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Pulmonary rehabilitation for COPD

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Summary Pulmonary rehabilitation is a therapeutic process, which entails taking a holistic approach to the welfare of the patient with chronic respiratory illness—most commonly chronic obstructive pulmonary disease (COPD). Pulmonary rehabilitation is considered essential throughout the lifetime management of patients with symptomatic chronic respiratory disease. It requires the coordinated action of a multidisciplinary healthcare team in order to deliver an individualised rehabilitation programme to best effect—incorporating multiple modalities, such as advice on smoking cessation, exercise training and patient self-management education, among others. As core components of pulmonary rehabilitation, exercise training and self-management education have been shown to be beneficial in improving health-related quality of life (HRQoL) in patients with chronic respiratory disease. Physical training can help to reduce the muscle de-conditioning that occurs when the activity of patients is restricted by their breathlessness and fatigue, and is often associated with an increase in patient HRQoL. HRQoL can also be improved by the use of self-management education, which is designed to provide the patient with the skills to manage the health consequences of their disease. In doing so, patients are better able to cope with disease symptoms, potentially leading to reduced healthcare costs.

Abbreviations: COPD, chronic obstructive pulmonary disease; CRQ, chronic respiratory disease questionnaire; FIO_2, fraction of inhaled oxygen; HRQoL, health-related quality of life; PFSS, pulmonary function status scale; HRQoL, health-related quality of life; SGRQ, St. George's Respiratory Questionnaire; TDI, transitional dyspnoea index

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A great deal of research has been conducted to try and fully define which patients will benefit most from pulmonary rehabilitation. Although progress has been made, many questions remain as to the best means of delivering rehabilitation, particularly with respect to the optimum programme of physical training and patient self-management education.

Introduction

Pulmonary rehabilitation is a comprehensive, multidisciplinary intervention designed to reduce symptoms, and increase functional status and health-related quality of life (HRQoL) in patients with chronic respiratory conditions.[1–3] Pulmonary rehabilitation is now seen as integral to the life-long management of individuals with symptomatic chronic respiratory illness, rather than being reserved to manage only those with severe disease.[3] Pulmonary rehabilitation focuses on both the primary and secondary impairments associated with respiratory disease. Strategies include exercise training, self-management education, nutritional intervention and psychosocial support.[3,4]

Reduced physical activity occurs as a result of chronic breathlessness and fatigue. The subsequent deconditioning is aggravated by systemic effects such as peripheral muscle, cardiac, nutritional and psycho-social dysfunction. Suboptimal self-management strategies add to the burden of the disease. Not surprisingly, peripheral muscle dysfunction is a major cause of reduced function and participation in patients with chronic obstructive pulmonary disease (COPD), hence physical training is crucial in order to increase exercise capacity, functional status and associated quality of life (QoL).[3]

The goal of patient education is to improve clinical outcomes by teaching self-management skills, thus increasing self-efficacy and adherence. Traditionally, education has focused on supplying the patient with disease-specific information and appropriate technical skills.[5] More recently, however, patient self-management education—aimed at teaching patients disease-related problem solving skills—has been employed.[5]

For pulmonary rehabilitation programmes to be successful, they must be continuously tailored to the individual patient, and administered by a multidisciplinary team. Consequently, close coordination is necessary between all team members, including the patient, the family, the multidisciplinary team of health professionals, as well as the programme co-ordinator and the medical director.

Much research has been conducted to understand the multi-systemic effects of chronic respiratory disease, how a comprehensive pulmonary rehabilitation programme addresses the resultant functional limitations, which patients will benefit most from pulmonary rehabilitation, and how best to administer such programmes. Within this framework, we will discuss recent scientific advances in our understanding of the core components of pulmonary rehabilitation—physical training and patient education—and how they address the functional limitations seen in chronic respiratory diseases such as COPD.

How do we prescribe physical training in pulmonary rehabilitation for COPD?

