Rehabilitation programs for patients with chronic obstructive pulmonary disease (COPD) have existed for more than 30 years. The American College of Chest Physicians in 1974 defined pulmonary rehabilitation and described aspects of care for patients with respiratory impairments. The American Thoracic Society incorporated these into an official position statement in 1981. More recently, the 2006 American Thoracic Society and the European Respiratory Society Statement on Pulmonary Rehabilitation stated, “Pulmonary rehabilitation is an evidence-based, multidisciplinary, and comprehensive intervention for patients with chronic respiratory diseases who are symptomatic and often have decreased daily life activities. Integrated into the individualized treatment of the patient, pulmonary rehabilitation is designed to reduce symptoms, optimize functional status, increase participation, and reduce health care costs through stabilizing or reversing systemic manifestations of the disease.” Most of the research available has addressed the benefits of rehabilitation for patients with COPD while neglecting rehabilitation outcomes for patients with other chronic respiratory diseases such as restrictive lung diseases, spinal and chest deformities, neuromuscular conditions that lead to respiratory failure, pulmonary vascular diseases, and those that affect the very obese. Early research in the area of pulmonary rehabilitation focused on the lack of improvement, as documented by pulmonary function testing, or the failure to reverse the natural progression of the disease process.

Today, many successful pulmonary rehabilitation programs exist and the need for early detection and treatment of respiratory dysfunction is widely accepted. Rehabilitation research now emphasizes symptom improvement, functional and exercise gains, and health-related quality-of-life outcomes as measures of efficacy instead of changes in pulmonary physiologic parameters. This research supports the benefit of pulmonary rehabilitation.

The history of physical therapy involvement in the care of pulmonary patients has roots back to the First World War. A British nurse, Winifred Linton, initially treated traumatic respiratory complications during the war. Following the war, she entered physical therapy training and began to teach localized breathing exercises to other physical therapists (PTs) and surgeons at the Royal Brompton Hospital in London. Her work continued through the 1940s and during the Second World War. A few PTs in the United States were instructed in airway clearance techniques and began to use and teach them to patients during the polio epidemic of the 1940s.

The Cardiovascular and Pulmonary Section of the American Physical Therapy Association (APTA) is an organization formed 30 years ago to promote and support the practice of Cardiovascular and Pulmonary Physical Therapy. The organizational website states, “The Cardiovascular and Pulmonary Section will serve its members, the physical therapy profession, and the community, by promoting the development, application and advancement of cardiovascular and pulmonary physical therapy practice, education, and research.” All licensed PTs and physical therapy assistants (PTAs) who are members of APTA are eligible to join the section.

A cardiovascular and pulmonary residency was initiated in 2008 by APTA that includes an intensive 1-year plan of didactic, clinical practice, and research study. This residency
is intended to expand the physical therapist’s knowledge and clinical skill and to prepare those who successfully complete the residency to sit for the Cardiovascular and Pulmonary APTA Board Certification examination.9,10

Pulmonary rehabilitation principles can be generalized to many chronic disease patient populations: the need for multidisciplinary programming; individualized goals aimed at restoring optimal physical and psychological functioning; and adding components of exercise, education, and counseling. Disease-specific aspects of rehabilitation include the following:

- Patient assessment and goal-setting
- Exercise training
- Self-management education
- Nutritional intervention
- Psychosocial support

In this chapter, goals for rehabilitation of the pulmonary patient, the structure of pulmonary rehabilitation programs, and physical therapy strategies are presented.

### Choosing Goals and Outcomes in Pulmonary Rehabilitation

The goals for an individual pulmonary patient must be very specific and pertinent to his or her lifestyle, needs, and personal interests. This is possible only after a thorough evaluation of the patient's disease state and clinical course, physical examination, and possibly a patient-family interview.

The rehabilitation personnel should assist the patient in identifying realistic goals that can be described in behavioral terms and measured as outcomes for rehabilitation. They should be goals that can make the most impact on daily function as well as be realistic and life enhancing. Examples of unrealistic goals are to eliminate dyspnea, to have a normal lifestyle, or to discontinue supplemental oxygen use. Examples of more realistic goals would be learning and implementing strategies to relieve dyspnea, increasing activity tolerance, and improving oxygen saturation levels during activity.

Pulmonary rehabilitation outcomes are measures that generally assess the success of set goals. Outcome assessments are usually a combination of objective and subjective measures. Three essential areas that require outcome measurements in pulmonary rehabilitation include the following:

- **Exercise capacity**
- **Symptoms (dyspnea and fatigue)**
- **Health-related quality of life**

These domains have been supported by various national and international organizations as key areas for outcome assessment in pulmonary rehabilitation.2,5,11,16-20

- **Improvement in exercise capacity.** The patient will (1) gain sufficient strength, flexibility, and endurance to accomplish identified activities of daily living (ADLs) and requirements of employment and recreational tasks and (2) learn to employ strategies to manipulate the environment to maximize physical functioning. Outcome measures related to this area of improvement include graded exercise tests, timed distance walk tests, incremental or endurance shuttle walk tests, and timed ADL tests.21-35

- **Improvement in clinical symptoms.** For example, the patient will (1) be able to effectively mobilize respiratory secretions, (2) employ strategies to relieve symptoms of dyspnea and cough, (3) recognize early signs of the need for medical intervention, (4) decrease the frequency and severity of respiratory exacerbations, and (5) obtain optimal oxygen saturation throughout the day and night. Outcome measures for this area may include the use of a Borg or visual analog scale to measure dyspnea or fatigue, dyspnea questionnaires to measure the impact of dyspnea on ADLs, the distress of dyspnea, the influence of dyspnea on quality of life (QOL), and the evaluation of fatigue.2,5,11,16-19

- **Improvement in health-related behaviors.** For example, the patient will (1) stop tobacco use and drug or alcohol misuse, (2) comply with medical and rehabilitation treatments, (3) improve coping skills, and (4) improve psychosocial function. Outcome measures for this area of change include behavioral surveys, patient diaries, and other self-report tools, as well as carbon monoxide levels for tobacco use.2,5,11,16,18,19,36-38

Other outcome assessments such as functional performance, home-based activity, psychosocial outcomes (anxiety and depression), adherence (dropout or attendance rate), knowledge and self-efficacy, smoking cessation, nutrition/weight, healthcare utilization, mortality and morbidity, and patient satisfaction may also be of interest and some pulmonary rehabilitation programs may choose to measure these parameters (Table 19-1).36-39

### Structure of the Pulmonary Rehabilitation Program

Pulmonary rehabilitation programs vary widely in their overall structure and settings. Programs are offered in an inpatient rehabilitation or subacute facility, as an outpatient program in a hospital or freestanding clinic, or in the patient’s home. Each setting has its advantages and disadvantages in terms of convenience for patients, cost of delivering services, resources available, and socialization opportunities. Benefits associated with pulmonary rehabilitation have been demonstrated in each setting.40

In some cases, pulmonary rehabilitation begins during an acute hospitalization, at which time appropriate candidates for outpatient rehabilitation can be identified, patient education and support can be initiated, and the response to activity and exercise can be evaluated. Treatment is aimed at reducing immobility and maintaining function during the hospitalization. All components of pulmonary rehabilitation can begin during the acute inpatient program, within the limits of patient tolerance and medical condition.41,42

Despite the variability in the structure of pulmonary rehabilitation programs, there are some accepted...
Table 19-1  Pulmonary Rehabilitation Outcome Measures

<table>
<thead>
<tr>
<th>Domain</th>
<th>Outcome Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise capacity and function</td>
<td>Symptom-limited graded exercise test</td>
</tr>
<tr>
<td></td>
<td>Submaximal exercise test</td>
</tr>
<tr>
<td></td>
<td>6-minute walk test</td>
</tr>
<tr>
<td></td>
<td>Shuttle walk tests (incremental or endurance)</td>
</tr>
<tr>
<td>Symptoms</td>
<td>Dyspnea  Borg Scale</td>
</tr>
<tr>
<td></td>
<td>Visual Analogue Scale (VAS)</td>
</tr>
<tr>
<td></td>
<td>Baseline (BDI) and Transitional (TDI) Dyspnea Indexes</td>
</tr>
<tr>
<td></td>
<td>Medical Research Council (MRC)</td>
</tr>
<tr>
<td></td>
<td>University of California San Diego (UCSD) Shortness of Breath Questionnaire</td>
</tr>
<tr>
<td></td>
<td>Pulmonary Functional Status and Dyspnea Questionnaire (PFSDQ or PFSDQ-M)</td>
</tr>
<tr>
<td></td>
<td>Pulmonary Function Status Scale (PFSS)</td>
</tr>
<tr>
<td></td>
<td>Symptom domain of the St. George Respiratory Questionnaire (SGRQ)—evaluates dyspnea,</td>
</tr>
<tr>
<td></td>
<td>cough, sputum, and wheeze</td>
</tr>
<tr>
<td></td>
<td>Activity domain of SGRQ—evaluates activity limitation resulting from dyspnea</td>
</tr>
<tr>
<td></td>
<td>Dyspnea Domain of the Chronic Respiratory Disease Questionnaire (CRQ)</td>
</tr>
<tr>
<td></td>
<td>Fatigue  Borg scale (substitute the word dyspnea with a comparable word of fatigue (e.g., tired, exhausted))</td>
</tr>
<tr>
<td></td>
<td>Visual Analogue Scale (VAS) (with word substitution)</td>
</tr>
<tr>
<td></td>
<td>Multidimensional Fatigue Inventory (MFI)</td>
</tr>
<tr>
<td></td>
<td>Multidimensional Assessment of Fatigue (MAF)</td>
</tr>
<tr>
<td></td>
<td>Vitality dimension of the Short-Form 36 (SF-36)</td>
</tr>
<tr>
<td></td>
<td>Fatigue dimension of the CRQ or PFSDQ-M</td>
</tr>
<tr>
<td></td>
<td>Fatigue/inertia and vigor/activity subscales of the Profile of Mood States (POMS)</td>
</tr>
<tr>
<td>Health-related quality of life</td>
<td>Medical Outcomes Study (MOS)—Commonly called the SF-36</td>
</tr>
<tr>
<td></td>
<td>St. George Respiratory Questionnaire (SGRQ)</td>
</tr>
<tr>
<td></td>
<td>Chronic Respiratory Disease Questionnaire (CRQ)</td>
</tr>
<tr>
<td></td>
<td>Seattle Obstructive Lung Questionnaire (SOLQ)</td>
</tr>
</tbody>
</table>

recommendations for the qualifications of personnel, program components, and patient candidacy.2,5,40

