for continuous ECG monitoring, and for what duration, remains controversial, and is often influenced by insurance reimbursement.

A primary goal of phase 2 cardiac rehabilitation is to improve exercise tolerance, focusing primarily on endurance and flexibility. Population-specific goals are addressed later in this article. In general, a typical session will include an active warm-up, a period of endurance exercises, an active warm-down, and a period of stretching. Strength exercises may be incorporated, beginning with light hand weights or therabands. Traditional weight lifting should be avoided for at least 3 months for postsurgical patients, and for 4 to 8 weeks following myocardial infarction [17].

Phase 3: outpatient—nonmonitored cardiac rehabilitation

Phase 3 cardiac rehabilitation has historically been referred to as "maintenance rehab" for patients who have completed phase 2 and wish to remain in a medically supervised setting. With the decline in insurance reimbursement, however, many patients do not participate in phase 2, and instead directly enter the phase 3 program. Phase 3 is very rarely reimbursed by insurance. The patient may receive periodic telemetry, but it does not occur at every session. A physician may be readily available, but presence is not required. Patients are supervised by rehabilitation staff and receive ongoing support, education, and exercise progression.

Phase 4: adult fitness

Phase 4 cardiac rehabilitation has traditionally meant adult fitness programs, or those that are less medically supervised than in phase 3. Patients in phase 4 programs may be primary prevention patients, or may be stable cardiac patients who have previously participated in phases 2 and 3. Phase 4 programs differ tremendously in scope of service. Some programs offer care identical to phase 3 programs, whereas other programs are more consistent with the level of screening and supervision received at non medically-based health clubs.

Triage to non medically-supervised programs

Because exercise is quite safe for most cardiac patients [1,9,12,18], and because insurance reimbursement is typically limited to less than 3 months, patients have often been triaged to phase 4 community-based programs or home programs after a specified amount of time in phase 2 or 3. A recent study reported that significant improvements in relevant cardiac rehabilitation outcomes can continue or be maintained when length of rehabilitation participation is extended past 3 months [19]. For example, although improvements in physical activity were noted early, improvements in mental health parameters were not noted until later in the rehabilitation course. This study highlights the fact that cardiac rehabilitation outcomes are achieved at different time points during the course of participation, providing additional evidence that limiting participation to 3 months may not be in the best interest of the patient.

In addition to the fact that health outcomes occur in different time frames, it should be remembered that heart disease is a progressive disease. The patient who is stable one month after percutaneous intervention may develop symptoms at 6 months.

Thus, an alternative approach takes the stance that, because heart disease is progressive, outcomes are achieved at different rates, and compliance to secondary prevention decreases when patients leave structured programs, cardiac patients should be encouraged to remain in medically supervised programs for longer periods or indefinitely. The advantages to this approach include ongoing exercise supervision, careful monitoring of disease progression, social and emotional support, evaluation of secondary prevention, communication back to the patient's physician, and the ability of the medical center to keep patients within the umbrella of their health care system. The primary disadvantage is that the patient is likely paying out of pocket for these services, so they must be affordable.

Preparticipation screening—stress testing

The use of stress testing before cardiac rehabilitation participation is controversial. The American College of Sports Medicine recommends that all individuals with known cardiovascular disease or diabetes be evaluated by a physician and undergo exercise stress testing before beginning vigorous exercise, though the physician may waive the test if the patient has had other testing (eg, angiography) [9]. The importance of preparticipation stress testing and annual retesting is promoted in the 2001 American Heart Association Exercise standards for testing and training [10]. The 1997 American College of Cardiology guidelines for exercise testing [20] list exercise stress testing as a class 1 recommendation after myocardial infarction for the purposes of: (1) predischarge prognostic assessment; (2) early after discharge for prognosis, activity counseling, evaluation of medical therapy, and cardiac rehabilitation if the predischarge test was not done; (3) late after discharge for prognostic assessment, activity prescription, evaluation of medical therapy, and cardiac rehabilitation if the initial test was submaximal. Exercise testing is a class 2a recommendation for activity counseling/rehabilitation in patients who have undergone revascularization, and is a class 2b recommendation predischarge for patients who have undergone angiography for evaluation of ischemia in the distribution of a lesion of borderline severity, for patients who have baseline ECG abnormalities (ie, LBBB, pre-excitation, LVH, digoxin therapy, resting ST depression greater than 1 mm, pacemaker), and as periodic monitoring for patients who continue to participate in cardiac rehabilitation.