Principles of physical training

Physical training is important, even in healthy individuals, because muscle deconditioning occurs naturally as a consequence of inactivity—muscle mass, and the expression of genes associated with muscle growth, are both rapidly (within 2 weeks) reduced with muscle immobilisation.[6] However, these changes are quickly reversed over 6 weeks of exercise rehabilitation, with changes in gene expression being detectable as early as 24 h after initiating exercise.[6] Because the aetiology of muscle deconditioning in otherwise healthy individuals is similar to that in COPD, it is reasonable to assume that physical training is capable of reversing this process in these patients.[7] Physical training is essential in order to address the disability (reductions in functional performance and QoL) that can arise from muscle deconditioning and peripheral muscle dysfunction—caused by physical inactivity (due to chronic breathlessness and fatigue) and the systemic effects of chronic respiratory disease (Fig. 1).[3] Other factors known to play a role in peripheral muscle dysfunction include poor nutrition and the effects of certain drugs (e.g. systemic corticosteroids[8]). It is important to note, that there is currently no direct relationship established between changes in exercise performance and health status.[9] Rather, improvements in health status with exercise training likely stem from indirect effects on improved

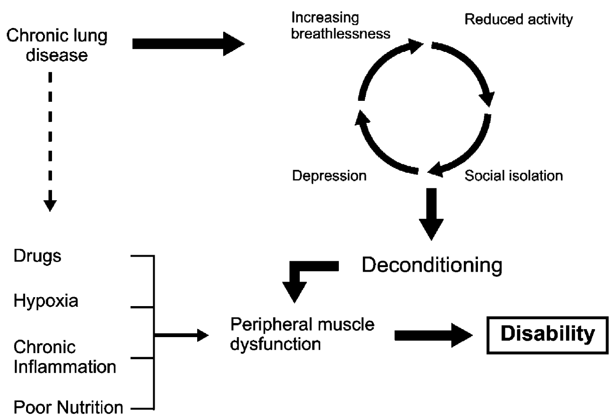

Figure 1 The relationship between chronic lung disease, muscle deconditioning and disability.[3]

self-efficacy, coping strategies or task-associated dyspnoea.

The benefits of exercise training in COPD are well established, and as part of a co-ordinated rehabilitation programme, have been shown to improve exercise tolerance and HRQoL.[2] Exercise training programmes should combine both endurance and resistance training (multi-gyms, free weights or isokinetic dynamometry),[10,11] and should be offered for at least three sessions per week[3]—at least two of which should be supervised. Recent data have explored the benefits of individualised,[12] reduced intensity[13] and interval training[14] and provided some indication as to the required duration of exercise.

Defining the optimum prescription of physical training

Individualisation

In 1997, Vallet et al.[12] published a study illustrating the importance of individualised training. In this study, patients with chronic airway limitation were assigned to 4 weeks of individualised ($n = 12$) or standardised ($n = 12$) stationary bike training. In the former, training was conducted at the individually measured gas exchange threshold (anaerobic threshold), and in the standardised group was conducted at 50% of calculated maximal heart rate reserve. Despite the fact that the target training level was similar between the two groups, there were greater physiological improvements (Fig. 2) in

