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REVIEW

Pulmonary rehabilitation and COPD: providing patients a good environment for optimizing therapy

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Abstract: Chronic obstructive pulmonary disease (COPD) is an obstructive and progressive airway disease associated with an important reduction in daily physical activity and psychological problems that contribute to the patient's disability and poor health-related quality of life (HRQoL). Nowadays, pulmonary rehabilitation (PR) plays an essential role in the management of symptomatic patients with COPD, by breaking the vicious circle of dyspnea–decreased activity–deconditioning–isolation. Indeed the main benefits of comprehensive PR programs for patients with COPD include a decrease in symptoms (dyspnea and fatigue), improvements in exercise tolerance and HRQoL, reduction of health care utilization (particularly bed-days), as well as an increase in physical activity. Several randomized studies and meta-analyses greatly established the benefits of PR, which additionally, is recommended in a number of influential guidelines. This review aimed to highlight the impact of PR on COPD patients, focusing on the clinical usefulness of PR, which provides patients a good support for change.

Keywords: chronic obstructive pulmonary disease, exercise training, physical activity, quality of life

Introduction

The prevalence of Chronic Obstructive Pulmonary Disease (COPD) is constantly increasing,[1] while its incidence is growing in old age.[2,3] COPD is also a leading cause of morbidity worldwide, particularly in developing countries.[1] Whereas COPD is an obstructive and progressive airway disease, it is also associated with a significant reduction in physical activity, and psychological problems, all of which contribute to the patient's disability and poor health-related quality of life (HRQoL).[3] Recently, emphasis has been placed on questionnaires designed to assess health status and prognosis in COPD.[4]

For a long time, the treatment of COPD has focused mainly on pharmacological improvement of the airway obstruction. However over the last two decades, growing evidence of systemic manifestations in COPD patients and their negative effects on the functioning of these patients has accelerated the development and use of nonpharmacological treatments, such as pulmonary rehabilitation (PR). PR and pharmacological therapy are not competitive but rather, must work closely together, if they are to result in a more successful outcome. One particular study has shown that a better outcome (exercise tolerance) of PR can be obtained when it is associated with long-acting anticholinergic bronchodilators.[5] Moreover, PR has been shown to be the most effective nonpharmacological intervention for improving health status in COPD patients and has become a standard of care for COPD patients.[3]

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Many PR programs have been developed and provided by multidisciplinary teams and typically include components such as patient assessment, exercise training, education, nutritional intervention, and psychosocial support.

The benefit of PR in patients with COPD in improving exercise capacity and HRQoL, and in reducing breathlessness and health care utilization (particularly bed days) has been widely established by randomized studies, summarized in reviews, and by meta-analyses.[6–10] PR is now recommended in several influential guidelines.[3,11] Unfortunately the practical use of rehabilitation in COPD is virtually nonexistent or under-resourced in most countries. Misunderstanding on the usefulness of a PR program, in addition to the high cost has hindered the widespread distribution of comprehensive PR centers.

This review aimed to present the use of PR in COPD and to highlight the impact of PR on patients with COPD, focusing on the clinical usefulness of PR, which provides patients a favorable environment for optimizing therapy. We also hoped to stimulate or persuade pulmonary physicians to use PR more often.

COPD: a systemic disease with effort limitation

For a long time, COPD was considered to be a respiratory disease, mainly caused by tobacco smoking and leading to progressive dyspnea. However, additionally, COPD produces inactivity, which promotes further loss of exercise capacity (deconditioning) through the loss of muscle mass, creating a "vicious" circle (Figure 1). Indeed, COPD has substantial manifestations beyond the lungs − the so-called systemic effects, such as unintentional weight loss and skeletal muscle dysfunction. The chronic systemic inflammation that is linked to COPD may also initiate or exacerbate comorbid diseases, such as cardiovascular disease, osteoporosis, anemia, type 2 diabetes, lung cancer, and depression[3,12,13] and is one of the key mechanisms underlying these extrapulmonary effects.[12–14] Consequently, COPD patients are disabled by the systemic manifestations of the disease, the most significant systemic dysfunction in COPD patients being the peripheral muscle dysfunction resulting from both physical inactivity and systemic inflammation,[15,16] to which we can add hypoxemia, undernutrition, oxidative stress, and systemic corticosteroid therapy.[16] This peripheral muscle dysfunction is related to diverse pathophysiological changes in the skeletal muscle, namely reduced oxidative capacity with early lactic acidemia and oxidative stress,[17–19] decrease in the volume of muscular fibers,[20] fiber type redistribution (shift from type 1 to type 2 fibers),[20–22] and altered capillarization of these fibers.[22] These alterations lead to higher concentrations of lactate for a given work, which stimulate ventilation, provoking dynamic hyperinflation and increasing ventilatory burden. Moreover, they induce an increasing susceptibility to muscular fatigue and a too early termination of exercise. The limitation of activity also

