Guidelines for Decannulation

- Patients are ready for decannulation when they no longer need mechanical ventilation and can adequately clear airway secretions
- Patient should be evaluated for aspiration risk
- Should be able to cough secretions out of the tracheal tube
- Gradual cuff deflation allows weaning from cuffed to uncuffed TT. The cuffless TT is down sized to a smaller size and the patient evaluated for ability to cough secretions
- When the patient does not need excessive suctioning and the outer diameter of the TT is 8 mm., you may discontinue the TT or place a tracheal button temporarily

Tracheal buttons—extend only to the inner surface of the anterior tracheal wall without causing tracheal lumen obstruction. They are used when there is doubt about the success of the tracheostomy weaning. When plugged, the patient may breathe through the upper airway without resistance from the tracheostomy tube.

🕮 Another means of invasive ventilatory support is electrophrenic respiration with the use of a diaphragmatic pacer, used in patients with intact phrenic nerves and diaphragm. This is discussed in detail in the spinal cord injury chapter.

■ CARDIAC REHABILITATION

DEFINITION

Cardiac rehabilitation is the process by which persons with cardiovascular disease (including but not limited to patients with coronary heart disease) are restored to and maintained at their optimal physiological, psychological, social, vocational, and emotional status. (American Association of Cardiovascular and Pulmonary Rehabilitation–AACPR)

GOALS

The goal is to improve or maintain a good level of cardiovascular fitness, thereby returning the individual to a normal and productive life.

- For those able to return to work:
  1. Return to productive employment as soon as possible
  2. Improve and maintain as good cardiovascular fitness
- For those not able to return to work:
  1. Maintain as active a life as possible
  2. Establish new areas of interest to improve quality of life
- Patient Education and Reduction of Coronary Risk Factors

Risk Factors for Coronary Artery Disease (CAD)	
Irreversible	**Reversible**
Age Male gender Family history of CAD Past history of CAD, PVD, CVA	Hypertension Cigarette Smoking Hypercholesterolemia Hypertriglyceridemia Diabetes Mellitus Obesity Sedentary lifestyle Type A personality

EPIDEMIOLOGY

- Cardiovascular disease is the leading cause of morbidity and mortality in the United States, accounting for almost 50% of all deaths
- Coronary Heart Disease (CHD) with its clinical manifestations of stable angina pectoris, unstable angina, acute myocardial infarction (MI), and sudden death affects about 13.5 million Americans. Nearly 1.5 million Americans sustain myocardial infarction each year, of which almost 500,000 episodes are fatal
- 50% of MI occurs in people under age 65
- Annually, 1 million survivors of MI and more than 7 million patients with stable angina pectoris are candidates for cardiac rehabilitation, as are patients following coronary artery bypass graft (CABG) (309,000 patients in 1993), and a similar number will require angioplasty
- Although several million patients with CHD are candidates for cardiac rehabilitation services, only 11% to 20% have participated in cardiac rehab programs
- The mortality rate for CAD has fallen 47% since 1963; 30% of that decrease occurring from 1979–1989
- The Framingham study credits three factors as playing possible roles in this marked decrease in those with CAD. (Wilson et al., 1987)
  1. The modification of risk factors in those with CAD:
     – Lower cholesterol
     – Lower blood pressure
     – Better hypertension management
     – Reduced cigarette smoking
  2. Improved treatment methods
  3. Improved prevention

PHASES OF CARDIAC REHAB

Phase I	During acute inpatient hospitalization
Phase II	Supervised ambulatory outpatient lasting 3 to 6 months
Phase III	Maintenance phase in which physical fitness and risk factor reduction are accomplished in a minimally supervised or unsupervised setting

Phase I (Inpatient Period)

This stage of rehabilitation can last from as short as one day to as long as 14 days for cardiovascular patients undergoing invasive procedures or suffering from acute events

Phase II (Immediate Outpatient Period)

This period is the convalescent stage following a hospital discharge. The length is partly determined by risk satisfaction and monitoring need. By definition this period is the most closely monitored phase of rehabilitation.

Phase III and Phase IV (Intermediate and Maintenance Periods)

The third stage of recovery is an extended outpatient period that may be divided into two components, intermediate and maintenance. The intermediate stage follows immediate outpatient cardiac rehabilitation, that is, when the patient is not intensely monitored and/or supervised but is still involved in regular endurance exercise training and lifestyle change. The transition to Phase IV varies according to the individual outcomes and medical needs.

🕮 EXERCISE PHYSIOLOGY

- Total Oxygen Consumption (VO_2) represents the oxygen consumption of the whole body, therefore it mainly represents the work of the peripheral skeletal muscles rather than myocardial muscles.
- Aerobic capacity (VO_2 max) is a term used to measure the work capacity of an individual. As the individual increases the workload (exercise) the VO_2 increases in a linear fashion until it levels off and reaches a plateau, despite further increases in the workload. This is the aerobic capacity of the individual. It is usually expressed in the millimeters of O_2 consumed per kilogram of body weight per minute.
- Myocardial Oxygen Consumption (MVO_2) is the actual oxygen consumption of the heart. It can be measured directly with cardiac catheterization. In a clinical setting, however, the rate pressure product (RPP) can be used since the heart rate and systolic blood pressure correlates well with the MVO_2.
- Double Product, also called Rate Pressure Product (RPP) refers to the work required of the heart, which closely parallels the systolic blood pressure (SBP) × heart rate (HR).
- Rate Pressure Product (RPP) = SBP × HR
- Cardiac Output (CO) = HR × stroke volume
- Metabolic equivalent (met): Resting metabolic unit—1 met = 3.5 ml O_2 consumed per kilogram of body weight per minute (Pashkow, 1993)

🕮 OUTCOMES OF CARDIAC REHABILITATION SERVICES

The results of cardiac rehabilitation services, based on reports in the scientific literature. The most substantial benefits:

Improvement in Exercise Tolerance

Cardiac rehabilitation exercise training improves objective measures of exercise tolerance in both men and women, including elderly patients with CHD and heart failure.

