Pulmonary Rehabilitation and Chronic Lung Disease: Opportunities for the Respiratory Therapist

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Pulmonary rehabilitation is a core component of the management of a patient with chronic lung disease. The respiratory therapist plays a vital role in pulmonary rehabilitation. Identifying patients who are eligible for pulmonary rehabilitation, assessing the individual patient prior to entry into the program, providing education regarding the patient's disease, and actively participating in the exercise and training programs are just a few of the ways that the respiratory therapist can participate in this very important activity for patients with chronic lung disease. *Key words: pulmonary rehabilitation, chronic obstructive pulmonary disease, COPD, chronic lung disease, respiratory therapy, disease management.* [Respir Care 2009;54(8):1091–1099.

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Introduction

Pulmonary rehabilitation is an essential component of care for patients with chronic lung disease. It helps to control and alleviate symptoms, optimize functional capacity, and reduce the use of health-care resources for such patients. The first controlled trials of pulmonary rehabilitation were done in the 1970s, yet skepticism remained throughout the next 2 decades regarding the effectiveness of this therapy. The 1990s brought increasing acceptance, and pulmonary rehabilitation can now be viewed as a standard of care for patients with chronic lung disease.[1,2] Evidence-based clinical practice guidelines have been developed to assist the practitioner about decisions regarding the use of pulmonary rehabilitation.[3]

The respiratory therapist (RT) plays a vital role in patient evaluation, program development, and patient care with regards to pulmonary rehabilitation. This review will focus on the rationale behind pulmonary rehabilitation, patient assessment, components of care, and outcome measurements, with particular regard to the role of the RT in providing this type of care.

Definition

Pulmonary rehabilitation is defined as:

> 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.[1]

That definition focuses on 3 main components: multidisciplinary, individualized, and attentive to psychological and social function. Pulmonary rehabilitation uses a *multidisciplinary* approach, with utilization of expertise from various health-care disciplines, in particular respiratory therapy. The program is *individualized*, with assessment of the individual's needs followed by designing a program to meet the individual's goals. Finally, the program pays *attention to physical and social function* through attempts to improve lung function and exercise tolerance.

Pulmonary rehabilitation should be provided as a component of the overall long-term care of a patient with symptomatic lung disease. The program includes education, exercise training, psychosocial intervention and support, and nutritional intervention. Most programs are 6–12 weeks duration and are conducted in an out-patient setting. The sessions are usually held 3 days per week for 2–4 hours each. All programs promote lifetime changes to adapt the patient's behavior to their disease process.[4]

Table 1. Components of Comprehensive Pulmonary Rehabilitation

Patient assessment
Education
Exercise training
Psychosocial and behavioral support
Nutritional support
Outcome assessment

Rationale

Patients with chronic obstructive pulmonary disease (COPD) develop airflow limitation that results in air trapping. They then develop an increase in shortness of breath, which is then followed by a decrease in activity level. In addition, the systemic effects associated with COPD contribute to peripheral muscle weakness.[5] These factors contribute to deconditioning. Eventually the patient becomes disabled.

Pulmonary rehabilitation has no direct effect on airflow limitation or diffusing capacity. Various mechanisms for the improvement noted following pulmonary rehabilitation are now being uncovered. These improvements include reduction in lactate production and ventilation at a given work load, improvement in peripheral muscle dysfunction, and reduction in dynamic hyperinflation during exercise.[6,7] Exercise has also been shown to improve peripheral muscle dysfunction and—along with bronchodilator therapy, oxygen therapy, and breathing retraining—has been shown to decrease dynamic hyperinflation. These improvements result in a reduced respiratory rate during exercise and reduced "load" to the respiratory system. The patient has reduced dyspnea and has generalized improvement in exercise capacity.

Components of Pulmonary Rehabilitation

The goals of pulmonary rehabilitation are to alleviate symptoms, restore functional capacities, reduce handicap, and enhance overall quality of life. This is done through the comprehensive program provided by members of an integrated care team. The team members include physicians, RTs, nurses, physical therapists, occupational therapists, psychiatrists and psychologists, nutritionists, vocal rehabilitation therapists, and social workers. The program consists of various components (Table 1).

Patient Assessment

Patients with chronic lung disease who are symptomatic are candidates for pulmonary rehabilitation. RTs are well

positioned to identify such candidates, since they interact with patients in both in-patient and out-patient settings (eg, pulmonary function laboratory, office setting, hospital, and community-based educational program) and can easily identify patients who might benefit from the therapy.

Appropriate candidates include those patients with chronic lung disease who are symptomatic. The candidate should be motivated and willing to comply with the therapy. Some patients are not candidates for therapy and would include those who lack motivation for participation, have cognitive or psychiatric illness, have an unstable comorbidity (eg, congestive heart failure, angina, diabetes), or are unable to exercise (eg, orthopedic injury). Knowledge regarding the appropriate candidates for therapy, as well as the components of the program, will help the RTs answer patient questions as they arise.