The exercise stress test provides useful information for development of the patient's exercise prescription, including his maximal heart rate and workload, his blood pressure response to heavy exertion and whether or not he develops symptoms, ECG changes, or other abnormalities with exercise [10]. The preparticipation stress test may guide the need for changes in medical therapy. In addition, it provides important prognostic information. In male subjects who have an exercise capacity of less than five metabolic equivalents (METS), risk of death is roughly double that of subjects whose exercise capacity is more than eight METS [21].

A recent retrospective analysis revealed that cardiac rehabilitation could be initiated and delivered safely for post-MI and post-CABG patients without an exercise test [22]. The authors recommend that certain subgroups be given serious consideration for a pre-entry stress test, however, including those who are symptomatic with exertion, have exercise-induced rhythm disturbances, have unknown severity of disease, or who plan to return to heavy occupational or recreational activities. Thus, it is difficult to execute an inflexible "test required" or "no test required" policy, because this decision is more prudently made on an individualized basis.

The patient's physician should consider the following when determining the need for and timing of exercise testing:

Are there concerns about the patient becoming ischemic with exercise, such as in the case of the patient with inoperable CAD who is being medically managed? If so, the test will help guide both exercise therapy and medical therapy so that the patient can remain below an ischemic threshold.

Are there concerns regarding exercise-related arrhythmias? An exercise test may help guide appropriate evaluation and management.

Will scheduling the test defer the patient being able to get started in rehabilitation? If so, is this counterproductive to the patient's recovery?

Would better information be obtained from the test at a later date when the patient is not acutely deconditioned from his hospitalization? If so, the patient could begin rehabilitation at low levels (ie, standing rest heart rate >20 bpm or rating of perceived exertion [RPE] < 13), completing a test 4 to 8 weeks later.

Exercise prescription in cardiac rehabilitation

Warm-up

A gradual and progressive warm-up improves performance in patients with coronary artery disease [9,10,13,23–25]. There are several proposed mechanisms for this improvement. Most recently, investigation has sought to determine whether the warm-up phenomenon might be related in part to ischemic preconditioning [25]. Although the exact mechanism of the warm-up phenomenon remains unknown, it is clear that a period of physical preparation both enhances performance and increases safety.

Exercise should be preceded by a warm-up period of 5 to 10 minutes. One method of warming up is for the patient to perform a prescribed mode of exercise at a lower intensity (eg, walking on a treadmill at 2–2.5 mph for 10 minutes before beginning his usual program of treadmill walking at 3.2 mph). As a general guide, heart rate should rise during warm-up to within 20 beats per minute of the lower end of the target heart rate range [9,10].

Aerobic and strength training prescription

Exercise prescription is related to four primary factors: intensity, frequency, duration, and type, and may be further broken down into aerobic (endurance) exercise and strength exercises.

intensity

There are several models for providing prudent exercise intensity guidelines for cardiac rehabilitation patients:

Heart Rate: exercise prescription for endurance exercises may be based on heart rate. The premise behind this is explained in detail elsewhere [9].

If a patient has had a maximal stress test, the heart rate from this test, along with resting heart rate, can be used in the Karvonen equation to generate a training heart rate range. For cardiac patients, the American College of Sports Medicine (ACSM) [9] recommends a training intensity of 45% to 85%. Below is an example of a target heart-rate range calculation:

Maximal heart rate from GXT: 130 bpm

Resting heart rate: 60 bpm

$$130 - 60 = 70(\text{heart-rate reserve})$$

$$70 \times .45 = 32 + 60(\text{resting heart rate}) = 92$$

$$70 \times .85 = 60 + 60(\text{resting heart rate}) = 120$$

$$\text{Training heart-rate range} = 92 - 120 \text{ bpm}$$

Important caveats related to use of target heart rate. The use of beta-blockers or other heart-rate altering drugs does not affect the ability to use the maximal heart rate from the exercise test, assuming the patient was on the medication at the time of the exercise test and that the dose does not change after the test [9–11].

Angiotensin converting enzyme (ACE) inhibitors, angiotensin 2 blockers (ARB), and diuretics do not alter heart-rate response and therefore changes in dose should not limit the ability to use heart-rate range with these drugs. The heart-rate response with calcium channel blocking drugs is variable. Some, including verapamil and diltiazem, reduce heart rate, and thus addition, withdrawal, or dosage change of these drugs will negate the use of the exercise test heart rate.

The test heart rate should not be used for exercise prescription if the patient undergoes a pharmacologic test rather than an exercise test.

If the patient demonstrates a significant abnormality on the stress test, such as chest pain, significant EKG changes, or a reversible perfusion defect on the nuclear scan, then the upper limit of the target heart rate range should be at least 10 beats per minute below the heart rate in which the abnormality occurred [1,9–11].