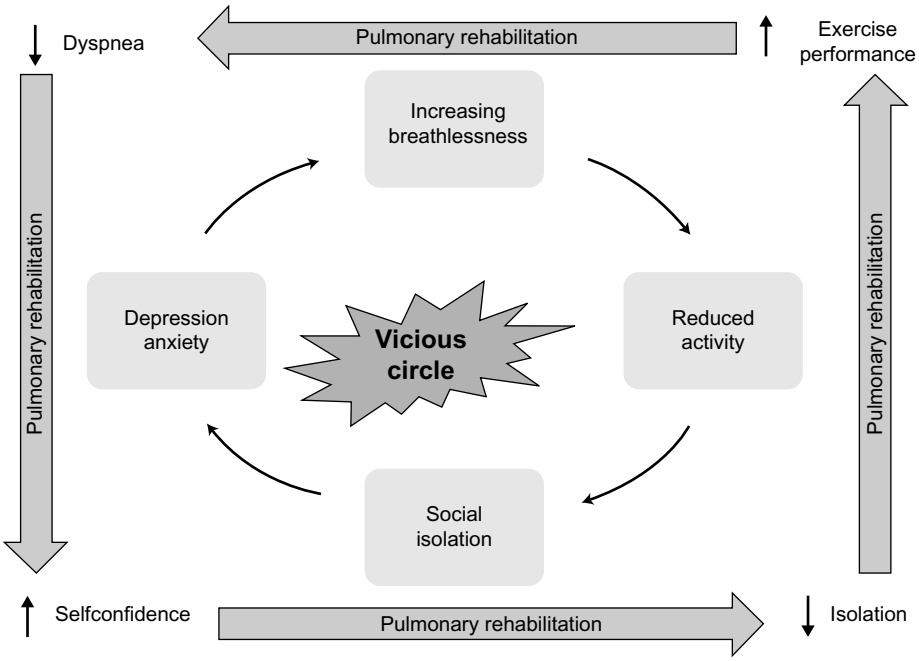

Figure 1 COPD's "vicious" circle.
Abbreviation: COPD, chronic obstructive pulmonary disease.

promotes a sedentary lifestyle and the social isolation of COPD patients, with an increased risk of depression and anxiety, leading to further inactivity due to fear of breathlessness and consecutively further physical deconditioning. Exacerbations of COPD also promote the reduction of exercise performance, dyspnea, and the loss of HRQoL, accelerating the path of this vicious circle.[23]

In summary, inactivity leads to deconditioning, mainly caused by breathlessness. This breathlessness leads to an increased fear of exertion and an avoidance of physical and social activities, thrusting the patient into a vicious circle leading to further isolation and depression, accompanied by a reduced HRQoL (Figure 1).

What is pulmonary rehabilitation?

The updated statement by the American Thoracic Society and the European Respiratory Society (ATS/ERS) Task Force on PR gives the following definition of PR:

> Pulmonary rehabilitation is a comprehensive intervention based on a thorough patient assessment followed by patient-tailored therapies, which include, but are not limited to, exercise training, education and behavior change, designed to improve the physical and emotional condition of people with chronic respiratory disease and to promote the long-term adherence of health-enhancing behaviors.[24]

This definition emphasizes that PR is a well-proven structured and multidisciplinary treatment approach including patient assessment, physical training and peripheral muscle strengthening, occupational therapy, education of the patient, smoking cessation intervention, nutritional intervention, and psychosocial support. PR thus establishes a personalized and global treatment for the symptomatic COPD patient. A PR program is not a stand-alone therapy, but rather, should be integrated into a management program in which the general practitioner as well as the patient's pulmonary specialist take an active part. By using a holistic approach centered on the patient, PR aims to reverse the systemic manifestations of COPD as well as to relieve the fears and anxiety associated with social and exterior activities, thereby leading to a change in the patient's day-to-day life. Finally, PR aims to break the aforementioned vicious circle in COPD (Figure 1).

Who should attend a pulmonary rehabilitation program?

PR offers benefits for all patients suffering from a chronic respiratory disease of whatever origin, who have a decrease of pulmonary function, who are symptomatic, and who have intolerance to effort, in spite of an optimal pharmacological treatment.[6,8,9] Even candidates for lung volume reduction surgery for severe emphysema or for lung transplantation are good candidates for PR.[25] A program of PR may be proposed in stable COPD as well as immediately after COPD exacerbation.[26] In agreement with the joint statement of the ATS/ERS of 2006, all patients suffering from the systemic consequences of COPD are good candidates for PR.[8] According to the new Global initiative for Obstructive Lung Disease (GOLD) guidelines, COPD patients (groups B–D) will benefit from a PR program.[3] However, a recent evidence-based practice guideline from the American College of Physicians supports the use of PR for symptomatic severe COPD patients (FEV_1 <50% of predicted: strong recommendation) and for symptomatic or exercise-limited patients with FEV_1 ≥50% of predicted (weak recommendation).[11]

Usually COPD patients are referred to a PR center by their chest physician or directly by their general practitioner, after which the pneumologist, center manager, or one of the team assesses the appropriateness of the indication for a multidisciplinary PR program. If a home-based PR program is considered, a close coordination between the different care providers is essential, if possible, in a care network. However, the reimbursement of the PR costs in the various modalities depends on the financial situation of the patient and their social security, as well as the rules of each country's particular health care system.