The Pulmonary Rehabilitation Team

The specific professionals involved in pulmonary rehabilitation vary from program to program. Optimally, the core of the pulmonary rehabilitation program team consists of at least three to four rehabilitation specialists who have experience and varied academic backgrounds. Additional professionals may consult with patients on an as-needed basis or serve as program advisers to meet the needs of a diverse patient population.40

The Patient and Family

The patient with pulmonary disease participating in the pulmonary rehabilitation program, the patient’s spouse or family, and the primary care provider play a central role on the team. The patient must be empowered to lead the rehabilitation process with the assistance and guidance of the rehabilitation professionals and family. This may be difficult for some patients who have taken a passive role in their own treatment, and for families who have become caretakers. Individualized and family counseling may be indicated for those who are unable to assume the responsibility of this role.

The Medical Director

The medical director should be a physician who has interest and expertise in pulmonary diseases. He or she directs the rehabilitation program in matters of overall policy, procedures, and medical care, including specialized diagnostic tests and medical treatments for pulmonary diseases.

The Program Director

The program director is the administrator or coordinator of services. This person is the team leader, directing day-to-day
functions of the pulmonary rehabilitation program according to established policies and procedures. A diverse background in pulmonary care, education, and administration are necessary for this individual. In most programs, the program director also provides direct patient care services.

Other Team Members
Other team members may include a variety of specialists who can assume leadership in the areas of exercise, breathing re-training, respiratory care, education, counseling or behavior management, pharmacology, and nutrition.

Program Components
A comprehensive pulmonary rehabilitation program should incorporate the following components:

- Patient assessment and goal-setting
- Exercise and functional training
- Self-management education
- Nutritional intervention
- Psychosocial management

A physical therapist may participate in any or all of these pulmonary rehabilitation program components, but makes their greatest contributions in the areas of pulmonary care, exercise and functional training, and education.

Patient Assessment and Goal Setting
The patient evaluation is the foundation for an individualized program design and measurement of outcomes. Each patient is different and each will have a distinctive plan of care. Components of the initial patient assessment include the following:

- Patient interview
- Medical history
- Physical assessment
- Review of diagnostic tests
- Symptom assessment

The patient interview can set the stage for ongoing communication, trust, and a healthy rapport between the patient and rehabilitation team. Establishing a comfortable atmosphere during the initial interview will facilitate a feeling of ease with the staff and rehabilitation setting, decrease anxiety or fear associated with therapy, and allow the patient to ask any questions he or she may have concerning rehabilitation.

A thorough review of the medical history by reading the patient’s medical records and personal communication will offer a snapshot into the history of the patient’s disease course and comorbidities. Items to be noted include surgical procedures, family history, use of medical resources (e.g., hospitalizations, emergency department visits), medications, oxygen use, allergies, smoking/alcohol/other substance abuse history, occupational and environmental exposures, social support, and prior level of function.

An overall physical evaluation gives the physical therapist a baseline pathophysiological assessment of the patient upon which specific musculoskeletal and functional parameters may be observed. Basic components of the physical evaluation include vital signs (e.g., blood pressure, heart rate, oxygen saturation, respiratory rate), height, weight, body mass index, breathing pattern including use of accessory breathing muscles, chest examination (e.g., auscultation of lung and heart sounds, inspection, palpation, symmetry), presence of clubbing of distal digits (see Fig 16-12), vascular integrity (e.g., edema, skin coloration, hair growth), and skin integrity (e.g., bruising, skin tears). A review of diagnostic tests will offer additional information to accurately plan the treatment regime and adjuncts to treatment (e.g., need for oxygen use, exercise tolerance and fatigue, special precautions with exercise, such as negative bone density scores).

Finally, asking specific questions and observing the patient during the interview will provide added information related to symptom assessment. Those may include dyspnea, fatigue, cough and sputum production, wheezing, hemoptysis, chest pain, gastroesophageal reflux, dysphasia, pain and/or weakness, feelings of anxiety/panic/isolation, and depression.

Exercise and Functional Training
The determination of safe and appropriate exercise should be preceded by a thorough musculoskeletal assessment by the physical therapist. The assessment should begin with a gross manual muscle test of the upper and lower extremities and the trunk. A range-of-motion (ROM) and flexibility examination must focus on specific areas such as the rib cage, shoulders, cervical/thoracic/lumbar spine, hamstrings, and gastrocnemius/soleus muscles. The rib cage, shoulders and spine lose ROM as a result of progressive lung disease, poor posture, and accessory breathing muscle use. The lower extremity musculature typically loses flexibility because of disuse.

Poor posture also develops simultaneously as lung disease progresses, activity levels decrease, and metabolic changes effect bone density. Furthermore, postural changes continue to occur with the loss of chest mobility, the adoption of proping postures, and the use of accessory breathing muscles of the shoulders, cervical and thoracic spine (see Fig 16-3). Poor postural habits further inhibit breathing mechanics, and particular attention should be given to chest wall mobility within the treatment plan.

Many patients with chronic respiratory disease simultaneously suffer from musculoskeletal abnormalities, for instance, pulmonary diagnoses of restrictive lung disease (e.g., scleroderma, pulmonary fibrosis due to unspecified connective tissue disease, rheumatoid arthritis, spinal cord injury, and scoliosis). Elderly chronic respiratory disease patients often experience osteoarthritis of the shoulders, spine, hips, knees, and feet. Those who have used systemic corticosteroids for prolonged periods of time and in higher doses may experience pain and functional disabilities due to osteoporosis, vertebral compression fractures, or loss of peripheral joint and neurological integrity.

Instruction in posture, balance, gait, strengthening, flexibility, energy conservation/pacing, and the use of adaptive
Self-Management Education

An educational assessment is helpful to determine how well the patient understands and manages his or her disease. This information allows the physical therapist to design an educational plan and evaluate change following intervention. The educational focus in pulmonary rehabilitation has transitioned from only didactic lectures in a group setting to instruction in self-management in collaboration with the health care provider. For example, the chronic respiratory disease patient should be able to recognize an early acute exacerbation of his or her disease; when/how to initiate or increase specific therapy such as antibiotics, steroids, and bronchodilators; and when to contact their health care provider. Other areas to note are the patient’s ability to read, write, hear, and see. Physical therapists should also be aware of cognitive impairments, language barriers, and cultural diversity issues.

Educational topics may include anatomy and pathophysiology of chronic respiratory diseases, use and misuse of oxygen, and practical solutions to incorporate activity into daily lives. Self-management education involves the transfer of knowledge and skill in performing self-care techniques. Other topics include airway clearance and relieving dyspnea, breathing techniques, cough facilitation, postures to improve breathing, and relaxation techniques.

It is important to try a variety of procedures while the patient is in the rehabilitation setting and evaluate which are most effective for the patient in the home environment. Patients whose production of mucus is copious may require two to three airway clearance sessions each day, whereas other patients may require treatment only during an acute illness. These procedures are described in more detail in Chapter 17 and later in this chapter under Physical Therapy Management.

Nutritional Assessment and Intervention

Patients with respiratory disease frequently have alterations of their nutritional status and body mass index (BMI). Chronic respiratory disease patients such as those with COPD or cystic fibrosis experience malabsorption, decreased body mass with muscle mass depletion, and high energy costs as a result of an increased work of breathing. Obesity associated with respiratory disease may be related to hypercarbia due to obesity-hypoventilation syndrome, a decreased activity level due to dyspnea and fatigue, and comorbidities such as cardiac disease.

Accordingly, the nutritional assessment should include at least the measurement of height, weight, calculation of BMI (Weight [kg]/Height2 [m2]),67 and documentation of a recent and significant (>3 lbs.) weight change. Additional notations regarding nutrition may include dysphasia, dentition, mastication problems, gastrosophageal reflux, change of the taste of food due to oxygen use, dyspnea while eating, fluid intake, person responsible for buying and cooking food, alcohol consumption, caffeine consumption, laboratory values for serum albumin and prealbumin, drug–food interactions, and use of nutritional or herbal supplements.

Psychosocial Evaluation and Plan of Care

Screening questionnaires are useful in assessing the psychosocial symptoms of anxiety and depression. Moreover, a psychosocial assessment should address motivational level, emotional distress, family and home environment, substance abuse, cognitive impairment, conflict and/abuse, coping strategies, sexual dysfunction, and neuropsychological impairments (e.g., memory, attention, concentration).