Improvement in Symptoms

Cardiac rehabilitation exercise training decreases symptoms of angina pectoris in patients with CHD and decreases symptoms of heart failure in patients with left ventricular systolic dysfunction. Improvement in clinical measures of myocardial ischemia, as identified by ECG and nuclear cardiology techniques, following exercise rehabilitation.

Improvement in Blood Lipid Levels

Multifactorial cardiac rehabilitation in patients with CHD, including exercise training and education, results in improved lipid and lipoprotein levels. Exercise training as a sole intervention has not effected consistent improvement in lipid profiles. Optimal lipid management requires specifically directed dietary and, when medically indicated, pharmacological management as a component of multifactorial cardiac rehabilitation.

Reduction of Cigarette Smoking

Education, counseling, and behavioral intervention are beneficial for smoking cessation.

Improvement in Psychosocial Well-being and Stress Reduction

Improvement in psychological status and functioning, including measures of emotional stress and reduction of the Type A behavior pattern

Reduction in Mortality

Multifactorial cardiac rehabilitation service can reduce cardiovascular mortality in patients following myocardial infarction.

Safety

The safety of exercise is established by the very low rate of occurrence of myocardial infarction and cardiovascular complications during exercise training.

TABLE 9-2. Absolute Contraindications for Entry into Inpatient and Outpatient Exercise Training

• Unstable angina
• Resting systolic blood pressure > 200 mm Hg or resting diastolic blood pressure > 110 mm Hg
• Significant drop (20 mm Hg) in resting systolic blood pressure from the patient's average level that cannot be explained by medication
• Moderate to severe aortic stenosis
• Acute systemic illness or fever
• Uncontrolled atrial or ventricular arrhythmias
• Uncontrolled tachycardia (> 100 bpm)
• Symptomatic congestive heart failure
• Third-degree heart block without pacemaker
• Active pericarditis or myocarditis
• Recent embolism
• Thrombophlebitis
• Resting ST displacement (> 3 mm) (as seen on ECG)
• Uncontrolled diabetes
• Orthopaedic problems that would prohibit exercise

Candidates for Inpatient Cardiac Rehabilitation
• Patients who have had myocardial infarction
• Coronary artery bypass surgery (CABG) or angioplasty patients
• Coronary patients with or without residual ischemia
• Heart failure and arrhythmias
• Patients with dilated cardiomyopathy
• A variety of patients with nonischemic heart disease
• Patients with concomitant pulmonary disease
• Patients who have received a pacemaker or an automatic implanted cardioverter-defibrillator
• Patients who have had heart-valve repair or replacement
• Aneurysm, aneurysm resection, organ transplantation

Modified from "Exercise Prescription for Cardiac Patients" In ACSM Guidelines for Exercise Testing and Prescription (5th ed) p.179, Philadelphia; Lea & Febiger, 1995, with permission.

INPATIENT VERSUS OUTPATIENT REHABILITATION

1. Inpatient program: Strictly supervised inpatient hospitalization lasting 1–2 weeks (phase I)
2. Structured outpatient program: Supervised ambulatory out-patient program lasting 3–6 months (phase II)
3. Maintenance program: Minimally supervised or unsupervised setting (phase III/IV)

Inpatient Program 7–14 Days

Acute Period—CCU (Coronary Care Unit):

- Activities of very low intensity (1–2 mets)
  Passive ROM (1.5 mets)
  Upper extremity ROM (1.7 mets)

Lower extremity ROM (2.0 mets)
Avoid: isometrics (increases heart rate), valsalva (promotes arrhythmia), raising the legs above the heart (can increase preload)
- Use protective chair posture—can reduce the cardiac output by 10%
- Bedside commode (3.6 mets) versus bedpan (4.7 mets)

The goal of an inpatient rehabilitation program is to provide a coordinated, multifaceted program designed to assist and direct patients and their families early in the recovery process following an acute cardiovascular event. The focus is on the medical care, physical activity, education, and psychological issues.

Subacute Period—Physical program can vary among institutions. Transfer from the CCU to either a telemetry unit or to the medical ward.
- Activities or exercises of intensity (3–4 mets)
  Calisthenics of known energy cost
  ROM exercise: intensity can be gradually increased by increasing the speed and/or duration; may add mild resistance or low (1–2 lbs.) weight
  Early ambulation: starting in the room and then corridors of the ward, treadmill walking at 0% grade starting at 1 mph and gradually increasing to 1.5 mph, 2 mph, 2.5 mph as tolerated
- Energy cost of low grade ambulation:
  1 mph (slow stroll) = 1.5–2 mets
  2 mph (regular slow walk) = 2–3 mets
  Propelling wheelchair = 2–3 mets
- Serial progression of the self-care activities should parallel to the intensity of the monitored program, particularly with earlier hospital discharge

Bypass Surgery—Rehabilitation regime is differentiated into Aggressive vs. Slow to Recover Fig. 9–7).