Contraindications and barriers to pulmonary rehabilitation

The main contraindications are lack of motivation and nonadherence, psychiatric illness or dementia, uncontrolled cardiovascular diseases, inability to do exercise (for orthopedic or other reasons), and unstable diseases (eg, hepatic, diabetes).[6] In some countries, active cigarette smoking is considered as a relative contraindication. While it has been proven that current smokers obtain the same benefits from PR, they will nevertheless be encouraged to undergo a smoking cessation program. However, the adherence to PR by smokers generally remains less than that of ex-smokers.[27–29]

Nevertheless, we believe that excluding smoking patients would deprive them of a potential opportunity to quit smoking.[30] Age[31] as well as the degree of the bronchial obstruction[32,33] do not constitute contraindications to PR; neither does continuous or intermittent noninvasive ventilation. Exertional severe hypoxemia must be corrected beforehand, by oxygen therapy.

Few studies have established the predictive factors of nonadherence to PR. However, besides active smoking, there is social isolation,[29] depression, and lower quadriceps strength.[27] Furthermore, a retrospective analysis has shown that COPD patients are less likely to complete a PR program if they are current smokers, attend a long-lasting program, have suffered frequent exacerbations requiring hospital admission in the preceding year, have a long journey time to reach the center, and higher Medical Research Council (MRC) dyspnea score.[34] In a more recent review, Keating et al identified travel and transport, a lack of perceived benefit of PR, being current smoker, illness, and depression as barriers to completion of a PR program.[28] For such reasons, the dropout rate from PR reported in most of these studies was within the order of 20%−30%. The aforementioned reasons are often intercurrent illnesses (severe exacerbations of COPD and COPD-related and non-COPD-related hospitalizations) and logistical problems (such as transport facilities, cost for the patient, and distance from the center).

Evidence of the effectiveness of pulmonary rehabilitation in COPD

Based on various published RCTs and on meta-analyses, numerous evidence-based reviews have evaluated the effect of PR programs on symptomatic COPD patients. These have demonstrated the effectiveness and utility of PR. The main outcomes, including exercise performance, dyspnea, HRQoL, psychosocial benefits, cost effectiveness, reduced health care utilization, and survival (Tables 1 and 2) have been reported. Some of these reviews and meta-analyses are summarized in Tables 1 and 2 along with some comments.[3,7,9,26,35–39] The benefits on many laboratory and clinical parameters associated with PR are produced without demonstrable improvements in pulmonary function. This apparent contradiction could be explained by the fact that we know that PR acts mainly on the systemic effects of the disease.

Among the multiple benefits of PR, we would like to examine the reduction of exacerbations, followed by the cost effectiveness. Indeed, a reduction in the use of the health care system is an important goal of PR because COPD

Table 1 Main outcomes of pulmonary rehabilitation in COPD patients

Outcome	Source	Comments
Improvement of exercise performance	ACCP/AACVPR[9]	High evidence and strong recommendation (1A)[†]
	ACP clinical practice guideline[37]	PR programs improve exercise capacity
	Clinical practice guideline for physiotherapists[35]	Strong recommendation
	GOLD[3]	Evidence grade A[‡]
	ACP systematic review[39]	No clinically significant improvement in the 6-minute walk distance[#]
	Cochrane review[7]	Clinically insignificant improvement in the 6-minute walk distance
	Meta-analysis[38]	No clinically significant improvement in the 6-minute walk distance
Dyspnea relief	ACCP/AACVPR[9]	High evidence and strong recommendation (1A)
	Cochrane review[7]	Effect on the dyspnea domain of the CRQ[§] was a greater than the minimum clinically important difference
	GOLD[3]	Evidence grade A
	ACP systematic review[39] Meta-analysis[38]	Average effect on the dyspnea domain of the CRQ was clinically significant
Improved health-related quality of life	ACCP/AACVPR[9]	High evidence and strong recommendation (1A)
	ACP clinical practice guideline,[37] ACP systematic review[39]	PR programs improve health status
	GOLD[3]	Evidence grade A
	Clinical practice guideline for physiotherapists[35]	Strong recommendation
	Cochrane review[7]	Effect on all domains of the CRQ were greater than the minimum clinically important difference
	Meta-analysis[38]	Pooled difference in health status scores on the SGRQ was clinically significant*

Notes: [†]Evidence comes from well-designed RCTs yielding consistent and directly applicable results: benefits clearly outweigh the risks and burdens; [‡]GOLD RCTs: A = rich body of data; B = limited body of data; [#]clinically significant effect size of 53 meters or more; [§]for the CRQ health status questionnaire for COPD (with dyspnea, fatigue, emotion, and mastery domains), an increase of 0.5 points per item or 10 points for total score is considered to be clinically significant;[77] *for the SGRQ health status questionnaire, a 4-unit reduction (out of 100) is defined as a clinically noticeable improvement.[79]

Abbreviations: ACCP/AACVPR, American College of Chest Physicians/American Association of Cardiovascular and Pulmonary Rehabilitation; ACP, American College of Physicians; COPD, chronic obstructive pulmonary disease; CRQ, Chronic Respiratory Questionnaire; GOLD, Global initiative for Obstructive Lung Disease; PR, pulmonary, rehabilitation; RCT, randomized controlled trial; SGRQ, St George's Respiratory Questionnaire; 1A, high evidence and strong recommendation.

