

Rehabilitation of COPD patients: which training modality

E. Clini, S. Costi, M. Romagnoli, F. Florini

ABSTRACT: *Rehabilitation of COPD patients: which training modality. E. Clini, S. Costi, M. Romagnoli, F. Florini.*

Non pharmacological therapy has been gaining more interest and has been evolving rapidly over the last decade as an essential part of therapy for COPD patients. Pulmonary Rehabilitation (PR), the most important non pharmacological treatment in patients with COPD, has a primary goal: to achieve the highest possible level of individual exercise tolerance, thus reducing the primary and/or secondary health care utilisation. The aim of the present review is to focus the role of exercise training in these patients as well as to address the question on which training methods are the most beneficial. We have therefore undertaken a MEDLINE-based search including the terms: *pulmonary rehabilitation, exercise, lung disease/obstructive*.

Several strategies based on endurance or strength training are nowadays implemented during PR programmes in order to maximise the benefits for each patient. The impaired function of ambulation muscles causing breathlessness as one of the more frequent symptoms in many COPD, suggests that training the lower extremities is the most important goal to achieve during pulmonary rehabilitation of these patients. On the other hand, as muscle strength appears to be an independent contributor to survival and utilisation of health care resources, it seems largely justified also to include this further modality in the PR program of these patients.

In conclusion, both modalities are effective and useful for COPD patients. However, whether resistance training should be administered to all COPD and which is the optimal length of strength training still needs to be elucidated. *Monaldi Arch Chest Dis 2004; 61: 3, 167-173.*

Keywords: *Exercise, strength, endurance, rehabilitation.*

Fondazione Villa Pineta and University of Modena-Reggio Emilia. Dpt. of Pulmonary Rehabilitation. Pavullo (MO).

Correspondence: Enrico Clini; Fondazione Villa Pineta; Division of Pneumology & Pulmonary Rehabilitation; Via Gaiato 127, 41020 Pavullo n/F (MO), Italy; e-mail: eclini@qubisoft.it

Introduction

In recent years evidence-based guidelines on the risk factors, pathogenesis, diagnosis and treatment of patients with Chronic Obstructive Pulmonary Disease (COPD) have been developed [1]. Pharmacological therapy involves a substantial part of resources in the long-term management of these patients [2], which increases according to the severity of the disease [3] and especially during exacerbations [4].

Non pharmacological treatment has been gaining more interest and has been evolving rapidly over the past decade as an essential part of therapy for COPD patients. They have a role both in the early and advanced stages of COPD. Moreover, most of these therapeutic options appear to be associated with improved quality of life and are cost-effective [5].

Pulmonary Rehabilitation (PR) is the most important amongst non pharmacological treatments for COPD patients. The aim of the present review is to focus on the role of exercise training as the most important part of the rehabilitation process for these patients, as well as to address the question on which training methods are the most beneficial. So far, training the lower extremities during PR has been recognised as the only effective activity according to scientific evidence [6].

Methods

This review is based on an evaluation of the literature using a multimethod approach. This approach consisted of both a computerised MEDLINE search from 1966 through June 2004 using the following terms: *pulmonary rehabilitation, exercise, lung disease/obstructive*. Moreover, a further search on the most relevant review articles has been performed. Finally, consensus statements and recommendations synthesised into general guidelines were also examined.

Therefore, this review is based mainly upon data obtained from the major and relevant articles, reviews and guidelines throughout the considered research period.

Pulmonary rehabilitation: programs and efficacy

Pulmonary Rehabilitation (PR) is a multidisciplinary intervention with high level of scientific evidence aiming to reduce disability and to improve patient's participation [7]. Indeed, PR covers a range of non-pulmonary problems that may not be adequately addressed by medical therapy in chronic respiratory diseases such COPD: these problems include exercise de-conditioning, relative social isolation, altered mood states (espe-

cially depression), muscle wasting, and weight loss. The components of PR may vary widely from programme to program. However, a comprehensive PR program might include exercise training, nutrition counselling, and education sessions.