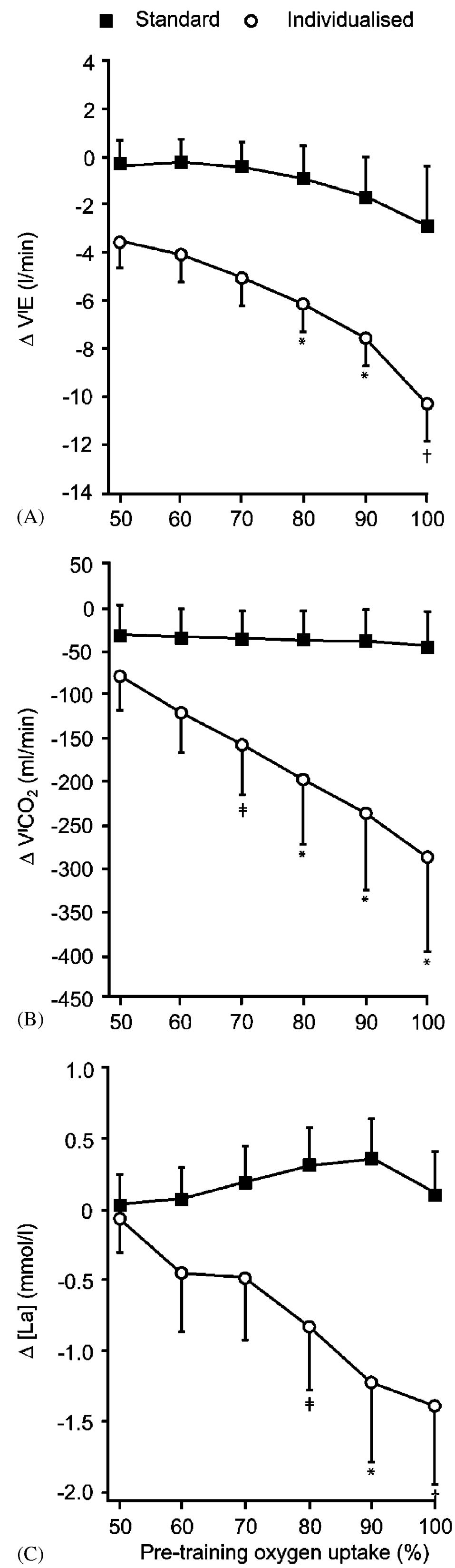

Figure 2 The effect of 4 weeks of standard or individualised training on change (±standard error mean) in (A) minute ventilation ($\Delta V'E$), (B) CO_2 output ($\Delta V'CO_2$) and (C) blood lactate concentration (Δ[La]), at different levels of pre-training symptom-limited oxygen uptake, in patients with COPD.[12]

the individualised group (increased submaximal cardiorespiratory responses with reduced ventilation and lactic acidosis), indicating that tailored training can provide greater benefits than standardised regimens.

Intensity

The benefits of training generally increase with intensity. Gains in exercise tolerance have been shown to be superior when high intensity targets are chosen.[13] However, there are still benefits to be gained at lower training intensities. A recent study authored by Normandin et al.[13] compared the effects of a high-intensity lower extremity endurance programme, with a low-intensity peripheral-muscle training programme placing emphasis on the upper extremities (calisthenics), in patients with COPD ($n = 20$ for both groups). Both programmes were conducted during two 30-min sessions, twice-weekly for 8 weeks. After completing the 8 weeks of training, patients undergoing either programme showed significant and equivalent improvements (Fig. 3) in questionnaire-rated dyspnoea (transitional dyspnoea index [TDI]), functional performance (pulmonary functional status scale [PFSS]) and health status (chronic respiratory disease questionnaire [CRQ]). Importantly therefore, in the short term, low-intensity exercise training provides similar benefits in questionnaire-based measures as more intensive training methods, and is more convenient for the patient.

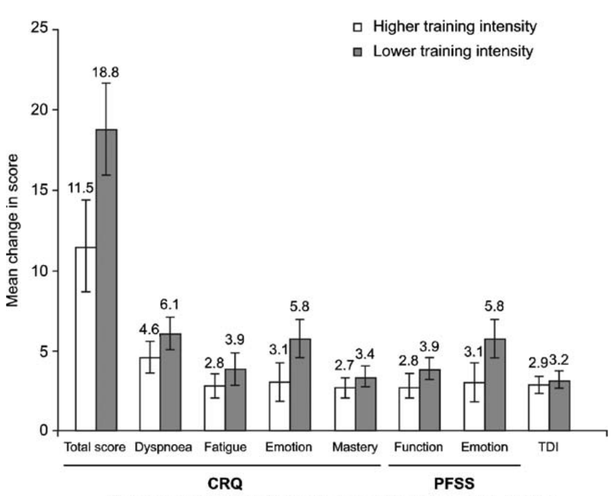

Figure 3 Change in chronic respiratory disease questionnaire (CRQ), pulmonary function status scale (PFSS) and transition dyspnoea index (TDI) scores from baseline to 8 weeks among patients undergoing high- or low-intensity physical training.[13]

Interval training

The use of interval training as opposed to continuous training is one strategy that can be used to increase exercise load. The benefits of the two strategies were compared in a study published by Vogiatzis et al. in 2002.[14] In this study, 36 patients with COPD were assigned to 40 min of cycling, twice-weekly for 12 weeks, either as 30-second intensive intervals (20 times with a 30-second rest interval) or continuously at 50% of baseline peak work rate.[14] Both groups showed similar adherence to the exercise programmes, and had similar improvements in exercise tolerance and QoL (CRQ). Importantly, the interval group had less dyspnoea (Borg scale) during exercise, despite intermittently exercising at twice the intensity (Fig. 4).

