

Pulmonary rehabilitation: An overview

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ABSTRACT

The burden of chronic obstructive pulmonary disease (COPD) has increased recently in developing countries. On the other hand, structured or non-structured rehabilitation services for COPD patients are not routinely available in these countries. We, therefore, planned this review to re-emphasize the emerging benefits of pulmonary rehabilitation in COPD population. Aim of this review is to stimulate pulmonary physicians in India and other resource-poor areas of the world so that they start using pulmonary rehabilitation or its components more often. The search included standard english literature PubMed citation of relevant original articles, review articles and practice guidelines. The articles and reviews were searched including standard MeSH terms – Rehabilitation (TIAB) and pulmonary disease, chronic obstructive/therapy (MAJOR) and guidelines (TIAB). Available 58 articles in English including 23 reviews from July 2001 to October 2010 were screened for evidence-based benefits regarding respiratory rehabilitation as a whole or its different components. The cross references and current citations relating to primary articles were also included for description. No attempt was done to make a systematic analysis because our purpose was not to derive evidence-based recommendations from database and because sufficient evidence is already available for benefits of selected components of pulmonary rehabilitation in COPD patients. Pulmonary rehabilitation has emerged as an important modality as an adjunct to other therapies in patients of COPD. Limited and more cost-effective protocols are to be developed and executed by healthcare providers, especially in developing countries like India.

KEY WORDS: Chronic obstructive pulmonary disease, guidelines, rehabilitation

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INTRODUCTION

How is a Mount Everest winner different from a healthy person of his age with sedentary habits? An Everest winner can manage to climb 30,000-feet high mountain, while a sedentary healthy person may feel difficulty in climbing even a 300-feet high hill. How can one explain such a difference in great performance and capabilities? Capability of higher work performance can be attained by proper conditioning of body by regular practice so that oxygen and body energy are utilized optimally. Can we utilize the performance improvement skills in patients with crippling respiratory diseases such as chronic obstructive pulmonary disease (COPD)? Pulmonary rehabilitation

deals with this aspect. Recent evidence-based guidelines have contributed significantly to the clarification of this question.^[1,2] In patients with COPD, rehabilitation has been recognized as an established modality of treatment as it can increase functional capacity, leads to improvement in dyspnea and quality of life.^[1] The role of rehabilitation in other respiratory disorders is less clearly established; however, further work is in progress. Some of these studies are highly disease specific and fall outside the scope of this review.

With the availability of inhaled and other modern means of therapy, we now have highly effective treatment to reduce the agony of COPD patients to a certain extent. Despite the availability of effective therapy, many patients in developing countries still have to suffer due to ignorance, lack of understanding and faulty perception of the disease. The practical use of rehabilitation in respiratory diseases is virtually non-existent in such countries. Worldwide organized rehabilitation facilities are limited to urban or semi-urban settings. In countries like India where most of the population lives in rural setting, the burden of diseases like COPD is rising.^[3] Widespread dissemination of

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structured rehabilitation services is difficult. To be widely acceptable, pulmonary rehabilitation ought to be applied in a cost-effective and logical manner in such a scenario. Therefore, there is an urgent need of recapitulating basic principles of rehabilitation with respect to respiratory diseases. This review aims to highlight the role of pulmonary rehabilitation in COPD, concentrating mainly on clinical utility of various aspects of pulmonary rehabilitation.

HISTORICAL ASPECTS

As for coronary artery disease patients, rest was considered essential part of the treatment for respiratory patients during the first half of the last century.^[4] In 1952, Barach suggested that in chronic respiratory patients, the progressive improvement in ability to walk without dyspnea might be a physiological response similar to a training program in athletes.^[5] In 1960s, Petty established a standardized out-patient program of pulmonary rehabilitation.^[6] In 1980, the American Thoracic Society acknowledged benefits of pulmonary rehabilitation notably and included exercise conditioning as an important constituent in treatment program. However, during this period, some trials showed no significant benefit.^[7,8] The failure to show benefit was probably because these studies looked for effect in only an individual variable related to exercise. After the mid 1980s, important and more comprehensive work in rehabilitative research by Ries *et al.* and Casaburi *et al.* established the role of pulmonary rehabilitation for patients with chronic respiratory diseases.^[9,10]