Education/Collaborative Self-Management Strategies

Education represents a very important component of the rehabilitation process. Education regarding the individual's condition is vital to help the patient gain insight into the disease process as well to promote a healthy lifestyle, given the limitations that may exist. Education also includes appropriate use of medication(s), breathing retraining and energy-conservation techniques, early recognition and treatment of exacerbations, and adherence to therapy.

Determination of the educational needs of an individual patient is important. Deficits in the patient's knowledge, understanding, and management of the disease process have been studied using focus-group meetings.[8] Patients in that study preferred knowledge in 6 areas: disease education, management of breathlessness, management of an exacerbation, medication, psychosocial support, and welfare and benefits systems. The patients preferred to have group informational sessions provided by knowledgeable personnel speaking in layman's terms. They also preferred oral presentations supplemented by written information.

Various types of questionnaires have been developed to help assess the patient's educational needs. The Lung Information Needs Questionnaire (LINQ) assesses the patient's needs for education.[9] The questionnaire evaluates 6 domains, including disease knowledge, medicine, self-management, smoking, exercise, and diet. This appears to be a practical tool for detecting those areas where the patient needs education. It has also been shown to be sensitive to change after pulmonary rehabilitation. While research studies are limited in regards to the effects of education on patients undergoing rehabilitation, most experts feel that education is an essential component in the rehabilitation process. The RT can provide a great deal of input into these educational sessions.

Table 2. Exercise-Training Protocol Program

Duration of each session	30 min
Frequency of sessions	3 per week (minimum)
Intensity of training	60–70% of maximum symptom-limited capacity
Type	Continuous or interval

Exercise Training

Exercise training is the essential component of pulmonary rehabilitation programs. Exercise training consists of various types of training, including lower-extremity training, upper-extremity training, and strength training. Combinations of the various types of exercise training should be used and individualized for each patient.

Lower-extremity training should be performed by all individuals.[2] It generally consists of treadmill walking or stationary cycling. Most centers use treadmill walking, given its ease of performance and the patient's familiarity with walking. Various types of lower-extremity training can be used. Both high and low intensity training programs have been shown to benefit patients with COPD.

Duration, frequency, and intensity of training should be developed with each patient (Table 2). A patient with COPD should undergo exercise training at as high a level of exercise as possible. Patients should undergo at least 20–30 min of exercise during each session and perform this at least 3 times per week. The exercise should be started at an intensity level of 60–70% of the maximum symptom-limited capacity. Continuous exercise is often used, but in some patients interval exercise is better tolerated.[10] The exercise duration should be increased first, and then the intensity should be increased when the preset duration goals have been met.

Upper-extremity training has been shown to increase the arm work capacity and also to result in a decrease in oxygen consumption at isowork levels following pulmonary rehabilitation.[11,12] Strength training is also an important component of the exercise-training program. Strength training, in addition to endurance training, has been shown to increase muscle strength and mass and also to improve performance of activities of daily living. It has also been shown to increase exercise capacity.[13,14] Strength training can be done safely and should be added to endurance training as part of a comprehensive rehabilitation program. Both should be added (and not substituted) to lower-extremity training as part of each individual's training regimen.

Inspiratory muscle training can be used as an adjunct to endurance and strength training. The rationale behind the use of inspiratory muscle training is that patients with COPD have weak respiratory muscles. This weakness re-

sults in increased dyspnea and decreased exercise tolerance. By decreasing the inspiratory muscle weakness, the level of dyspnea will decrease and exercise tolerance should increase. The use of inspiratory muscle training (either resistive, threshold, or normocapnic hyperventilation) has been shown to increase inspiratory muscle strength and endurance, improve exercise capacity, improve health-related quality of life, and decrease dyspnea in patients with stable COPD.[15] The clinical importance of these findings is unclear, and further investigation into the clinically important improvements following inspiratory muscle training should be undertaken.

Psychosocial Support/Intervention

Nearly 50% of patients with moderate to severe COPD have depression.[16] Anxiety often accompanies COPD as well. In addition, feelings of loneliness, anger, and fear are often present. All of these characteristics help to promote a very sedentary lifestyle and force the patient to withdraw from the community in general. Educating and teaching the patient stress-reduction techniques, addressing problems such as sexual intimacy and general relations with family members, and promoting return of the patient into the community are just a few of the techniques that are used during rehabilitation to help overcome these characteristics. Pulmonary rehabilitation has been shown to improve depression and anxiety in patients with COPD.[17]

