Review Article

Pulmonary Rehabilitation in Resource Poor Settings

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ABSTRACT

Pulmonary rehabilitation is an important component in the management of chronic obstructive pulmonary disease (COPD) and other chronic respiratory diseases. The goal of rehabilitation is to evaluate various systems, treat optimally, improve dyspnoea and health-related quality of life. It is a multi-disciplinary approach and involves a physician, a psychiatrist, a dietician and a physiotherapist. However, in a resource-poor setting, even an experienced physician alone may suffice. Exercise training is the backbone of pulmonary rehabilitation, which may be hospital-based or home-based. Though, the previous trials have shown benefit with hospital-based rehabilitation, several recent studies have demonstrated significant improvement in the 6-minute walk test and quality of life even with unsupervised, home-based pulmonary rehabilitation. In the resource-poor settings, the goal of rehabilitation may be achieved by incorporating regular unsupervised exercise in daily routine. This is not only better accepted and more suitable but is also more feasible for the lifelong maintenance of rehabilitation. **[Indian J Chest Dis Allied Sci 2011;53:163-172]**

Key words: Pulmonary rehabilitation, Resource poor setting, COPD.

INTRODUCTION

Pulmonary rehabilitation is an important component in the management of chronic obstructive pulmonary disease (COPD) and other chronic respiratory diseases where symptoms and disability persist despite optimal medical management. As per American Thoracic Society (ATS) and European Respiratory Society (ERS) pulmonary rehabilitation is defined 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 individualised treatment of the patient, pulmonary rehabilitation is designed to reduce symptoms, optimise functional status, increase participation, and reduce health care costs through stabilising or reversing systemic manifestations of the disease." [1] Though, pulmonary rehabilitation includes measures given in table 1, pulmonary rehabilitation programmes usually involve exercise training, education, nutritional intervention, and psycho-social support.

As per 2001 Census, 72% Indian population resides in rural areas. The prevalence of tobacco use and COPD is higher in the rural as compared to urban areas.[2] However, the facilities of rehabilitation are usually available at the tertiary care centres which are located in the district or the state headquarters or the teaching hospitals. The cost of rehabilitation is also very high about ₹1,00,000.[3] This leads to poor availability and adherence to pulmonary rehabilitation where it is required the most. For pulmonary rehabilitation to reach the resource-poor settings, it is essential that low cost model is endorsed and encouraged.

Table 1. Management of advanced chronic respiratory diseases

Optimising medical therapy including
Pharmacotherapy
Improving oxygenation by home oxygen therapy
Non-invasive ventilation
Preventive therapy
Smoking cessation
Prevention of infections
Assessment and treatment of associated disorders like CAD, osteoporosis, and SDB
Assessment and treatment of complications like pulmonary hypertension/cor-pulmonale
Nutritional assessment and intervention
Psychosocial and behavioural intervention
Physical rehabilitation
Exercise training programme
Breathing exercises and chest physiotherapy

CAD=Coronary artery disease; SDB=Sleep disordered breathing

[Received: March 14, 2011; accepted: April 6, 2011]

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GOALS OF REHABILITATION

The goals of rehabilitation are preserving optimal lung function, improving function in daily living and quality of life (QOL) and preventing symptoms and recurrence of exacerbations (Table 2). In a broader sense, pulmonary rehabilitation includes a spectrum of intervention strategies integrated into the life-long management of the patients with chronic respiratory disease and involves a dynamic, active collaboration among the patient, family, and health-care providers.[4]

Table 2. Goals of rehabilitation

Preserving optimal lung function
Improving function in daily living
Improving quality of life
Reducing symptoms
Preventing recurrent exacerbations

In severe COPD, there are negative effects on a number of other systems, magnifying the functional impairment. The sensation of breathlessness can provoke anxiety,[5,6] and peripheral muscle weakness can further contribute to exercise limitation. In resource-poor settings due to pre-existing poor nutrition and the peripheral muscle deconditioning the impact on functional impairment is worse. A case illustration explaining the impact of this vicious circle is given below.

A 65-year-old man was admitted in an infective exacerbation of COPD. On admission, oxygen saturation on pulse oximetry was 80 percent. He was treated with nebulisation, antibiotic, systemic steroid and low flow oxygen. The saturation improved to 93% on room air after five days. He was being considered for rehabilitation. However, the patient had difficulty in walking due to severe muscle wasting (Figure 1). On enquiry it was learnt that the patient had not moved from the bed for the past one year due to anxiety related to dyspnoea. The body mass (BMI) index was only 11kg/m^2. The vicious circle of breathlessness, anxiety and mal-nutrition had made the patient bed-ridden compounding to the morbidity related to the disease. If he had been counselled about rehabilitation early in the course of the disease he would have probably not developed such a severe wasting.