In 1999, a group of experts under the auspices of the American Thoracic Society produced a document that reviewed the state of the art management of pulmonary rehabilitation in patients with COPD.^[11]

DEFINITION

The definition of pulmonary rehabilitation has been continuously revised over the last many years and the latest one is specified by American College of Chest Physicians (ACCP) and the American Association of Cardiovascular and Pulmonary Rehabilitation (AACPR) as follows: “Pulmonary rehabilitation is an evidence-based, multidisciplinary and comprehensive intervention for patients with chronic lung disorders who are symptomatic and have some disability. Pulmonary rehabilitation is aimed to decrease symptoms, optimize functional state, increase participation, and reduce health-care costs through stabilizing or reversing systemic manifestations of the disease”.^[12] To simplify, a symptomatic COPD patient has some compromise in functional state, depending on the stage of the disease which can be rectified by rehabilitation.

THE “EFFECTS” OR “BENEFITS” OF EXERCISES

Patients with respiratory disease have limitation of their

work capacity, mainly because lungs are unable to perform the normal function of either alveolar ventilation or diffusion of the gases across the alveolar-capillary barrier. It causes reduced oxygen supply to the skeletal muscles. The most significant systemic dysfunction in COPD patients is skeletal muscle dysfunction due to anaerobic environment and subsequent lactic acidosis produced inside the muscle. Sedentary lifestyle and some disease-specific factors may also contribute to this dysfunction.^[13] Decreased aerobic enzyme activity, increased inflammatory cells, apoptosis and even low number of aerobic fibers (change of type IIa muscle fibers to type IIb fibers) have been shown in muscles of COPD patients.^[14]

High-intensity rehabilitation exercises alter the muscle metabolism in a direction that enables a person to tolerate higher magnitude of work without appreciable dyspnea. Peak oxygen consumption (VO₂ max) is improved by such training. With rehabilitation, structural changes are also observed such as conversion of type IIb muscle fibers to type IIa fibers, increased number of mitochondria in type I fibers and increased activity of mitochondrial enzymes like citrate synthetase and 3-hydroxyacyl-CoA dehydrogenase. It leads to more aerobic metabolism and therefore less lactic acid and less CO₂ production for a given level of exercise.^[15-17]

Dynamic hyperinflation present in COPD patients is also reduced because exercise conditioning leads to reduced demand on the system and hence lower respiratory rate for a given level of exercise.^[17] Additional beneficial effect of rehabilitation is desensitization to dyspnea [Figure 1].

AIMS OF REHABILITATION

The basic goals of pulmonary rehabilitation are to (1)

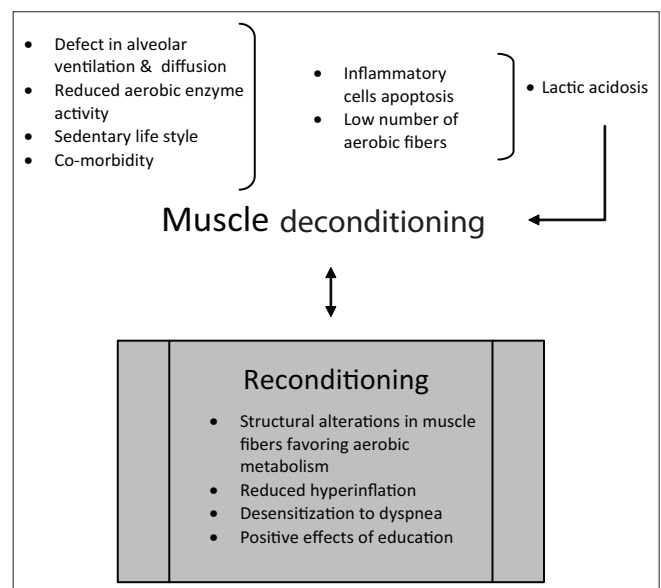


Figure 1: Muscle deconditioning due to chronic respiratory illness can be reversed back to improved muscle physiology by rehabilitation