Nutritional/Pharmacologic Intervention

Many patients with COPD suffer from weight loss and muscle wasting. Patients with COPD who are underweight have a worse prognosis than those who are of normal weight. Decrements in lean body mass have been shown to occur even in patients with normal weight. Treatment for those patients who are nutritionally depleted includes caloric support. For those patients who have a body mass index less than 21 kg/m^2, or when there is a voluntary weight loss of greater than 10% over the last 6 months, caloric supplements should be offered.[18] Pharmacologic supplementation (eg, anabolic steroids) has been shown to increase fat-free body mass, but the effects on overall exercise performance are still under study.[19] Testosterone supplementation was shown to have an additive effect on strength improvements as a result of a strength-training program.[20] Strength training has also been shown to increase fat-free body mass, but, again, its effects on overall exercise performance are questionable. There has been very limited study of the effects of pulmonary rehabilitation per se on nutritional status for patients with COPD. Research into these various types of nutritional and/or pharmacologic supplementation combined with pulmonary rehabilitation needs to be undertaken.

Table 3. Examples of Outcome Assessment Measures

Patient-centered outcomes
Dyspnea
Fatigue
Health-related quality of life
Performance evaluation
Exercise capacity
Education
Health-care resource utilization
Program outcomes
Patient attendance
Number of patients completing program
Patient satisfaction
Adherence to home exercise program

Outcomes Assessment

An important component of pulmonary rehabilitation is the measurement of various types of outcomes. These measurements help to ensure that the patient and the program are reaching the goals that have been developed (Table 3). The use of patient-centered assessment tools is most important to measure. Dyspnea is the most common symptom of patients with chronic lung disease. Measurement of dyspnea can be done using a variety of standardized measures (eg, Borg scale; Medical Research Council dyspnea scale; baseline dyspnea index/transitional dyspnea index; University of California, San Diego shortness of breath questionnaire).[21,22] Functional impairment is another measure and can be done with the use of the exercise capacity that is attained during a timed walk test. Either a 6-min walk test or shuttle walk test can be used as the modality to determine the level of exercise that a particular patient can perform.[23,24] The BODE score (an index of body mass, degree of airway obstruction, dyspnea, and exercise capacity) is another measure that can be used to monitor outcomes throughout the rehabilitation program.[25] All outcome measures should be made at the beginning of the program, at various times during the program, and at the end of the program.

Health-related quality of life is another important measure to assess during the rehabilitation program. Various types of general health-related-quality-of-life measures (eg, Medical Outcomes Study Short-Form 12-item or 36-item questionnaire) and disease-specific health-related quality-of-life scales (eg, Chronic Respiratory Questionnaire, St George's Respiratory Questionnaire) are commonly used by many programs.[26,27] The recently improved and validated version of the St George's Respiratory Questionnaire[28] contains the best items from the original questionnaire, no longer specifies a recall period, and produces scores equivalent to the original questionnaire. Measures of activities of daily living (eg, London Activities of Daily

Table 4. Benefits Resulting from Pulmonary Rehabilitation

Reduction in dyspnea
Improvement in exercise capacity
Improvement in health-related quality of life
Reduction in health-care resource utilization
Reduction in depression and anxiety

Living scale) can be used to evaluate the effects of the rehabilitation on performance of those activities that the patient performs on a routine daily basis.[29]

Health-care resource utilization is an important outcome of any type of chronic disease-management program. Managing the chronic disease should be reflected in a reduction in the use of health-care resources (eg, hospitalizations, emergency department visits, unscheduled physician office visits, telephone calls to physician offices). This has been shown to occur for patients with COPD who have undergone a pulmonary rehabilitation program.[30-32] In addition, some patients gain enough benefit from rehabilitation to be able to forgo more complex (and costly) procedures (eg, lung-volume-reduction surgery or lung transplantation).

Measurement of several different outcomes should be performed in all programs. This includes measures of patient-centered outcomes (eg, dyspnea, health-related quality of life, exercise capacity) as well as program outcomes. The number of patients completing the program, the use of health-care resources, and the morbidity (and mortality) associated with the program are just a few of the program-centered outcomes that can be measured in addition to the patient-centered outcomes. Through the use of outcome assessments, ongoing improvements from both a patient and program perspective can then be developed.

Benefits

There are many benefits that occur following pulmonary rehabilitation (Table 4). These range from a reduction in dyspnea to an improvement in exercise tolerance to an improvement in health-related quality of life. These benefits tend to decline after 6–12 months following the formal program, with benefits in health-related quality of life being better preserved than exercise performance. Overall, however, the benefits can still be identified up to 2 years after the rehabilitation program.[33,34] Recently, it has been shown that there is no worsening in exercise tolerance, dyspnea, and health-related quality of life in patients with COPD who have undergone repeated pulmonary rehabilitation programs over a course of 7 years.[35]

Duration of Program/Maintenance

The duration of the initial pulmonary rehabilitation program should be at least 8 weeks. Studies have shown that shorter-duration programs of 4 weeks (compared to 7 weeks) do not confer as great a benefit.[36] Most studies also suggest that short-term programs are not sufficient to maintain the benefits beyond a 6–12 month period. Various types of maintenance programs have been used and are successful to maintain benefits beyond the initial formal pulmonary rehabilitation program.[37] Supervision of activities appears to be a key component in this maintenance phase.[38] The use of self-help groups appears to be particularly effective. The socially supportive environment helps the adjustment process through encouragement of adaptive behaviors and thoughts.