The goal is to break these cycles of progressive impairment by focusing on the affected systems and their interaction with breathing. Specific breathing techniques can reduce the work of breathing and can be applied in the times of anxiety or stress, when inefficient breathing patterns appear.[7,8] The peripheral muscle conditioning improves exercise tolerance.[9] Attention to nutrition is essential, and the patients must be educated in this regard.[10] Comprehensive programmes examine and intervene in all of these areas and can increase the exercise endurance, reduce the breathlessness, and improve the QOL for treated patients. It is essential to tailor rehabilitation programme to make it affordable while including all the aspects of rehabilitation.[1]

Figure 1. Clinical photograph showing extreme muscle wasting (sarcopaenia).

ADVANTAGES OF REHABILITATION

Rehabilitation improves the exercise tolerance, reduces the sensation of dyspnoea, and improves the health-related quality of life (HRQOL) (grade of recommendation, 1A).[11-21] It also improves peripheral muscle strength and mass and reduces the number of days spent in the hospital (grade of recommendation, 2B).[22-25] The programmes are overall cost-effective (grade of recommendation, 2C).[25-27] Rehabilitation also leads to improvement in the ability to perform routine activities and reduction in the rates of exacerbations (grade of recommendation, 1B),[26-28] anxiety and depression (grade of recommendation, 2C).[29-31] The advantages are summarised in table 3 and grades of recommendation are given in table 4. There is insufficient evidence to determine whether pulmonary rehabilitation improves the survival in patients with COPD.

Table 3. Advantages of rehabilitation

Improves exercise tolerance
Reduces the sensation of dyspnoea
Improves health related quality of life
Improves peripheral muscle strength and mass
Reduces number of days spent in hospital
Low cost benefit ratio
Improves ability to perform routine activities
Reduction in rates of exacerbations
Reduces anxiety and depression

TIMING OF PULMONARY REHABILITATION

The timing of pulmonary rehabilitation depends on the clinical status of the individual patient. It should not be a "last ditch" effort for patients with severe respiratory impairment. Rather, it should be an integral part of the clinical management of all patients with COPD, addressing their functional deficits.[1]

TEAM

Rehabilitation is a holistic and comprehensive approach to medical care, a combined expertise of an interdisciplinary team is recommended. The rehabilitation team includes a physician specialised in cardio-respiratory care, physical therapist, occupational therapist, respiratory therapist, social worker and psychologist.[1] However, an experienced physician can contribute significantly to most aspects of the management.[52]

Table 4. Grades of recommendation derived by benefits to risks and burdens based on strength of the supporting evidence[28]

Grade of recommendation, 1A	=	Strong recommendation; High strength of evidence, Benefit outweighs risk OR Risk outweighs benefit
Grade of recommendation, 1B	=	Strong recommendation; Moderate strength of evidence, Benefit outweighs risk OR Risk outweighs benefit
Grade of recommendation, 1C	=	Strong recommendation; Low strength of evidence, Benefit outweighs risk OR Risk outweighs benefit
Grade of recommendation, 2A	=	Weak recommendation; High strength of evidence, Evenly balanced benefit and risk
Grade of recommendation, 2B	=	Weak recommendation; Moderate strength of evidence, Evenly balanced benefit and risk
Grade of recommendation, 2C	=	Weak recommendation; Low strength of evidence, Evenly balanced benefit and risk OR uncertain risk *vs* benefit

DURATION OF REHABILITATION PROGRAMME

The minimum length of an effective programme is two months; the longer the programme continues the more effective are the results. Six to twelve weeks of pulmonary rehabilitation produces benefits in several outcomes that decline gradually over 12 to 18 months (grade of recommendation, 1A).[28, 32-34] Some of the benefits, such as HRQOL remain above the control levels at 12 to 18 months. Maintenance strategies following pulmonary rehabilitation have a modest effect on long-term outcomes (grade of recommendation, 2C).[28]