Baseline and outcome assessments of each participant in a PR program should be made to quantify individual gains and target areas for improvement. Assessments should include: detailed measurements of respiratory function and muscle strength (either peripheral and respiratory), exercise capacity, breathlessness, impact of disease by means of specific (e.g. St. George's Respiratory Questionnaire) [8] or generic (e.g. Medical Outcomes Study Short Form-SF36) [9] questionnaires. The last three assessments should also be recorded at the end of the PR program.

PR has been carefully evaluated in a large number of clinical trials; the various benefits (improving exercise capacity and quality of life and/or reducing symptoms) were summarised in a very recent systematic review [10]. It has been shown that exercise capacity is an independent factor positively influencing hospital re-admission in COPD [11]. Although PR *per se* has not been demonstrated to improve patients' survival, patients who can benefit the most from PR have shown the best survival over time [12].

COPD and disability

One of the elements in the vicious circle which develops in patients with COPD is progressive limitation in activity due to the progression of airway obstruction. Lack of exercise leads to physical deconditioning which in turn decreases exercise capacity.

It is commonly found that COPD patients feel better after PR: they improve their exercise tolerance not as a result of improvement in lung function but simply because they improve their ability to perform exercise. Psychological as well as physiological changes are the basis for this improvement.

For many years the focus on the factors limiting exercise tolerance in respiratory patients has been considered the pulmonary defects leading to the ventilatory limitation to exercise. Many patients with COPD exhibit hyperinflation, the result of a combination of decreased lung elastic recoil and expiratory flow limitation. The problem of hyperinflation is particularly acute during exercise, when the combination of ventilatory limitation and increased breathing frequency leads to a progressive increase in dynamic hyperinflation that rapidly curtails the patient's ability to exercise [13]. During incremental exercise tests a large proportion of COPD patients experience decrease in inspiratory capacity (IC) [14]. However, patients alter their activity levels because of their perception of breathlessness (dyspnoea). Clinical studies have suggested that there is a strong relationship between the degree of hyperinflation and the severity of exercise-induced dyspnoea. Re-

cently, it has been found that a strong correlation exists between the dynamic increase in IC and the degree of exertional dyspnoea as assessed by the Borg scale during a 6 minute walking distance [15]. This suggests that the reduction in exercise capacity observed in patients with COPD may be a function of hyperinflation, but mediated *via* an increase in exertional dyspnoea. So far, Wegner et al. [16] has provided a numerical analysis of the interaction between several measures of lung function, exercise capacity and clinical ratings of symptoms: they used a principal component analysis to aggregate these outcomes into 3 independent factors (lung function, exercise capacity and clinical ratings), which together could explain 79% of the total variance. The fact that these 3 factors are independent demonstrates that measures of lung function cannot be used to reliably predict exercise capacity or dyspnoea. Indeed, COPD is a systemic disease with many extrapulmonary effects. The impact of a given degree of lung function impairment is highly dependent upon secondary physiological factors (muscle wasting, malnutrition, hormonal changes, depression and/or social isolation) [13].

In particular, recent studies have proved the possible role played by the dysfunction of the skeletal muscles of the limbs of COPD patients. Several pathophysiological changes have been documented as evidence of skeletal muscle dysfunction in these patients: low lactic acidosis threshold, more rapid fall in intramuscular pH, reduction in muscles aerobic enzymes and in oxygen uptake kinetics, reduction in muscle mass [17]. Despite this, the relative importance of each mechanism still remains to be defined. These findings, taken as a whole, suggest that function of the ambulation muscles is abnormal in many COPD patients and that this dysfunction may be a contributor to exercise intolerance, as well.