Candidates for Rehabilitation (Diseases Other Than COPD)

Patients with diseases other than COPD can also benefit from pulmonary rehabilitation. Regardless of the pathophysiology associated with the other lung diseases, physical deconditioning is present in many of these patients. These patients can benefit from the education and exercise training. Recent studies have shown benefit following pulmonary rehabilitation for patients with interstitial lung disease and pulmonary vascular disease.[39-41] Individualization of therapy is important in these patients, given the different pathophysiology that is associated with that particular disease process.

Adjunctive Therapies

Pharmacologic Therapy

Patients with symptomatic COPD are often treated with bronchodilator therapy. Such therapy has been shown to reduce dyspnea, improve quality of life, decrease exacerbation rate, and improve endurance time during constant-work-rate exercise. The combination of optimal bronchodilator therapy and pulmonary rehabilitation has been shown to improve ventilatory mechanics and augment the exercise-tolerance benefits, when compared with a control group. This combination has also been shown to amplify the effectiveness of pulmonary rehabilitation, as noted by an increase in the patient self-report of participation in physical activities.[42,43]

Oxygen Therapy

Oxygen therapy has been shown to improve survival in patients with COPD who have hypoxemia.[44-46] The use of oxygen supplementation for those patients who have hypoxemia during sleep or exercise has been less well studied. Oxygen supplementation during exercise training has been shown to improve exercise capacity in those patients with COPD who were not hypoxemic during exercise.[47]

Oxygen supplementation during exercise may allow these patients to train at a higher intensity during pulmonary rehabilitation and improve the overall exercise training. The long-term benefits when using oxygen in this setting have yet to be determined, however.

One often under-recognized aspect of oxygen therapy involves the delivery of the gas itself. Like other medications, oxygen should be prescribed in an appropriate amount to allow for adequate oxygenation at all activity levels and monitored continually for effectiveness and ongoing benefit. If an inappropriate amount of oxygen is delivered, the patient will not be able to ambulate as much as possible and ultimately will become more sedentary.

The types of oxygen-delivery systems currently available (eg, continuous, demand) have different characteristics of gas delivery, and the RT must be knowledgeable about these differences. This will allow the therapist to determine the correct "dose" (or flow rate or bolus size) of oxygen. In many instances the initial oxygen flow rate is determined by performing an exercise study in a hospital or office setting, using the oxygen source that is available to the staff at that time. Rarely is this oxygen "prescription" test performed using the patient's own oxygen delivery system. Discrepancies in the amount of oxygen actually delivered can easily occur under such circumstances.[48-50]

Rehabilitation programs provide an ideal means to help determine the correct oxygen "prescription." During the exercise-training periods the patient should be monitored using the particular oxygen delivery system that is used in the home environment. This provides an effective means to determine the level of support that the patient should use in that setting with the equipment that the patient currently has available. This will help to more accurately determine the patient's needs and device delivery capabilities, thus helping to optimize the performance of activities of daily living.

Other Therapies

Other types of support during exercise are also being investigated regarding their effects on dyspnea and exercise training. These include the use of ventilatory support and physical support modalities. The addition of noninvasive ventilation over the short-term in a home environment, to an out-patient rehabilitation program, improved the shuttle walk distance and quality of life to a greater extent than did rehabilitation alone.[51] Neuromuscular electrical stimulation (the use of low-voltage stimulation to cause contraction of peripheral muscles) has been shown in patients with severe muscle weakness to result in significant improvements in muscle function, maximum and endurance exercise tolerance, and dyspnea.[52] Further study is necessary to evaluate the long-term effects of each of these therapies when combined with a formal pulmonary rehabilitation program.

Physical support during ambulation has been used by patients with COPD for many years. The use of a rollator (a stroller with wheels) has been shown to increase the 6-min walk distance and reduce dyspnea.[53] The effects are felt to be mediated by allowing an increase in minute ventilation with optimization of walking efficiency. The use of the rollator is well tolerated by most patients.[54] Dyspnea has also been shown to be reduced through the use of a rollator. Further study with the use of the rollator combined with pulmonary rehabilitation should be conducted to determine the benefits from using this type of support modality.

