

# Pulmonary rehabilitation: today and tomorrow



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## Educational aims

- › To review the rationale for and the components of comprehensive pulmonary rehabilitation.
- › To evaluate the role of pulmonary rehabilitation in chronic obstructive pulmonary disease exacerbation.
- › To discuss the potential role of pulmonary rehabilitation in the critically ill patient and the patient with lung cancer

## Summary

Comprehensive and effective clinical management of chronic obstructive pulmonary disease (COPD) requires an interdisciplinary, integrated care approach that includes both pharmacological and nonpharmacological therapies. Pulmonary rehabilitation is a non-pharmacological, interdisciplinary, patient-centred intervention that is a crucial component of the optimal care for patients with COPD, and, as such, has a prominent place in all current guidelines for the treatment of this disease [1–3].

This article will begin by outlining the components of pulmonary rehabilitation and the rationale behind its effectiveness. It will then focus on some emerging areas of clinical and research interest which will illustrate how the principles of pulmonary rehabilitation can be adapted to nontraditional areas to improve patient outcomes. These include COPD exacerbations, lung cancer and critical illness.

## Introduction

The American Thoracic Society and European Respiratory Society have defined pulmonary rehabilitation as: "...an evidence-based, multi-disciplinary, 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" [4].

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### Table 1 Established benefits from pulmonary rehabilitation

- Decreased symptoms (dyspnoea, fatigue)
- Improved functional performance
- Increased exercise capacity
- Improved health-related quality of life

### Table 2 Essential components of pulmonary rehabilitation

- Patient assessment, including selection criteria
- Exercise training, including both endurance and strength training
- Self-management education
- Psychosocial support

This intervention includes patient assessment, exercise training, self-management education and psychosocial support.

Established benefits from pulmonary rehabilitation are listed in table 1 and include decreased symptoms (dyspnoea and fatigue), increased exercise tolerance and improved functional performance and health-related quality of life. Emerging data also support its role in decreasing healthcare costs in COPD, probably through reducing the severity of acute exacerbations. Since pulmonary rehabilitation targets and treats the secondary impairments associated with chronic respiratory disease, such as peripheral muscle dysfunction and ventilatory, nutritional and cardiac limitations, it is likely to be effective in both a wide range of chronic respiratory diseases as well as in alternative clinical settings.

## Components of pulmonary rehabilitation

The American Association of Cardiovascular and Pulmonary Rehabilitation Guidelines for Pulmonary Rehabilitation Programs [5] lists the following essential components of pulmonary rehabilitation: patient assessment, including selection criteria; exercise training; self-management education; and psychosocial support (table 2). The following sections will briefly discuss each of these components.

### Patient assessment and selection criteria

A thorough assessment is essential prior to the initiation of pulmonary rehabilitation, in order to understand the patient's physiological and

functional impairments and set realistic and achievable goals that are important to that individual. The initial assessment sets the stage for all subsequent treatment and typically includes a thorough history and physical examination, a review of the patient's medical record with particular emphasis on comorbidities, and any necessary testing to further define physiological and functional impairments.

Indications for referral to pulmonary rehabilitation include persistent respiratory symptoms (especially dyspnoea) or functional status limitation despite otherwise optimal medical therapy. Contraindications to pulmonary rehabilitation are few but include any condition (such as unstable angina) that would place the patient at substantially increased risk during rehabilitation, or any condition (such as severe musculoskeletal disease) that would substantially interfere with the rehabilitative process. In reality, many seemingly contraindicating problems can be addressed or the pulmonary rehabilitation process can be adapted to allow the patient to participate [5].

While abnormalities noted on standard pulmonary function testing are helpful to characterise the patient's physiological abnormalities, pulmonary rehabilitation guidelines state that pulmonary function (such as the forced expiratory volume in 1 s (FEV1)) is not a major selection criterion for pulmonary rehabilitation. This is because the severity of COPD, including its symptom burden, is influenced by much more than airflow limitation alone [6]. Therefore, symptom burden and functional status limitation (decreased participation) are the major indications for referral.

### Exercise training

Exercise training, including upper and lower extremity endurance training and strength training, is the cornerstone of comprehensive pulmonary rehabilitation. Because there is significant peripheral muscle dysfunction in COPD, with decreased muscle mass, alterations in fibre-type distribution and decreased metabolic capacity, exercise training is highly effective in improving exercise tolerance in these patients [7-11]. Exercise training is based on general principles of intensity (higher levels lead to greater results), specificity (only those muscles trained show an effect) and reversibility (cessation of regular exercise training results in a decrease in training effect) [12].

Despite ventilatory limitations, patients with COPD are capable of exercising for prolonged periods of time at levels close to their peak exercise

capacity [13]. However, it is important to note that most patients are so dyspnoea-limited that they exercise well below this level. While higher levels of exercise are associated with a physiological training effect, including dose-dependent increases in oxidative enzymes and greater improvement in exercise performance [14–16], patients who cannot tolerate high levels of exercise training can also benefit from this intervention [17]. Strength training should be included in the exercise prescription and has been shown to yield additive benefits [18].