Table 2 Main outcomes of pulmonary rehabilitation in COPD patients

Outcome	Source	Comments
Psychosocial benefits	ACCP/AACVPR[9]	Moderate evidence and weak recommendation (2B)
	GOLD[3]	Reduced anxiety and depression; evidence grade A‡
Improvement of upper extremities performance	ACCP/AACVPR[9]	Unsupported endurance training of upper extremities: high evidence and strong recommendation (1A)†
	GOLD[3]	Strength and endurance of the upper limbs improve arm function (evidence grade B)‡
Cost effectiveness	ACCP/AACVPR[9]	Low evidence and weak recommendation (2C)
Reduced health care utilization	ACCP/AACVPR[9]	Moderate evidence; weak recommendation (2B)
	ACP clinical practice guideline[37]	PR programs reduce hospitalizations
	Meta-analysis[38]	No material effect was observed on hospitalization rates
	Meta-analysis,[26] Cochrane review[36]	PR after acute COPD exacerbations reduced hospitalizations
	GOLD[3]	PR reduced the number of hospitalizations and the number of days in hospital: evidence grade A‡
Improved survival	ACCP/AACVPR[9]	Insufficient evidence and no recommendation provided
	GOLD[3]	Evidence grade B‡
	ACP clinical practice guideline,[37]	No improvement in death
	ACP systematic review,[39] Meta-analysis[38]	

Notes: †Evidence comes from well-designed RCTs yielding consistent and directly applicable results: benefits clearly outweigh the risks and burdens; ‡GOLD RCTs: A = rich body of data; B = limited body of data.

Abbreviations: ACCP/AACVPR, American College of Chest Physicians/American Association of Cardiovascular and Pulmonary Rehabilitation; ACP, American College of Physicians; COPD, chronic obstructive pulmonary disease; GOLD, Global initiative for Obstructive Lung Disease; PR, pulmonary, rehabilitation; RCT, randomized controlled trial.

patients are heavy users of health care resources. A large study examining health care utilization following a 6-week PR program found that, in comparison with a control group who received "usual care," patients in the rehabilitation group had the same number of hospital admissions but spent less time in hospital (10 versus 21 days) during the 1-year follow up.[40] A reduction of health care utilization with PR was also confirmed in another randomized, controlled trial (RCT) study with a follow up of 2 years[41] and in nonrandomized clinical studies.[42–44] Moreover, in two meta-analyses involving respectively 230 and 432 COPD patients, PR following the exacerbation of COPD significantly reduced hospital admission and mortality.[26,36] Finally, Griffiths et al reported that PR was found to be cost effective and resulted in financial benefits.[45] A more recent Canadian study suggested that PR is cost effective for patients with relatively high utilization of emergency and hospital-based services.[46]

Components in pulmonary rehabilitation

PR is a comprehensive, multidisciplinary (Figure 2), multicomponent, patient-centered intervention, consisting of a prerehabilitation assessment program, exercise and muscle training, self-management education, occupational therapy, psychosocial support, and nutritional intervention. Although most PR programs include these aspects, they may vary considerably from one center to another. Most programs involve 2 to 3 hours of education and exercise, three times weekly for at least 6 weeks. Figure 3 summarizes the steps and benefits of PR.

Setting and length for pulmonary rehabilitation programs

The structure and the setting of PR vary widely around the world. PR programs can be conducted with benefits in inpatient, hospital, or community-based outpatient or home-based settings.[8,47,48] However, most of the evidence for PR has been obtained from studies performed in a hospital-based outpatient setting.[6,8,9] In the case of home-based PR, patients do not benefit from the group dynamics or from the same safety as can be found in the other modalities. Home-based PR remains limited to exercise training, without the numerous benefits gained from a multidisciplinary team, and in addition, can be inferior in efficacy to the out- and inpatient supervised programs.[8,49] Nevertheless, a recent study by Maltais et al boosted the interest in home-based PR as an alternative equivalent to hospital outpatient PR.[48] Finally, the choice setting remains a question of patient motivation, disease severity and complex morbidities, local program availability, and available resources.

The minimum duration of an effective ambulatory PR program is currently unknown,[9] but the GOLD guidelines suggest 6 weeks.[3] It appears that a minimum of 20 sessions is needed to achieve physiological benefits,[8,9] although longer