EXERCISE TESTING

🕮 Graded Exercise Testing

Graded exercise stress tests (GXTs) assess the patient's ability to tolerate increased physical stress. The GXT may be used for diagnostic, prognostic, and therapeutic application, with or without addition of radionuclide or echocardiography assessment.
- 🕮 The cardiac rehabilitation health professionals usually use GXTs as a functional rather than diagnostic tool
- 🕮 GXTs also provide useful information when applied to risk stratification models. GXTs also allow the establishment of appropriate limits and guidelines for exercise therapy and the assessment of functional change over time
- Submaximal GXT is recommended for inpatients and prior to outpatient cardiac rehabilation programs
- GXTs may be submaximal or maximal relative to patient effort in addition to common indications for stopping the exercise test (see Contraindications to Exercise Testing). Endpoint criteria for submaximal testing may include heart rate limits, perceived exertion, and predetermined met levels
- 🕮 Most of the activities of daily living in the home environment require less than 4 mets (*Guidelines for Cardiac Rehabilitation* 2nd ed. 1995)
- The American Heart Association suggests a heart rate limit of 140 and 130 beats per minute for patients not on beta-blocking agents, or Borg rating of perceived exertion (RPE) of 13–15 (Table 9–7), as additional end point criteria for low-level testing

- The low-level test provided sufficient data to permit most activities of daily living and serve as a baseline for ambulatory exercise therapy.
- The frequency of the test should be relative to the patients clinical course rather than a fixed schedule.

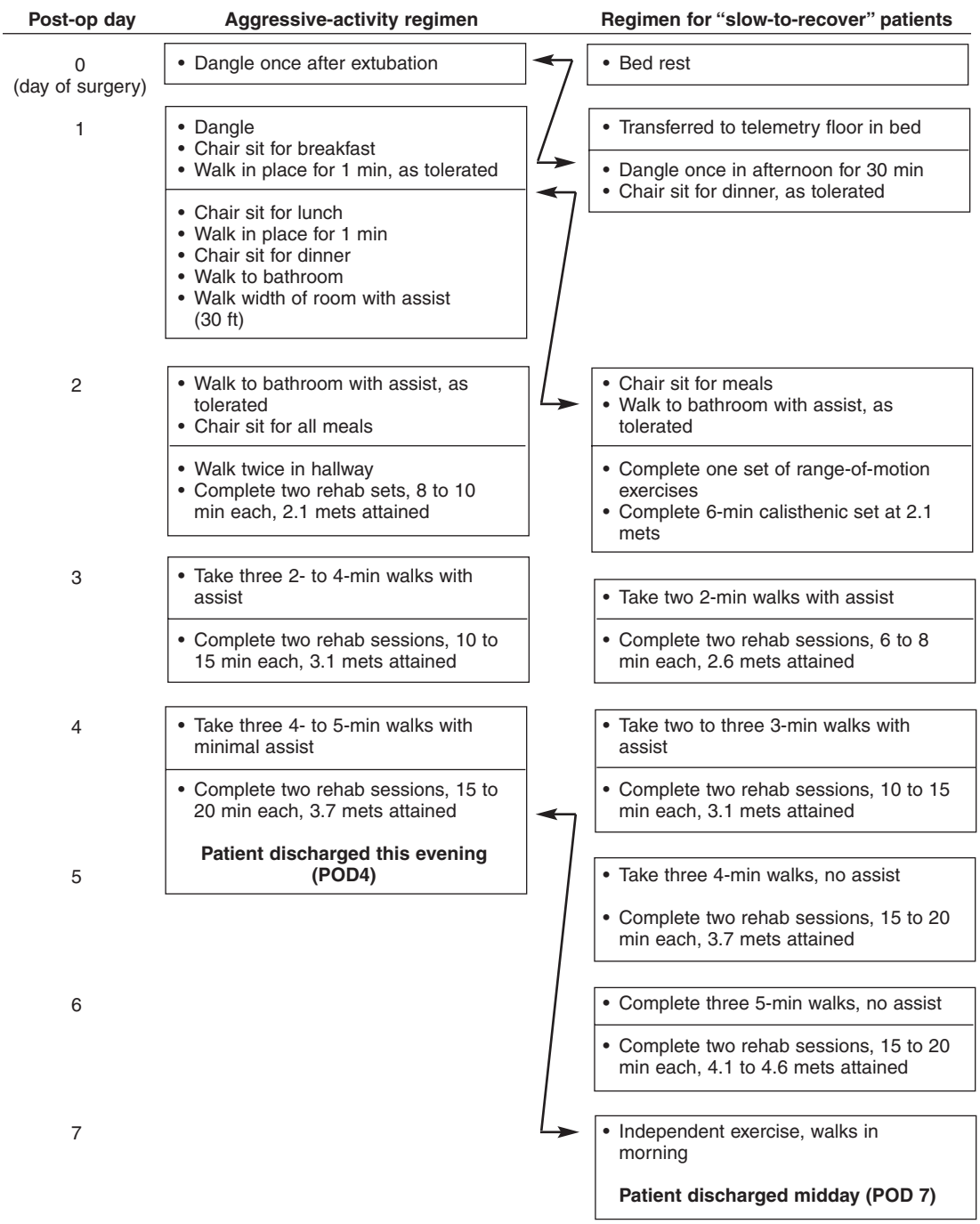

FIGURE 9–7. Activity regime for patients recovering from bypass surgery.

🕮 Exercise Testing Protocols

A variety of exercise testing protocols are available, whether the test is conducted using treadmill, cycle, or arm ergometer.

- 🕮 Amputee patients use arm ergometer
- 🕮 Treadmill testing provides a more common form of physiologic stress, (i.e., walking), in which subjects are more likely to attain a slightly higher VO_2 maximum and peak heart rate
- 🕮 The cycle ergometer has the advantage of requiring less space and generally is less costly than the treadmill. Minimized movements of the arm and thorax facilitates better quality EKG recording and blood pressure monitoring. (*Guidelines for Cardiac Rehabilitation* 2nd ed. 1995)
- 🕮 To perform a stress test in an above-knee amputee, an upper extremity ergometer is used
- Balke-Ware protocols that increase metabolic demands by 1 met per stage are appropriate for high-risk patients with functional capacity of less than 7 mets

🕮 Bruce Protocol

Metabolic demands of > 2 mets per stage may be appropriate for low to intermediate risk patients with functional capacity greater than 7 mets

🕮 The widely used Bruce Protocol of 2–3 mets per stage is useful with stable patients with functional capacities of 10 mets.