SETTING

Despite a substantial variability in programme structure, efficacy of pulmonary rehabilitation performed in in-patient, out-patient, or home settings has been documented. Home-based pulmonary rehabilitation is convenient for the patient and family members and may provide sustained motivation for continued exercise training.[35-39] A large of number of clinical trials have reported that home-based pulmonary rehabilitation is very effective.[19, 35-38, 40-50] Some of these trials have even shown that home-based exercises are as good as hospital-based training.[35,42,43] It is essential that the patient is adequately educated for a successful outcome of home-based rehabilitation programme. Self-management manual for COPD (SPACE: A Self-management Programme of Activity, Coping and Education) has also been developed to reduce the cost and improve the viability of the programme.[51]

ASSESSMENT FOR PULMONARY REHABILITATION

The clinical history, physical examination, spirometry, baseline saturation/arterial blood gas and timed 6-minute walk test (6MWT) are essential to determine the severity of airway disease. The 6MWT and baseline saturation can be easily evaluated with an affordable finger pulse oximeter.[52]

Other assessments that may be performed include assessment of performance of activities of daily living, health status, cognitive function, emotional and mood state, and nutritional status. Questionnaires may be used to screen for anxiety and depression. There are well-validated generic and specific QOL tools available. The two most widely used respiratory-specific HRQOL questionnaires are the Chronic Respiratory Disease Questionnaire (CRDQ) and the St. George's Respiratory Questionnaire (SGRQ).[16, 53-56] The questionnaires used for rehabilitation programme are lengthy and time consuming. A simple Airway Questionnaire (AQ 20) which is much less time consuming may be used; comparative studies have shown a good correlation of AQ 20 with the traditional questionnaire for the measurement of health status in COPD.[57]

ASSESSMENT OF ASSOCIATED DISORDERS

The nutritional assessment is important as COPD is often associated with sarcopaenia [45, 46] and osteoporosis.[58, 59] Loss of muscle mass or sarcopaenia due to inadequate dietary intake, increased resting energy expenditure, and poor appetite is a poor prognostic indicator and it compounds dyspnoea due to deconditioned state.[60] Sarcopaenia can be evaluated by calculating fat free mass index (FFMI)[61, 62] with the help of duel-energy x-ray absorptiometry (DXA) scan or bioelectrical impedance. The DXA is accurate whereas, bioelectrical impedance is cost effective.

Osteoporosis is due to low body weight, poor nutrition, smoking, chronic debility associated with lack of exercise and corticosteroid therapy. If not treated, it can lead to fractures which are responsible for significant morbidity due to pain, immobility and pulmonary embolism. The DXA scan is not only useful for measuring FFMI but it is also the most widely investigated tool for estimating fracture risk and is a gold standard for estimating the bone mineral density (BMD).[63] The World Health Organization (WHO) has defined osteoporosis based on the measurement of BMD.[64] In a resource-poor setting, quantitative ultrasono-graphy may be used to detect low BMD. Though, ultrasonography is not useful for diagnosing osteoporosis, it may help identify patients at high risk of fracture. Whether treating such patients reduces the risk of fracture has not been established, but given the limited access to DXA in some places, treatment strategies based on the quantitative ultrasonography would be an attractive option.[65]

Assessment of depression is usually performed by using Hamilton rating scale.[66] However, this is lengthy and time consuming. Instead simple scoring questionnaires like the Patient Health Questionnaires (PHQs) are available; PHQ-2 for evaluating depression and PHQ-3 for evaluating anxiety (Table 5). These allows simple and easy detection of depression and anxiety at primary care level.[67, 68] Diagnosis and treatment of associated problems like coronary artery disease (CAD), pulmonary hypertension/cor-pulmonale, and sleep disordered breathing, whenever feasible is also vital.

Table 5. Screening questionnaire for depression and anxiety[68]

Depression Screen (PHQ-2)
In the past month, have you been bothered a lot by:
Little interest or pleasure in doing things?
Feeling down, depressed, or hopeless?
Anxiety Screen (PHQ-3)
In the past month, have you been bothered a lot by:
"Nerves," or feeling anxious or on edge?
Worrying about a lot of different things?
During the last month:
Have you had an anxiety attack (suddenly feeling fear or panic)?

Note: Each point is further scored into 0, 1, 2, 3 depending on "Not at all", "Several days in a week", "More than half the day", "Every day in the week", respectively. Thus, PHQ-2 has a maximum score of 6 and PHQ-3 has a maximum score of 9.