Calculating the heart rate range from a treadmill or bike test will result in an overestimation of the prescribed heart rate for arm-only exercises, such as the arm crank; however, this range should be appropriate for combined arm-leg exercises, such as rowing [9].

If the patient undergoes revascularization after the stress test, the test will not be helpful in determining the exercise prescription.

If the patient has not had a recent maximal stress test, standing rest heart rate >20 beats per minute may be used early after myocardial infarction. For post-CABG patients, standing rest >30 beats per minute is the recommended guide for early rehabilitation [9,11]. These ranges will likely be appropriate only for the initial weeks of rehabilitation, at which time a stress test should occur to update the target heart rate range, or this method of prescription should be waived.

MET level/percentage of VO_2. If the patient has had a recent stress test, then maximal work load achieved on the test can be used to develop an exercise prescription. Unless oxygen consumption was directly measured, maximal work load is usually expressed in METS.

The most accurate method of calculating exercise prescription based on oxygen consumption factors is estimated resting oxygen consumption. This is called VO_2 reserve (VO_2R). The use of $\%VO_2R$ rather than $\%VO_2max$ is recommended for cardiac patients and healthy adults [26,27].

Thus, the maximal METS should be used as the maximal heart rate was used:

$$\text{MET level achieved on test} = 8$$

$$\text{Resting MET} = 1$$

$$8\ \text{METS} - 1\ \text{MET} = 7\ \text{MET reserve}$$

$$7\ \text{METS} \times .45 = 3.2\ \text{METS} + 1\ \text{MET} = 4.2\ \text{METS}$$

$$7\ \text{METS} \times .85 = 6\ \text{METS} + 1\ \text{MET} = 7\ \text{METS}$$

$$\text{MET prescription}: 4.2 - 7\ \text{METS}$$

The MET prescription is used to guide exercise protocols by calculating workload on the exercise modalities the patient will use. Metabolic equations for use in calculation may be found in the ACSM Guidelines for Exercise Testing and Prescription [9]. In addition, most manufacturers of exercise equipment provide tables to aid in these calculations.

Important caveats related to use of METS for exercise prescription. The maximal MET level achieved on the exercise test is most accurate if the patient undergoes an oxygen consumption test in which expired gases are measured. This type of testing is only recommended if exact measures are indicated, however, such as in the classification of heart failure or in a research setting.

Thus, most patients will have an estimated maximal MET level. Estimated maximal METS are based largely on time spent on the treadmill, so patients allowed to hold on to the front of the treadmill during the test will be able to stay on longer, and therefore the maximal workload achieved will be overestimated [9,10]. If the patient has a pharmacologic test, then there is no MET level for use in exercise prescription.

Ratings of perceived exertion. The subjective rating of perceived exertion (RPE) scale is a valuable tool for exercise prescription, either in conjunction with heart rate or in place thereof (ie, for patients who have not undergone exercise testing). The RPE is a composite of central factors (eg, breathing) and peripheral factors (eg, muscular fatigue) [9,10].

The most commonly taught rating of perceived exertion scale uses a 6 to 20 numerical rating score. Exercise rated as a 11 to 13 (fairly light to somewhat hard) generally corresponds to the upper limit of exercise prescription early in the rehabilitation course (phase 2). Ratings in the range of 15 (hard exercise) may be used later in the rehabilitation course. (phases 3–4) [9,10].

Other scales that may be useful in altering the exercise prescription for certain patients include the claudication scale, the angina scale, and the dyspnea scale [9,10].

In summary, the prescribed exercise intensity should be below the level of exercise known to elicit symptoms of angina, the development of significant ECG abnormalities, an abnormal systolic blood pressure response (ie, a failure to rise or hypotension), or hypertension (systolic blood pressure >240 mmHg or diastolic blood pressure >110 mmHg) [9,10].

Frequency

Cardiac patients are encouraged to exercise a minimum of three days per week with a preferred guideline of "most days of the week". This is particularly important for those who are deconditioned, as these patients are performing at low intensity and duration. Exercising most days of the week will provide increased benefits, provided care is taken to avoid overuse injuries. Injury can usually be avoided by progressing exercise frequency slowly, cross-training, and wearing supportive shoes [9,10].

Intensity versus duration

There is an interrelationship between all of the exercise prescription parameters, but particularly between intensity and duration. Higher intensity exercise of shorter duration may be better than lower intensity exercise of longer duration for achieving certain health and fitness goals, including improvement in maximal exercise capacity [27]. There have been concerns that higher intensity exercise might adversely affect left ventricular remodeling after a myocardial infarction, but a recent study did not find an adverse effect on left ventricular remodeling with moderate to high intensity exercise [28]. Nonetheless, because high intensity exercise appears to decrease safety and increase risk for cardiac patients, duration may be emphasized over intensity, particularly in the rehabilitation phase [10].