improve symptoms, (2) restore functional capabilities, and (3) enhance overall quality of life. Thus, an ideal pulmonary rehabilitation program should be structured to bring about specific changes in underlying pathophysiology to improve functional capabilities, leading to symptomatic improvement and reduction in handicap, thereby refining quality of life in a cost-effective and individualized manner.^[18] With the help of education, the rehabilitation also aims to relieve fears and anxiety associated with program and lung condition, thereby ensuring long-term commitment to exercise.

TYPES OF PULMONARY REHABILITATION PROGRAMS

Out-patient, in-patient and home-based programs are three basic types of pulmonary rehabilitation. Each patient is prescribed a customized program that is most appropriate for his needs. With out-patient program higher intensity exercises can be achieved, and therefore it gives the best results. Out-patient program is relatively easy since it can be conducted by only a few persons, e.g., a program supervised by physiotherapists.^[19] More disabled patients cannot attend out-patient programs regularly, therefore they are advised in-patient programs. People requiring optimization of medical and ventilatory treatment may also be subjected to in-patient pulmonary rehabilitation.^[18] Home-based programs are also effective, but can be inferior in efficacy to the out-patient and in-patient programs.^[20] Home-based program is used when other programs are not available or when exercise is more important than other aspects of rehabilitation.^[21]

EVIDENCE FOR EFFECTIVENESS OF PULMONARY REHABILITATION

Patients with COPD

Various randomized controlled trials (RCTs) have shown the effectiveness of pulmonary rehabilitation for COPD patients.^[22-24] Ries and his colleagues studied 119 COPD patients, comparing the effect of a comprehensive pulmonary rehabilitation program and education alone (control group). They showed significant benefits of comprehensive pulmonary rehabilitation in improving exercise performance and important symptoms.^[18]

Cochrane meta-analysis examined the effect of 23 randomized trials.^[25] It was seen that pulmonary rehabilitation for COPD improves dyspnea and disease-specific quality of life. Functional exercise capacity as assessed by 6-minute walk distance was also increased by 49 m. The benefits were more in severe COPD as compared to mild and moderate disease and effects were maintained for up to 6 months. In these studies, supervised programs provided greater benefit than unsupervised programs. Though lack of blinding and heterogeneity among studies were the limiting factors in these studies, yet results were impressive. Importantly, the Cochrane

review concluded that no additional trials are needed to compare pulmonary rehabilitation with conventional community care in patients with COPD. However, they suggested the need of additional studies to determine essential components, duration, intensity and frequency of an ideal rehabilitation program. They also recommended in favor of more homogeneity in reporting of pulmonary rehabilitation studies in future. A few other studies have found reduction in anxiety and depression after pulmonary rehabilitation in patients with COPD.^[26-28]

Non-COPD disorders

Though the work is limited, yet rehabilitation may seem to be of significant advantage for patients with many non-COPD disorders.^[29,30] As long as patients have enough reserve to perform some exercise, it is likely that they can obtain a training benefit. Pulmonary rehabilitation has been used in diseases such as asthma, cystic fibrosis, interstitial lung disease (ILD), obesity-related respiratory disorders, pulmonary hypertension, neuromuscular and chest wall disorders.^[1] Studies have shown that pulmonary rehabilitation is important for patients with idiopathic pulmonary fibrosis and ILD.^[31,32] An Indian study incorporating 6 weeks of home-based pulmonary rehabilitative program was effective in increasing exercise endurance in patients with ILD.^[33] Table 1 summarizes the recommendations based on current evidence.^[2,12,34]

ESSENTIAL COMPONENTS OF PULMONARY REHABILITATION

Team

The program schedule is implemented by a team consisting of a program coordinator and a rehabilitation specialist.^[35] The team should meet initially to evaluate patient