Duration

In 2000, Troosters et al.[15] published results from a study examining the benefits of extended training programme duration. The effects of an exercise programme (cycling, walking and strength training) were compared with usual care over a period of 18 months in patients with COPD ($n = 50$). At 6 months, those patients undergoing exercise training had statistically significant improvements in several outcome measures, including 6-min walking distance, maximal exercise performance, peripheral and respiratory muscle strength and QoL (as measured by the CRQ). Importantly, most of these changes were maintained throughout the 18-month programme.[15] Shorter periods of training can also produce substantial improvements in patient exercise performance.[16] In a randomised trial, Green

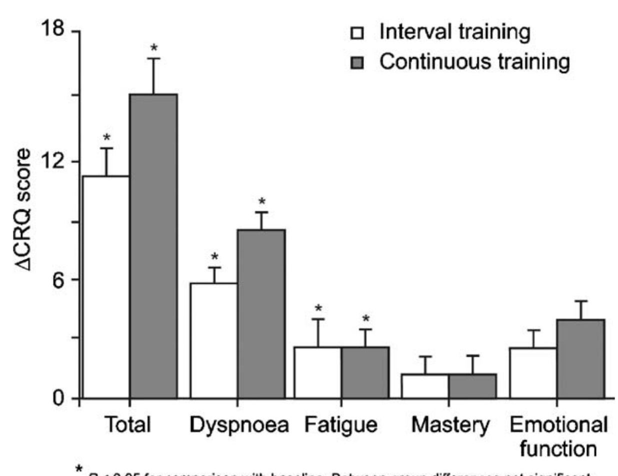

Figure 4 Change in chronic respiratory disease questionnaire (CRQ) scores from baseline to 12 weeks in patients with COPD undergoing interval or continuous training.[14]

and colleagues reported on a controlled trial of 4 weeks ($n = 23$) versus 7 weeks of pulmonary rehabilitation ($n = 221$). Although there were trends toward greater improvements in exercise tolerance in the incremental shuttle walk test and the treadmill endurance test in the group completing 7 weeks, the differences between groups did not reach statistical significance. Notably, the patients in the 7-week programme had significant improvements in the major outcome variables—CRQ total score as well as the domains of dyspnoea, emotion and mastery—that were greater than the patients in the 4-week programme.[16] It is clear, therefore, that even relatively brief (4-week) periods of training can provide beneficial effects, and furthermore, that these benefits may continue to increase after training has ceased.

Strategies for enhancing the effectiveness of pulmonary rehabilitation in COPD

Advances in our understanding of the pathophysiological basis underlying the airflow limitations, have allowed us to develop a number of strategies for improving exercise tolerance in COPD. While these can be used alone to improve exercise tolerance in COPD, they can also be adjunctive therapy to the exercise training of pulmonary rehabilitation. For example, optimal bronchodilation will allow patients to exercise at a greater intensity and duration before symptom limitation, thereby allowing patients to gain greater benefit from the training.

Supplemental oxygen

In patients with COPD, small increases in the fraction of inhaled oxygen (FIO_2) result in measurable improvements in exercise tolerance, which increase further up to an FIO_2 of about 50%, even in patients who are not hypoxaemic.[17] These changes likely result from a slower breathing pattern, which allows a greater length of time for exhalation, hence allowing reduced lung hyperinflation.[17] The benefits of increasing the FIO_2 could potentially be produced through three mechanisms—decreased carotid body stimulation, increased arterial oxygen content and increased pulmonary vasodilation. Recent data suggest that decreased carotid body stimulation may be an important target for intervention.[18] Other strategies such as the use of portable oxygen concentrators,[19] pharmacotherapies to stimulate haematopoiesis[20] and pharmacotherapies to induce pulmonary vasodilation[21] could be applied.

Bronchodilators

Both anticholinergics and β-agonists are modestly effective in improving exercise tolerance. This effect is enhanced when long-acting agents are taken regularly.[22,23] Bronchodilators also reduce the dynamic hyperinflation that occurs with faster respiratory rates. It remains to be seen whether combination therapy incorporating both types of long-acting agents is more effective than monotherapy in improving exercise tolerance in the long-term.

Surgery

Lung-volume-reduction surgery has been shown to improve exercise tolerance by improving lung mechanics and reducing hyperinflation.[24] Although lung transplantation normalises lung function and improves exercise tolerance, the latter is not normalised.[25] This observation highlights the importance of non-pulmonary factors in determining exercise tolerance in COPD. Pulmonary rehabilitation is indicated before and after surgical intervention.