Pharmacological testing in debilitated patients for whom exercise testing cannot be performed, has been used to evaluate ischemia. The data from pharmacologic testing cannot be used in exercise presumption. (Froehlicher, 1987)

TABLE 9-3. Approximate met Costs for Sample Exercise Testing Protocols

FUNCTIONAL CLASS	CLINICAL STATUS	O_2 COST ml/kg/min	METS	BICYCLE ERGOMETER	TREADMILL PROTOCOLS								METS
					BRUCE	KATTUS	BALKE-WARE	ELLESTAD	USAFSAM	"SLOW" USAFSAM	McHENRY	STANFORD	
					3 MIN STAGES MPH %GR			3/2/3 MIN STAGES MPH %GR				% GRADE AT 3 MPH / % GRADE AT 2 MPH	
				1 WATT = 6 KPDS	5.5 20		% GRADE AT 3.3 MPH	6 15	MPH %GR				
		56.0	16		5.0 18		1-MIN STAGES		3.3 25				16
NORMAL AND I	HEALTHY, DEPENDENT ON AGE, ACTIVITY	52.5	15	FOR 70 KG BODY WEIGHT KPDS		MPH %GR		5 15					15
		49.0	14	1500		4 22					MPH %GR		14
		45.5	13		4.2 16				3.3 20		3.3 21		13
		42.0	12	1350		4 18					3.3 18	22.5	12
	SEDENTARY HEALTHY	38.5	11	1200				5 10		MPH %GR		20.0	11
		35.0	10	1050		4 14			3.3 15	2 25	3.3 15	17.5	10
		31.5	9		3.4 14					2 20		15.0	9
		28.0	8	900		4 10		4 10				12.5	8
	LIMITED	24.5	7	750					3.3 10	2 15	3.3 12		
II		21.0	6	600	2.5 12	3 10		3 10			3.3 9	10.0	7
	SYMPTOMATIC	17.5	5	450					3.3 5	2 10		17.5	6
III		14.0	4		1.7 10	2 10		1.7 10			3.3 6	7.5	5
		10.5	3	300						2 5		14	4
		7.0	2		1.7 5				3.3 0			5.0	3
		3.5	1	150							2.0 3	10.5	2
IV					1.7 0				2.0 0	2 0		2.5	1
												7	
												0.0	
												3.5	

Reprinted from Froehlicher VF. Exercise and the Heart. Clinical Concepts p.15, Year Book Medical Publishers, Inc. Chicago 1987., with permission.

TABLE 9-4. Contraindications to Exercise Testing

Absolute Contraindications
1. A recent significant change in the resting ECG suggesting infarction or other acute cardiac events
2. Recent complicated myocardial infarction
3. Unstable angina
4. Uncontrolled ventricular dysrhythmia
5. Uncontrolled atrial dysrhythmia that compromises cardiac function
6. 3rd degree A-V block
7. Acute congestive heart failure
8. Severe aortic stenosis
9. Suspected or known dissecting aneurysm
10. Active or suspected myocarditis or pericarditis
11. Thrombophlebitis or intracardiac thrombi
12. Recent systemic or pulmonary embolus
13. Acute infection
14. Significant emotional distress (psychosis)
Relative Contraindications
1. Resting diastolic blood pressure > 120 mmHg or resting systolic blood pressure >200 mmHg
2. Moderate valvular heart disease
3. Known electrolyte abnormalities (hypokalemia, hypomagnesemia)
4. Fixed-rate pacemaker (rarely used)
5. Frequent or complex ventricular ectopy
6. Ventricular aneurysm
7. Cardiomyopathy, including hypertrophic cardiomyopathy
8. Uncontrolled metabolic disease (e.g. diabetes, thyrotoxicosis, or myxedema)
9. Chronic infectious disease (e.g. mononucleosis, hepatitis, AIDS)
10. Neuromuscular, musculoskeletal, or rheumatoid disorders that are exacerbated by exercise
11. Advanced or complicated pregnancy

Modified from "Guidelines for Exercise Test Administration" In ACSM Guidelines for Exercise Testing and Prescription (5th ed) p. 42, 1995, Philadelphia: Lea & Febiger, with permission.

TABLE 9-5. Indications for Stopping an Exercise Test

Symptom-limited maximal test
1. Progressive angina (stop at 3+ level or earlier on a scale of 1–4)
2. Ventricular tachycardia
3. Any significant drop (20 mm HG) of systolic blood pressure or a failure of the systolic blood pressure to rise with an increase in exercise load
4. Light-headedness, confusion, ataxia, pallor, cyanosis, nausea, or signs of severe peripheral circulatory insufficiency
5. 3mm horizontal or downsloping ST depression or elevation (in the absence of other indicators of ischemia)
6. Onset of second- or third-degree A-V block
7. Increasing ventricular ectopy, multiform PVCs, or R on T PVCs
8. Excessive rise in blood pressure: systolic > 250 mm Hg; diastolic pressure > 120 mmHg
9. Chronotropic impairment
10. Sustained supraventricular tachycardia
11. Exercise-induced left bundle branch block
12. Subject requests to stop
13. Failure of the monitoring system

Additional Criteria for Stopping Low-level/Hospital Discharge Exercise Test
1. Exercise heart rate > 130 bpm
2. Borg RPE (Rate perceived exertion) 15 (15 grade scale) (Table 9–7)

Continued

Suggested Endpoint Criteria for a Submaximal Exercise Progress Evaluation
1. Appearance of any criteria that indicate ending an exercise test
2. Exercise heart rate in excess of previous GTX peak heart rate
RPE = Rate Perceived Exertion > 16 (Borg 15 grade scale)
(Elaboration of Borg Scale—see below)

Modified from "Guidelines for Exercise Test Administration" ACSM Guidelines for Exercise Testing and Prescription (5th ed) p. 78 Philadelphia: Lea & Febiger, 1995, with permission and from Fletcher GF, Hartley, LH, Haskell WL, Pollock ML. "Exercise Standards, a Statement for Health Professionals from the American Heart Association" Circulation 1990; 82: 2297.