It is important to assess the patient’s psychosocial status in order to tailor the educational and exercise intervention accordingly. Patients with significant psychosocial problems should be referred to appropriate professionals, in particular, social workers, a psychiatric nurse, licensed counselor, psychologist, or psychiatrist. Failure to do so may lead to poor outcomes following rehabilitation.

Patient Candidacy

Most of the research devoted to pulmonary rehabilitation has addressed the benefit to COPD patients. The basic components of pulmonary rehabilitation may, however, be applied to a variety of chronic disease patients such as those with restrictive lung disease, pulmonary hypertension, significant musculoskeletal disease (e.g., arthritis), heart failure, and other stable cardiovascular diseases (e.g., peripheral vascular disease and stroke).

Pulmonary function test data are not exclusively considered when determining candidacy for pulmonary rehabilitation. Most patients are referred and seek rehabilitation as a result of disabling symptoms of dyspnea, inability to perform everyday household activities such as dressing and climbing steps, or a decreased ability to perform job responsibilities. These disabilities may not have a strong correlation to pulmonary function test results.

Patients who continue to smoke, yet have lung disease, may have a significant need for pulmonary rehabilitation and may demonstrate adequate motivation and adherence to therapy. Smoking cessation counseling should be included as part of the therapy and considered a rehabilitation goal. Similarly, a lack of motivation perceived by health care professionals may reverse during and following participation once the patient begins to understand his or her disease and begins to feel better.
Additional issues to consider in patient candidacy include the patient’s financial ability and transportation to rehabilitation. Personal out-of-pocket expense must be clearly defined. Third-party payers should be contacted to verify coverage and co-pays. Financial and insurance counselors are helpful in this respect. Discussing transportation with the patient and providing a list of local transportation options are helpful to facilitate regular attendance.

Generally, candidates for pulmonary rehabilitation have a diagnosed pulmonary disease and functional limitation. Because of legislation passed by Congress in July 2008, via the Medicare improvements for Patients and Providers Act (MIPPA), pulmonary rehabilitation benefits for COPD patients insured by Medicare will change. Those COPD patients, referred by a physician, with moderate to very severe disease (GOLD classification II, III, and IV) will be covered for pulmonary rehabilitation under a bundled billing code. Comprehensive Medicare Services (CMS) will cover 36 one-hour sessions, with a maximum of 2 sessions per day. Each session must include a form of aerobic exercise. Physician supervision is required during the pulmonary rehabilitation session(s) and no component services may be billed separately (e.g., evaluation, 6-minute walk test).

Other patients with risk factors (Box 19-1) for the development of pulmonary disease, mild or very advanced disease, chronic respiratory diseases other than COPD, pre–post pulmonary surgical, and others who are limited by respiratory symptoms can demonstrate important functional gains and should not be excluded from rehabilitation programs.

### Physical Therapy Management

Because of regional differences in practice patterns, the role of the physical therapist in pulmonary rehabilitation varies widely among programs. Some programs do not have a physical therapist at all, whereas others consult with a physical therapist only for patients with certain diagnoses, such as those who have musculoskeletal or neuromuscular conditions in addition to pulmonary disease.

Optimally, the physical therapist has expertise in evaluating and treating patients with a wide variety of pulmonary conditions, and is involved in all components of the program. In addition to evaluating each patient and leading exercise sessions, the physical therapist may provide educational sessions, smoking cessation programs, stress management, and relaxation training. The physical therapist also re-evaluates the patient’s response to activity, guides exercise progression, assesses outcomes, and provides individualized home exercise programs.

### Patient Evaluation Procedures

Information on patient evaluation, treatment, and follow-up are reviewed in this section to facilitate the development of the physical therapist in assuming a significant role in pulmonary rehabilitation. A more comprehensive guide for examination, evaluation, intervention, and outcomes is described in “The Cardiopulmonary Preferred Practice Patterns” in the Guide to Physical Therapist Practice (Table 19-2).

A patient referred to a pulmonary rehabilitation program should be receiving regular medical care from a personal physician and should have seen a physician within the last 30 days. Diagnostic testing should be completed and all medical conditions must be considered stable prior to beginning the rehabilitation program.

The physical therapist should evaluate each pulmonary rehabilitation candidate by completing a chart review of medical conditions, laboratory and other test results, interviewing the patient, and performing a physical examination, including an assessment of activity tolerance.

### Box 19-1

**Risk Factors for the Development of Obstructive Pulmonary Disease**

- Smoking: cigarette, pipe, cigar, environmental tobacco smoke
- Environmental exposures: air pollution, cooking over an open fire in enclosed spaces
- Occupational dusts and chemicals: asbestos, grain farmers, furnace workers, vapors, irritants, and fumes
- Family history (genetic): α₁-antitrypsin, cystic fibrosis
- Allergies and asthma
- Dietary: poor nutrition (e.g., low levels of vitamins A, C, and E)
- Gestational and childhood factors: low birth weight, respiratory infections
- Periodontal disease

### Table 19-2 Practice Patterns for Patients with Pulmonary Diseases

<table>
<thead>
<tr>
<th>Practice Pattern</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6A</td>
<td>Primary prevention/risk reduction for cardiovascular/pulmonary disorders</td>
</tr>
<tr>
<td>6B</td>
<td>Impaired aerobic capacity/endurance associated with deconditioning</td>
</tr>
<tr>
<td>6C</td>
<td>Impaired ventilation, respiration/gas exchange, and aerobic capacity/endurance associated with airway clearance dysfunction</td>
</tr>
<tr>
<td>6D</td>
<td>Impaired ventilation and respiration/gas exchange associated with ventilatory pump dysfunction or failure</td>
</tr>
<tr>
<td>6E</td>
<td>Impaired ventilation associated with respiratory failure</td>
</tr>
</tbody>
</table>

Chart Review

The chart should be reviewed for the current pulmonary diagnosis and all diagnostic and laboratory testing that has established the diagnosis, prognosis, and stage of disease. This may include, but is not limited to, pulmonary function testing, chest x-ray, arterial blood gas analysis, electrocardiogram, blood counts, and blood chemistry. In addition, all treatments related to the disease should be identified, such as surgical interventions, medication, oxygen therapy, and assisted ventilation therapy.

Equally important to pulmonary conditions, the chart must be reviewed for other medical diagnoses that should be addressed during rehabilitation. These diagnoses include cardiac disease, diabetes, hypertension, peripheral vascular disease, lipid disorders, arthritis, and cancer, or any chronic condition that may interfere with activity tolerance and function. Pertinent family history may indicate the patient's risk for developing some chronic conditions such as hypertension, diabetes, and cardiac disease.

The information obtained in the chart review will assist the physical therapist in setting individualized goals and treatments, monitoring for adverse responses, providing appropriate education and counseling, or initiating referrals to other professionals.

Patient Interview

The physical therapist can gather additional information from the patient and family during the interview. To prompt the therapist and make the process efficient, interview questions may be standardized for all participants.

The physical therapist should make sure to ask about the following:
- Use of tobacco, alcohol, and nonprescription drugs
- Usual activity level, including employment, recreation, and home
- Regularity of exercise, including availability of equipment at home
- Two to three activities that the patient names as the most difficult to perform because of his or her pulmonary disease
- Compliance with prescribed medication and treatments
- Pain levels
- Support from family and friends
- History of environmental exposures and sensitivities (including passive smoke)
- Goals for participating in the rehabilitation program

As discussed earlier in this chapter, outcomes questionnaires related to quality of life and function may be used to further assess the patient's current status.

Patient Examination

The patient examination should include tests and measurements that yield a description of function and physical capabilities. The initial physical therapy evaluation will lead to the formation of patient-specific rehabilitation goals and treatments and provide a baseline measurement for re-evaluation and documentation of change as a result of rehabilitation.

The nutritional evaluation should include the following:
- Weight
- Height
- Calculation of BMI

Patients with respiratory disease often have significant alterations in nutritional status and body composition. Excess weight contributes to higher energy demands and work of breathing. Patients who are underweight must have adequate nutrition and calorie intake to build strength and endurance. Poor nutritional status is a significant and independent predictor of mortality among chronic respiratory patients.44-46

Chest evaluation should include the following:
- Auscultation of lung and heart sounds
- Cough assessment
- Inspection of breathing pattern

Patients who demonstrate lung secretion retention or an ineffective cough may benefit from airway clearance techniques. Those who demonstrate bronchial wheezing may benefit from a trial of bronchodilator therapy. All patients with atypical use of respiratory accessory muscles at rest or with activity will benefit from instruction in breathing re-training, relaxed, and paced breathing techniques.

Musculoskeletal and integumentary evaluation should include the following:
- Joint range of motion
- Gross strength assessment of extremities and trunk
- Posture
- Gait
- Skin inspection
- Edema inspection

Patients undergoing pulmonary rehabilitation may have a multitude of joint abnormalities, pain, postural deviations, gait, and strength deficiencies—often because of inactivity.50

Indeed, it is not unusual for this population to experience musculoskeletal anomalies due to nutritional deficits, systemic inflammation, or as a result of medication side effects.51

Furthermore, the frequent existence of cardiac and endocrine comorbidities add to the likelihood of integumentary disorders that the physical therapist must consider when developing the treatment plan.

