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ORIGINAL ARTICLES

Pulmonary Rehabilitation for Chronic Lung Diseases

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Abstract

Chronic Obstructive Pulmonary Disease (COPD) is now the main cause of disability in the developed world. The advance of COPD is related to increasing breathlessness, disability and periodic hospitalizations. An aging population in the developed world and increasing cigarette consumption in developing countries expand the global impact of this condition. The disorder associated with COPD leads to a decrease in physical activity and failure of functional independence.

*The aim o*f this study was to evaluate the effects of PR in patients with normal exercise capacity on health-related quality of life and exercise capacity.

The mean FEV1/FVC was 59.4± 14.1%, and the mean FEV1 was 64.8± 23.0% as expected. Most topics had mild to moderate COPD. The P_{Imax} and P_{Emax} were normal. These subjects had no previous participation in home-based or hospital-based PR. All the subjects had normal maximal V˙O2 and work rate before PR.

After PR there were still considerable improvements in maximal V˙O2 (mean increase of 101.3 mL/min, $p < 0.001$) and work rate (mean increase of 8.2 watts, $p<0.001$). Ventilation, heart rate, and mean blood pressure were constant following PR. The maximum oxygen pulse at maximum exercise was significantly increased with PR ($p<0.02$). The SpO2 and end-tidal PCO2 at peak exercise did not significantly improve after PR.

Although dyspnea scores at rest were low and did not improve significantly with PR, dyspnea at end-exercise was significantly improved after PR ($p=0.01$). PR should be the responsibility of the clinical management of patients with COPD, even for those with normal exercise capacity. However, the benefits of disease progression, hospitalization, and survival for these patients remain unknown.

The main role in the management of any chronic disease, including lung disease, is to improve the quality of life (QL) in patients.

Conclusion; Although strongly recommended by scientific societies pulmonary rehabilitation programs still need to be more widely implemented. PR programs have shown a high level of evidence of benefits in chronic respiratory patients, particularly those with COPD.

Keywords: pulmonary rehabilitation; COPD; exercise capacity, lung diseases

Introduction

COPD is now the main cause of disorder in the developed world. The advance of COPD is associated with increasing breathlessness, disability, and periodic hospitalizations. An aging population in the developed world and the increase in cigarette consumption in developing countries compound the universal impact of this condition [1, 2].

The disability associated with COPD leads to a reduction in physical activity and loss of functional independence. The disability may not develop in COPD

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until there has been an irreversible loss of lung function. Treatment concentrated on regressive airflow obstruction is frequently ineffective and therapeutic strategies are better aimed at decreasing symptoms and reducing disability. Pulmonary rehabilitation has been demonstrated to reduce disability in COPD [3, 4]. Pulmonary rehabilitation intends to improve symptoms, disability, and handicaps in patients with COPD and significantly improve whole functional independence.

Evidence of benefit for pulmonary rehabilitation was secured. Randomized controlled trials have repeatedly shown increased exercise performance and improved health outcomes [5, 6].

Recent NICE guidelines for COPD management emphasize the importance of pulmonary rehabilitation as part of an integrated multidisciplinary approach. At the same time, it is recognized that the delivery of pulmonary rehabilitation services in the UK and other developed countries is poor and currently serves only a minority of people with disabling lung disease. The general rule is that pulmonary rehabilitation programmers should be designed around individual needs [4]. This is usually limited to individual prescriptions for exercise training intensity and usually includes brisk walking or static cycling [7, 8].

A natural extension of this principle is that highly individualized training directed at the individual's expressed functional goals improves pulmonary rehabilitation outcomes. More specifically, it can be hypothesized that goal-directed exercise in pulmonary rehabilitation improves measures of daily activities and domestic functioning [9, 10].

The need to assess individualized pulmonary rehabilitation was emphasized in the GOLD guidelines. However, no studies have been conducted on pulmonary rehabilitation in individuals. Assessing domestic functions and daily activities is an emerging science.

A self-report scale of domestic functioning was developed for use with COPD patients and is known as the Functional Status Scale. These consist of a planned list of daily tasks that patients are asked to use to assess their current level of functioning. Less attention has been paid to the use of individualized measures of functional status in pulmonary rehabilitation. Individualized measurements allow patients to assess only those daily activities that they consider relevant. The aim of this study was to investigate the effects of PR on health-related quality of life and exercise performance in patients with normal exercise capacity.

Material and Methods;

Subject Selection

Forty-five subjects with COPD and normal exercise capacity were engaged in our outpatient clinic, from August 2020 to March 2022. They met the following inclusion criteria: a diagnosis of COPD based on the GOLD staging of the disease10; normal exercise capacity with maximal oxygen uptake (VO2) of 85% by incremental cardiopulmonary exercise test; stability from exacerbations with no worsening of respiratory symptoms (i.e., dyspnea, chest tightness, and cough); no increase in the use of rescue medication; no unscheduled visits due to COPD worsening for at least 3 months 13; and capacity to mobilize individually.