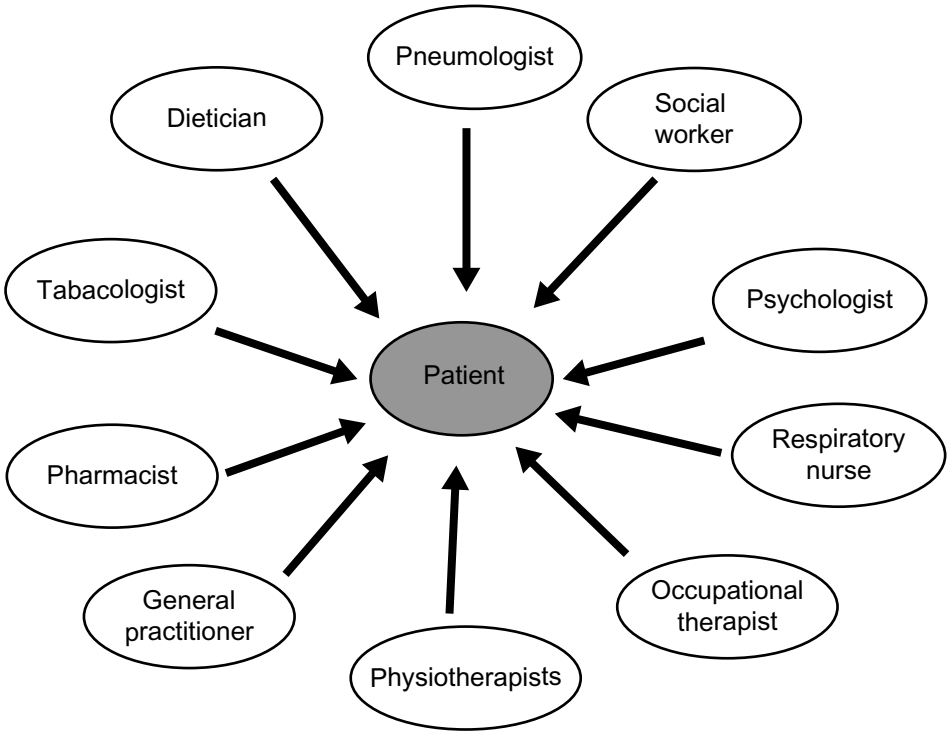

Figure 2 Multidisciplinary team involved in comprehensive pulmonary rehabilitation centered on the COPD patients.
Abbreviation: COPD, chronic obstructive pulmonary disease.

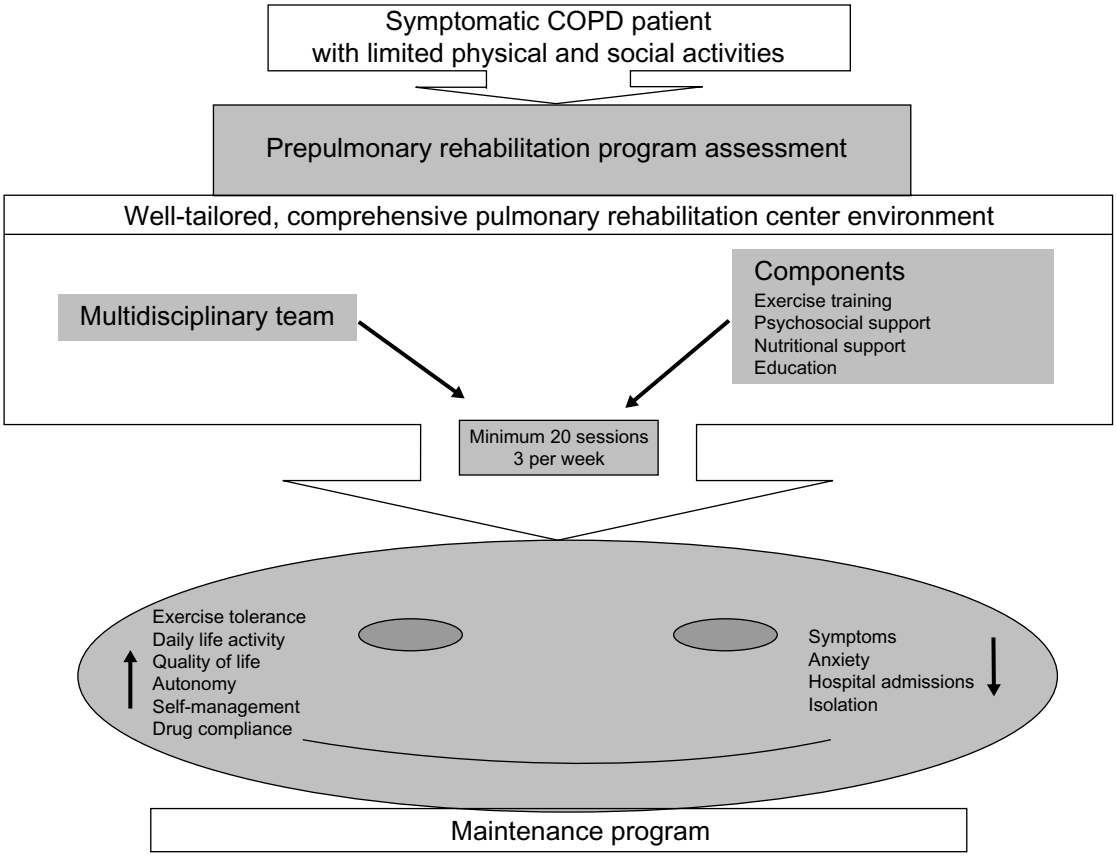

Figure 3 Summary of the steps and benefits of pulmonary rehabilitation.
Abbreviation: COPD, chronic obstructive pulmonary disease.

programs are associated with better results.[3,50,51] A recent review concluded that prolonged PR programs tend to have more favorable effects on HRQoL, but the results for exercise capacity are less clear.[52] Furthermore the limited number of RCTs comparing different lengths of PR prevents a more definitive conclusion on the optimal duration of PR.[52] Conversely, an interesting meta-analysis concluded that patients with mild or moderate COPD benefit from short- and long-term rehabilitation, whereas patients with severe COPD may benefit from rehabilitation programs of at least 6 months.[53] On the other hand, inpatient PR programs have a shorter duration and may result in physical performance improvement within 2 weeks[47] but are generally more expensive.[54] Inpatient PR can be particularly reserved for more disabled patients with severe comorbidities, patients with limited transportation to the outpatient setting, or patients residing in areas where outpatient PR program facilities are limited.[8]

Prerehabilitation assessment program

Assessment of the patient, prior to initiation of PR but also, during and at the end of PR, is an essential element in the practice of PR. It allows the patient to have an individually tailored treatment based on their needs and problems and for adaptation of the program of PR according to the progress obtained.[8,10] This assessment is carried out under the direction of the pulmonary physician specialized in rehabilitation. The pulmonary physician leads and coordinates the multidisciplinary team and is responsible for the medical treatment and rehabilitation program and for investigating comorbidities that could contraindicate or interact with PR (as described previously).[6,9,55] The possible assessments include past medical history (including comorbidities), physical examination, cycling cardiopulmonary exercises (incremental workload), the 6-minute walk test, the shuttle walking test, pulmonary function tests, maximal expiratory and inspiratory pressure evaluations, measurement of peripheral muscle forces, disease-specific questionnaires, and nutritional and psychological evaluations.