Maximising bronchodilation, interval training (alternating high and low intensities), and oxygen supplementation may allow for higher exercise training intensity in some COPD patients [19–24]. The optimal duration of exercise training depends on the progress of an individual patient; however, the Global Initiative for Obstructive Lung Disease (GOLD) guidelines recommend that the minimum duration of an effective programme is three times per week for 6 weeks [2]. It is important to note that longer duration programmes produce greater effects [25].

### Self-management education

Education is considered to be an integral component of all comprehensive pulmonary rehabilitation programmes [4]. Rather than to simply provide didactic education, the goal is to promote self-efficacy through teaching self-management skills [26–28] and foster collaborative self-care [29, 30]. Self-management education is typically provided in a small-group setting with an emphasis on practice and problem solving. Educational needs are determined as part of the initial evaluation and then are re-assessed during the course of the programme. Important topics addressed during pulmonary rehabilitation education include advance directives [31, 32] and use of action plan for early recognition and treatment of exacerbations. Self-management education has been demonstrated to be highly effective in improving health status and reducing utilisation of medical resources [33].

### Psychosocial support

Anxiety, depression, inadequate coping mechanisms and poor self-management skills all contribute to the burden of advanced respiratory disease [34–36]. Psychosocial support and behavioural intervention usually involve educational sessions and support groups, focusing on areas such as coping strategies and relaxation and stress management techniques. Progressive muscle relaxation, identification of stressors and panic control

may reduce not only anxiety but dyspnoea as well. Participation by family members and friends in pulmonary rehabilitation support groups is encouraged and may provide additional emotional support to patients and their families. Individuals with substantial psychiatric illness should be referred for appropriate professional care outside of the pulmonary rehabilitation programme. However, it is important to note that there is a wide spectrum of symptom burden.

## Rationale behind the effectiveness of pulmonary rehabilitation

Pulmonary rehabilitation leads to substantial improvements in symptoms, (especially dyspnoea and fatigue), exercise tolerance, and health-related quality of life. Remarkably, these benefits are realised without a demonstrable effect on traditional lung function measurements, such as FEV<sub>1</sub>. This apparent paradox is explained by the fact that pulmonary rehabilitation identifies and treats the systemic effects of COPD, such as peripheral muscle dysfunction resulting from physical inactivity and/or systemic inflammation, muscle wasting, inadequate self-management skills, anxiety and depression. For example, physical conditioning of leg muscles through exercise training leads to less lactate production and a reduction of the ventilatory burden. A lower ventilatory burden will, in turn, allow the patient to breathe slower during exercise, thereby reducing dynamic hyperinflation. These physiological effects reduce exertional dyspnoea even in the absence of a change in FEV<sub>1</sub>. Another example is the successful adoption of self-management strategies, such as the use of an individualised action plan that can promote the early recognition and treatment of the COPD exacerbation, thereby lessening its impact. Finally, increased activity levels through promoting a healthy lifestyle are associated with less healthcare utilisation and increased long-term survival.

## Applying the principles of pulmonary rehabilitation to nontraditional settings

As mentioned previously, pulmonary rehabilitation targets and treats the secondary impairments associated with chronic respiratory disease;

therefore, it is likely to be effective in both a wide range of chronic respiratory diseases as well as in alternative clinical settings. This section will examine three clinical areas where there is growing body of evidence to support a role for pulmonary rehabilitation.

First, pulmonary rehabilitation at the time of the acute exacerbation of COPD may have substantial affects ranging from prevention of subsequent exacerbation to lessening its severity and deleterious effects. Secondly, pulmonary rehabilitation in the lung cancer patient may both increase candidacy for curative resection and improve symptoms and quality of life in those where cure is no longer an option. Finally, pulmonary rehabilitation, at the time of critical illness (in the intensive care unit), may lessen the profound muscle dysfunction seen in these patients that often leads to a prolonged need for ventilatory support and protracted institutional rehabilitation.

### **Pulmonary rehabilitation at the time of the acute exacerbation of COPD**

The COPD exacerbation is costly to both the patient and the healthcare system, resulting in accelerated decline in lung function, prolonged decreases in functional performance and in health-related quality of life, increased healthcare utilisation and higher mortality risk [37]. In addition, exacerbations are responsible for a large proportion of the total cost of care for this common disease.

Pulmonary rehabilitation can impact on the detrimental effects of the exacerbation in three settings: before, during and immediately after the exacerbation. Prior to the exacerbation, pulmonary rehabilitation has several components that may directly or indirectly reduce the frequency and/or severity of subsequent exacerbations. It promotes adherence to medical therapy through selfmanagement education, and the regular use of inhaled corticosteroids and long-acting bronchodilators are associated with fewer COPD exacerbations [38–39]. Furthermore, higher levels of physical activity, which may result from pulmonary rehabilitation, are associated with fewer respiratory and all-cause hospitalisations [40]. Finally, the development and implementation of an individualised, collaborative action plan leads to the early recognition and treatment of the exacerbation, thereby lessening its impact.

The exercise training component of pulmonary rehabilitation can be initiated during hospitalisation at the time of the COPD exacerbation. This

may lessen the deleterious effects of inactivity and systemic inflammation on muscle function, thereby diminishing the reductions seen in functional performance and health-related quality of life.