MANAGEMENT OF MALNUTRITION

The individuals who are stable and whose nutritional status is normal require a caloric intake of 1.33 times the resting energy expenditure (REE) to maintain their body weight. In order to achieve the nutritional repletion due to COPD additional calorie intake of 50% of the REE is required. The distribution of calories among carbohydrates, protein and fat is also important. Based on the trials, it appears that protein supplementation of 1.2- 1.7 g/kg of body weight per day is associated with nitrogen retention and physiologic improvement.[69-72] It is also recommended that calories from protein or amino acids, carbohydrates and fat should be 15%, 50% and 35% of calories, respectively. Proteins, carbohydrates and fats yield 4Kcal/g, 4Kcal/g and 9kcal/g, respectively. High-fiber foods such as vegetables, cooked dried peas and beans (legumes), whole-grain foods, bran, cereals, pasta, rice and fresh fruit should be included in the meal. High-calorie food should be the first meal of the day. To prevent excessive consumption of oxygen patients should be asked to take six small meals each day instead of three large meals. They should consume foods that need little preparation, should eat slowly, and avoid gasforming foods. There is an insufficient evidence to support the routine use of nutritional supplementation in pulmonary rehabilitation of patients with COPD.[28] The basic dietary advice can be given by an experienced physician in a resource-poor setting.

MANAGEMENT OF OSTEOPOROSIS

The current evidence suggests that the total calcium intake of 1,000 to 1,500 mg per day is required for the treatment of osteoporosis. Calcium carbonate is the most efficient source of calcium and is the least expensive. Because calcium is absorbed well with food, it should be given with meals. Vitamin D intake must be adequate (400 IU daily) for the optimal absorption of calcium.[58] In addition, treatments with bisphosphonates, which restore BMD are indicated. The main bisphosphonates are etidronate, tiludronate, clodronate, pamidronate, alendronate, and risendronate. Oral alendronate is administered in a dose of 10mg daily or 70mg

once weekly; or 35mg twice weekly ensuring adequate fluids intake. The patient should be instructed not to recline for half an hour after ingestion of the dose to prevent oesophageal reflux. All the three treatment regimens have similar profiles of side effects and efficacy, but once weekly regimen has better tolerability and compliance. The treatment with bisphosphonate is given for a period of three years with yearly assessment of BMD. Calcitriol has also been evaluated but it is an inferior alternative to bisphosphonate for the treatment of osteoporosis.[58, 63]

PSYCHO-SOCIAL AND BEHAVIOURAL INTERVENTION

Anxiety, depression and inability to cope-up with chronic lung disease contribute to the handicap of advanced respiratory disease. Psycho-social and behavioural interventions in the form of regular patient education are very helpful. Instructions in progressive muscle relaxation, stress reduction, and panic control may help reduce dyspnoea and anxiety.[73-75] Selective serotonin re-uptake inhibitors (SSRIs), e.g. sertraline, are considered the first-line treatment for co-morbid depressive or anxiety disorders. These agents are associated with a relatively low incidence of anticholinergic and other side effects and minimum interactions with other drugs commonly used by the patients.[76] Support groups increase the social interaction and offer a chance to discuss disease-related medical, psychological, and social issues with the other patients. Because of the effects of chronic respiratory disease on the family, participation of family members or friends in pulmonary rehabilitation support groups is also important.[75]

There is minimal evidence to support the benefits of psycho-social interventions as a single therapeutic modality (grade of recommendation, 2C).[28] Although, no recommendation is provided, since scientific evidence is lacking, current practice and expert opinion support the inclusion of psycho-social interventions as a component of comprehensive pulmonary rehabilitation programmes for patients with COPD.

EDUCATION

Education should be an integral component of pulmonary rehabilitation. It should include information on collaborative self-management, and the prevention and treatment of exacerbations. Self-management interventions are required to educate the patient about complying with medication, prioritising daily activity, early treatment of exacerbation, regular vaccination, and keeping active lifestyle, healthy dietary and sleep habits. These interventions combined with pulmonary rehabilitation and exercise maintenance after completion of rehabilitation are important parts of COPD management.[77-79]

PHYSICAL REHABILITATION

Physical rehabilitation is the backbone of a successful rehabilitation programme. A programme of exercise training of the muscles of ambulation is recommended as a mandatory component of pulmonary rehabilitation for patients with COPD. Comprehensive physical rehabilitation programmes have three major components: exercise training, chest physical training and outcome assessment.[28]