Structured Outpatient Program/Maintenance Program

Traditionally, outpatient cardiac rehabilitation has been divided into three phases:
Phase II (immediate)
Phase III (intermediate)
Phase IV (maintenance)

Phase II (immediate) will define the stage of cardiac rehabilitation that occurs immediately after discharge, in which higher levels of surveillance, monitoring of ECGs, and intensive risk factor modification occurs

Phase III (intermediate) is the period of rehabilitation when ECG monitoring occurs only if signs and symptoms warrant, although endurance training and risk factor modification continue

Phase IV (maintenance) is the stage in the program that is structured for patients who have plateaued in exercise endurance and achieved stable risk factor management

Physical Activity Program

Slow walk	2 mph	2–3 mets
Regular speed walk	3 mph	3–4 mets
Brisk walk	3–5 mph	4–5 mets
Very brisk walk	4 mph	5–6 mets
Sexual intercourse*		3–4 mets
Outdoor work—shovel snow, spade soil		7 mets
Jog, walk	5 mph	9 mets
Mop floor		2–4 mets
Push power lawn mower		4 mets

* **Note:** met level for sexual intercourse varies depending upon reference source. Tardif (1989) states that patients who reach 5–6 mets on stress-testing without ischemia or arrhythmias can, in all likelihood, resume their normal sexual activities without any risk.

The goal is the improvement of the cardiovascular capacity through physical exercise training whether in a minimally supervised or unsupervised setting.

Types of Physical Activities

- Begin with the last exercise program performed during the supervised cardiac exercise program
- Aerobically trained, clinically stable candidates may participate in resistive or circuit training. An overall lifestyle that includes proper diet, weight control, stress management, and smoking cessation should be maintained along with good physical fitness
- Active participation, within prescribed limits, in sport activity is encouraged

Sport Activity	Energy Cost in Mets
Golf	2–5
Bowling	4–5
Volleyball	3–4
Ping pong	3–6
Tennis	4–7
Roller-skating	5–6

CARDIAC FUNCTIONAL CLASSIFICATION

Class I

- NY Heart Association—Patient's cardiac disease does not limit physical activity. Ordinary physical activity does not cause undue fatigue, palpitation, dyspnea, or anginal pain.
- Specific Activity Scale
  Patients can perform to completion any activity requiring > or = 7 mets:
  Can carry 24 lbs. up 8 steps
  Can carry objects that weigh 80 lbs.
  Do outdoor work (shovel snow, spade soil)
  Do recreational activities (skiing, basketball, squash, handball, jog at 5 mph)

Class II

- NY Heart Association—Patient's cardiac disease results in slight limitation on physical activity. They are comfortable at rest. Ordinary physical activity results in fatigue, palpitation, dyspnea, or anginal pain.
- Specific Activity Scale
  Patient can perform to completion any activity requiring > or = 5 mets, but cannot and does not perform to completion of activities requiring > or = to 7 mets:
  Sexual intercourse to completion without interruption
  Garden, rake, weed
  Roller-skate, walk at 4 mph on level ground

Class III

- NY Heart Association—Patient's cardiac disease results in marked limitation of physical activity. They are comfortable at rest. Less than ordinary physical activity causes fatigue, palpitation, dyspnea, or anginal pain.
- Specific Activity Scale
  Patient can perform to completion any activity that requires > or = 2 mets and < 5 mets:
  Shower without interruption
  Strip and make bed
  Clean windows
  Walk 2.5 mph
  Bowl, golf
  Dress without stopping

Class IV

- NY Heart Association—Patient's cardiac disease results in inability to carry on any physical activity without discomfort. Symptoms of cardiac insufficiency or of the angina syndrome may be present even at rest. If any physical activity is undertaken, discomfort is increased.
- Specific Activity Scale
  Patient cannot or does not perform to completion activities requiring > or = 2 mets. Cannot carry out activities in Class I – III.

TABLE 9-6. Criteria for Determination of the Specific Activity Scale Functional Class

	Any yes	No
1. Can you walk down a flight of steps without stopping (4.5-5.2 METs)?	Go to #2	Go to #4
2. Can you carry anything up a flight of eight steps without stopping (5-5.5 METs)? Or can you (a) have sexual intercourse without stopping (3-4 METs); (b) garden, rake, weed (5.6 METs); (c) roller skate, fox-trot (5-6 METs); or (d) walk at a 4 mph rate on level ground (5-6 METs)?	Go to #3	Class III
3. Can you carry at least 24 lb up eight steps (10 METs)? Or can you (a) carry objects that are at least 80 lb (8 METs); (b) do outdoor work—shovel snow, spade soil (7 METs); (c) do recreational activities such as skiing, basketball, touch football, squash, handball (7-10 METs); or (d) jog/walk 5 mph (9 METs)?	Class I	Class III
4. Can you shower without stopping (3.6-4.2 METs)? Or can you (a) strip and make a bed (3.9-5 METs); (b) mop floors (4.2 METs); (c) hang washed clothes (4.4 METs); (d) clean windows (3.7 METs); (e) walk 2.5 mph (3-3.5 METs); (f) bowl (3-4.4 METs); (g) play golf (walk and carry clubs) (4.5 METs); or (h) push a power lawn mower (4 METs)?	Class III	Go to #5
5. Can you dress without stopping because of symptoms (2-2.3 METs)?	Class III	Class IV

From Goldman L., Hashimoto B., Cook EF., Loscalzo A. Comparative reproducibility and validity of systems for assessing cardiovascular functional class: advantages of a new specific activity scale. *Circulation 1981* Dec; 64(6): 1227–37 © American Heart Association, with permission.