The degree of physical activity also has a distinct influence on survival. So far, it has been shown that a 2 year-survival of COPD patients undergoing long-term oxygen therapy was higher (70%) among those who had a normal activity score as compared with the one (20%) of those who were confined to bed [18]. More interestingly, Gerardi et al. [19] studied the predictors of mortality (up to 3-years) in 158 patients with severe COPD following a comprehensive PR program: they found that both high PaCO₂, and low 12-minute walking distance, FEV₁, PaO₂, BMI and score on the CRD questionnaire were all associated with mortality. However, a low 12-minute walking distance was the only significant predictor of mortality (both total or due to a respiratory cause) in a stepwise regression and multifactorial analysis. Even if it is difficult to determine which specific components of the rehabilitation program were responsible for the better survival, there is no doubt that improvement in physical performance in these patients plays an important role (at least) in improving their quality of life. Therefore, exercise training is a crucial part of any rehabilitation program.

Training and rehabilitation

As a matter of fact, enhancing physical performance is the most important therapeutic goal of PR in patients with COPD.

Patient's general physical activity can be measured by ergometry (either bicycle or treadmill to assess the lower limb, and arm ergometer to assess the upper limb performances) with the measurement of a large number of physiological variables (i.e. oxygen uptake, heart rate, or work rate) [20]. Submaximal intensity and duration are the modalities of choice to assess the patient's ability to exercise [7, 21]. A less complex approach is to use a self-paced, timed walking test (6-minute walking distance) [22] or the modified incremental walking test (namely, a Shuttle test) [23].

Despite the fact that it is not possible to predict the patient's exercise capacity from the baseline evaluation of lung function when in a stable condition, recent data suggests that the baseline level of exercise performance and arterial oxygenation appears the most consistent correlating with the change in walking ability in COPD patients recovering from an acute exacerbation [24].

COPD patients at all stages of disease appear to benefit from exercise training programs, improving with respect to both exercise tolerance and symptoms of dyspnea and fatigue [25]. Data suggests that these benefits can remain over the end of the program [26, 27], particularly if the patient could maintain exercise activity at his/her home [28]. To date, there is no consensus on whether repeated rehabilitation courses enable patients to sustain (or improve) the benefits gained throughout the initial course.

Training modality

Training of peripheral muscles can be applied as endurance training or strength training. Endurance training involves a larger muscle mass working at moderate intensity for a longer period of time; strength training, on the other hand, involves a smaller muscle mass working at high intensity for a short period of time. Both types of training might significantly improve the patient's exercise performance, symptoms and the perceived quality of life [21].

Due to the impaired function of the ambulation muscles causing breathlessness as the more frequent symptom in many COPD patients [29], training the lower extremities appears to be the most important goal to achieve during pulmonary rehabilitation of these patients. Nonetheless, lower extremities training is the only "scientific evidence A" based component of comprehensive PR programs [6].

However, most of the COPD patients, due to the systemic effect of their muscles dysfunction, also experience an important loss of the upper limbs functions which fairly correlates with reduction of patient's participation to daily living activities involving arms. Therefore, training upper limbs, might also be important in limiting the process of

patient's deconditioning [30]. Upper limbs may be specifically trained using arm ergometer and adopting modality similar to those used to train the lower muscle limbs. Several upper extremity training programs were performed in COPD: in a randomised control study significant improvements were observed only in specific upper limbs performance tests, but this result did not translate into a significant improvement in tests simulating activities of daily living [31].

Finally, due to their compromise of the respiratory muscles contributing to dyspnea, exercise limitation and hypercapnia [32, 33], COPD patients might also benefit from training these group of muscles. Positive results have been shown applying not only inspiratory [34] but also expiratory muscle training [35] to the most compromised COPD patients. No data is available on which method of respiratory muscle training should be practiced (resistance loading, threshold loading, maximal inspiratory manouevres, or a combination of both); however, this training modality is not widely recommended in all patients undergoing comprehensive PR programs [21].

Exercise training sessions range in frequency and duration. The optimal length of the PR program should be no less than 10-12 sessions (with different distribution within consecutive weeks); nevertheless, the longer the program, the higher the gains obtained [10]. Table 1 resumes the main characteristics of different exercise training, duration of sessions and length of the programs.

As a matter of fact, the question is not whether exercise should be provided to patients, but which kind of training modality is the most beneficial.