Exercise Training

Exercise training does not alter the underlying respiratory impairment but increases the tolerance to dyspnoea and improves the other outcome measures. It can be divided into strength training and endurance training (Figure 2). The endurance tasks require repetitive actions over an extended period of time, e.g. walking, cycling, and swimming. Whereas, the strength tasks are explosive exercises over a short time period of time, e.g. sprinting, jumping and lifting weights. The endurance training is achieved by treadmill walking and bicycle ergometry while the strength training is obtained by machine weights, free weights, elastic resistance, and lifting the body against gravity.[28]

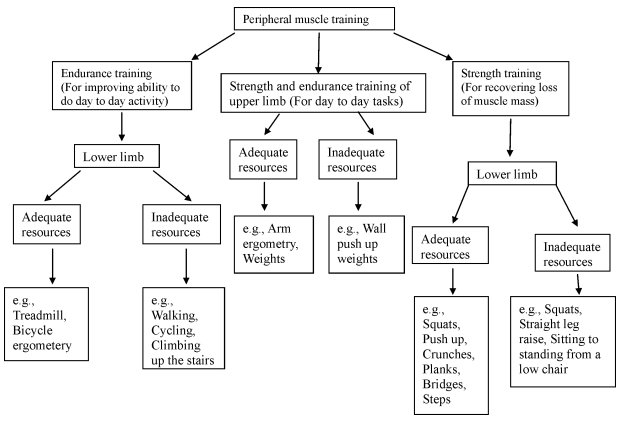

Figure 2. Exercise training options.

Though both endurance training and strength training improve muscle strength and mass (grade of recommendation, 1A), endurance training is the key component of pulmonary rehabilitation and is mainly achieved by lower extremity exercise training.[28,80] Optimally, the approach consists of relatively long exercise sessions at high levels of intensity (>60% maximal work rate) 2 to 5 times a week. The intensity of exercise is determined by cardiopulmonary exercise testing. The total effective training time should ideally exceed 30 minutes.[81-83] For some patients, it may be difficult to achieve this target training in time or intensity, even with close supervision. In this situation, interval training may be a reasonable alternative. An interval-training regimen consists of 2 to 3 minutes of high-intensity training (60% to 80% maximal exercise capacity) alternating with equal periods of rest.[84-86] Lower extremity exercise training at a higher exercise intensity produces a greater physiologic benefits than lower intensity training in patients with COPD (grade of recommendation, 1B).[28] Since the performance of many day-to-day activities involve use of the arms, endurance training of the upper extremities to improve arm functions is also important. Arm training alone is less effective than leg training,[86] however, when combined with leg training it shows a significant improvement in functional status[87,88] (grade of recommendation 1A). Supported arm exercises are prescribed with arm ergometry or unsupported arm exercises by lifting free weights or stretching armbands.[89]

In a resource-poor setting where cardio-pulmonary exercise test to determine maximal exercise capacity and treadmill or ergometry for the endurance and strength training of the muscle are not available, simple measures can be applied. In these settings, walking at greater than 90% of speed of 6MWT is used to achieve the desired target intensity.[41,44] Simple exercises like walking,[43] cycling[19] and climbing stairs[19,42,48] can be utilised for endurance training of muscle, whereas squats, straight leg raise and sitting to standing from a low chair[90] are useful for strength training. Wall push up and weights can be prescribed for upper limb strength and endurance training.[91] The role of these exercises at home without supervision has been proven in multiple trials.[36-38, 41-44, 46, 47, 50, 92] Thus, if the facilities for supervised exercise training programmes are not available, the physician should encourage the patient to be active and undergo unsupervised, slow incremental exercise guided by his ability to tolerate the exercise with the periods of rest if desired, increasing the intensity of the exercise slowly over a period of time. This allows the patient to incorporate exercise in his daily routine and is better accepted and is more suitable for a resource-poor setting. Table 6 shows outlines of rehabilitation that can be followed in resource-poor settings. The effects of training are maintained only as long as exercise is continued. Therefore, efforts at improving long-term adherence with exercise training at home are necessary for the long-term effectiveness of physical rehabilitation.[19, 93]