Functional evaluation should include the following:
- ADLs
- Balance and gait assessment
- Prior level of function
- Need for adaptive equipment
- Fall risk
- Leisure, social and family activity

Shortness of breath, muscle weakness, and poor stamina frequently lead to a diminished ability and desire to perform ADLs among respiratory disease patients. Even individuals who were previously gainfully employed and involved in community, family, and recreational activities may have to
face severe limitations in mobility. Even basic self-care such as taking a shower or getting dressed may be overwhelmingly difficult. For these reasons, the physical therapist must assess the respiratory patient’s ability to perform everyday tasks.

Various questionnaires and functional tests are available to evaluate occupational performance and ADLs; specifically, the Functional Independence Measure (FIM), the Assessment of Motor and Process Skills (AMPS), and a Functional Capacity Evaluation (FCE). Occasionally, metabolic equivalent values (METs) may be used to gauge the endurance and performance levels of patients (1 MET = 3.5 mL O₂/kg/min) (Table 19-3). Knowing these values will assist the therapist to determine the need for adaptive equipment and set realistic performance expectations and goals. If specific functional abnormalities are observed in conjunction with muscle weakness or gait disturbances, it may be necessary to perform additional testing such as balance and/or sit-to-stand tests.

As is the case in standard physical therapy practice, following evaluation of the respiratory disease patient, the PT must synthesize the assessment findings and transition them to a reasonable treatment plan. The treatment plan should be designed to improve the patient’s deficits and progress them toward their expressed goals. The physical therapist functions as the navigator, allowing the patient to move forward toward achieving success.

**Treatment Intervention**

**Airway Clearance**

The physiologic basis for treatment and descriptions of airway clearance techniques are reviewed in Chapter 17. The main emphasis of airway clearance in the rehabilitation setting is the removal of excessive secretions that obstruct airways, to improve cough, and decrease the incidence of respiratory infections and deterioration of lung function. This is especially important for patients who have chronic, copious, or thick pulmonary secretions, such as those with cystic fibrosis, bronchiectasis, and chronic bronchitis. Patients with severe neuromuscular weakness of the respiratory muscles may also benefit from airway clearance techniques because acute pulmonary infections often cause respiratory failure in this patient group.

Following a thorough evaluation, the physical therapist should employ treatment techniques that offer the best therapeutic results and are most convenient for the patient to continue at home. It is essential to offer the patient and family a variety of treatment options to enhance compliance and encourage self-management. Treatment modifications may be necessary if the patient does not have assistance at home. Modifications that may allow for self-treatment include the following:

- Percussion and/or vibration may be necessary under certain circumstances. If assistance is not available, palm cups, or a self-administered, high-frequency chest compression system can be used.

<table>
<thead>
<tr>
<th>Intensity</th>
<th>MET Level</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very light</td>
<td>1 MET</td>
<td>Resting</td>
</tr>
<tr>
<td>Very light</td>
<td>1 MET</td>
<td>Eating</td>
</tr>
<tr>
<td>Very light</td>
<td>1 MET</td>
<td>Writing</td>
</tr>
<tr>
<td>Very light</td>
<td>1 MET</td>
<td>Knitting</td>
</tr>
<tr>
<td>Light</td>
<td>2 METs</td>
<td>Light calisthenics</td>
</tr>
<tr>
<td>Light</td>
<td>2 METs</td>
<td>Driving (nonsstressful conditions)</td>
</tr>
<tr>
<td>Light</td>
<td>2 METs</td>
<td>Light housework</td>
</tr>
<tr>
<td>Light</td>
<td>2 METs</td>
<td>Sweeping, ironing, dusting</td>
</tr>
<tr>
<td>Light</td>
<td>2 METs</td>
<td>Walking (2.2 mph)</td>
</tr>
<tr>
<td>Moderate to heavy</td>
<td>3 METs</td>
<td>Self-care (washing, dressing)</td>
</tr>
<tr>
<td>Moderate to heavy</td>
<td>4 METs</td>
<td>Gardening (weeding)</td>
</tr>
<tr>
<td>Moderate to heavy</td>
<td>4 METs</td>
<td>Ballroom dancing</td>
</tr>
<tr>
<td>Moderate to heavy</td>
<td>4 METs</td>
<td>Canoeing, golf</td>
</tr>
<tr>
<td>Moderate to heavy</td>
<td>4 METs</td>
<td>Bed-making</td>
</tr>
<tr>
<td>Moderate to heavy</td>
<td></td>
<td>Woodworking (drilling, sawing)</td>
</tr>
<tr>
<td>Moderate to heavy</td>
<td></td>
<td>Walking on level ground (4 mph)</td>
</tr>
<tr>
<td>Very heavy</td>
<td>5 METs</td>
<td>Shovelling snow</td>
</tr>
<tr>
<td>Very heavy</td>
<td>6 METs</td>
<td>Digging vigorously</td>
</tr>
<tr>
<td>Very heavy</td>
<td>6 METs</td>
<td>Tennis</td>
</tr>
<tr>
<td>Very heavy</td>
<td>6 METs</td>
<td>Downhill skiing (slow)</td>
</tr>
<tr>
<td>Very heavy</td>
<td>6 METs</td>
<td>Walking on level ground (5 mph)</td>
</tr>
<tr>
<td>Very heavy</td>
<td>7 METs</td>
<td>Cycling (13 mph)</td>
</tr>
<tr>
<td>Very heavy</td>
<td>8 METs</td>
<td>Swimming (40+ yard/min)</td>
</tr>
<tr>
<td>Very heavy</td>
<td>8 METs</td>
<td>Cross-country skiing (4 mph)</td>
</tr>
<tr>
<td>Very heavy</td>
<td>8 METs</td>
<td>Running</td>
</tr>
<tr>
<td>Very heavy</td>
<td>8 METs</td>
<td>Walking on level ground (5-6 mph)</td>
</tr>
<tr>
<td>Very heavy</td>
<td>9 METs</td>
<td>Swimming (crawl, 55 yards/min)</td>
</tr>
<tr>
<td>Very heavy</td>
<td>&gt;10 METs</td>
<td>Downhill skiing (fast)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Walking uphill (5 mph)</td>
</tr>
</tbody>
</table>

Adapted from Woods SL. Cardiac Nursing. 5th ed. Philadelphia, Lippincott, Williams & Wilkins, 2004.
Postural drainage positions in conjunction with the performance of a series of deep breathing exercises, forced expirations, and coughing or use of devices that provide intermittent positive expiratory pressure are effective to mobilize secretions. Breathing and coughing exercises may be done after bronchodilator treatments to remove the secretions that have accumulated overnight, or before and after each exercise session.

Sustained exercise, if tolerated by the patient, can have very beneficial airway-clearing effects. Pulmonary rehabilitation should include an assessment of the patient’s ability to perform treatments independently and effectively. The short-term effects or outcomes of these treatments, such as improved breath sounds, decreased atelectasis, increased tissue perfusion and oxygenation, and subjective improvements in shortness of breath, are important to monitor immediately after treatments.

Long-term benefits or outcomes of airway clearance that are monitored over the rehabilitation period may include the following:

- Ability to perform physical actions, tasks, or activities related to self-management, home management, work (job/school/play), community, and leisure is improved.
- Performance of and independence in ADLs with or without devices, equipment, and assistance, are increased.
- Health status is improved.
- Cost of health care services is decreased.
- Sense of well-being is improved.

### Functional Training

Functional training is especially important for patients who have symptoms of weakness, fatigue, or dyspnea that limit activities. Essential to rehabilitation is the reversal of deconditioning to improve the patient’s ability to do work.

Treatment goals include the following:

- Adapting the environment to improve the ease of performing ADLs
- Altering the performance of tasks to decrease energy costs
- Incorporating methods to relieve symptoms associated with activity

### Energy Conservation

Identification of the ADLs that are most problematic for the patient is the first step to modify the environment. Once identified, the areas in the home in which these activities are performed should be evaluated for modification. Adaptations are usually necessary in the bathroom, bedroom, and kitchen. Basic concepts include the following:

- Providing work areas with supported seating of appropriate height for tasks done on a counter or table
- Placing equipment that is used most often in convenient locations so that bending, reaching, and lifting are minimized
- Locating a table or counter at work stations on which one can slide heavy items instead of lifting and carrying them
- Locating chairs at appropriate places when rests are needed, such as on the bordering of stairs or beside the bathtub
- Using adaptive equipment to simplify tasks and improve comfort, for instance, a bath seat and hand-held shower head, a wheeled cart for transporting laundry or items for the dinner table, a set of grab bars or booster seats to get up from a toilet or a low chair, a wheeled walker and hospital bed if necessary
- Improving ventilation for the bathroom, kitchen, or other areas in which fumes, dust, smoke, or steam may cause respiratory symptoms

Including energy conservation techniques to modify tasks allow the patient to complete work that might otherwise be impossible. Each activity can be broken down into smaller tasks and analyzed with regard to the most energy-efficient method of work. Basic concepts include the following:

- Instruct in paced breathing techniques
- Slow down the pace
- Setting priorities and organizing activities to minimize wasted movement
- Planning appropriate amounts of time to complete the task, including rest breaks

**Clinical tip**

The basic concepts of paced breathing/activity are inhale with rest/exhale with work, slow down, set priorities, get organized, and take rest breaks along the way toward task completion. Instructions can include examples such as “Exhale during the hardest part of an activity and inhale during the rest phase”; “When you stand up from a chair, take a breath in before you stand, and then exhale as you stand”; and “Blow yourself out of the chair.”