The exclusion criteria were the use of oral corticosteroids; history of other lung diseases, including pneumoconiosis, bronchiectasis, pulmonary tuberculosis, primary pulmonary hypertension, pulmonary embolism, interstitial lung disease; and orthopedic, neurologic, or cardiovascular impairment that might deliver the subject unable of completing the exercise training.

Measurements

Physiologic parameters were charged by spirometry, respiratory muscle strength testing (maximal inspiratory pressure [P_{Imax}] and maximal expiratory pressure [P_{Emax}]), and cardiopulmonary exercise test before and after PR. The HRQL and dyspnea symptoms were assessed by the St George's Respiratory Questionnaire (SGRQ) [14] and dyspnea scores.

Pulmonary Function Test

Pulmonary function tests for measurement of FEV1 and FVC were generated by spirometry), following the standards of the American Thoracic Society and European Respiratory Society. The best flow-volume loop was applied in the final data analysis. Knudson made reference equations for FEV1 and FVC based on the normal populations available.

Respiratory Muscle Strength

The P_{Imax} and P_{Emax} were estimated using a standard mouthpiece and a direct dial pressure gauge.

P_{Imax} was measured at residual volume, and P_{Emax} at total lung capacity, according to procedures already described. The P_{Imax} and P_{Emax} were measured several times, and after 4 or 5 attempts, a plateau of values then showed relatively little variability (±10% of reading). The highest values for P_{Imax} and P_{Emax} were registered.

Pulmonary Rehabilitation

All subjects participated in a 12-week, 2-session per week, outpatient-based PR program. In each session, formal education, including breathing retraining, correct use of medications, and self-management skills, was given independently. After the education, the exercise training with lower limb cycle ergometer exercise was practiced. Exercise demonstrations were 40 min, and exercise intensity targets were set at high intensity, with 75–100% of the maximal VO2 observed in the pre-PR incremental exercise test. Sessions were nearly monitored by a rehabilitation therapist.

We monitored work rate, SpO2, heart rate, dyspnea scores, and leg fatigue during every exercise training session. During the period of PR, these subjects were not allowed to perform the exercise by themselves at home.

Results

The clinical characteristics and lung function of these subjects with COPD are shown in Table 1.

The mean FEV1/FVC was 59.4± 14.1%, and the mean FEV1 was 64.8± 23.0% as predicted. Most subjects had mild to moderate COPD. The P_{Imax} and P_{Emax} were normal. These subjects had no previous participation in home-based or hospital-based PR.

VARIABLES	VALUES
Age, yrs.	69 ±9.8
BMI	24.2±4.9
COP Dstage n, (%)	
I mild	11 (22.7)
II moderate	24 (54.0)
III severe	10 (23.3)
IVvery severe	0
P_{Imax}, cm H2o	67.2±24.4
P_{Imax}, % of predicted	72.5±23.7
P_{Emax}, cm H2o	107.3±29.2
Treatment	
Theophylline	34 (75.0)
Inhaled long-acting muscarinic antagonists	26 (57.0)
Inhaled long-acting b antagonist + corticosteroid	20 (44.0)
Oral corticosteroid	0

Table 1- Baseline characteristics of patients with COPD and normal exercise capacity

Changes in HRQL with Pulmonary Rehabilitation

Table 2 shows the SGRQ scores, total symptoms, activity and impact before, and after PR.

There were significant improvements in all domains of SGRQ (all p<0.001). The mean changes of scores of all domains were more than 4 units, which was associated with clinical importance.

Changes in Lung Function and Respiratory Muscle Strength with Pulmonary Rehabilitation

There were no significant changes in pulmonary function test results (FEV1, FVC, and FEV1/FVC) after 12 weeks of PR. However, respiratory muscle strength (P_{Imax} and P_{Emax}) was significantly improved (p<0.05).

Changes of Exercise Capacity, Cardiorespiratory Function and Dyspnea with Pulmonary Rehabilitation

All the subjects who participated had normal maximal V˙O2 and work rate before PR. After PR there were still important improvements in maximal V˙O2 (mean increase of 101.3 mL/min, p <0.001) and work rate (mean increase of 8.2 watts, p<0.001). Patients with COPD are frequently less active in daily life than healthy older adults [13, 14].

In addition, inactivity is related to poor functional status and a higher risk of hospital admissions and mortality [15, 16]. It appears clear that COPD patients would be more physically and socially active after PR.

Despite there is currently no strong evidence that patients translate the benefits achieved from PR into a more active lifestyle in real life. Ventilation, heart rate, and mean blood pressure were constant following PR. The maximum oxygen pulse at maximum exercise was extremely increased with PR (p<0.02).