Exercise training

Continuous and interval training as well as strength training may be regarded as the major exercise components of PR.[56]

Continuous and interval training

Endurance training is the most common exercise modality in COPD patients. The main objective is to improve aerobic exercise capacity as aerobic activities are part of many tasks.[56] The exercise training is guided by the following three parameters: intensity, frequency, and duration.[9]

Lower extremity exercise training at a higher exercise intensity produces greater physiologic benefits than does training at a lower intensity, in patients with COPD.[9] Nonetheless, both low-intensity and high-intensity exercise training produce clinical benefits for patients with COPD.[9] Indeed, muscular functional disorders are reversible with moderate- to high-intensity rehabilitation exercise,[8,57,58] with the same magnitude changes across GOLD stages II to IV.[59] Low-intensity training results in improvements in symptoms, HRQoL, and some aspects of performance of the activities associated with daily living;[8] moreover, the long-term adherence seems to be better with low-intensity training. However, training programs should attempt to achieve maximal physiologic effects.[8] So high-intensity training is proposed in PR centers. High-intensity training targets have been defined to be at least 60% to 80% of the peak work rate achieved in an incremental maximal exercise test.[9] This intensity seems sufficient to elicit some physiologic training effects.[8] The total effective training time should ideally be over 30 minutes.[8] Endurance exercise of the leg muscles is the main focus, with walking, stationary cycling, and treadmill exercise being

B

Recording time	6 days, 22 hours, 27 minutes
Total energy expenditure	53,320 joules
Number of steps per day	1,068
Time standing (min/day)	204
Time sitting (min/day)	359
Time lying (min/day)	114
Mean MET	1.2
Duration of daily physical activity (≥3 MET) (min/day)	49

Figure 4 Use of a multisensory accelerometer.
Notes: (**A**) An accelerometer worn on the arm. (**B**) Data recorded by the accelerometer from a severely disabled GOLD IV COPD patient.
Abbreviations: MET, metabolic equivalent; COPD, chronic obstructive pulmonary disease; GOLD, Global initiative for Obstructive Lung Disease; min/day, minutes per day.

commonly performed.[55] In clinical practice, symptom scores can be used to adjust the training load (eg, a Borg score of 4 to 6 for dyspnea).[8,60]

Most programs involve three sessions per week, of which a minimum of two sessions should be supervised,[8] with a duration of at least 6–8 weeks.[3,61]

For severely breathless patients, it is not possible to achieve the above training targets. In such cases, an interval training regime may be preferred.[55,62] Here, the continuous exercise session is substituted by a succession of shorter high-intensity exercise periods alternated with low- to moderate-intensity exercise recovery periods.[62] This form of training may be more comfortable for patients with more severe dynamic hyperinflation,[10] and adherence to the treatment may be better.[63] Patients with severe COPD may also increase the total exercise duration with lower metabolic and ventilatory stress.[56]

During the training sessions, oxygen saturation, heart rate, and blood pressure are measured. Supplementary oxygen is given in order to maintain an oxygen saturation of above 90%.[6,9,31] All the measured parameters are recorded in the medical file. As the rehabilitation program proceeds, therapists should be encouraged to adjust the training intensity. Retesting may provide physiological evidence that a training response has occurred and may be useful in the adjustment of intensity levels during the program.[64]

Strength training

Strength training (resistance exercises) would be particularly indicated for patients with significant muscle atrophy and marked dyspnea on minimal exertion.[8] For each patient, the physiotherapist chooses the optimal resistance, frequency of exercise, speed, and mode of training and also, the implementation during the PR program. The addition of the strength training component increases muscle mass and strength.[9] The combination of endurance and strength training generally has multiple beneficial effects and is well tolerated.

Upper limb training

PR programs have traditionally focused on the lower extremities, but many patients report dyspnea during daily activities that involve use of their arms, such as dressing, washing, and carrying groceries. Accordingly, upper limb exercises should be incorporated into the training program,[8] using an arm cycle ergometer, free weights, or elastic bands. All modes of arm exercise have been shown to increase arm endurance capacity by a clinically significant level compared with no arm training.[65,66]

Adjunct to the exercise training

Neuromuscular electrical stimulation

Neuromuscular electrical stimulation (NMES) may be an adjunctive therapy for patients with severe chronic respiratory diseases who are bedbound or suffering from extreme skeletal muscle weakness.[9] NMES can be conducted at home and is safe and relatively inexpensive.[10] NMES was shown to enhance walking performance in patients with severe COPD.[67]