As a general rule, patients will perform at least 20 minutes of sustained aerobic exercise, not including warm-up and cool-down. With time, most patients exercise for 30 to 60 minutes.

Even though cardiac patients should have an absolute set of parameters to guide their exercise program and to ensure safety, they should be encouraged to manipulate intensity and duration to avoid becoming complacent and bored with performing the same routine each day. They should also be encouraged to modify the exercise prescription based on how they feel each day. For example, a patient who feels fatigued due to a poor night's sleep should be encouraged to "listen to the body" and cut back as needed, rather than feel compelled to perform the exact protocols he might normally perform.

Type

Type of aerobic exercise refers to the specific modality or activity. There are pros and cons to each type. When choosing which modalities or activities a patient will perform, the following should be considered:

Is it safe for the patient? Should the patient do the treadmill if he has balance problems, or would he be better served by walking around a track?

Are the inherent demands of the exercise type too intense for the patient based on his exercise stress test? Metabolic requirements of jogging are typically >8 METS. This mode of exercise should be ruled out for patients with a lower exercise capacity.

Does it help the patient meet his goals? Those patients who also have osteoporosis, for example, will be best served by performing weight-bearing exercises, such as stair climbing, walking, or jogging.

Is the exercise likely to aggravate another medical problem? Patients with osteoarthritis may do better with non weight-bearing exercises, such as the stationary cycle.

Are there specific goals related to the patient's occupation? A carpenter will need to focus more heavily on upper body exercise, such as the arm crank or arm bike, as compared with a worker who does not perform physical labor of this nature.

Does the patient like the exercise modality? Listening to patients' likes and dislikes may enhance their commitment and compliance.

Strength training

Previously, cardiac patients were prohibited from strength training because of safety concerns. Numerous studies have since confirmed the safety of strength training for cardiac patients, and it has thus become a widely accepted mode of exercise in rehabilitation programs [17,29]. In addition to improving muscular strength, endurance, and flexibility, strength training can improve bone mineral density, reduce falls and fracture, and increase the patient's ability to remain independent with ADLs. In addition to these benefits, strength training offers enhanced modification of certain health issues, such as improved glycemic control in diabetics.

General guidelines and considerations for strength training in cardiac patients include these [17,29]:

- Post-MI patients should defer traditional weight training for at least 4 weeks, and postsurgical patients for at least 3 months (to allow proper healing of the sternotomy incision). Before this, light dumbbells or therabands may be used.
- Once the traditional weight training program is initiated, 1 to 3 sets of 10 to 15 repetitions should be safe and effective for most cardiac patients. It should be noted that the majority of muscular strength gains are incurred with the progression from no weight training to just one set per exercise; thus, those patients who feel that they are short of time may have better compliance—and most of the gains—by being guided towards a single set weight training program.
- Performing single-limb exercises will cause less cardiac demand and a lower blood pressure response than performing double-limb exercises.
- Upper and lower body exercises should be performed.

Cool-down

A gradual cool-down is very important in preventing postexercise complications, such as hypotension and arrhythmias. Patients should be instructed to spend several minutes exercising at low intensities (eg, slow walking) to allow heart rate to reduce to near baseline levels. At this point, stretching exercises may begin. Patients should be counseled against straining or holding their breath during stretching. Generally, full-body stretches, held for 15 to 30 seconds each, are recommended [1,9,13].

Population-specific exercise guidelines

Postsurgical patients

Postsurgical patients should begin range-of-motion exercises within 48 hours of surgery, and these exercises should continue in the convalescence period. Representative exercises include the "corner stretch," squeezing the elbows together in front of the body for 10 to 20 repetitions, and reaching up over the head [17,29]. These patients should avoid vigorous aerobic exercises using the upper body, such as rowing and arm biking, until they have received surgical clearance. Postoperative patients may begin light hand weight and or therabands after surgical clearance, but should defer traditional weight training for 3 months to allow for proper healing of the sternum [17,29].

Heart failure patients

There is no consensus regarding the most appropriate level of intensity for patients with congestive heart failure (CHF). Prescription should take into consideration the underlying pathology of heart failure, the patient's physiological response to exercise, and data from stress testing [30]. A recent update [31] suggests that because CHF patients have an impaired force-frequency relationship in myocardial performance, indicating a decrease in cardiac index with increasing heart rate, heart rate should be kept low. However, many studies have shown that exercise using the standard 45% to 85% of VO2max/heart rate reserve (HRR) is safe for CHF patients [10,11,30]. An RPE of <13 for these patients is prudent, and use of the dyspnea scale is recommended. Very deconditioned patients (maximal exercise capacity <3 METS) may need to use short intervals of activity several times per day [11]. Those with higher functional capacities may be able to exercise at the more typical level of three to five times per week for roughly 30 minutes.