Endurance training

Endurance training is performed by progressively increasing intensity (up to 70-90% of the baseline achieved workload, mostly targeted by means of the percentage of the maximal heart rate or the percentage of the maximal oxygen uptake) and duration (up to 20-45 consecutive minutes, and repeated 3-5 times per week) of exercise delivered on a ergometry (cycloergometry or treadmill for the lower limbs and arm ergometry for the upper limbs) [21].

Endurance is the ability to sustain physical activity over time. This goal appears essential for tasks with which COPD patients frequently struggle such as walking, housework or climbing stairs. A recent survey in the UK confirmed the importance of these activities to patients: respondents also identified walking as the activity they would most like to regain [36]. A common thought is that the physical benefits of training are restricted to the mode of exercise employed. Therefore, endurance appears as the most appropriate means of improving the ability to sustain exercise. Indeed, this allows patients to adopt a more active lifestyle, not depending on old age, and linking this result with other health outcomes (i.e. reduced risk of subsequent hospitalisation) [11] in COPD.

Table 1. - Training modality: sites, types, intensity, duration of sessions and length of the programs

Sites	Type	Intensity	Duration of the session	Length of the program
Lower limbs	<i>Endurance</i>	• 70-90% of the max HR or VO ₂	• 20-45 minutes	• 3-5 times/week up to 8 weeks
	<i>Strength</i>	• 50-80% fraction of max weight lifted	• 8-10 repetitions up to 3 series	• 3 times/week up to 8 weeks
Upper limbs	<i>Endurance</i>	• 70-90% of the max HR or VO ₂	• 20-45 minutes	• 3-5 times/week up to 8 week
	<i>Strength</i>	• 50-80% fraction of max weight lifted	• 8-10 repetitions up to 3 series	• 3 times/week up to 8 weeks
		• Specific ADL (washing, dressing, ironing, etc.)	• ????	• ????
Respiratory muscles	<i>Strength</i>	• 15 to 60% of MIP or MEP	• 1 hour	• 3-6 times/week up to 3 months

Legenda: HR= Heart Rate; VO₂= Oxygen Uptake; ADL= Activity of Daily Living; MIP= Maximal Inspiratory Pressure; MEP= Maximal Expiratory Pressure.

Overall, there is more scientific evidence to support endurance training than other modalities. Despite PR programs adopting a wide variety of training regimes, a recent systematic review including up to 1000 COPD underlined that around 90% of treated patients received endurance (aerobic) training [10]. Strength training has also been shown to be as effective as endurance modality [37, 38], however the number of patients included in these studies was small. Moreover, the addition of strength to endurance training does not systematically confer an additional improvement in the whole body exercise performance or in the perceived health-related quality of life [38, 39]. Finally, the benefits of endurance training programs may extend over one year [27, 40], while those obtained by strength activities are no longer documented.

In debating the pros and cons of endurance versus strength training one may really compare different things. As a matter of fact the evidence that endurance training may improve exercise performance and health status in COPD patients is convincing. On the other hand, given the high prevalence of peripheral muscle dysfunction in COPD patients, strength training *per se* also might benefit these patients. However, convincing demonstrations on the positive effect of the latter training are less evident.

Strength (resistance) training

Strength training is performed by applying additional weights to lower and upper limb movement. By varying the additional load (lifting weights that represent a 50-80% fraction of the maximal weight that can be lifted just once by a trained muscle) or the number of repetitions (three series of 8-10 repetitions for three times a week), the muscle adaptation in strength or endurance can

be modified [21]. Weight training can be done lifting free weights, or on “multigym” systems.

Two major points may appear determinant to encourage the use of strength (resistance) training in COPD patients undergoing PR. Firstly, COPD is now considered not only a disease of the respiratory system but also a more complex disease with a systemic impact, peripheral muscle weakness becoming a hallmark of the systemic impact of the disease [41]. Secondly, quadriceps force has been identified as a contributor to survival [42] and utilisation of health care resources [43] in these patients.