The benefits of exercise training in pulmonary rehabilitation for diseases other than COPD

Asthma

Physical training is beneficial in patients with asthma[26] and, as in patients affected by COPD, there is a negative correlation between exercise capacity and disease severity. A study conducted by Cochrane and Clark[26] to determine the effects of a 3-month physical training programme, showed significant ($P > 0.05$) improvements in cardiorespiratory performance and reduced breathlessness in asthma subjects who underwent training ($n = 18$), compared with those who did not ($n = 18$). An important finding from this study was that continuous medical supervision of training was required to monitor the subject's asthma and to adjust treatment accordingly.[26]

Cystic fibrosis

The benefits of pulmonary rehabilitation are also evident in patients with cystic fibrosis. In a study published by Braggion et al. in 1989,[27] children with

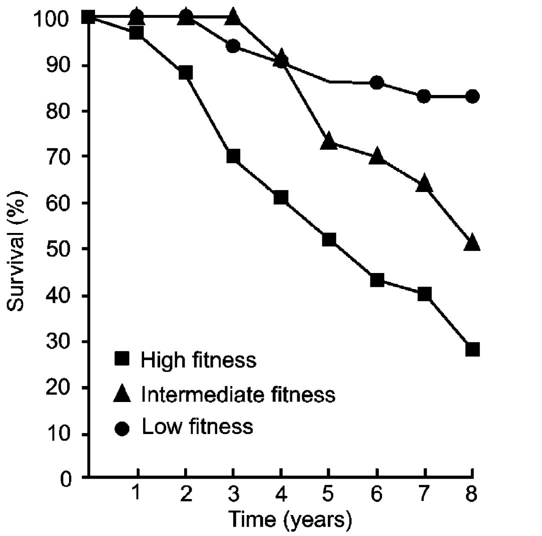

Figure 5 The relationship between survival and fitness (as measured by peak oxygen uptake [VO_{2peak}]) in patients with cystic fibrosis. High fitness defined as $VO_{2peak} \geqslant 85\%$ of predicted; intermediate, VO_{2peak} 59–81% of predicted; low, $VO_{2peak} \leqslant 58\%$ of predicted.[28]

cystic fibrosis and mild airway obstruction ($n = 10$) were shown to have significantly ($P < 0.05$) increased endurance following an 8-week aerobic training programme. These data are important, because previous studies have shown that aerobic fitness is a strong predictor of survival in patients with cystic fibrosis.[28] Indeed, 8-year survival is 28% in patients with a peak oxygen uptake ($VO_{2\text{-}peak}$)$\leqslant$58% of predicted, compared with 83% survival in patients with a $VO_{2peak} \geqslant 82\%$ of predicted (Fig. 5).[28]

Other forms of chronic respiratory disease

In an analysis of patients admitted to a 4-week inpatient comprehensive pulmonary rehabilitation programme, Foster et al.[29] showed that the benefits of pulmonary rehabilitation are comparable between COPD patients and those with other forms of chronic respiratory disease. In fact, patients with a range of different chronic respiratory illnesses (e.g. pulmonary fibrosis and neuromuscular disease) all showed improvements in ambulatory measurements following pulmonary rehabilitation. These findings are supported by those of Congleton et al.[30] who examined the outcome from a 6-week outpatient pulmonary rehabilitation programme in patients with COPD ($n = 15$), interstitial pulmonary fibrosis ($n = 6$) and chest wall disease ($n = 8$). All the patients showed an improvement in physical functioning and also in HRQoL, as measured using the Short Form-36 measure.[31]

There is certainly an emerging interest in, and evidence supporting the use of, pulmonary rehabilitation in many patients with chronic respiratory diseases who would not have formerly been considered to be suitable candidates for rehabilitation.[32]

The role of patient self-management education

Principles of patient education

As we have already stated, patient education is an important, if not essential, component for the care of patients with COPD.[33] Traditionally, patient education has focused on providing the patient with disease-specific information and appropriate technical skills.[5] In contrast to traditional education, patient self-management education teaches problem-solving skills designed to help patients identify problems associated with their disease, and overcome them by designing 'action plans' in partnership with their health care provider.[5] The objective of self-management education, therefore, is to improve the patient's self-efficacy, and confidence in their ability to make life-improving changes, with the ultimate aim of achieving a better clinical outcome.

Several strategies could conceivably be used to improve patient self-efficacy. These include addressing any deficits in skills that are required by the patient, encouraging the patient to enlist the support of others in practising new skills, and providing positive and constructive feedback on the patient's experiences. In addition, sharing the successes of others with the patient, reviewing progress regularly, and discussing the means to cope with potential threats to therapeutic adherence, are all potential means of improving self-efficacy.