Respiratory muscle training

Inspiratory muscle training (IMT) is not recommended as a routine component of a PR program[9] but should be considered in COPD patients with ventilatory muscle weakness.[8] Normocapnic hyperpnea resistive training and threshold loading have been described as training modalities.[8] The use of a threshold loading device can be recommended for training the inspiratory muscles.[37,68] Moreover, a meta-analysis of 25 studies that assessed the efficacy of IMT in patients with stable COPD found significant increases in inspiratory muscle strength, exercise capacity, and one measure of quality of life, and a significant decrease in dyspnea.[69]

Alternative treatment

Beyond the classical modes of training, such as walking, cycling, stepping, and arm training, there have been a few recently published papers on the effects of alternative exercise training modalities, in people with COPD. Among these, we have found two alternative modes – water-based rehabilitation (in patients with physical comorbidities, including musculoskeletal, peripheral vascular disease, and neurological conditions or obesity)[70] and Tai Chi – that seem to be well tolerated and enjoyed by patients.[71,72]

Education

Patient education, incorporating self-management training, remains an important component of any comprehensive PR program, despite the difficulties in measuring its direct contribution to overall outcome.[8,9] The content of the education program varies depending on local resources, but the topics commonly covered are aspects of the disease, physiotherapy skills, nutrition interventions, energy conservation, and psychosocial interventions.

Disease education

All patients should receive disease education to improve their compliance with medication regimens,[10] oxygen therapy, smoking cessation, nutritional interventions, exercise, and

health preservation, all of which contribute to the overall autonomy of the patient. Patient education includes relevant topics associated with COPD (eg, anatomy, pathophysiology, nutritional advice, disease education, breathing techniques and pharmacology, oxygen therapy, smoking cessation, inhalation techniques, symptom management, chest clearance techniques, energy conservation, daily exercise, psychological interventions, anxiety management, relaxation, goal setting, travelling with COPD, sexuality issues, prevention and early recognition/management of COPD exacerbation, end of life issues, etc). Patient education aims to equip the patient with the knowledge and skills they need to manage their disease and to change their lifestyle, which is the ultimate aim of PR. All the multidisciplinary team members participate in educational programs.

Physiotherapy skills

Chest physiotherapy represents a nonessential component of PR but proves its usefulness in patients with a marked bronchial hypersecretion.[55] Relaxation exercises, flexibility and stretching exercises, breathing techniques (eg, pursed lip and diaphragmatic breathing) are often coupled with an exercise training session.[35,73] These are administered for a brief period (5−10 minutes) and are recommended to maintain muscle length and to prevent injury and soreness.

Energy conservation

Occupational therapists contribute to the evaluation of a patient's autonomy and may recommend technical support and energy conservation techniques, depending on the type of disability. They also educate the oxygen-dependent patient.

Nutritional intervention

In COPD, nutritional depletion is common and has a negative impact on respiratory as well as on skeletal muscle functions, and contributes to the morbidity and mortality of COPD patients.[74] Achievement of optimal nutritional status should help to maximize the patient's state of health, respiratory muscle function, and overall sense of wellbeing.[55] The dietician's role is to establish a dietary history, evaluate the body mass index (BMI), measure the body fat percentage (eg, by impedancemetry), and ensure dietary follow up. Underweight patients may require nutritional advice (caloric supplements may be required) prior to commencing a PR program to ensure that the extra physical activity does not lead to further weight loss. Overweight patients may also need nutritional advice regarding weight loss, but the challenge here, is to not lose fat-free mass.[10] Current scientific evidence does not support the routine use of anabolic agents in PR for patients with COPD.[9]

Psychosocial support

Anxiety and depression are important comorbidities of COPD,[3,12,13,75] and a significant proportion of COPD patients referred to PR centers suffer from these psychiatric disorders.[13,75] The psychologist can be helped to evaluate for anxiety−depression disorders by means of tools such as the Hospital Anxiety and Depression Scale (HADS), as symptoms of anxiety in COPD have been demonstrated to have a negative impact on quality of life (QoL).[76]

QoL can be assessed with a disease-specific questionnaire, such as the Chronic Respiratory Disease Questionnaire (CRQ)[77] or the St George's Respiratory Questionnaire (SGRQ).[78,79] The psychosocial interventions for patients include disability evaluation, vocational counseling, and continued education of patient and family. In addition, psychological support can facilitate the adjustment process by encouraging adaptive thoughts and behavior − coping strategies that help patients to reduce their negative emotions, which in turn, may improve compliance with PR. Psychological support helps in overcoming addictions, especially tobacco smoking and, along with medical treatment for smoking cessation, is an important intervention in PR programs.[10] In some instances, the social worker provides assistance to the patient in securing financial support.

Maintenance program

The benefits of a PR program tend to diminish over the months following its discontinuation. PR programs are usually not associated with sustained benefits beyond 12 months.[40,43,80,81] However, programs lasting for at least 6 months have been more successful in maintaining outcomes, even in the absence of structured maintenance programs.[41,82] Maintenance of the benefits of PR – such as physical activity and lifestyle changes – is an important challenge for those who have undergone a comprehensive PR program.