More important than an arbitrary numerical recommendation based on either heart rate or RPE is the principle that exercise training must be diligently monitored and terminated for abnormalities such as serious rhythm disturbances, onset of angina or extreme dyspnea, or an acute decrease in blood pressure [31]. Rehabilitation staff should remember that the status of these patients can change quickly from well-compensated to uncompensated, and that uncompensated heart failure is an absolute contraindication for exercise training (see the list of indications and contraindications for cardiac rehabilitation above). Heart failure patients represent a clinical challenge because they have a greater tendency towards serious arrhythmias, their status can be "tipped" easily by dietary or medication noncompliance or a minor illness, and many will deteriorate despite appropriate exercise and medical therapy.

Peripheral arterial disease patients

Studies indicate that to specifically benefit the symptoms of claudication, the exercise program should focus on walking to a point of maximal tolerable pain [32]. The patient should rest or decrease intensity once the discomfort becomes maximal, and return to this level again once able. It should be noted that although this program is best for improving claudication, it should be weighed against the fact that patients are more likely to drop out of an exercise program when asked to endure discomfort, and may be unable to exercise enough to favorably impact other health factors. Thus, it is generally recommended that the program include exercises that specifically benefit claudication (ie, walking) but also those more easily tolerated by the patient (ie, cycling) [10,32].

Patients with chronic atrial fibrillation

Patients with chronic atrial fibrillation should not use target heart-rate range for exercise prescription. Atrial fibrillation patients on sodium warfarin (Coumadin) should take special care to prevent falls and should avoid contact sports. Patients with chronic atrial fibrillation should be frequently assessed regarding their rate control with exercise.

Post heart-transplant patients

These patients should follow the same guidelines as other surgical patients for the use of upper extremity exercise. Due to denervation, they will have an elevated resting heart rate and a delayed and sluggish exercise heart rate. The magnitude of this abnormality is greatest soon after surgery and is less pronounced at one or more years post-transplant [33].Warm-up should be prolonged to allow the body time to raise heart rate through circulating catecholamines. To assess recovery following a bout of exercise, systolic blood pressure is a better indicator than heart rate alone [11]. Most of these patients are quite deconditioned and may need work/rest intervals. Due to presurgery inactivity and the use of immunosuppressants and corticosteroids, these patients are particularly susceptible to bone loss and muscle atrophy, so strength training and weight-bearing aerobic exercise are important and may be particularly beneficial.

Hypertensive patients

Hypertension should be adequately controlled before initiating exercise training. In general, patients with a resting systolic blood pressure of >200 mmHg or a resting diastolic blood pressure of >115 mmHg should not be allowed to exercise [1,11].

Patients with hypertension should perform moderate intensity exercise of 40% to 70% VO_2max (rather than high intensity exercise), at least until their blood pressure control has improved, as more moderate intensities appear to be as good or better than higher intensity exercise for the purpose of blood pressure reduction [11]. Weight training can be initiated once blood pressure is under adequate control, but it should be in addition to (not in place of) aerobic exercise. Single-limb exercises are preferred, due to the lower blood pressure rise [17,29].

Diabetic patients

Diabetic patients should follow safety parameters according to clinical practice guidelines of the American Diabetes Association [34]. These include measurement of pre- and postexercise blood glucose. Associated diabetic complications must be known and considered in the exercise prescription. Specific guidelines for exercise prescription are available to help guide the program for patients with autonomic or peripheral neuropathy, retinopathy, or nephropathy [9,11]. General safety recommendations include avoiding high intensity exercise, heavy weight training, and the valsalva maneuver in those with proliferative retinopathy; minimizing weight-bearing exercise in those with peripheral neuropathy; and providing a temperature-controlled environment for those with autonomic neuropathy. It should be remembered that many diabetic patients have silent ischemia, vascular disease, or an elevated risk for cardiac arrhythmias.

Dyslipidemic patients

There is a dose-dependent, lipid-lowering effect of exercise. Exercise of higher intensity, longer duration, and increased frequency will have a larger impact on dyslipidemia [7,10]. Some experts recommend daily exercise for maximal lipid-altering benefit. Aerobic exercise training has a larger impact on lipids than does weight training [35].