Newer exercise-training modalities are also being studied. By reducing ventilatory limitation with exercise, a patient with COPD might be able to undergo more intensive exercise training. One-legged training, at half the load of 2-legged exercise, places similar metabolic demands on the targeted muscles and is associated with a reduced ventilatory load, thus enabling patients to increase work capacity. An improvement in aerobic capacity was noted during such training in patients with stable COPD.[55] Although the number of patients in the study was small, this offers an intriguing method to optimize the exercise-training regimen.

Another training modality that has been used in an attempt to optimize exercise involves ventilation feedback through use of a computer-based program.[56] A computer program provided patients with real-time biofeedback and individualized goals. The program allowed patients to see their speed on the treadmill and depth of breathing in relation to the set goal on the computer screen. The feedback provided would encourage them to inhale more slowly and exhale more fully in order to achieve the goal. The combination of ventilation feedback plus exercise training was found to decrease exercise-induced dynamic hyperinflation and increase exercise duration more than ventilation feedback alone. Further investigations of various exercise training regimens should be conducted.

Newer Strategies for Delivery of Pulmonary Rehabilitation Services

Currently there is limited availability of pulmonary rehabilitation programs in the United States and other countries. Strategies for providing pulmonary rehabilitation in other types of out-patient settings are being investigated. Self-monitored home-based rehabilitation programs are an alternative to the traditional out-patient (hospital or independent facility) based programs. In a recent study comparing a home-based rehabilitation program with an out-patient, hospital-based program over an 8-week course (including aerobic and strength-exercise training), similar

improvements in dyspnea, exercise capacity, and health-related quality of life were noted in both groups.[57] This type of setting may provide an alternative in those areas where a comprehensive out-patient pulmonary rehabilitation program is not readily available, and may allow easier access for many more patients.

Pulmonary rehabilitation is an established component of care for patients with chronic lung disease. In unstable patients who have suffered from an exacerbation, the effects of pulmonary rehabilitation are less well established. A recent review of randomized controlled trials comparing pulmonary rehabilitation after a COPD exacerbation with conventional care (no rehabilitation) has shown that pulmonary rehabilitation significantly reduced hospital admissions and mortality, and improved health-related quality of life for those patients treated with pulmonary rehabilitation. No adverse effects were noted. Thus, pulmonary rehabilitation appears to be very effective and safe for those patients who have recently suffered a COPD exacerbation, and should be considered before the onset of "stable disease."[58]

Coverage of Pulmonary Rehabilitation Services

The enactment of House Resolution 6331, the Medicare Improvements for Patients and Providers Act of 2008, established a specific Medicare benefit for pulmonary rehabilitation, effective January 2010. This mandate will provide uniform coverage criteria and payment for services. Until January 2010 the Medicare administrative contractors still retain the authority to determine and change what is covered, or not covered, under the set of services designated as pulmonary rehabilitation. Several of these contractors have developed or are developing local coverage policies that will be in effect until January 2010. Details regarding coverage and payment issues from the Centers for Medicare and Medicaid Services are being developed in conjunction with other major national organizations (eg, American Association for Respiratory Care, American Thoracic Society, American Association of Cardiovascular and Pulmonary Rehabilitation, National Association for the Medical Direction of Respiratory Care, and the American College of Chest Physicians). Information regarding the coverage determinations should be available later in 2009. Further information regarding the local coverage determinations should be obtained from the Medicare administrative contractor in the area where the services are being provided.

Summary

Pulmonary rehabilitation has been shown to benefit patients with chronic lung disease. Increase in exercise capacity, reduction in dyspnea, improvement in health-related quality of life, and reduction of health-care utilization are just a few of the many benefits that patients with chronic lung disease can expect following pulmonary rehabilitation. Similar benefits are also seen in patients who have undergone surgical therapy for their COPD (eg, lung-volume-reduction surgery or lung transplantation) as well as in patients who have other chronic lung diseases (eg, interstitial pulmonary fibrosis, pulmonary hypertension).

Despite the well known benefits associated with pulmonary rehabilitation, it is often under-utilized. It is estimated that only 2% of the COPD population has access to pulmonary rehabilitation, and, as such, strategies to increase access to pulmonary rehabilitation programs must be developed. The passage of the recent legislation should help to increase the number of programs available for patients by providing reimbursement for the services provided. Provider education (including physician, nonphysician providers, and trainees) regarding the importance of rehabilitation in the integrated care model for COPD should also help to increase access to programs for patients with chronic lung disease.

There is an extremely bright future for patients with chronic lung disease who are symptomatic. The inclusion of pulmonary rehabilitation as a routine part of the overall care of a patient with chronic lung disease will result in improved patient care. The optimal management of COPD should involve an integrated care approach stressing a comprehensive assessment; a self-management education program; an individually tailored treatment plan; and a communication strategy among health-care professionals, the patient, and the family. All of these components are routinely performed during a comprehensive pulmonary rehabilitation program. By using pulmonary rehabilitation as part of this integrated care approach, patients will be able to develop behavioral changes and self-management strategies that will contribute to their improved health and reduce health-care resource utilization.