Table 1: Current evidence favoring various aspects related to rehabilitation

Strong evidence* in respiratory rehabilitation ^[1,2,12]
High benefits (level IA) [§]
Improvement in dyspnea
Improvement in HRQL [#]
Limb muscle exercise training
Unsupported upper limb endurance training in COPD [§]
Increased muscle power and bulk by addition of strength training
Benefits decline over 12 to 18 months but HRQL benefits persist beyond this
Moderate benefits (level IB)
Education is an integral component of respiratory rehabilitation
Higher intensity lower limb training is more effective than lower intensity
Rehabilitation benefits chronic respiratory diseases other than COPD
No support for respiratory muscle training
Low benefits (level IC)
Longer programs (>12 weeks) produce more benefits than short programs
Use of oxygen in severe exercise induced hypoxemia

*Weaker evidence is there for reduced health care utilization, psychological benefits, and about Non invasive ventilation in rehabilitation programs (IIB); cost effectiveness, modest effect of maintenance strategy, psychological intervention as single modality and supplemental oxygen during high intensity training (IIC). [§]Levels of evidence, [#]HRQL: Health related quality of life, [§]COPD: Chronic obstructive pulmonary disease

assessment and develop a coordinated treatment plan [Figure 2]. At the time of discharge of the patient, the team should meet again for planning of discharge and post-program treatment.

Pre-program evaluation (patient selection) – indications and contraindications

Indications

Any patient, who is suffering from long-term symptomatic respiratory illness, is a candidate for pulmonary rehabilitation program. Unfortunately, exercise modality is usually considered to be the last option in management of a respiratory disorder. If the consequences of COPD are to be minimized, patients should be referred early during the course of disease. Following are some of the important indications of pulmonary rehabilitation in general:^[18]

- Symptomatic respiratory dysfunction
- Dyspnea of at least Medical Research Council (MRC) grade III
- Sufficiently motivated patient who can take part in intensive program schedule
- Preoperative rehabilitation for lung volume reduction surgery or lung transplantation
- Evaluation of elective mechanical ventilation or home oxygen

Contraindications

In broad sense, contraindications indicate inability of the patient to follow the rehabilitation program due to any reason. These may include patients having:^[18]

- Angina pectoris, recent myocardial infarction, severe pulmonary hypertension
- Congestive heart failure
- Unstable diabetes
- Inability to do exercise due to orthopedic or other reasons
- Psychiatric illness, dementia
- Severe exercise-induced hypoxemia, not correctable with O₂ supplementation
- Lack of motivation, non-adherence, unwilling to give consent
- Active cigarette smoking is considered as a relative contraindication in some countries

Initial evaluation

Initial testing is done to judge the exercise ability of a COPD patient by simple symptom-limited exercise tests. The initial maximal exercise capacity can be better evaluated by dyspnea scores.^[36] Usually, Borg 0-10 scale or visual analogue scale is recorded during ECG monitored and supervised baseline incremental exercise test. Baseline 6-minute walk test (6-MWT) is done.^[37] Pulmonary function tests including spirometry, lung volume measurement and diffusion capacity for carbon monoxide (DL_{CO}) are performed. Quality of life is most commonly assessed by Saint George Respiratory Questionnaire (SGRQ).

Rehabilitation exercise training

Exercise is the core component of the rehabilitation program.^[38]

Lower limb

Lower limb muscle dysfunction is largely responsible for exercise limitation in COPD patients.^[39] Exercise training has muscle group specific effect and lower extremity training provides the best physiological gains, according to the present evidence-based guidelines.^[1,2,12] It has been seen that reducing the total metabolic demand by using one-legged training may also improve aerobic capacity compared with conventional two-legged training in patients with stable COPD.^[40] Lower extremity exercises are usually done by treadmill walking or cycle ergometer. Corridor walk or modified weight lifting may also be considered.

Upper limb

Upper extremity training is also useful as it has been shown to decrease oxygen demand and increase arm muscle capacity at similar work level following pulmonary rehabilitation. Unsupported upper limb exercises including weight lifting are superior to supported exercises like arm ergometry.^[12] Upper extremity training is usually done with arm ergometry, arm weight lifting or throwing.