### Relief of Dyspnea

Simple procedures to minimize and relieve shortness of breath during ADLs can become incorporated into the functional training. Controlling the breathing pattern with paced breathing and movement, altering postures to improve respiratory muscle function, and using relaxation techniques are some key principles of treatment. Bending over at the waist, from either a standing or a sitting position, should be limited because a Valsalva maneuver actually occurs, making the patient more breathless and raising the blood pressure. It is more work efficient to bring work closer; for example, when donning/doffing socks and shoes, have the patient cross their leg over the opposite leg, or place their foot onto an ottoman so that the bend is modified.

It may also be beneficial for the patient to learn dyspnea monitoring with functional training. Patients should become aware of their dyspnea level with all tasks. Instruction in methods to decrease dyspnea with activity and manage symptoms by using paced breathing and pursed-lip breathing are
Breathing Re-Training

An important principle in relieving dyspnea is to avoid breath holding, Valsalva maneuver, or unnecessary talking during the task. Pursed-lip breathing is useful for patients whenever an increase in breathing effort is noticed or to facilitate a paced breathing pattern. This naturally slows down respirations and decreases minute ventilation, relieving dyspnea in some patients.\textsuperscript{60,62} Exhalations through pursed lips during walking, lifting, pushing, or pulling activities prevents breath holding and straining. Physiologically, pursed-lip breathing decreases premature airway closure/trapping thereby decreasing residual volume (see Fig 16-7).\textsuperscript{60}

Patients with restrictive lung disease experience greater work of breathing as a result of progressive stiffness, increased compliance, and scarring of lung tissue. At rest and more dramatically during effort, these patients may demonstrate a rapid, shallow breathing pattern and dry cough. Typically, interstitial lung disease patients have low lung volumes and reduced diffusing capacity; thus the need for increased amounts of supplemental oxygen during activity. They have difficulty pacing their breathing and often have increased accessory muscle use.\textsuperscript{1} Breathing re-training or teaching the patient to use a specific breathing strategy is not always easy. When successfully re-trained in a new breathing pattern, the patient is likely to resume his inherent breathing pattern when attention is diverted to a task and away from breathing. This is normal behavior; the patient should still be encouraged to use daily “practice sessions” of breathing re-training using newly learned mechanics.\textsuperscript{62}

<table>
<thead>
<tr>
<th>Grade</th>
<th>Degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>0 Not troubled with breathlessness except with strenuous exercise</td>
</tr>
<tr>
<td>Slight</td>
<td>1 Troubled by shortness of breath when hurrying on the level or walking up a slight hill</td>
</tr>
<tr>
<td>Moderate</td>
<td>2 Walks slower than people of the same age on the level because of breathlessness, or has to stop for breath when walking at own pace on the level</td>
</tr>
<tr>
<td>Severe</td>
<td>3 Stops for breath after walking about 100 yards or after a few minutes on the level</td>
</tr>
<tr>
<td>Very severe</td>
<td>4 Too breathless to leave the house or breathless when dressing or undressing</td>
</tr>
</tbody>
</table>

Table 19-4 Dyspnea Scale

Breathing re-training or teaching the patient to use a specific breathing strategy is not always easy. When successfully re-trained in a new breathing pattern, the patient is likely to resume his inherent breathing pattern when attention is diverted to a task and away from breathing. This is normal behavior; the patient should still be encouraged to use daily “practice sessions” of breathing re-training using newly learned mechanics.\textsuperscript{62}

Many patients with severe COPD have diaphragms flattened by lung hyperinflation. A leaning-forward position (see Fig. 16-4) may offer postural relief from dyspnea by improving the function of a flattened diaphragm.\textsuperscript{35,61,63} This position increases the intraabdominal pressure and pushes the diaphragm up into the thorax and into a better position for contraction. Leaning forward with upper extremity support has the additional benefit of fixing the proximal muscle attachments of respiratory accessory muscles (e.g., pectoralis major or sternocleidomastoid) and allowing the thoracic attachments to pull the chest into inspiration. Supported leaning-forward postures, along with a comfortable, controlled breathing pattern may be used when experiencing dyspnea with activity to help relieve shortness of breath.

Relaxation techniques may decrease energy consumption and hasten relief of dyspnea. Contraction--relaxation techniques or autogenic (mental imaging) relaxation may be used for this purpose. In some cases, biofeedback may help the patient learn to relax specific muscle groups. By reaching the patient control of the relaxation response and breathing pattern, the anxiety associated with dyspnea can be reduced. More recently, the conventional medical community has shown an increased interest in complementary and alternative therapies for a wide range of common diagnoses. There have been a few studies to look at the effect of yoga postures and breathing within the pulmonary population. By far, the majority of yoga studies have been conducted with the asthmatic population.\textsuperscript{64} However, Behera conducted a preliminary study by instructing a small group of chronic bronchitis patients in yoga therapy consisting of 8 asans (postures) and pranayamas (breathing control) over a 4-week period. The results were a perceptible improvement in dyspnea measured by a visual analog scale and an improvement in selected lung function parameters.\textsuperscript{65}

Three additional small studies instructed patients with COPD in asans and pranayamas with improvements, including lower dyspnea-related distress with activity, decreased breathing rate, greater breathing depth, and improved 6-minute walk test distances.\textsuperscript{66-68}

Oxygen Evaluation and Use

Physiologic monitoring during functional training should be employed to ensure the safety and appropriateness of exercises. Pulse oximetry, dyspnea and effort scales such as the Borg and Visual analog scales, respiratory rate, heart rate, and blood pressure are typically monitored.\textsuperscript{58} Among lung disease patients, it is imperative that physical therapists understand the proper use of oxygen, be able to accurately monitor its use, and appreciate the logistics regarding the operation of oxygen equipment.

The APTA recognizes the role physical therapists have in the administration and adjustment of oxygen while treating various patient populations.\textsuperscript{43} The APTA’s Guide to Physical Therapist Practice, second edition, delineates the physical therapist’s scope of practice in the management of patients who require oxygen to improve ventilation and respiration/gas exchange. The APTA is unaware of any regulations that
prohibit the use of oxygen for patient management if it is prescribed and if parameters set by the physician are maintained. Physicians specify oxygen flow rates in their orders, and any deviation in the prescribed dosage requires an updated order from the physician. The Food and Drug Administration of the United States Department of Health and Human Services states that “medical oxygen is defined as a prescription drug which requires a prescription in order to be dispensed except … for emergency use.”

Within the APTA’s Guide, supplemental oxygen is listed as a procedural intervention within the scope of physical therapist practice under Prescription, Application, and, as appropriate, Fabrication of Devices and Equipment (supportive device) to improve ventilation and respiration/gas exchange. The APTA has a position statement adopted by the House of Delegates that states:

> PT patient/client management integrates an understanding of a patient’s/client’s prescription and nonprescription medication regimen with consideration of its impact upon health, impairments, functional limitations, and disabilities. The administration and storage of medications used for physical therapy interventions is also a component of patient/client management and thus within the scope of PT practice. Physical therapy interventions that may require the concomitant use of medications include, but are not limited to, agents that facilitate airway clearance and/or ventilation and respiration.

There are no official statements or opinions in any individual state Board of Physical Therapy regarding the administration of oxygen at this time.

A thorough knowledge of oxygen equipment is imperative for the physical therapist. Pulse oximetry is a noninvasive method of photoelectrically determining the oxyhemoglobin saturation of arterial blood. A sensor is placed on a thin part of the patient’s anatomy such as a fingertip or earlobe and a light containing both red and infrared wavelengths is passed through the skin to the small arteries. A microprocessor compares the signals received and calculates the degree of oxyhemoglobin saturation based on the intensity of transmitted light. Larger, stationery oximetry monitors are typically used in intensive care units. Small, hand-held, portable monitors are easily clipped to the distal end of a finger or attached to the earlobe by an earlobe clip. A variety of oxygen delivery devices may be used to administer oxygen to the patient. The most common is the nasal cannula, which can provide oxygen flows from 0.25 to 6 L/min. An Oxymizer delivery device is a nasal cannula with a reservoir incorporated into the tubing mechanism. During exhalation, the reservoir fills with oxygen and is available to the patient upon the next inhalation, essentially providing equivalent saturations at lower flow rates. Manufacturers state that an oxygen savings of approximately 75% may be obtained using the Oxymizer, and lower flow rates provide greater patient comfort.

In addition, oxygen masks are used to deliver even higher concentrations of supplemental oxygen. When pulmonary patients exercise, higher percentages of oxygen are needed to meet the demand of working muscles and to maintain oxygen saturation levels within prescribed limits (usually 88% to 90%). Two types of oxygen masks may be used during exercise with pulmonary patients. The venturi mask uses a mechanical opening that increases the rate at which the oxygen flows into the mask (commonly 24% to 50%). A partial rebreather mask has a reservoir bag attached and delivers between 70% and 80% of oxygen. A non-rebreather mask also incorporates a reservoir bag, but can deliver up to 100% oxygen. Flows between 7 and 10 L/min are required to keep the reservoir bag inflated at all times. See Chapter 13 for pictures of oxygen devices. Less conspicuous forms of oxygen delivery are available for low to moderate oxygen flow patients. Transtracheal oxygen delivery consists of a small catheter being surgically placed into the trachea through the second and third tracheal rings. Transtracheal is well accepted by patients and delivers oxygen more efficiently than a nasal cannula. Because oxygen is delivered directly into the trachea, approximately 50% less oxygen is needed. Other more aesthetically appealing methods of oxygen delivery exist such as small oxygen tubes being imbedded into eyeglass frames.