Contraindications to Exercise Testing

Exercise Prescription

Exercise for the cardiac patient should specify the type of exercise, the intensity, duration and frequency

🕮 Type of Exercise

Exercise for cardiovascular conditioning should be isotonic, rhythmic, and aerobic; should use large muscle masses and should not involve a large isometric component

- Sessions of exercise should incorporate aerobic activity such as walking/jogging, stationary cycling or water aerobics. Sessions should also incorporate warm-up and cool-down periods. In addition to aerobic activity, resistance exercise (using light weights) may be added on an individual basis
- 🕮 Resistance exercises have been shown to be a safe and effective method for improving strength and cardiovascular endurance in low-risk patients. Surgical and myocardial infarction patients should wait three to six weeks before beginning resistance training. Patients diagnosed with the following conditions should be excluded from resistance training:

CHF
Uncontrolled arrhythmias
Severe vascular disease
Uncontrolled hypertension
Systolic blood pressure > 160 mm/Hg, or diastolic blood pressure > 100 mm/Hg
Aerobic capacity less than 5 mets

- Results in increase in aerobic capacity of all muscle fibers exercised: both type I and type II fibers. Type I fibers continue to show approximately five times the aerobic capacity of type II fibers, as before exercise. (Flores and Zohman, 1993)

Exercise Intensity

- Exercise intensity is usually prescribed as some percentage of the maximum capacity obtained on exercise testing, (i.e., O_2 consumption, heart rate workload and/or degree of exertion)

O_2 Consumption

Threshold	40–50% max VO_2	60% max HR
Optimum	55–65% max VO_2	70% max HR
Ceiling	80–90% max VO_2	90% max HR

For the deconditioned cardiac patient, exercise even at 40% to 50% of max VO_2 will result in improvement

Target Heart Rate (THR)
Exercise intensity is based on target heart rate
Note: Clearance Heart Rate (HR) is the clinical maximum HR attained on stress test.
Target HR is the following range:
Clearance HR × .7 = beginning range
Clearance HR × .85 = end range

1. For the cardiac patient, 70% of the maximum HR attained on the exercise stress test
2. For the healthy patient, 70% to 85% of the predicted age-adjusted maximum HR:
   Average maximum = 220 – age
3. Karvonen formula—useful for those on chronic beta blockade or with abnormally high resting heart rate

- The age-predicted formula of (220 – age = HR maximum) has the potential for over- and underestimating the actual exercise intensity and, therefore, places patients with heart disease at risk for exercise-induced cardiovascular complications
- The percent HR maximum reserve method of establishing a target HR uses the subject's potential heart-rate increase and assumes that the resting heart rate represents zero intensity. Thus, this method corrects for the nonzero value of resting heart rate associated with the percent HR maximum method
  Karvonen Method:
  THR range = 0.7 to 0.85 (HR maximum - resting HR) + resting HR
  Example: Patient is a 60 year old with a HR maximum of 160 and a resting HR of 60.
  (160 – 60) × 0.7 + 60 = 130 for lower limit
  (160 – 60) × 0.85 + 60 = 145 for upper limit
  Therefore, the target HR (THR) range = 130–145
  Age Predicted Method:
  THR range = 0.7 (220 – age) to 0.85 (220 – age)
  Example: same as previous patient
  (220 – 60) × 0.7 to (220 – 60) × 0.85
  THR range = 112–136

Perceived Exertion Method

1. Borg RPE scale (Table 9–7): A linear scale of rating from 6–20. This scale is a valid indication of physical exertion and correlates linearly with HR, ventricular O_2 consumption, and lactate levels. The new exerciser can proceed with exercise to level 13, (somewhat hard) provided he has been given clearance to do so from his exercise stress test.
2. Conversational exercise level: Patient should be able to talk while exercising (Talk Test) The conversational level is of adequate intensity to induce a training effect but allows the exerciser to talk without becoming excessively out of breath while exercising at the same time

The American Heart Association suggest a heart rate limit of 130–140 beats per minute (b/min) for patients not on beta-blocking agents, or Borg rating of perceived exertion (RPE) of 13–15 as an additional point criteria for low-level testing

Duration and Frequency of Exercise

- The duration depends on the level of fitness of the individual and the intensity of the exercise
- The usual duration when exercise is at 70% of maximum heart rate is 20–30 minutes at conditioning level
- In the poorly conditioned individual, daily exercise as low as 3–5 minutes can bring about improvement. For the conditioned individual who prefers to exercise at higher intensities, duration of exercise may be reduced to 10–15 minutes

Format of an Exercise Session

- There should be a warm-up phase before and a cool-down phase after the period of training
- The warm-up period is usually at the lower intensity levels of exercise to be performed, gradually increasing to the prescribed intensity
- At the cool-down period, there is gradual reduction in exercise intensity to allow the gradual redistribution of blood from the extremities to other tissue and to prevent sudden reduction in venous return, thereby reducing the possibility of postexercise hypotension or even syncope. (*Guidelines for Cardiac Rehibilitation* 2nd ed. 1995)