Obese patients

Obese patients should emphasize non weight-bearing exercise or low impact weight-bearing exercise due to the common issues of joint pain and arthritis in this subgroup. Equipment modification such as wider exercise cycle seats may be necessary. Caloric expenditure is of major importance and can be accomplished by manipulating intensity, frequency, and duration of exercise as well as increasing activities of daily living. Although increased intensity may result in maximal weight loss, it may not be worth the risk of injury. In addition, higher intensity exercise has a higher level of attrition. Weightlifting is beneficial as a complement to aerobic exercise training, but should not replace the aerobic exercise program [11].

Elderly patients

Elderly patients are more likely to have poor functional fitness, decreased muscular strength, decreased bone mineral content, limited flexibility, impaired eyesight, poor balance, isolated systolic hypertension, cerebral vascular disease, and a host of other comorbidities and health concerns [10,11,36,37]. The exercise program should be modified accordingly, with careful minimization of safety risks.

The goals for exercise training include reducing fall risk through the development of increased strength, flexibility, and balance. As such, weight training or theraband exercises will provide an excellent complement to the aerobic exercise program. Initial resistance should be light, with a gradual and careful progression towards a resistance that can be lifted 10 to 15 times. Participation in activities that increase socialization is recommended to combat isolation and depression [10,11,36,37].

Other patients

In addition to the above medical issues, it should be realized that many patients also suffer from other disorders that may effect the exercise prescription; therefore, the exercise prescription must take into account and balance all relevant issues, providing a program of maximal safety and benefit. Many of these common conditions and their subsequent effects on the exercise program are detailed in the ACSM's Exercise Management for Persons with Chronic Diseases and Disabilities [11].

Contemporary cardiac rehabilitation programs: more than just exercise

Over the past decade the trend in cardiac rehabilitation programs has been towards comprehensive secondary prevention. A recent American Heart Association/American Association of Cardiovascular and Pulmonary Rehabilitation (AHA/AACVPR) Scientific Statement lists core components of cardiac rehabilitation programs, providing specific information regarding evaluation, intervention, and expected outcomes [8]. These recommendations provide referring physicians and health insurers important information regarding the expected scope of practice of a comprehensive rehabilitation program, and help to guide program staff in the organization and development of their programs.

Comprehensive cardiac rehabilitation programs are expected to provide a scope of practice that includes [6,8,38]:

Clinical assessment
Nutritional counseling
Lipid management
Hypertension management
Smoking cessation
Weight management
Diabetes management
Psychosocial services
Activity counseling and exercise prescription

The collective goal of these services is to provide the patient with an individualized plan of care, in concert with the referring physician.

Benefits of comprehensive cardiac rehabilitation

The benefits of a comprehensive cardiac rehabilitation program are many, including a 25% reduction in all-cause and cardiac mortality at three years [39–41]. Because rehabilitation programs combine exercise therapy, nutritional counseling, greater attention to health issues, and other interventions, it is often difficult in clinical trials to determine the independent effects of each component. A recent trial [35] examined the effects of exercise training alone in cardiac rehabilitation, and found only minimal effects of this isolated intervention—it resulted in a large increase in exercise capacity, but only a modest improvement in high-density lipoprotein (HDL) cholesterol, triglycerides, and body composition after 3 months, with no significant improvement in glucose, insulin, or low-density lipoprotein (LDL) cholesterol. Though this study was of short duration, failed to include a control group, and had other methodological concerns, it does add more weight to the notion that maximal benefits of cardiac rehabilitation are incurred when programs offer comprehensive secondary prevention interventions. Nonetheless, exercise alone does provide certain benefits.

Improved strength, fitness, and appearance

Exercise capacity is improved, as measured by pre- and post-training maximal graded exercise testing, an increased level of exercise before the development of cardiac symptoms or other abnormalities, and patient reports of improvement in ability to carry out activities of daily living [1,8,9,13,42]. The improvements are related to both central (cardiac) and peripheral (skeletal muscle and vascular) factors, including improved oxygen extraction and increased capacity to deliver substrate to cardiac and other muscles [10,24]. Cardiac adaptations include increases in cardiac dimensions, stroke volume, cardiac output, and after-load corrected indices of left ventricular function [24]. Vascular adaptations include increased skeletal muscle capillaries, and improvements in endothelial function [24,43]. Skeletal muscle adaptations include increased fiber area and oxidative-enzyme activity [1,8–11,13,17,29,43]. Muscular strength and flexibility is improved, and decreased bone mass is avoided or delayed. These benefits, plus improved balance, result in a decreased fall and fracture rate [9,11,17,29]. Body composition is also improved by maintenance of lean mass and reduction in fat mass [9–11].