Defining the benefits of self-management education

The most recent evidence for the benefits of self-management education comes from two randomised clinical trials, published by Monninkhof et al. and Bourbeau et al. both in 2003.[34,35] These were well-designed prospective trials comparing patients receiving usual care with patients enlisted to comprehensive skill-orientated self-management programmes. At 1 year of follow-up, the trial

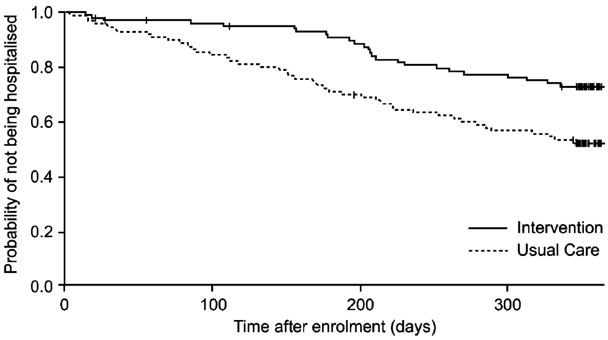

Figure 6 Kaplan–Meier curves showing the probability of not being admitted to hospital during 12 months follow-up of patients with COPD treated with self-management education or usual care for a 2-month period.[35]

reported by Bourbeau et al.[35] showed that, among patients undergoing self-management education ($n = 95$), there were overall reductions in the number of unscheduled hospital visits (Fig. 6), including reduced admissions for exacerbations (39.8%; $P = 0.01$) and reduced admissions for other health problems (57.1%; $P = 0.01$). Furthermore, self-management education was associated with fewer emergency department (41.0%; $P = 0.02$) and unscheduled physician visits (58.9%; $P = 0.03$). Health status, as measured by the St. George Respiratory Questionnaire (SGRQ),[36] was improved with self-management education, but only at 4 months. In contrast, the results of Monninkhof et al. failed to show positive effects—patient-reported exacerbations actually increased with self-management education, and there was no improvement in QoL (SGRQ). Monninkhof et al. concluded that self-management education is not an efficient or cost-effective treatment modality. This conclusion, in addition to contradicting the findings of Bourbeau et al., is also contrary to another 1-year randomised trial conducted in Norway. In the Norwegian trial, self-management education improved outcomes and reduced costs in patients with COPD—for every Norwegian Krone (NOK) spent on education, there was a saving of 4.8 NOK.[37]

The reasons for these apparent discrepancies could be due to the fact that, in the Monninkhof trial, the patients were stabilised at baseline, having already completed a 4-month inhaled corticosteroid substudy. Also, these patients were highly motivated (having agreed to participate in the two trials over 3 years) but compared with the patients in the Bourbeau trial were younger, less well-educated, had less severe functional impairment, had fewer exacerbations in the year preceding the trial and had better SGRQ scores at baseline. Prompted by these conflicting results, and anecdotal reports of patient satisfaction in the self-management arm, a qualitative follow-up was conducted in a subgroup of 20 patients who participated in the Monninkhof trial.[38] During interviews, these 20 patients expressed very favourable experiences regarding self-management, including increased energy levels, emotional well-being, self-confidence, coping skills and autonomy. Taken together, these results suggest that the SGRQ and other such measures may not sufficiently capture the benefits associated with self-management education programmes, in patients with COPD.

Unanswered questions

While there are positive data regarding the usefulness of patient self-management education, questions remain as to precisely how much patient benefit is afforded by this strategy, how to identify which patients will benefit the most and whether or not the economic costs justify the clinical benefits. In addition, it will be important to determine which aspects of self-management are critical for cost-effective success, and which self-management strategies result in long-term maintenance of positive behaviour. These considerations accepted, providing patients with the tools they need to properly manage a chronic condition such as COPD, should be seen as an important part of pulmonary rehabilitation.[33]

Conclusions

A great deal of research has been carried out in order to define the best application of pulmonary rehabilitation. While recent research has yielded some useful insights into the potential benefits associated with the use of rehabilitation in patients with chronic respiratory disease, more work is required to fully define the best use of the core components: exercise training and patient self-management training. By refining the training methods used, patients will be able to exercise at greater intensities than might be expected, and thereby gain greater benefit from their training. Establishing the optimum duration of the exercise programme will be an important research objective in the future.

Patient self-management education holds much promise for increasing the ability of patients to come to terms with their disease and cope with the consequences of it more effectively. Importantly, there is some evidence to suggest that this modality cannot only improve the well-being of patients, but can also reduce health care expenditure. Once again, further research will be required to establish definitively how beneficial self-management is for the patient with COPD, which patients will benefit most, and the impact of cost implications.

Recent data have underlined the importance of pulmonary rehabilitation in the management of COPD, and firmly place this concept at the centre of efforts to manage patients throughout the course of their disease.

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