RTs are well positioned to participate in all aspects of pulmonary rehabilitation. Providing education to patients with chronic lung disease regarding the benefits to be gained from pulmonary rehabilitation can help to direct patients to rehabilitation programs. Providing pulmonary rehabilitation can help these patients improve their overall quality of life and allow them to regain their self efficacy and functioning in their community. Providing outcomes assessments will help evaluate the benefits that are noted following completion of rehabilitation, from both a patient and program perspective. Clinical competency guidelines for pulmonary rehabilitation professionals have been developed to assist the provider with best practice expectations and to serve as a self-assessment tool to help identify continuing education needs.[59]

As more pulmonary rehabilitation programs are developed over the ensuing several years, there will be an increased need for provision of these services The RT is

superbly and uniquely positioned to use the available tools and resources to become a member of the integrated care team and to help provide rehabilitation to those who are in need.

REFERENCES

1. Nici L, Donner C, Wouters E, ZuWallack R, Ambrosino N, Bourbeau J, et al; on behalf of the ATS/ERS Pulmonary Rehabilitation Writing Committee. American Thoracic Society/European Respiratory Society statement on pulmonary rehabilitation. Am J Respir Crit Care Med 2006;173(12):1390-1413.
2. Ries AL, Bauldoff GS, Carlin BW, Casaburi R, Emergy CF, Mahler DA, et al. Pulmonary rehabilitation: joint ACCP/AACVPR evidence based clinical practice guidelines. Chest 2007;131(5 Suppl):4S-42S.
3. Lacasse Y, Goldstein R, Lasserson TJ, Martin S. Pulmonary rehabilitation for chronic obstructive pulmonary disease. Cochrane Database Syst Rev 2006;(4):CD003793.
4. American Association of Cardiovascular and Pulmonary Rehabilitation. Guidelines for pulmonary rehabilitation programs, 3rd edition. Champaign, IL: Human Kinetics; 2004.
5. Gosselink R, Troosters T, Decramer M. Peripheral muscle weakness contributes to exercise limitation in COPD. Am J Respir Crit Care Med 1996;153(3):457-477.
6. Casaburi R, Patessio A, Ioli F, Zanaboni S, Donner CF, Wasserman K. Reductions in exercise lactic acidosis and ventilation as a result of exercise training in patients with obstructive lung disease. Am Rev Respir Dis 1991;143(1):9-18.
7. Porszasz J, Emtner M, Goto S, Somfay A, Whipp BJ, Casaburi R. Exercise training decreases ventilatory requirements and exercise-induced hyperinflation at submaximal intensities in patients with COPD. Chest 2005;128(4):2025-2034.
8. Wilson JS, O'Neill B, Reilly J, MacMahon J, Bradley JM. Education in pulmonary rehabilitation: the patient's perspective. Arch Phys Med Rehabil 2007;88(12):1704-1709.
9. Jones RC, Wang X, Harding S, Bott J, Hyland M. Educational impact of pulmonary rehabilitation: lung information needs questionnaire. Respir Med 2008;102(10):1439-1445.
10. Puhan MA, Busching G, Schunemann JH, Van Oort E, Zaugg C, Frey M. Interval versus continuous high-intensity exercise in chronic obstructive pulmonary disease: a randomized controlled trial. Ann Intern Med 2006;145(11):816-825.
11. Couser JL, Martinez FJ, Celli BR. Pulmonary rehabilitation that includes arm exercise reduces metabolic and ventilatory requirements for simple arm elevation. Chest 1993;103(1):37-41.
12. Epstein SK, Celli BR, Martinez FJ, Couser JI, Roa J, Pollock M, Benditt JO. Arm training reduces the V_{O2} and V_E cost of unsupported arm exercise and elevation in chronic obstructive pulmonary disease. J Cardiopulmon Rehabil 1997;17(3):171-177.
13. Clark CJ, Cochrane LM, Mackay E, Paton B. Skeletal muscle strength and endurance in patients with mild COPD and the effects of weight training. Eur Respir J 2000;15(1):92-97.
14. Mador MJ, Bozkanat E, Aggarwal A, Shaffer M, Kufel TJ. Endurance and strength training in patients with COPD. Chest 2004;125(6):2036-2045.