Combined upper and lower limb training

Combined upper limb and lower limb training results in a significant improvement in the exercise performance and health-related quality of life.^[41]

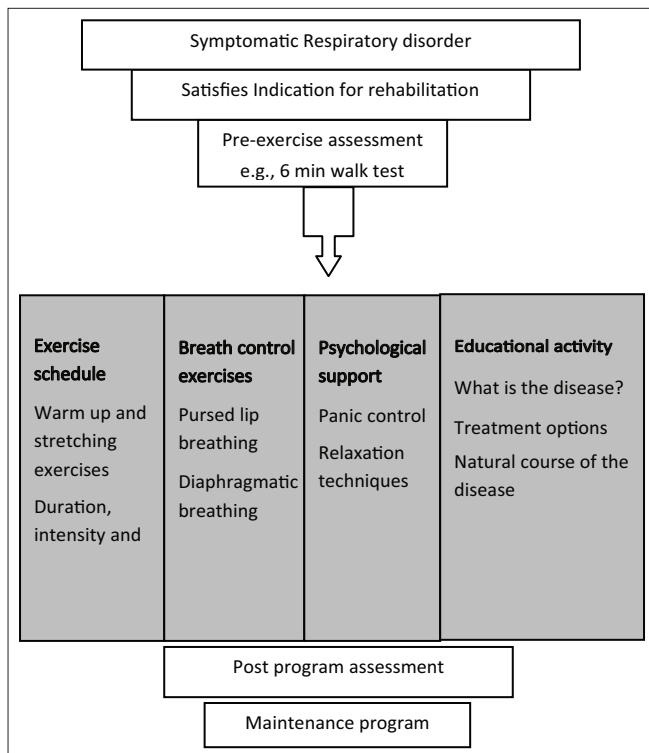


Figure 2: Diagrammatic presentation of various important steps in rehabilitation

The usual schedule may incorporate:

- minimum three sessions per week for 4, 6, 8 or 12 weeks;
- 30 minutes to 1 hour is given to each session of exercise;
- intensity/duration of exercise is usually limited by symptom; and
- type of exercise can be continuous/intermittent and endurance/strength training.

Exercise training begins at a level which can be tolerated by a patient without discomfort. Subsequently, exercises are increased in graded manner. Duration of exercise is increased first and then the intensity. In COPD patients with less severe disease, activities like walking, bike riding, swimming or golfing may be used. High-intensity exercise, just below 80% of maximum work capacity, is more useful than low-intensity exercise, below 50% maximum work capacity, and strength training is useful in improving muscle mass and strength.^[42,43]

Inspiratory muscle training

Present evidence does not support these exercises to be of significant physiological benefits.^[12,44] Inspiratory muscle training may be accepted as an adjunct to limb training as better methods of evaluation of respiratory muscle training become available in the future. In a recent meta-analysis, inspiratory muscle endurance training was found to be less useful than respiratory muscle strength training in general. However, in patients with inspiratory muscle weakness, additional inspiratory muscle training led to improvement in exercise performance.^[45]

Chest physical therapy techniques

Though chest physical therapy is practiced for centuries, in modern rehabilitation schedules it is used as a combined modality.^[2] Chest physical therapy techniques include: a) breath retraining-purse lip breathing, diaphragmatic breathing exercises and b) chest physiotherapy – postural drainage, chest percussion, vibration, and directed cough. In purse lip breathing, patient inhales through nose and then exhales over 4-6 seconds through partly opened lips. It produces a whistling sound. In diaphragmatic breathing, a patient breathes mainly with the help of abdomen. He places dominant hand on upper mid-abdomen and the other hand on the upper chest to have mainly abdominal movements. Patient breathes slowly through nose and exhales through purse lip with a conscious effort to move diaphragm during inspiration to protrude upper abdomen and displace the dominant hand maximally. It facilitates outward movement of abdominal wall and reduces upper chest movement during inspiration. These excursions can be measured during a respiratory cycle.^[46] Energy conservation techniques, e.g., while eating or climbing stairs and effective positioning of body may also be suggested during these sessions.