Many centers currently offer maintenance programs in the hope of consolidating and prolonging the benefits of a successful rehabilitation program. However, the optimal strategy to meet this aim has not yet been described. Among the available options, we find telephone contacts and monthly supervised reinforcement sessions,[83,84] home exercise training (with or without a weekly supervised outpatient session),[85] and recurrent PR programs.[86,87]

A systematic review concluded that after 8 weeks of supervised physical exercise training, maintenance programs consisting of weekly telephone calls and monthly reinforcement sessions for 1 year were unsuccessful in altering behavior and maintaining the treatment effects.[35] Moreover a recent meta-analysis has suggested that post-PR exercise programs for COPD patients are superior to traditional care in maintaining exercise capacity in the medium term (6 months) but not in the long term (≥1 year) and have no sustained effect at all with regard to the HRQoL.[88] These results should be interpreted with caution, given the heterogeneity in interventions, follow-up intervals, and outcomes measures.

The best and the most effective maintenance program currently remains to be found. Beyond post-PR exercise programs, the PR center staff, as well as family members and general practitioners, should encourage and motivate the patient to follow the maintenance program and continue with a more active lifestyle, in order to retain the gains. This advice is supported by the 12-month follow-up data taken from a cohort of COPD patients who had completed a 10-week comprehensive PR program and who were invited to follow a structured home program at the end of the PR program.[89] At the 1-year follow-up evaluation, only the patients who had continued with the "prescribed" exercise routine had maintained the gains achieved in physical endurance, and psychological and cognitive functioning during the initial intervention.

Pulmonary rehabilitation and effect on physical activity

Patients with COPD are typically less active in daily life than are healthy older adults.[90] In addition, inactivity is associated with poor functional status and higher risk of hospital admissions and mortality.[91] It appears obvious that COPD patients would be more physically and socially active after PR. However, there is currently no strong evidence that patients translate the benefits obtained from PR into a more active lifestyle in real life.

Cindy et al[92] recently published the first meta-analysis evaluating the effect of exercise training on measures of physical activity. This meta-analysis pointed out that supervised exercise training confers a significant but small effect on physical activity. The principal limitation of the meta-analysis was that the majority of the included studies did not use the same method to measure physical activity; moreover, it is well known that questionnaires and pedometers are an insufficiently sensitive means of detecting changes in physical activity in this particular clinical (slow-walking) population.[90,93,94] When the authors considered only those studies that utilized a multisensory accelerometer to measure physical activity, they obtained more significant improvements in physical activity.[92] Accelerometers or activity monitors are small devices carried on the arm, leg, or waist that measure energy expenditure, movement pattern, and body position over a period of time (24 hours to 7 days) and provide objective measurements of daily life activity (Figure 4). Two parameters appear to be crucial to enhancing physical activity in COPD patients after PR: the frequency of supervised exercise training and the duration of the program. Indeed, in the meta-analysis by Cindy et al,[92] the studies that proposed an exercise training regimen of three times per week showed a significant increase in physical activity, in contrast with those that offered exercise only two times a week. Moreover, in a study measuring physical activity with an accelerometer, Pitta et al[93] showed that a 6-month, supervised exercise training program was required to obtain a significant effect on physical activity, while three months was shown to be insufficient. This is consistent with the recent concept that 6 months are needed for most people to change behavior.[95] The recording of spontaneous daily physical activity provides a new dimension in patient assessment that goes beyond any measurement of physiological capacity. Daily activity and the completion of domestic tasks are more important for the patient than an improvement in the 6-minute walk test, total CRQ score, or maximal load achieved during ergospirometry. Thus clinicians should take into account what people actually do (eg, walking, climbing stairs, dressing, etc), rather than what they are capable of doing since it is the natural level of physical activity that seems to best determine the prognostic benefit.[96]

As mentioned above, a study showed that a better outcome of PR can be obtained by its association with long-acting anticholinergic bronchodilators.[5] This treatment appears to amplify the effectiveness of PR, as seen by greater improvements (beyond that obtained with PR alone) in patient self-reported participation in physical activities outside of the PR program, during the 8 weeks of PR and the 12 weeks following.[97]

Finally, new studies using accelerometers are needed to validate their use[98] and to go further in this crucial domain linking PR and physical activity, since we know that physical activity levels determine the survival in COPD patients.

Conclusion

Tailored pulmonary rehabilitation programs should be considered for COPD patients of all stages, who have respiratory

symptoms and/or who have intolerance to physical effort despite optimal pharmacological treatment.

PR has certainly been demonstrated to provide beneficial effects on dyspnea, improvement in muscle strength and endurance, improvement of psychological status, reduction of hospital admissions, and improvement of HRQoL in COPD patients, with a gradual increase in daily physical activity and autonomy.

Successful PR therefore requires behavioral changes. To achieve this, patients' skill and adherence may be facilitated if they are enrolled in longer, comprehensive programs comprising interactions with a multidisciplinary team offering support, council, encouragement, and coaching. These changes rest on the following: exercise training; psychosocial support; nutritional intervention; self-management; and education, as well as pacing and energy conservation strategies, all of which are intended for motivated COPD patients. Therefore, PR embodies a very important and safe therapeutic option that aims to reverse the systemic manifestations of COPD and which, along with pharmacological therapy, can be used to obtain optimal patient management, leading to a favorable change in the daily life of our COPD patients. Accordingly, with the increasing burden of COPD patients in the world, there is an urgent need for advocacy with the concerned authorities, for a more widespread reimbursement of PR programs worldwide.

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