Other cardiovascular benefits

There is protection against coronary artery disease due to anti-atherogenic effects, probably related to the effect of exercise on coexisting risk factors, including: (1) a 5 to 10 mmHg reduction in blood pressure that may last up to 22 hours after exercise [8–11,13,42,44]; (2) an improvement in insulin sensitivity [11,34,45]; and (3) a favorable alteration in the lipid profile that includes a significant reduction in triglycerides, a modest improvement in HDL, and a shift in LDL particle size from small, dense to large and fluffy [7,35,46].

There are antithrombotic effects, as evidenced by an altered fibrinolytic system, including increased endogenous tissue plasminogen activator and a decreased plasminogen activator inhibitor-1 [10,24,47].

There is endothelial function alteration, as suggested by sensitized arterial response to adenosine [10,43,48].

Autonomic functional changes occur, as demonstrated by improved heart rate variability after training [10,12,21,49,50].

There are anti-ischemic effects, likely in part due to a lower myocardial oxygen demand at submaximal workloads [10,13].

There are anti-arrhythmic effects, with decreased risk of ventricular fibrillation in habitual exercisers, probably related to decreased myocardial demand, reduced sympathetic tone, and attenuated catecholamine release [10,18,49].

It should be noted that the optimal dose of exercise necessary to create a positive effect on many of the above factors is unknown but is currently under investigation in the Studies of a Targeted Risk Reduction Intervention through Defined Exercise (STRRIDE) trial [51].

Dietary benefits

Benefits of nutritional counseling will vary with the compliance of the patient as well as the actual diet promoted. In general, nutritionists in cardiac rehabilitation will promote a diet that lowers saturated fat, trans fatty acids, and dietary cholesterol; increases fiber through increased intake of whole grains, fruits, and vegetables; and is balanced in calories [52]. Other modifications may include a reduction in sodium intake (heart failure and hypertensive patients) and supplementation with folic acid, omega 3 fatty acids, or stanol/sterol margarine. Several diets are noteworthy for their beneficial effects on cardiac disease risk factors, including very low fat diets [53] (such as Pritikin or Ornish), and the Mediterranean-style diet [54].

The primary benefits of dietary changes are:

- Improved lipid profile: improvements in LDL can be dramatic (eg, with the Ornish plan). Triglycerides will be lowered, with extra benefit seen through portion control and moderation of alcohol consumption. HDL can be effectively raised by diets like the Mediterranean-style diet, which substitute monounsaturated fat for saturated fat [52–54].
- Improved blood pressure, particularly with diets that encourage increased servings of fruits, vegetables, whole grains, and low fat dairy, while restricting sodium [52]
- Improved glucose/glycemic control, particularly with diets that emphasize increased fiber consumption [52]
- Improved body composition/weight maintenance [52]
- Improved homocysteine, with a diet high in B-vitamins or supplementation of folic acid [52]

In addition to the above, dietary changes that include supplementation of omega 3 fatty acids or increased fish consumption may decrease risk of sudden cardiac death and all-cause mortality [52].

Other benefits

Other cardiac rehabilitation interventions, such as smoking cessation, stress management, and social support also play a role in improving the patient's life. In addition, cardiac rehabilitation participation, probably due to all of the typical interventions, results in decreased depression and trait-anxiety, and an improved quality of life. A recent study reported that cardiac rehabilitation resulted in substantially improved quality-of-life indicators, especially for women [19]. This is particularly noteworthy, as previous studies have shown that women are at greater risk than men for psychosocial impairment following a cardiac event [55].

Thus, the expected outcomes of participation in a comprehensive cardiac rehabilitation program are compelling arguments for their use. There is no question that such a program can help the patient meet the recommendations provided in the AHA/ACC Guidelines for Preventing Heart Attack and Death in Patients with Atherosclerotic Cardiovascular Disease [4]. For example, a study by Ades et al revealed that cardiac rehabilitation participants had a threefold increased rate of achieving LDL goals when compared with patients not participating in rehabilitation [7].

Experts state that the most effective method of carrying out secondary prevention as described above is to use case management [7,38]. A single individual, usually a nurse or exercise physiologist, is assigned as the case manager for a group of patients. This individual works within the context of medical supervision by the patient's referring physicians and the program medical director. The advantages of this style have been demonstrated when comparing case management with usual care, with greater improvements in exercise capacity, rates of smoking, and achieving LDL targets. It is sensible to promote this concept in cardiac rehabilitation programs, allowing for a more targeted and coordinated effort of secondary prevention.

However the above health outcomes are achieved, there seems to be expert endorsement of the transition of cardiac rehabilitation programs from exercise-only to comprehensive secondary prevention centers [5,6,38]. Because of the profound effect of secondary prevention methods, and the decreasing ability that physicians have to adequately address these issues in a single office visit, there has been a recent call-to-action for rehabilitation programs to address all aspects related to cardiac risk reduction. Ades et al stated the case eloquently in a 1999 article [6]: "as a 1% decrease in LDL is associated with a 2% decrease in risk of a second cardiac event, it is no longer acceptable for programs to deliver exercise-only interventions with a passive observation of lipid outcomes" [7]. This same sentiment can be applied to other cardiac risk factors and health indices.