15. O'Brien K, Geddes EL, Reid WD, Brooks D, Crowe J. Inspiratory muscle training compared with other rehabilitation interventions in chronic obstructive pulmonary disease. J Cardiopulm Rehabil 2008;28(2):128-141.
16. Maurer J, Rebbapragada V, Borson S, Goldstein R, Kunik ME, Yohannes AM, Hanania NA. Anxiety and depression in COPD: current understanding, unanswered questions, and research needs. Chest 2008;134(4 Suppl):43S-56S.
17. Coventry PA, Hind D. Comprehensive pulmonary rehabilitation for anxiety and depression in adults with chronic obstructive pulmonary disease: systematic review and meta-analysis. J Psychosom Res 2007;63(5):551-565.
18. Ferreira I, Brooks D, Lacasse Y, Goldstein RS. Nutritional intervention in COPD: a systematic overview. Chest 2001;119(2):353-363.
19. Schols AM, Soeters PB, Mostert R, Pluymers RJ, Wouters EF. Physiologic effects of nutritional support and anabolic steroids in patients with chronic obstructive pulmonary disease: a placebo-controlled randomized trial. Am J Respir Crit Care Med 1995;152(4 Pt 1):1268-1274.
20. Casaburi R, Bhasin S, Cosentino L, Porszasz J, Somfay A, Lewis MI, et al. Effects of testosterone and resistance training in men with chronic obstructive pulmonary disease. Am J Respir Crit Care Med 2004;170(8):870-878.
21. Mahler MA. Mechanisms and measurement of dypsnea in chronic obstructive pulmonary disease. Proc Am Thorac Soc 2006;3(3):234-238.
22. Borg GA. Psychophysical bases of perceived exertion. Med Sci Sports Exerc 1982;14(5):377-381.
23. Sciurba F, Criner GJ, Lee SM, Mohsenifar Z, Shade D, Slivka W, et al. Six-minute walk distance in chronic obstructive pulmonary disease. Am J Respir Crit Care Med 2003;167(11):1522-1527.
24. Singh SJ, Morgan MD, Scott S, Walters D, Hardman AE. Development of a shuttle walking test of disability in patients with chronic airways obstruction. Thorax 1992;47(12):1019-1024.
25. Biscione GL, Mugnaini L, Pasqua F, Crigna G, Gerri L, Cardaci V, et al. BODE index and pulmonary rehabilitation in chronic respiratory failure. Eur Respir J 2006;27(6):1320.
26. Guyatt GH, Berman LF, Townsend M, Pugsley SO, Chamber LW. A measure of quality of life for clinical trials in chronic lung disease. Thorax 1987;42(10):773-778.
27. Jones PW, Quirk FH, Baveystock DM, Littlejohns P. A self-complete measure of health status for chronic airflow limitation. The St. George's Respiratory Questionnaire. Am Rev Respir Dis 1992;145(6):1321-1327.
28. Meguro M, Barley EA, Spencer S, Jones PW. Development and validation of an improved, COPD-specific version of the St George Respiratory Questionnaire. Chest 2007;132(2):456-463.
29. Garrod R, Bestall JC, Paul EA, Wedzicha PW. Development and validation of a standardized measure of activities of daily living in patients with severe COPD; the London chest activity daily living scale. Respir Med 2000;94(6):589-596.
30. California Pulmonary Rehabilitation Collaborative Group. Effects of pulmonary rehabilitation on dyspnea, quality of life, and health care costs in California. J Cardiopulm Rehabil 2004;24(1):52-62.
31. Griffiths TL, Burr ML, Campbell IA, Lewis-Jenkins V, Mullins J, Shiels K, et al. Results at 1 year of outpatient multidisciplinary pulmonary rehabilitation: a randomised controlled trial. Lancet 2000;355(9201):362-368. Erratum in: Lancet 2000;355(9211):1280.
32. Raskin J, Spiegler P, McCusker C, ZuWallack R, Bernstein M, Busby D, et al. The effect of pulmonary rehabilitation on health care utilization in COPD: the Northeast Pulmonary Rehabilitation Consortium. J Cardiopulm Rehabil 2006;26(4):231-236.
33. Güell R, Casa P, Belda J, Sangenis M, Morante F, Guyatt GH, Sanchis J. Long-term effects of outpatient rehabilitation of COPD: a randomized trial. Chest 2000;117(4):976-983.
34. Ries AL, Kaplan RM, Myers R, Prewitt LM. Maintenance after pulmonary rehabilitation in chronic lung disease: a randomized trial. Am J Respir Crit Care Med 2003;167(6):880-888.
35. Foglio K, Bianchi L, Bruletti G, Porta R, Vitacca M, Balbi B, et al. Seven-year time course of lung function, symptoms, health-realted quality of life, and exercise tolerance in COPD patients undergoing