Predicted Age-Adjusted Maximum Heart Rate

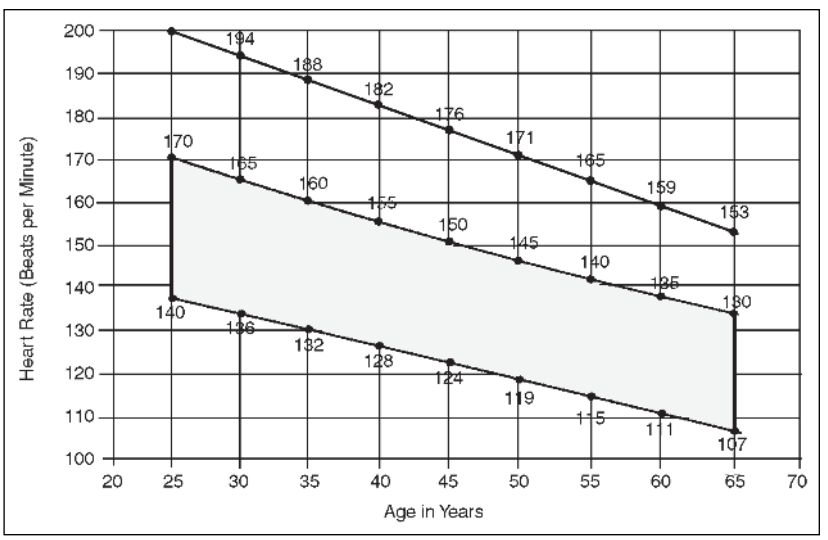

FIGURE 9–8. Exercise intensity based on the predicted age-adjusted rate. Shaded area is 70–80% of Age Adjusted Maximum Attainable Heart Rate. Top solid line is Age Adjusted Maximum Attainable Heart Rate.

TABLE 9–7. Borg Scale of Rate Perceived Exertion

Borg Scale: 15-Grade Rating of Perceived Exertion
6 No exertion at all
7
8
9 Very light
10
11 Light
12
13 Somewhat hard
14
15 Hard (heavy)
16
17 Very hard
18
19 Extremely hard
20 Maximal exertion

From Borg, G. An Introduction to Borg's RPE Scale. Ithaca, NY: Mouvement Publications; 1985, with permission. Copyright 1985 by Gunnar Borg.

TABLE 9–8 Patient Rating Scales: Angina, Dyspnea, Intermittent Claudication

Angina Scale
0 – No angina 1 – Light, barely noticeable 2 – Moderate, bothersome 3 – Severe, very uncomfortable 4 – Most pain ever experienced
Dyspnea Scale
0 – No dyspnea 1 – Mild, noticeable 2 – Mild, some difficulty 3 – Moderate difficulty, but can continue 4 – Severe difficulty, cannot continue
Intermittent Claudication
0 – No claudication pain 2 – Initial, minimal pain 2 – Moderate, bothersome pain 3 – Intense pain 4 – Maximal pain, cannot continue

Reprinted with permission from American Association of Cardiovascular & Pulmonary Rehabilitation, 1999, *Guidelines for Cardiac Rehabilitation and Secondary Prevention Programs*. 3rd ed. (Champaign, IL: Human Kinetics), 64 and "Guidelines for Exercise Test Administration" In *ACSM Guidelines for Exercise Testing and Prescription*. 5th ed. (Philadelphia: Lea & Febiger).

CARDIAC REHABILITATION OF SPECIAL GROUPS

Heart Transplantation

Pathophysiology

The heart is denervated (loss of vagal inhibition to the SA node), therefore, physiologic response is somewhat different then the one seen in a post-CABG patient.

1. High resting heart rate
2. Lower peak exercise heart rate

3. Postexercise recovery rate—slow return to resting level
   - At maximum effort—the work capacity, cardiac output, systolic BP, and the total O_2 consumption (VO_2) are lower
   - Pretransplantation, rehabilitative strength training may enhance pre-operative and operative recovery
   - Five- and ten-year survival is about 82% to 74% respectively
   - Accelerated arthrosclerosis occurs following transplantation

Exercise Prescription

1. Heart-rate guidelines are not used
2. Intensity of exercise is based on the following:
   - Borg RPE scale 11 to 14 (Table 9–7)
   - Percentage of maximum oxygen consumption or maximum workload performed on stress test
   - Anaerobic threshold
   - Duration frequency and types of exercise follow the same principles as those with other types of cardiac problems
   - During exercise testing, ischemia is not presented as angina, therefore, ECG changes and other symptoms should be followed

Outcome

Generally favorable, typically reporting increased work output and improved exercise tolerance.

Most Common Major Physical Disabilities That Often Exist with Coronary Artery Disease

1. Amputation
2. Stroke

1. Amputee

- The atherosclerotic vascular disease that affects the cardiovascular system also predisposes these patients to limb loss (dysvascular lower extremity amputation)
- Diabetes, in addition to causing accelerated atherosclerotic vascular disease, is a major risk factor for amputation. It has been estimated that 50% to 70% of all amputations are the result of complications of diabetes
- **Energy Cost of Ambulation for the Amputee** is based on percentage increase above the cost of normal ambulation at 3 mets (Table 9–9)

TABLE 9-9 Energy Cost of Ambulation for the Amputee

AMPUTATION	% INCREASE IN ENERGY	METS
No prosthesis with crutches	50%	4.5
Unilateral BK with prosthesis	9–28%	3.3–3.8
Unilateral AK with prosthesis	40–65%	4.2–5.0
Bilateral BK with prosthesis	41–100%	4.2–6.0
BK plus AK with prostheses	75%	5.3
Bilateral AK with prostheses	280%	11.4
Unilateral hip disarticulation with prosthesis	82%	5.5
Hemipelvectomy with prosthesis	125%	6.75

(Flores and Zohman, 1998)

Amputee Exercise Test
- Pharmacological stress testing using dipyridamole—for patients that are unable to perform any exercise stress test
- Upper extremity cycle ergometer stress test—first determine the safety and ability of mobility
- Telemetry monitoring of ambulation training:
  1. Preprosthetic period
  2. Prosthetic period
  3. Postprosthetic period

2. Stroke
- Acute MI and acute stroke
- CABG and acute stroke
- According to the studies, as much as 77% of stroke patients have some form of co-existing cardiac disease
- Roth et al., showed the overall incidence of cardiac complications of 27% to 34% during inpatient rehabilitation. The incidence was higher in patients with known CAD
- Complications include:
  Hypertension
  Angina
  Myocardial infarction
  CHF
  Rhythm disturbances