Limited and individualized protocols

It can be seen from above that not only more complex standard protocols but also individual components are

effective. Individual protocols can be developed by chest physicians in collaboration with physical therapy experts considering practical utility and cost-effectiveness. All one needs to do is to make best use of available evidence. One can issue charts similar to diet charts given to diabetic patients with different caloric requirements. Practical tips on the difficulties related to exercise in COPD and their solution may be included in these charts.

On-call physiotherapy

On-call physical therapy means providing respiratory physical therapy as required by the patient out of business hours. According to a recent study by Babu *et al.*, it can lead to a significant increase in pulmonary function parameter, 6-MWT distance and sustained maximal inspiration.^[47]

Psychosocial assessment and intervention

Anxiety and depression are common in chronic lung disorders and can contribute to significant morbidity and mortality.^[48] These co-morbidities complicate the course of the disorder, leading to a compromised functional and social life which further culminates into de-conditioning. Psychosocial interventions for these patients include disability evaluation, vocational counseling and continued education of patient and family. In addition to the studies mentioned above, many others have shown that pulmonary rehabilitation improves anxiety and depression associated with COPD.^[27,49]

Nutritional interventions

Resting energy expenditure is higher in COPD patients with weight loss, which is due to an increased resistive load imposed on respiratory muscles. Other probable pathophysiologic mechanisms that result in weight loss in COPD patients include systemic inflammation, tissue hypoxia, medications, inadequate dietary intake and catabolic/anabolic ratios.^[50] Weight loss in COPD patients is also associated with more severe lung function impairment. Undernourishment probably leads to deleterious consequences in these patients due to decreased respiratory muscle mass and muscle strength, decreased ventilatory response to hypoxia, decreased cell-mediated immunity and poor wound healing. COPD patients in India are significantly malnourished probably because of the underlying malnutrition.

Outcome assessment

One of the most important aspects of pulmonary rehabilitation is assessment of benefits of the program [Figure 3]. Quality of life, dyspnea and functional parameters can be assessed on various scales.^[51,52] The assessment can be real time (during program) or recall assessment (after completion of program).

Quality of life: It can be assessed by different types of questionnaire-based instruments. These include SGRQ, Chronic Respiratory Disease Questionnaire (CRDQ) and Medical Outcome Study Short Form-36 (MOS SF-36) scales. Very commonly used SGRQ is self-administered,

contains 50 items, and takes 10-15 minutes to complete. There are three separate scales based on symptoms, activity and impact on daily life.

Dyspnea

It can also be assessed with various scales such as Borg scale, MRC scale, baseline dyspnea index, transitional dyspnea index, University of California instrument and San Diego shortness of breath questionnaire. Among them, Borg scale and MRC dyspnea scale are more commonly used tools^[53,54] [Table 2]. Borg scale is a 10-point scale which represents entire range of severity of dyspnea. The patient is asked to select a point on this scale that corresponds to his perception of dyspnea. A change of 1 cm is believed to be the minimal clinically important difference. The MRC dyspnea scale is a set of five statements about dyspnea. The subject is asked to select the statement that most closely applies to the situation. Both scales are easy to use and quick to perform and are capable of detecting long- and short-term changes.

Functional assessment

It can be done with 6-MWT, shuttle walk test or BODE (Body mass index, Obstruction, Dyspnea, Exercise capacity) index^[37,55] [Table 2]. Among a variety of field

tests, the most widely used is the 6-MWT. It is a supervised measurement of the distance a patient can walk on the level surface in 6 minutes. Reference values are 576 m for healthy male subjects and 494 m for healthy female subjects. The distances for patients with COPD are generally less but are variable. The threshold of clinically significant change, as a result of rehabilitation program, has been reported to be 54 m for groups and 86 m for an individual patient.