pulmonary rehabilitation programs. Respir Med 2007;101(19):1961-1970.
36. Green RH, Singh SJ, Williams J, Morgan MD. A randomized controlled trial of four weeks versus seven weeks of pulmonary rehabilitation in chronic obstructive pulmonary disease. Thorax 2001; 56(2):143-145.
37. Foglio K, Bianchi L, Ambrosino N. Is it really useful to repeat outpatient pulmonary rehabilitation in patients with chronic airway obstruction? A 2 year controlled study. Chest 2001;119(6):1696-1704.
38. Puente-Maestu L, Sanz ML, de Ona RJM, Arnedillo A, Casaburi R. Long term effects of a maintenance program after supervised or self-monitored training programs in patients with COPD. Lung 2003; 181(2):67-78.
39. Ferreira A, Garvey C, Connors GL, Hilling L, Rigler J, Farrell S, et al. Pulmonary rehabilitation in interstitial lung disease. Chest 2009; 135(2):442-447.
40. Uchi M, Saji T, Harada T. Feasibility of cardiopulmonary rehabilitation in patients with idiopathic pulmonary arterial hypertension treated with prostacyclin infusion therapy. J Cardiol 2005;46(5):183-193.
41. Mereles D, Ehlken N, Kreuscher S, Ghofrani S, Hoeper MM, Halank M, et al. Exercise and respiratory training improves exercise capacity and quality of life in patients with severe pulmonary hypertension. Circulation 2006;114(14):1482-1489.
42. Casaburi R, Kukafka D, Cooper CB, Witek TJ, Kesten S. Improvement in exercise tolerance with the combination of tiotropium and pulmonary rehabilitation in patients with COPD. Chest 2005;127(3): 809-817.
43. Kesten S, Casaburi R, Kukafka D, Cooper CB. Improvement in self-reported exercise participation with the combination of tiotropium and rehabilitative exercise training in COPD patients. Int J COPD 2008;3(1):127-136.
44. Nocturnal Oxygen Therapy Group. Continuous or nocturnal oxygen therapy in hypoxemic chronic obstructive lung disease: a clinical trial. Ann Intern Med 1980;93(3):391-398.
45. Medical Research Council Working Party. Long-term domiciliary oxygen therapy in chronic hypoxic cor pulmonale complicating chronic bronchitis and emphysema. Lancet 1981;1(8222):681-686.
46. Bradley JM, O'Neill B. Short-term ambulatory oxygen for chronic obstructive pulmonary disease. Cochrane Database Sys Rev 2002; (2):CD000238.
47. Emtner M, Porszasz J, Burns M, Somfay A, Casaburi R. Benefits of supplemental oxygen in exercise training in nonhypoxemic chronic obstructive pulmonary disease patients. Am J Respir Crit Care Med 2003;168(9):1034-1042.
48. Bliss PL, McCoy RW, Adams AB. Characteristics of demand oxygen delivery systems: maximum output and setting recommendations. Respir Care 2004;49(2):160-165.
49. Shigeoka JW. Demand valves for oxygen therapy: your mileage may vary. Respir Care 2004;49(2):156-157.
50. Guell Rous MR. Long-term oxygen therapy: are we prescribing appropriately? Int J COPD 2008;3(2):231-237.
51. Garrod R, Mikelsons C, Paul EA, Wedzicha JA. Randomized controlled trial of domiciliary noninvasive positive pressure ventilation and physical training in severe chronic obstructive pulmonary disease. Am J Respir Crit Care Med 2000;162(4 Pt 1):1335-1341.
52. Vivodtzev I, Pepin JL, Vottero G, Mayer V, Porsin B, Levy P, et al. Improvement in quadriceps strength and dyspnea in daily tasks after 1 month of electrical stimulation in severely deconditioned and malnourished COPD. Chest 2006;129(6):1540-1548.
53. Solway S, Brooks D, Lau L, Goldstein R. The short-term effect of a rollator on functional exercise capacity among individuals with severe COPD. Chest 2002;122(1):56-65.
54. Hill K, Goldstein R, Gartner EJ, Brooks D. Daily utility and satisfaction with rollators among persons with chronic obstructive pulmonary disease. Arch Phys Med Rehabil 2008;89(6):1108-1113.
55. Dolmage TE, Goldstein RS. Effects of one-legged exercisee training of patients with COPD. Chest 2008;133(2):370-376.
56. Collins EG, Langbein WE, Fehr L, O'Connell S, Jelinek C, Hagarty E, et al. Can ventilation-feedback training augment exercise tolerance in patients with chronic obstructive pulmonary disease. Am J Respir Crit Care Med 2008;177(8):844-852.
57. Maltais F, Bourbeau J, Shapiro S, Lacasse Y, Perrault H, Baltzan M, et al. Effects of home-based pulmonary rehabilitaiton in patients with chronic obstructive pulmonary disease. Ann Intern Med 2008; 149(12):869-878.
58. Puhan M, Scharplatz M, Troosters T, Walters EH, Steuer J. Pulmonary rehabilitation following exacerbations of chronic pulmonary disease. Cochrane Database Syst Rev 2009;(1):CD005305.
59. Nici L, Limberg T, Hilling L, Garvey C, et al. Clinical competency guidelines for pulmonary rehabilitation professionals. J Cardiopulmon Rehabil 2007;27(6):355-358.