Table 6. Steps of pulmonary rehabilitation in resource-poor settings

Assess the patient with spirometry, saturation, 6MWT, weight/FFMI by biometric impedance, and bone density by sonography, AQ 20 and PHQ 2/3 questionnaire
Treatment of osteoporosis and dietary advice by the physician
Exercise training by the physician or a trained staff, or an assistant at the time of enrolment for 30 minutes
The exercise should simulate the patient's home environment
The endurance and strength training can be done by walking/cycling, walking uphill/climbing stairs and straight leg raise, respectively
The exercise should be guided by his ability to tolerate exercise and 6 MWT* with periods of rest if desired. The speed and distance should be increased gradually
The patient can be educated about breathing techniques by the physician/assistant
The patients should exercise twice in a day for 30 minutes for at least 5 to 6 days in a week
The patient may be given a diary to maintain
The patient may follow up once in a week or 15 days for reinforcement/increment/supervision of exercises

Note: This would reduce the burden on the paramedical staff and, would not require sophisticated exercise training equipment
6MWT=6 minute walk test; FFMI=Fat free mass index; AQ=Airway questionnaire; PHQ=Patient Health Questionnaire

Chest Physical Therapy

Breathing Exercises

The scientific evidence does not support the routine use of inspiratory muscle training as an essential component of pulmonary rehabilitation. Controlled breathing techniques and chest physical therapy are the two major components of the multi-disciplinary approach to the rehabilitation. The three major breathing techniques include the following:[94-97]

1. Pursed-lip breathing consists of slow exhalation for 4 to 6 seconds through pursed lips relieves dyspnoea by increasing expiratory airway pressure, thereby inhibiting dynamic expiratory airway collapse.
2. Shifting their breathing pattern from a rapid respiratory rate, which is under involuntary respiratory centre control, to a slower more controlled pattern also helps.
3. Diaphragmatic breathing. The patient is taught to employ only the diaphragm during inspiration by maximising abdominal protrusion during inspiration and during expiration, the patient may

contract the abdominal wall muscles to displace the diaphragm upwards.

Chest Physiotherapy

Chest physical therapy along with postural drainage enhances mucous clearance from central and peripheral lung airways. Standard chest physical therapy with postural drainage, cough, and the forced expiratory technique is the cornerstone of such treatment regimen.

OUTCOME ASSESSMENT

Outcome assessment is an important component of a comprehensive pulmonary rehabilitation for determining individual patient responses and for evaluating the overall effectiveness of the programme. Measurement of outcomes should be incorporated into every comprehensive pulmonary rehabilitation programme. Minimal requirements include assessment of the following measures of the patient's recovery both before and after rehabilitation: dyspnoea, exercise ability, health status and activity levels.[98] Improvement in 6MWT and HRQOL questionnaires (SGRQ/CRQ/AQ20) [55,57,64] integrates all these aspects of the assessment.

MAINTENANCE OF PULMONARY REHABILITATION

Pulmonary rehabilitation programmes have been shown to induce a short-term increase in the exercise tolerance; these improvements are not sustained.[95, 99] These programmes have demonstrated to produce benefits that last between 12 and 18 months after the intervention but then gradually disappear with time. A truly successful pulmonary rehabilitation programme entails implementing maintenance physical activity. Pulmonary rehabilitation should not stand alone; the best programme is that which can be maintained to translate into a continuous increase in the activities of daily living.[74] Changing patient beliefs and behaviours so as to enhance their willingness to maintain their exercise programme will help maintain QOL and exercise tolerance as well as reduce symptoms.[74] Findings suggest that participation in regular exercise such as walking after completing pulmonary rehabilitation is associated with slower declines in overall HRQOL and reduced progression of dyspnoea during daily activities.[100]

CONCLUSIONS

Pulmonary rehabilitation is a multi-disciplinary approach targeting primarily respiratory and musculo-skeletal system. It is a continuous process integrated into the lifestyle of an individual so as to enable him/her to achieve optimum functional capacity. Pulmonary rehabilitation programme can be exhaustive and may include physician/psychiatrist/physiotherapist and occupational therapist. However, the role of psycho-social and dietary intervention is not clearly established. Thus, it is essential to tailor the programme depending of the available facilities.

Exercise training is the backbone of pulmonary rehabilitation and lower limb endurance training is the key to exercise training. Exercise training can be achieved by supervised or unsupervised exercises. Though, the hospital-based, supervised exercises benefit the muscles optimally, home-based unsupervised exercises have also shown significant improvement in 6MWT. Moreover, the benefits of rehabilitation are lost after 12 to 18 months if regular exercises are not continued. Thus, prescription of simple, regular exercise incorporated into daily living along with adequate education about lifelong exercises would go a long way in permanently rehabilitating patients of COPD in resource-poor settings.

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