Maintenance program

Rehabilitation programs are usually not associated with sustained benefits beyond 12 months. Therefore, a maintenance program is required to sustain the benefits of a successful rehabilitation program. It is important to note here that cycle ergometers or treadmills are expensive items and are not routinely available especially in rural settings, therefore, simple walk test e.g., timed walk test or corridor walking can be incorporated into exercise schedules. Ideal time to enroll a patient for full pulmonary rehabilitation is shortly after hospitalization for a COPD exacerbation.^[56,57]

ANCILLARY THERAPY

These therapies are the measures commonly used for the

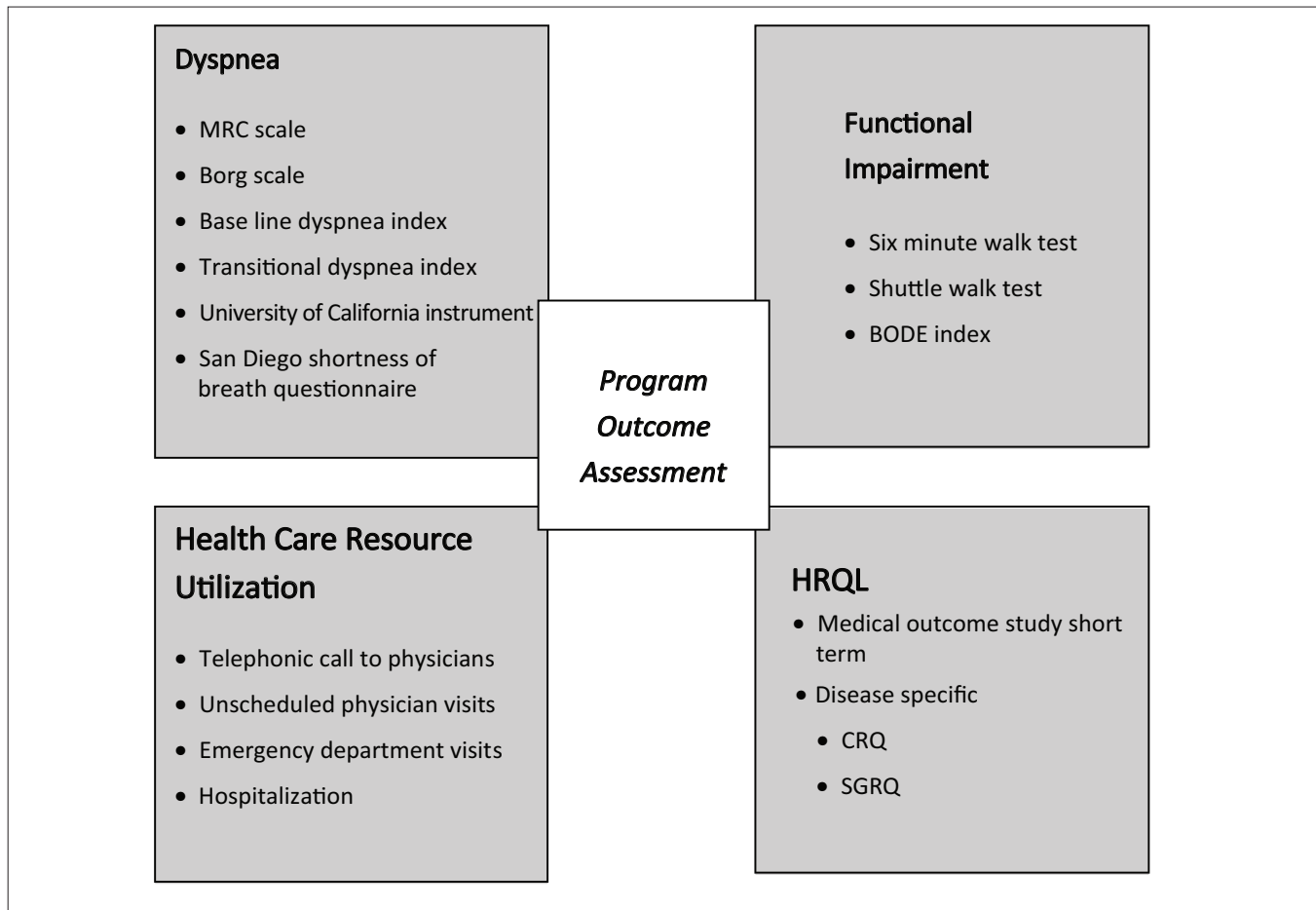


Figure 3: Program can be assessed usually with parameters like dyspnea scales, walk tests, health care resource utilization measures and quality of life parameter evaluation