Physical therapists must be well informed about the varied pathologies that may lead to the need for supplemental oxygen. A spectrum of lung, heart, and blood abnormalities warrants the use of supplemental oxygen. Accordingly, PTs should be able to choose the proper equipment for individual patients with various diagnoses by using cardiopulmonary evaluation techniques, monitoring equipment, and evidence-based practice. Oxygen flow rates may require titration depending on the level of physical activity (rest vs. exercise vs. sleep). In addition, different diagnoses, because of their pathophysiology, require lower or higher oxygen flow rates depending on the patient’s activity level.

The physician normally sets the flow rate for sleep and rest, but with exercise, the PT is instrumental in determining the proper oxygen flow rate needed. The indications for supplemental oxygen use are as follows:

- Arterial partial pressure of oxygen (PO₂) ≤ to 55 mm Hg or SpO₂ ≤ 88%
- Arterial PO₂ ≤ 59 mm Hg or SpO₂ ≤ 89% if evidence of cor pulmonale, right heart failure, or erythrocytosis

It is important to communicate with the physician about oxygen requirements during exercise. Specifically, it is important to request an oxygen prescription by a saturation level, for example, 88% to 90%, rather than by a specific oxygen liter flow, or fraction of inspired oxygen (FiO₂). To determine FiO₂, for every 1 L/min of oxygen, add 3% to the room air FiO₂ of 21%. For example: 4 L/min = ~33% FiO₂ (21 + 12) (Fig 19-1). With this knowledge, the physician can make crucial decisions concerning the patient’s medication effectiveness, dosage, stability of the disease, and surgical options.

A few basic concepts of oxygen delivery, functional ability, and biomechanics are necessary to guide the patient, physician, and oxygen vendor in meeting a patient’s specific
equipment needs. There are essentially three types of oxygen delivery systems. First, an oxygen concentrator has the ability to deliver oxygen up to a level of 5 L/min. It is a device that separates oxygen from room air. There are stationary models, under electrical power, that are suitable to use around the house and during sleep. Different lengths of oxygen tubing are available to accommodate movement from room to room. More recently, portable oxygen concentrators have become available that allow a patient to move in and out of the house and medical diagnosis. If a specific type of portable system or flow rate is required for a patient to participate in a full range of physical activities, it must be noted on the CMN. Otherwise, because DME suppliers are reimbursed at a fixed rate, regardless of the oxygen system they provide the patient, suppliers realize a larger profit by providing less costly systems. A supplier cannot change a physician’s prescription; therefore, it must be filled as written.

It is not uncommon for PTs to treat a variety of patients who require supplemental oxygen, either on an inpatient or
outpatient basis. It is within the physical therapy scope of practice to administer and adjust oxygen according to the physician's prescription. The physical therapist must have a thorough knowledge of oxygen equipment and how to use various devices to meet the physiological and biomechanical needs of the patient.

**Clinical tip**

It is within the physical therapy scope of practice to administer and adjust oxygen according to the physician's prescription. The prescription should be written based upon SpO₂ (e.g., keep SpO₂ >90).

**Physical Conditioning**

Activity can be described in terms of intensity, workloads, duration (minutes of continuous or intermittent work), and frequency or number of repetitions of the activity carried out. Symptoms (e.g., significant shortness of breath, fatigue, palpitations, chest discomfort) and musculoskeletal discomfort should be noted. Caution should be taken with all patients who have coexisting conditions, especially when the coexisting illness is cardiovascular disease. (See Chapter 3 for additional information.)

The physical therapist may advance functional training by the following:

- Increasing repetitions using lower weights and proper technique for strength training
- Encouraging a higher/level of work within a given time: bike, ambulation
- Encouraging fewer rest periods during task performance
- Decreasing the dependence on adaptive equipment: wheelchairs, motorized carts, ambulatory assistive devices

The ultimate goal is for the patient to be able to perform necessary functional activities with as much independence as possible, and without desaturation, or undue fatigue, and shortness of breath.

Progress in rehabilitation can be documented using a variety of measures, such as the quantity of work performed or the decrease in perceived exertion, symptoms, and heart rate during performance of the functional task. Such changes indicate that the patient is more efficient at performing the task. Improvement can also be documented by observing the patient apply the treatment concepts to new tasks or environments. As discussed earlier in the chapter, standardized timed walking tests or questionnaires that focus on functional abilities and quality of life offer outcome measures for functional training.

The goals of physical conditioning exercises are aimed at increasing cardiorespiratory endurance, maximizing work capacity, and improving strength, flexibility, and respiratory muscle function. Priorities should be set for individualized goals based on the needs and desires of the patient. It is optimal to prescribe exercises that accomplish more than one goal at a time and emphasize functional gains, such as increasing cardiorespiratory endurance for walking.

**Endurance Training**

Aerobic endurance training may be performed at high or low intensity. High-intensity training (e.g., 70% to 85% of maximal work rate) must be undertaken to gain maximal physiologic improvements in aerobic fitness such as increased VO₂max, delayed anaerobic threshold, decreased heart rate for a given work rate, increased oxidative enzyme capacity, and capillarization of muscle. High-intensity training is associated with substantial gains in exercise endurance.

**Clinical tip**

Endurance training for the pulmonary patient should include components of frequency, duration, mode, and intensity of exercise for the upper and lower extremities.

Not all patients can tolerate sustained high-intensity exercise training. However, these patients, working at their maximal tolerated exercise level, will achieve gains over time. Interval training, alternating periods of high and low intensity (or rest), is an effective training option for persons who cannot sustain extended continuous periods of high-intensity exercise. This less-intense aerobic exercise training does lead to significant improvements in exercise endurance, even in the absence of measured gains in aerobic fitness. In addition, lower-intensity training may be more readily incorporated into the patients’ daily activities, although this has not been demonstrated in clinical trials.

Transcutaneous neuromuscular electrical stimulation can improve lower extremity muscle strength and exercise endurance even in the absence of traditional cardiovascular exercise training. Although no large trials are available, this may be an option for patients with very severe diseases who are bed-bound or wheelchair-bound and are unable to participate in a conventional exercise training program.

**Frequency and Duration of Exercise**

In general, the frequency and duration of the supervised exercise component during a pulmonary rehabilitation program may vary from 3 to 5 times per week, 2,11,51,83,94-97 60 to 120 minutes per session, 1,4,97 and extend over a period of 4 to 72 weeks. If program constraints will not allow for supervised exercise at least 3 days per week, one or more unsupervised sessions per week in the home with specific guidelines and instruction may be an effective alternative. If the patient is very debilitated, the duration of the initial exercise sessions can be shorter, with more frequent rest breaks; however, the ultimate goal is to achieve fewer or no rest breaks and at least 30 minutes of endurance exercise within the first few weeks of rehabilitation.

**Modes of Exercise**

Many different modes of exercise training have been used successfully with pulmonary patients, including walking (e.g., treadmill, track, supported walking via walker or wheelchair),
cycling, stationary bicycling, arm ergometry, arm lifting exercises with or without weights, step exercise, rowing, water exercises, swimming, modified aerobic dance, and seated aerobics. Warm-up and cool-down periods must be included in each exercise session. Warm-up exercise allows for gradual increases in heart rate, blood pressure, ventilation, and blood flow to the exercising muscles. Cool-down reduces the risk of arrhythmias, orthostatic hypotension, and bronchospasm.

**Intensity of Exercise**

Because exercise training is in many ways a tool to help patients learn to cope with the frightening and disabling sensation of breathlessness that often limits their exercise capacity, almost any type of exercise that the patient enjoys or is willing to do can be helpful. When developing the exercise prescription, the rehabilitation team must incorporate the patient’s activity goals into the training plan. For example, if the patient wants to be able to walk the dog for 30 minutes each day at a relatively slow but steady pace without rest stops, the intensity of training should be designed to accomplish that goal.

The intensity of exercise should be related to time, workload, and physiological responses. The rehabilitation team may choose to have the patient work up to a selected level on the perceived exertion scale. Similarly, the team may instruct the patient to work up to a certain number on the dyspnea scale or to a predetermined MET level. A target heart rate is not always used during exercise training. It is important, however, to be aware of the patient’s heart rate at rest and with exercise, keeping in mind the age-predicted maximum heart rate, the upper limits achieved on the exercise test, and other factors that influence heart rate, such as medications and deconditioning.

In exercising patients with chronic lung disease, it is important to evaluate and monitor oxyhemoglobin saturation to determine the need for supplemental oxygen and the appropriate levels to use with various activities. While attending rehabilitation, patients should be tested during the maximal intensity level exercise they may undertake at home or in the community while using the type of portable oxygen system they will use outside the program.

It is important to optimize bronchodilator and other pharmacologic therapy before and during an exercise program. This includes not only ensuring that maintenance bronchodilators are taken but also that short-acting bronchodilators are used when necessary before exercise and kept with the patients at all times. Optimization of respiratory medication status allows for exercise training at higher intensities and for longer periods of time.

**Upper and Lower Extremity Training**

It is most beneficial to direct exercise training to those muscles involved in functional living. This typically includes training the muscles of both the lower and upper extremities and the trunk. Exercise that improves neuromuscular ability, such as balance and coordination to decrease fall risk, are equally important with the pulmonary population, particularly as the general population ages.