Stroke Exercise Testing Modality
- Treadmill ambulation, if tolerated
- Stationary bicycle/ergometer modified for involved leg (ace wrap)
- Portable leg ergometers that allow for seating in a wheelchair or arm chair
- Arm ergometer modified for involved hand or using one-handed arm ergometer
- Telemetry monitoring of level surface ambulation or general conditioning classes

Hemiplegic Ambulation Compared to Normal Ambulation
- Speed—40% to 45% slower
- Energy cost—50% to 65% higher

Cardiovascular Conditioning of the Physically Impaired

Choice of Modalities Used for Assessment Depends on Number of Variables
- Upper extremity cycle ergometer—impaired lower extremity with normal upper extremity
- Air dyne arm—leg cycle ergometer for lower extremity weakness
- Hemiparetic—strap the affected extremity to foot pedal and/or handle bar
- Wheelchair bound—extra wide treadmills that can accommodate a wheelchair

EVALUATION FOR RETURN TO EMPLOYMENT

- Evaluation of the patient
- Evaluation of the job
- Matching the patient and the job
- Other conditions

Evaluation of the Patient

- Clinical Evaluation – Functional Cardiac Classification
  Class I—can perform 7 mets or greater
  Class II—can perform 5 mets or greater but not 7 mets
  Class III—can perform 2 mets or greater but not 5 mets
  Class IV—cannot perform 2 mets or greater

- Functional Exercise Stress Test
  Recommendations are made based on the maximum work load performance.
  > 7 mets—can return to work to most jobs in the USA
  > 5, but < 7 mets—can return to sedentary job and household chores
  3–4 mets—not suitable to return to employment (Flores and Zohman, 1998)

Evaluation of the Job

- Physical Task Performed
  Regular work or steady activity not to exceed endurance limits
  Peak activity – not to exceed prescribed maximum intensity
  Duration of each task
- Environmental Conditions at Areas of Work
  Temperature and humidity
  Hot and humid environment can increase the energy cost of work two to three times
  Air pollution
  High altitude
  Motivation and emotional attitude of patients
  Transportation to and from work
  Household chores after work

Matching the Patient and the Job

- Matching the cardiac functional class and/or result of stress test to the requirement of the job
- Simulated job monitoring
- Monitoring the actual tasks at the job site

Other Conditions

- Emotional Disorders
- Alcoholism
- Financial compensation (security gain)
- Retirement age
- Legal aspect
- Strenuous job requirements
- Patient motivation

AMERICAN HEART ASSOCIATION DIET

Step 1 Diet

On this diet you should eat:
8% to 10% of the day's total calories form saturated fat
30% or less of the day's total calories from fat
Less than 300 mg of dietary cholesterol a day
Just enough calories to achieve and maintain a healthy weight

Step 2 Diet

If you do not lower your cholesterol enough on Step 1 diet or if you are at a high risk for heart disease or already have heart disease:
Less than 7% of the day's total calories from saturated fat
30% or less of the day's total calories from fat
Less than 200 mg of dietary cholesterol a day
Just enough calories to achieve and maintain a healthy weight

BENEFITS DERIVED FROM LONG-TERM OUTPATIENT CARDIAC REHABILITATION

- Increased oxygen extraction and wider AVO_2 difference. Skeletal muscles take up more oxygen from entering blood supply so that the venous return carries less back to the heart. The heart is thus doing less work to bring adequate oxygen to the tissue
- Improved utilization of oxygen by active muscles resulting from increased oxidative enzymes and number of mitochondria in the muscles
- Increased maximal oxygen consumption (VO_2 max) or aerobic capacity and physical work capacity
- The conditioned patient generally has a slower pulse and low blood pressure and lower rate pressure product; RPP = HR × SBP. Because RPP is a good indicator for the myocardial oxygen demand (MVO_2), the trained cardiac patients function at a lower myocardial oxygen demand. Thus, an angina patient may be below the angina threshold in daily life and is able to perform certain activities without angina or silent ischemia
  - Decreased MVO_2 at rest and any submaximal workload
  - Increased cardiac output at maximal exercise; cardiac output remains the same at rest and at submaximal exercise
  - Cardiac output = Heart rate × stroke volume
  - Fick equation $VO_{2\ max}$ = (HR × stroke volume) × AVO_2 difference
  - Fick equation measures cardiac output × AVO_2 difference
  - Increased stroke volume at rest, submaximal and maximum work. This increase is due mostly to a combination of increased blood volume and prolonged diastolic filling time. (Flores and Zohman, 1993; Garden and Gillis, 1996)
  - Exercise training, combined with intensive dietary intervention, with and without lipid-lowering drugs results in regression or limitation of progression of angiographically documented coronary atherosclerosis
  - Cardiac rehabilitation exercise training decreases myocardial ischemia as measured by exercise, ECG, and radionuclide perfusion imaging
  - Cardiac rehabilitation exercise has no apparent effect on development of a coronary collateral circulation and produces no consistent changes in cardiac hemodynamic measurement at cardiac catheterization
  - Exercise training in patients with heart failure and decreased ventricular systolic function resulted in documented improvement in functional capacity. Data reinforces that the favorable training effects in these patients are due predominantly to adaptation in the peripheral circulation and skeletal muscles rather than adaptation in the cardiac musculature. (Cardiac Rehabilitation: Clinical Practice Guidelines Number 17; 1995)

CANCER REHABILITATION

GOALS OF REHABILITATION:

The general rehabilitation goals of patients with cancer are similar to the general goals of patients with disabilities caused by other diseases.

Rehabilitation of the patient with cancer should begin when disability is anticipated, rather than after it has occurred. The number of individuals surviving five years or more with a history of cancer continues to grow. Survivors may face significant physical and psychosocial problems that affect their quality of life. Rehabilitation goals can be appropriately assessed according to the different stages of the disease manifestation.