Table 2: Measurements of breathlessness in exercise

Measurements	MRC chronic dyspnea scale	The modified borg scale	BODE index	The 6-MWT test
Description	0 = Without dyspnea 1 = Mild dyspnea (dyspnea on speeding up on flat surface or walking up a minor slope) 2 = Moderate dyspnea (able to walk slowly on the level because of dyspnea) 3 = Moderately severe dyspnea (has to stop because of dyspnea during walking at normal pace) 4 = Severe dyspnea (has to stop after walking about 100 yards or a few minutes) 5 = Very severe dyspnea (unable to leave the house or breathless on dressing)	0 = No breathlessness 0.5 = Just noticeable breathlessness 1 = Very slight breathlessness 2 = Slight breathlessness 3 = Moderate breathlessness 4 = Somewhat severe breathlessness 5 = Severe breathlessness 6, 7 = Very severe breathlessness 8, 9 = Very very severe breathlessness 10 = Maximum breathlessness	BODE index is composed of: Body mass index, degree of airflow obstruction, degree of dyspnea and exercise capacity BODE index is a very good predictor of mortality and progression of COPD	It is usually done along a measured corridor according to the ATS guidelines. ^[24] Participants are encouraged to cover as much distance as possible in 6 minutes. Age, height and body weight are recorded first. This is followed by measurements of saturation, pulse, blood pressure systolic and diastolic and Borg scale score are performed before and after the test

treatment of the respiratory disease and are of considerable help during a rehabilitation program. Bronchodilators, oxygen, and non-invasive ventilation (NIV) have been used successfully in rehabilitation programs.

Bronchodilators

Bronchodilators have been shown to have beneficial effects like reduced dyspnea, increased endurance, improved quality of life and reduced exacerbation frequency in patients with respiratory disease on rehabilitation.^[58,59] Additionally, they reduce the resistive work of breathing by increasing airway diameter, thereby decreasing dyspnea. Another important benefit of bronchodilators is that they also reduce the elastic work of breathing by decreasing static and dynamic hyperinflation.^[60,61] Bronchodilator therapy may allow patients with COPD to do exercise training at higher intensities or at higher anaerobic threshold, and therefore increases the likelihood of a substantial benefit in exercise performance.^[62,63]

Oxygen

Use of oxygen during rehabilitation has been shown to help an individual to undergo higher intensity of exercise training.^[64,65] Oxygen may be supplied continuously or on demand basis, according to the need of individual patient. Although the acute effect of oxygen administration on increasing exercise capacity has been demonstrated in the laboratory, studies showing the superiority of supplemental oxygen to room air use during exercise training in pulmonary rehabilitation have given mixed results.^[66-69] It remains to be determined whether supplemental oxygen will become an established option as an exercise enhancer for non-hypoxemic patients with COPD in the respiratory rehabilitation.

Other ancillary therapies

NIV, ventilation feedback, neuromuscular stimulation and helium-hyperoxia are some of the adjunctive therapies.^[70-73]

CONCLUSION

Effective pulmonary rehabilitation incorporates exercise schedules and patient education comprehensively to encompass treatment and other aspects needed to make any individual patient recover gradually from the deterioration of the condition and to remain in a fully functional state as far as possible. Looking at the increasing burden of COPD patients in developing countries, there is an urgent need of advocacy of pulmonary rehabilitation in complete management of this disease. The evidence-based approach, applied in a practical manner, suitable to individual, community or geographic region will definitely help to reduce morbidity associated with chronic respiratory diseases like COPD.

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