Moreover, it is also important to recognise that one major principle for successful training is the “overload principle”, so that muscular adaptations will only appear if the muscle is sufficiently stressed [44].

In healthy subjects muscular stress is obtained when exercise is delivered at individual 70% VO₂ peak [45]. Aerobic exercise capacity is often limited by ventilatory limitations in COPD patients. The inability to increase pulmonary ventilation above a level dictated by the lung function impairment results in a premature termination of exercise: however, it has been shown that at peak exercise significant metabolic reserve is still present in COPD patients [46]. Therefore, when large amounts of peripheral muscles are stressed, each individual muscle may be operating at an intensity far from its potential maximum [46]. This evidence suggests that training programs in COPD patients should be adjusted to allow sufficient muscular stress.

This option can be reached following two different strategies: 1) by increasing the peak ventilatory capacity (i.e. by giving optimal bronchodilation, reducing the work of breathing or supporting ventilation by means of supplying oxygen or non-invasive mechanical ventilation) [47, 48, 49, 50];

2) by reducing the amount of work performed (i.e. by training small muscle groups on a resistance basis, thus resulting in significant effects also with a modest number of repetitions) [37].

Resistance training is a very specific therapy for muscle weakness and it can restore muscle strength in COPD patients [39]. Besides the well documented effect mainly based on the improved muscle oxidative capacity [51], strength training might result, especially in the older patients, in additional benefits like improved bone mineral density [52], prevention in fall [53] and in whole body endurance [54].

Despite this, the combination of resistance and endurance training is the more common adopted feature to train COPD patients, strength training *per se* may produce overall improvements similar to those obtained with endurance training alone [37, 38].

Conclusions

Pulmonary Rehabilitation is widely considered as the most important non pharmacological treatment for COPD patients. Charges of PR mainly depend on program complexity and on the number of health professionals [55] involved. In recent years, it has been claimed that charges might enter in a more sophisticated cost-benefit analysis. A RCT from the UK provided evidence that an intensive (6-week, 18-visit) multidisciplinary rehabilitation program was effective in decreasing use of health services [56]. Indeed, the rehabilitation group had more primary-care consultations at the general practitioner's than the control group, but fewer primary-care home visits. As a matter of fact, a better management of this disease may positively impact on costs related to hospitalisation and drug usage under exacerbation [57]. In particular, improving the patient's exercise tolerance is the most important goal to achieve with this treatment, thus reducing the primary and/or the secondary health care utilisation.

Training should always be proposed to COPD patients irrespective of their age or functional status. Despite the fact that only training the lower limbs has the maximal level of scientific evidence, several data also shows that training the upper limbs or the respiratory muscles might result in specific benefits to these patients.

Several strategies based on endurance or strength training are nowadays implemented in order to maximise the patient's benefits [58, 59]. In COPD patients combination programs resulted in significant improvements of the overall skeletal muscle performance [37, 38]: however, strength training seems not to confer additional benefit to the whole body exercise capacity.

Nonetheless, the impaired function of the ambulation muscles causing breathlessness as the more frequent symptom in many COPD, suggests that training the lower extremities is the most important goal to achieve during PR of these patients. On the other hand, as muscle strength appears to be an independent contributor to survival and util-

isation of health care resources [42], it seems largely justified also to include this modality in the PR program of these patients.

In COPD, rather than arguing the primacy of one method over another, the most important goal should be to tailor the patient's training to meet his/her specific performance deficits. Therefore, not only endurance but also strength training, given the high prevalence of muscle weakness in COPD patients, should be implemented.

However, some more questions deserve further studies. In particular, could we administer resistance training to all COPD? Is the optimal length of resistance training similar to that usually performed for endurance training? To date, literature is still inconclusive regarding these aspects. Trying to interpret the evidence, we could conclude that resistance training can be used as a strategy in those patients with a severe ventilatory limitation; this approach to strengthen the skeletal muscles may serve as an additional modality to further improve the benefits of a PR program.

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Pavia - Università, Aula Magna