Lower extremity training involves large muscle groups; this modality can improve ambulatory stamina, balance, and performance in ADLs. Types of lower extremity training include the following:
- Walking
- Stationary cycling
- Bicycling
- Stair climbing
- Swimming
- Walking
- Stationary cycling
- Bicycling
- Stair climbing
- Swimming

Exercise training of the lower extremities often results in dramatic increases in exercise tolerance of patients with COPD and other respiratory diseases.

Exercise training of the arms is also beneficial in patients with chronic lung disease, although virtually all of the evidence comes from patients with COPD. Patients with moderate to severe COPD, especially those with mechanical disadvantage of the diaphragm due to lung hyperinflation, have difficulty performing ADLs that involve use of the upper extremities. Arm elevation is associated with high metabolic and ventilatory demand, and activities involving the arms can lead to irregular or dysynchronous breathing. This is because some arm muscles are also accessory muscles of inspiration.

Benefits of upper extremity training in COPD include improved arm muscle endurance and strength, reduced metabolic demand associated with arm exercise, and increased sense of well-being. In general, benefits of upper extremity training are task-specific. Because of its benefits, upper extremity training is recommended in conjunction with lower extremity training as a routine component of pulmonary rehabilitation. Alternative types of upper extremity endurance training, other than arm ergometry, must be used in those patients with osteoporosis or under post–surgical incisional precautions.

**Strength Training**

In addition to endurance training, strength training is beneficial for patients with chronic lung disease. Weight lifting may lead to improvements in muscle strength, increased exercise endurance, and fewer symptoms during ADLs. Lower extremity strengthening may be augmented through aerobic training such as cycling, stair climbing, bench stepping, and walking. Strength training should be started with low resistance and progressed first by increasing repetitions, for example, 10 to 20 repetitions, before adding additional weight.

Upper body (trunk and upper extremity) training requires more ventilatory work, and patients are more likely to hold their breath, develop asynchronous breathing patterns, and become dyspneic. However, clinical studies have demonstrated that patients with respiratory disorders can train successfully with upper body resistive work, which produces improvements in dyspnea, fatigue, and respiratory muscle function.

The strengthening program should
start with light weights (dumbbells, pulleys, elastic bands, weighted wands) and, again, advance first by increasing the number of repetitions. For stronger patients or patients not on special exercise precautions, weight machines can be used. Rotating days between machines for upper extremity and lower extremity exercise may also improve tolerance for the strengthening program. Aerobic training modes of arm cranking and leg cycles that include arm work, rowing machines, or cross-country ski machines can also promote upper body strengthening and endurance (Fig 19-2).

### Table 19-5 Movement/Exercise Precautions

<table>
<thead>
<tr>
<th>Condition</th>
<th>Precautions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incisional</td>
<td>Perform bilateral arm movement rather than unilateral arm movement for 6 weeks. Avoid driving for 6 weeks, unless physician gives permission. Upper extremity lifting should be &lt;5-10 lbs. Avoid arm ergometry for 6 weeks. Avoid significant trunk twisting for 6 weeks.</td>
</tr>
<tr>
<td>Osteoporosis</td>
<td>Avoid arm ergometry. Avoid trunk flexion/twisting. Avoid biceps weight machine for strength training (dumbbells with attention to posture is permitted).</td>
</tr>
<tr>
<td>Pulmonary arterial hypertension</td>
<td>Avoid Valsalva maneuver. Avoid weight lifting &gt;2 lbs. Avoid high workloads on stationary bicycle (increase time instead). Avoid desaturation &lt;92%</td>
</tr>
</tbody>
</table>

**Clinical tip**

Evidence indicates that strength training may lead to improvements in muscle strength, increased exercise endurance, and fewer symptoms during ADLs.

During resistive work, the physical therapist should monitor the breathing pattern and pulse oximetry. If the patient has a history of hypertension, blood pressure should be intermittently monitored during weight training. The results of standardized lifting tests or dynamometry or records of the resistive loads tolerated during training are objective ways to demonstrate the outcomes of a strengthening program. Recording the increase in repetitions of an exercise can show improvement in muscle endurance. Lastly, the measured or reported ability of the patient to carry out employment-specific, recreational, or daily activities should be documented.

### Flexibility

Most patients with chronic respiratory disease have significant changes in posture and reduced mobility. These changes can be a result of inactivity or structural changes of the chest wall, with hyperinflation and hypertrophy of the accessory respiratory muscles. Flexibility exercises should be included to improve posture, increase joint range of motion, decrease stiffness, and prevent injury.

Gentle stretching with full body movements, as occurs with yoga, are appropriate for the pulmonary rehabilitation patient, especially if breathing exercises are coordinated with the movements. For instance, movements that bring full shoulder flexion, back extension, and inspiration can be performed together to increase trunk flexibility and facilitate
breathing. Exercises with forward-reaching and trunk flexion or with unilateral or bilateral hip and lower trunk flexion may be combined with expiration.

The purpose of combined flexibility and breathing exercises is to teach the patient how body movements can influence and assist or resist ventilation. The flexibility or mobility exercises can be used as a warm-up or cool-down activity for aerobic conditioning or at any time to relieve muscle tension or anxiety.

Monitoring changes in posture, range of motion, and subjective ratings of stiffness can be used to document the effects of a flexibility program. Long-term outcomes of the program may be documented from a reduced incidence of back pain or joint injuries.

**Respiratory Muscle Exercise**

Exercises for improving respiratory muscle awareness and function are usually included in a pulmonary rehabilitation program. The increased work of breathing and chest wall changes that occur with chronic lung disease and poor breathing habits make abnormal breathing patterns more likely to occur. Respiratory muscle dysfunction and fatigue is common and may be related to symptoms of shortness of breath. An approach for improving respiratory muscle function is to improve the performance of the respiratory muscles through exercise training. This type of respiratory muscle training can take several forms.

First, the work of breathing is increased with most exercise or activity. Both tidal volume and respiratory rate increase during exercise, thus increasing the minute ventilation (TV × RR = V̇E). Similarly, the respiratory muscles must increase their work to allow the minute ventilation to increase. Aerobic exercise training of the upper or lower extremities or both, that is moderate to high intensity, may be an adequate stimulus to improve respiratory muscle endurance and strength.

Second, instruction in breathing re-training exercise, such as diaphragmatic breathing, may improve the strength, awareness, and coordination of the diaphragm muscle. It is not clear which chronic lung disease patients may benefit from diaphragmatic breathing. It has been suggested that patients with COPD who have elevated respiratory rates, low tidal volumes that increase during diaphragmatic breathing, and abnormal arterial blood gases with adequate diaphragmatic movement may benefit from instruction.

Last, instruction in pursed-lip breathing improves SpO₂ by increasing alveolar ventilation, increases tidal volume, reduces respiratory rate, slows expiratory flow, and improves CO₂ removal. An emphysema patient often discovers this method of breathing that speed postexertion breathlessness and accelerates recovery, on their own accord.

Training respiratory muscles with a resistive breathing device may be beneficial in patients who have decreased inspiratory muscle strength and breathlessness despite receiving optimal medical therapy. Recent studies have shown consistent improvements in inspiratory muscle function, increases in exercise performance, and reductions in dyspnea related to ADLs. Note that when a patient stops an inspiratory muscle training (IMT) program, clinically the benefit of inspiratory muscle training stops as well, similar to when individuals stop skeletal muscle training. Therefore, inspiratory muscle training needs to be a lifelong training program, or the benefits are diminished.

Although most of the clinical studies on the efficacy of inspiratory muscle training have included only patients with COPD or quadriplegia as subjects, the treatment may be applicable to other patient groups in whom respiratory muscle weakness or fatigability is demonstrated: those who have neuromuscular syndromes, those who have been on mechanical ventilation for extended period, those with thoracic wall deformities such as kyphoscoliosis, and those who are morbidly obese. Even though more recent studies provide further support for the efficacy of inspiratory muscle training, the ACCP/AACVPR guidelines do not support the routine use of IMT as an essential component of pulmonary rehabilitation.

Outcomes of respiratory muscle training can be documented by recording increases in the training resistance and maximal inspiratory pressures. Reported improvements in dyspnea and the ability to carry out ADLs are also potential outcomes of respiratory muscle training.

**Exercise Considerations for Different Stages of Lung Diseases**

Because exercise performance varies with the severity of disease, a discussion of the patient with mild, moderate, and severe respiratory disease is presented. Several classifications for describing clinical status are available, most of which use a combination of pulmonary function tests, symptoms, and exercise tolerance.

One of the best resources for identifying the stages of obstructive lung disease is the Global Initiative for Chronic Obstructive Lung Disease (or GOLD) guidelines. These guidelines were updated in 2008 and were created to increase awareness of COPD among health professionals, public health authorities, and the general public and to improve prevention and management of COPD.

**Patients with Mild Lung Disease**

Spirometry testing of the patient with mild disease shows values 280% of predicted values for forced expiratory volume in 1 second (FEV₁). Ventilatory responses to exercise are normal, with sufficient ventilatory reserves during maximum effort. Arterial blood gas values are normal or have slight reductions in arterial oxygen levels.