In the immediate post-hospitalisation period following the exacerbation, symptom burden is high, functional status is considerably decreased, healthcare needs are numerous and the risk of repeated hospitalisation is very high. Greater collaboration among healthcare professionals in the hospital and the community during this delicate transition is crucial. Pulmonary rehabilitation can facilitate the integration of care by performing a comprehensive assessment of the patient at the time of hospital discharge, developing an individualised plan of care and providing the framework for sharing this plan with the patient, family and all pertinent healthcare providers [41]. In an analysis of six trials involving 219 patients following an exacerbation, pulmonary rehabilitation significantly reduced hospital admissions and mortality, and improved exercise capacity and health-related quality of life [42].

### **Pulmonary rehabilitation in the lung cancer patient**

Pulmonary rehabilitation can play an important role in the management of patients with lung cancer in three different settings: during the assessment for surgical candidacy, during the immediate post-operative period, and during medical treatment in those patients with advanced disease. Since exercise capacity is an important determinant for lung resection and is a predictor of post-operative complications, it seems logical that any intervention that can improve and optimise this parameter would improve surgical outcomes [43, 44]. More intriguing perhaps, may be the role of pulmonary rehabilitation in improving patient function such that surgical resection may be offered to patients that otherwise might not have “qualified” at baseline evaluation. A small study by CESARIO *et al.* [45] enrolled eight lung cancer patients who, despite a favourable clinical stage, were denied surgery based on poor pulmonary function. After a four-week pre-operative pulmonary rehabilitation programme, all patients improved their exercise capacity and were subsequently operated on with no mortality and limited morbidity.

Pulmonary rehabilitation in the post-operative setting can help to optimise airflow and pain management, assist in early ambulation and help to prevent, recognise and promptly treat complications including hypoxaemia, hypercapnia and



infections [46, 47]. Pulmonary rehabilitation is the ideal forum to provide the services necessary to maximise respiratory and functional status.

Finally, pulmonary rehabilitation may be of great benefit to patients receiving medical management, *i.e.* chemotherapy and radiation therapy. Improvement in symptoms and quality of life can prove critically important when long-term survival is not an outcome that can be impacted on. Aerobic exercise has been shown to be a safe intervention during chemotherapy and can partially prevent loss of physical function [48]. In addition to exercise, relaxation and coping strategies have also been shown to be beneficial in reducing fatigue and psychological stress induced by systemic chemotherapy [49]. In this respect, pulmonary rehabilitation may dovetail nicely with palliative care. Future well-designed clinical trials are needed to better define the benefits and optimise the intervention in this patient population.

## Pulmonary rehabilitation in critical illness

Critical illness has many devastating effects, including profound neuromuscular weakness and psychological and cognitive disturbances that can result in long-term functional impairments [50]. Early rehabilitation started in the intensive care setting is emerging as an effective, feasible and important strategy to prevent and treat these sequelae and improve long-term outcomes. Rehabilitation may begin with range of motion and bed mobility exercise, then progress when the patient is fully alert to sitting and posture-based exercise, bed-to-chair transfers, strength and endurance exercises and ambulation. Adjunctive strategies, such as neuromuscular electrical stimulation and inspiratory muscle training are additional techniques that may be employed. To date, a limited number of studies have examined rehabilitation outcomes in this setting [51–53]. International guidelines recommend that rehabilitation should start as early as possible following critical illness, including in the intensive care unit [54, 55]. Further research is needed to identify optimal patient candidates

and procedures for providing rehabilitation in the critically ill.

## Conclusion

Today, pulmonary rehabilitation is the standard of care for patients with COPD, with proven benefits in exercise tolerance, dyspnoea and health-related quality of life. It probably also reduces healthcare utilisation, number and severity of exacerbations and mortality. Its components include patient assessment, exercise training, selfmanagement education and psychosocial support. Pulmonary rehabilitation should be considered for patients with any chronic respiratory disease who remain symptomatic or have decreased functional status despite otherwise optimal medical management.

Pulmonary rehabilitation is an important component of the integrated care of the COPD patient. The essence of this integrated care approach is to provide the right therapy to the right patient at the right time and to provide a seamless transition of care across settings (hospital, rehabilitation, community) and disciplines (primary care, subspecialty, home services) [56].

For years, pulmonary rehabilitation has used an integrated, interdisciplinary model in the management of chronic respiratory disease. As such, it has been a paradigm for chronic disease management. While the components of pulmonary rehabilitation are most often efficiently packaged as an interdisciplinary pulmonary rehabilitation programme, these components can and should be integrated into the lifelong management of all patients. The patient must be at the centre of this integrated care approach.

Emerging data support a role for pulmonary rehabilitation in other clinical settings where there are similar impairments, such as in the acute exacerbation, in the patient with lung cancer and in the critically ill. In the future, we look forward to applying the basic tenets of pulmonary rehabilitation to additional clinical situations in which morbidity and mortality exact a high toll and there is hope to improve patient-centred outcomes and utilisation of scarce healthcare dollars.

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