Compliance and adherence

Compliance in cardiac rehabilitation is indeed a major problem. As much as 80% of eligible patients do not participate in formal cardiac rehabilitation programs [1,5,42,56–58]. Participation further decreases over time: one study reported 50% of patients dropping out after 12 months, and another reported a program compliance of only 13% after 3 years [58]. Characteristics most highly associated with poor compliance include continued female sex, tobacco use, low socioeconomic status, work or time constraints, a long commute, patient motivation, and lack of physician endorsement [57,58]. In fact, several studies indicate that the most important predictor of participation is the specific and direct endorsement from the physician [6]. One strategy proven beneficial to combat noncompliance is a brief postdischarge phone call that includes education regarding the benefits of cardiac rehabilitation and information about enrolling. In a recent study conducted at Duke University, this intervention resulted in substantial improvement in participation rates, with 31% participation preintervention versus 56% after this brief intervention [59].

In summary, participation compliance can be increased significantly by a strong recommendation from the physician, a brief postdischarge phone call by a nonphysician professional, and by making rehabilitation programs convenient, accessible, and affordable/reimbursable. Perhaps these strategies will result in contemporary cardiac rehabilitation reaching the standard suggested by Dr. Phillip Ades, who calls for "cardiac rehab to be a systematic stop for all cardiac patients" [6].

Exercise risks

Atherosclerotic vascular disease is the primary cause of almost all exercise-related deaths [10,18]. Despite this, risk of death or acute myocardial infarction in cardiac rehabilitation programs remains quite low: .08 complications per 10,000 exercise hours, which equates to roughly one complication per 770 participants per year [14] The most common cause of death in patients with known cardiovascular disease is sudden cardiac death; for patients without a cardiac history, myocardial infarction is the predominant cause [18]. The rate of adverse events is higher for patients who are stratified to the "highest risk" profile, and in those who ignore their exercise prescriptions [10]. Other important identified triggers of exercise-related death include higher intensity exercise in the setting of infrequent exercise frequency (the so-called "weekend warriors") [50].

Risk of death or myocardial infarction can be minimized by having patients learn to recognize cardiac prodromal symptoms such as chest discomfort and unexpected dyspnea [18]. Previous studies indicate that warning symptoms were present in the majority of patients who died during or immediately after exercise.

In addition to patient education, risks of adverse events in the supervised rehabilitation setting can be minimized by ensuring that all patients have undergone proper preparticipation evaluation and referral [9,10]. Other important methods of reducing risk of adverse outcomes include regular emergency training of staff (eg, via a quarterly "mock code"); ensuring proper availability of emergency equipment; emphasizing exercise duration over intensity of effort, particularly in high risk groups; and evaluating patients for a recent change in condition before exercise [1].

With so many cardiac patients being triaged to non medically-oriented fitness facilities, it is important to realize that in the event of a cardiac emergency, early cardiopulmonary resuscitation (CPR), prompt defibrillation, and rapid access to advanced life support save lives. Along these lines, the American College of Sports Medicine and the American Heart Association recently published a scientific statement that recommends placement and use of automatic external defibrillators (AEDs) in large health clubs, health clubs that offer special programs to clinical populations (eg, the elderly), and health clubs in which the time to first shock provided by the EMS is anticipated to be more than 5 minutes [60].

Although the placement of AEDs and proper emergency procedures in nonsupervised settings will likely result in lowered risk of death for cardiac patients exercising in these settings, I believe that a medically supervised exercise program provides a much better choice. Cardiovascular disease is, after all, progressive. Patients may develop new atherosclerotic lesions or experience advancement of existing lesions. They may develop comorbid conditions such as vascular disease, heart failure, or diabetes. They may begin to struggle with lifestyle interventions once the initial scare factor wears off. For maximum health benefit and lowest overall risk, the patient with longstanding cardiovascular disease remains in need of the comprehensive care provided by the secondary-prevention focused programs of today.

Summary

Contemporary cardiac rehabilitation programs are more accurately described as "secondary prevention centers." They offer comprehensive care for the patient with cardiovascular disease, resulting in decreased mortality, improvement of most cardiac risk factors, and an enhanced quality of life. Although overall participation has increased with enhanced recognition of the importance of secondary prevention, 80% of eligible patients still do not participate, in part due to lack of insurance reimbursement. This rate can be significantly increased by specific endorsement from the physician.

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