Patients with mild lung disease usually have shortness of breath only with relatively heavy exercise, such as climbing hills and stairs, but may be asymptomatic with usual daily activities. Because respiratory symptoms are very mild, they do not often present to the physician for treatment of lung disease. The only indicating signs of mild disease may be symptoms with extreme effort, a chronic cough or spumum
production, or a history of smoking or occupational exposure. Identifying the presence of lung disease at this early stage may be possible through routine employment screenings and annual physical examinations.

Exercise for patients with mild disease can be recommended using testing and training protocols that would be used for a normal population. Pulmonary rehabilitation is usually not recommended for this stage of obstructive lung disease. Because exercise intensities associated with physiologic conditioning of the aerobic system are easily attainable, the patient should do very well on an independent training program following consultation with the physical therapist.

**Patients with Moderate Lung Disease**

The patient with moderate lung disease has an FEV$_1 < 80\%$ of predicted values and an exercise tolerance that is limited by ventilation. That is, the ventilatory reserves are exhausted at peak exercise loads. The patient becomes short of breath with usual ADLs and with a moderate to fast walking pace (approximately 3 to 4 METs). Mild to moderate hypoxemia may be present at rest and may either improve or worsen with exercise.

Patients with moderate lung disease may present with an acute exacerbation of their disease or worsening symptoms of shortness of breath with normal daily activities. These patients may describe a pattern of restricting or modifying their activity level to prevent respiratory symptoms. Still, they may attribute their symptoms to normal aging, to being out of shape or overweight, or to a smoking habit. Many believe that their symptoms could be resolved with simple changes in lifestyle.

An episode of acute pneumonia or pulmonary complications following an elective surgery may be the time the patient is identified with moderate lung disease and treatment initiated. Rehabilitation at this stage of the disease can modify risk factors and decrease the likelihood of future pulmonary complications.

Exercise tolerance assessments for patients with moderate lung disease can be performed using progressive exercise protocols. An electrocardiogram (ECG) should be taken and the blood pressure, heart rate, and pulse oximetry should be monitored continuously during the test. Alternatively, a functional 6-minute walking test with vital sign measurement can be used. (See Chapter 16 for more information on assessment.)

The aim of the exercise prescription is to increase the duration of a workload that is sufficient to cause physiologic adaptation to effort. An initial training workload can be estimated from the data gathered during the Graded Exercise Test (GXT). Supplemental oxygen may be needed to maintain SpO$_2$ levels $\geq 88\%$. The patient should first work to maintain this work load for 20 to 30 minutes. Intermittent short bouts of slightly higher workloads can then be introduced through interval training. As rating of perceived exertion (RPE) and HRs go down and exercise time is maintained at a satisfactory work level without rest breaks, workloads can be gradually advanced by the therapist.

The patient should exercise at least three to seven times per week. The total dosage of the exercise stimulus will bring about modest increases in the symptom-limited maximum O$_2$ and a decrease in the heart rate and minute ventilation response during submaximum workloads.

If the patient demonstrates arterial desaturation by pulse oximetry during exercise, supplemental oxygen will improve performance. It is unlikely that the majority of patients who require supplemental oxygen during exercise will be able to discontinue its' use due to physiological and anatomical lung tissue alterations.

**Patients with Severe Lung Disease**

Patients with severe lung disease may be restricted by symptoms of shortness of breath during most daily activities. Even walking at a slow pace may be limited. With spirometric testing, patients with severe lung disease demonstrate an FEV$_1$ below 50\% of predicted values. The patient may require intermittent or continuous oxygen at rest and with activity and may have elevated arterial carbon dioxide levels, for example, carbon dioxide (CO$_2$) retainer. Some patients with severe disease show signs of right ventricular dysfunction during exercise, which is related to oxygen desaturation. This may improve with supplemental oxygen during exercise.

In some cases, patients with severe lung disease require a modified approach to exercise testing. Lower workloads and interval training will facilitate improved tolerance to longer bouts of endurance exercise. A 6-minute walk test should be utilized as part of the evaluation process to determine functional levels and exercise tolerance. Monitoring the patient closely for desaturation and exercise-induced arrhythmias is important during testing procedures. Supplemental oxygen dosages that maintain a saturation level higher than 88\% should be identified and prescribed for patients who reach desaturation levels during exercise.

The exercise prescription for patients with severe lung disease should be based on the exercise test. Interval training programs may be best to use with initially short exercise bouts and rests. The prescription may be advanced gradually by increasing the number of bouts, lengthening the bouts, or decreasing the length of the rest periods. Because the initial training prescription (intensity and duration) is low, the patient should exercise a minimum of one time per day. As the total exercise duration increases to 20 minutes continuously, the frequency may be reduced to five to seven times per week. Even very small gains in exercise tolerance for the patient with severe lung disease can be significant for functional improvements and quality of life.

Patients in each lung disease category must be monitored using pulse oximetry, dyspnea and exertion scales, and heart rate with intermittent determinations of resting and exercise blood pressure. All patients should gradually require less supervision and monitoring as rehabilitation goals are met, and the patient develops independence in self-regulation and monitoring of the exercise intensity, duration, and frequency. When this occurs, the patient is ready for discharge from supervised therapy to an independent exercise regime.
CASE STUDY 19-1

For a detailed case study examining the pre- and postoperative pulmonary rehabilitation for a COPD patient undergoing lung transplantation, please see Evolve.

Summary

- “Pulmonary rehabilitation is an evidence-based, multidisciplinary, and comprehensive intervention for patients with chronic respiratory diseases who are symptomatic and often have decreased daily life activities. Integrated into the individualized treatment of the patient, pulmonary rehabilitation is designed to reduce symptoms, optimize functional status, increase participation, and reduce healthcare costs through stabilizing or reversing systemic manifestations of the disease.”
- Rehabilitation research now emphasizes symptom improvement, functional and exercise gains, and health-related quality-of-life outcomes as measures of efficacy instead of changes in pulmonary physiologic parameters.
- Three essential areas that require outcome measurements in pulmonary rehabilitation include exercise capacity, symptoms (dyspnea and fatigue), and health-related quality of life.
- A comprehensive pulmonary rehabilitation program should incorporate the following components: patient assessment and goal-setting, exercise and functional training, self-management education, nutritional intervention, and psychosocial management.
- Many patients with chronic respiratory disease simultaneously suffer from musculoskeletal abnormalities, for instance, pulmonary diagnoses of restrictive lung disease (e.g., scleroderma, pulmonary fibrosis due to unspecified connective tissue disease, rheumatoid arthritis, spinal cord injury, and scoliosis).
- The chronic respiratory disease patient should be able to recognize an early acute exacerbation of his or her disease; when and how to initiate or increase specific therapy such as antibiotics, steroids, and bronchodilators; and when to contact their healthcare provider.
- Patients with respiratory disease frequently have alterations of their nutritional status and body mass index (BMI).
- A psychosocial assessment should address motivational level, emotional distress, family and home environment, substance abuse, cognitive impairment, conflict and/or abuse, coping strategies, sexual dysfunction, and neuropsychological impairments (e.g., memory, attention, concentration).
- The basic components of pulmonary rehabilitation, may, however, be applied to a variety of chronic disease patients such as those with restrictive lung disease, pulmonary hypertension, significant musculoskeletal disease (e.g., arthritis), heart failure, and other stable cardiovascular diseases (e.g., peripheral vascular disease and stroke).
- Most patients are referred and seek rehabilitation as a result of disabling symptoms of dyspnea, inability to perform everyday household activities such as dressing and climbing steps, or a decreased ability to perform job responsibilities.
- Patients with respiratory disease often have significant alterations in nutritional status and body composition. Excess weight contributes to higher energy demands and work of breathing. Patients who are underweight must have adequate nutrition and calorie intake to build strength and endurance. Poor nutritional status is a significant and independent predictor of mortality among chronic respiratory patients.
- Patients undergoing pulmonary rehabilitation may have a multitude of joint abnormalities, pain, postural deviations, gait, and strength deficiencies—often due to inactivity.
- The main emphasis of airway clearance in the rehabilitation setting is the removal of excessive secretions that obstruct airways, improve cough, and decrease the incidence of respiratory infections and deterioration of lung function.
- Including energy conservation techniques to modify tasks allow the patient to complete work that might otherwise be impossible. Each activity can be broken down into smaller tasks and analyzed with regard to the most energy-efficient method of work.
- Simple procedures to minimize and relieve shortness of breath during activities of daily living can become incorporated into the functional training. Controlling the breathing pattern with paced breathing and movement, altering postures to improve respiratory muscle function, and using relaxation techniques are some key principles of treatment.
- Patients with restrictive lung disease experience greater work of breathing due to progressive stiffness, increased compliance, and scarring of lung tissue.
- A variety of oxygen delivery devices may be used to administer oxygen to the patient. The most common is the nasal cannula, which can provide oxygen flows from 0.25 to 6 L/minute.
- The Oxymizer delivery device is a nasal cannula with a reservoir incorporated into the tubing mechanism.
- It is important to request an oxygen prescription by a saturation level, for example, 88% to 90%, rather than by a specific oxygen liter flow, or, fraction of inspired oxygen (FiO₂).
- Endurance training for the pulmonary patient should include components of frequency, duration, mode, and intensity of exercise for the upper and lower extremities.
- Evidence indicates that strength training may lead to improvements in muscle strength, increased exercise endurance, and fewer symptoms during ADLs.
- Training respiratory muscles with a resistive breathing device may be beneficial in patients who have decreased inspiratory muscle strength and breathlessness despite receiving optimal medical therapy.
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