Variables	Before Pulmonary Rehabilitation	After Pulmonary Rehabilitation	Mean Difference	P
FEV_1/FVC, %	59.4 ± 14.1	61.5 ± 15.0	2.1	.34
FEV_1, L	1.29 ± 0.47	1.33 ± 0.46	0.04	.46
FEV_1, % predicted	64.8 ± 23.0	66.7 ± 22.3	2.0	.42
FVC, L	2.24 ± 0.79	2.21 ± 0.66	—0.03	.75
FVC, % predicted	88.3 ± 34.5	87.7 ± 32.0	—0.6	.87
P_{Imax}, cm H_2O	68.1 ± 25.7	75.9 ± 24.0	7.8	.02
P_{Imax}, % of predicted	73.6 ± 25.6	82.5 ± 22.2	8.9	.02
P_{Emax}, cm H_2O	109.4 ± 30.5	121.4 ± 37.3	12.0	.03
P_{Emax}, % of predicted SGRQ scores	65.2 ± 20.7	71.5 ± 20.4	6.3	.04
Total	39.8 ± 16.3	28.6 ± 16.0	—12.4	< .001
Symptoms	47.8 ± 23.9	35.5 ± 25.9	—7.8	.03
Activity	50.6 ± 18.7	42.8 ± 18.2	—12.5	< .001
Impact	31.2 ± 20.1	18.7 ± 15.3	—11.1	< .001
Values mean ± SD; PImax = Maximum Inspiratory Pressure; PEmax = Maximum Expiratory Pressure; SGRQ = St George's Respiratory Questionnaire				

Table 2 - Effects of Pulmonary Rehabilitation on Pulmonary Function Tests, Respiratory Muscle Strength, and Health Related Quality of Life

The SpO2 and end-tidal PCO2 at peak exercise did not significantly affect after PR. Albeit dyspnea scores at rest were low and did not change significantly with PR, dyspnea at end-exercise was significantly improved after PR (p=0.01). Lately published the first meta-analysis was recently published examining the effect of exercise training on measures of physical activity. This meta-analysis pointed out that supervised exercise training confers a significant but small effect on physical activity. The principal limitation of the meta-analysis was that the majority of the evolved studies did not use the same method to measure physical activity; furthermore, it is well known that questionnaires and pedometers are an inadequately sensitive means of detecting changes in physical activity in this particular clinical (slow walking) population [17, 18].

When the authors concluded only those studies that practiced a multisensory accelerometer to measure physical activity, they reached improvements that are more significant in physical activity [19]. Accelerometers or activity monitors are small devices carried on the arm, leg, or waist that measure energy expenditure, movement pattern, and body position over a period of time (24 hours to 7 days) and maintain objective measurements of daily life activity Two parameters appear to be essential to enhancing physical activity in COPD patients after PR: the frequency of supervised exercise training and the duration of the program. Surely, in the meta-analysis [20], the studies that proposed an exercise-training regimen of three times per week demonstrated a significant increase in physical activity, in contrast with those that offered exercise only two times a week.

Also, in a study measuring physical activity with an accelerometer, it was shown that a 6-month, supervised exercise training program was demanded to obtain a significant effect on physical activity, while three months was shown to be insufficient. This is constant with the recent concept that 6 months are needed for most people to change their behavior [21]. The recording of unplanned daily physical activity provides a new dimension in the patient assessment that goes beyond any measurement of physiological capacity. Daily activity and the completion of domestic tasks are more important for the patient than an improvement in the 6-minute walk test, total CRQ score, or maximal load accomplished during ergo spirometry. Thus, clinicians should take into account what people actually do (e.g., walking, climbing stairs, dressing, etc.), rather than what they are able of doing since it is the natural level of physical activity that seems to best complete the prognostic benefit [22].

Conclusion

Although strongly recommended by scientific societies pulmonary rehabilitation programs still need to be more widely implemented. PR programs have shown a high level of evidence of benefits in chronic respiratory patients, particularly those with COPD.

Personalized pulmonary rehabilitation programs should be considered for COPD patients of all stages, who have respiratory symptoms and/or who have an intolerance to physical effort although optimal pharmacological treatment. PR has certainly been shown to provide beneficial effects on dyspnea, improvement in muscle strength and endurance, improvement of psychological status, reduction of hospital admissions, and improvement of HRQoL in COPD patients, with a gradual increase in daily physical activity and autonomy.

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

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Abbreviation; *COPD - Chronic Obstructive Pulmonary Disease; NICE - National Institute for Health and Clinical Excellence; PR - Pulmonary Rehabilitation;* VO_2 *- Maximal Oxygen Uptake;* P_{Imax} *- Maximum Inspiratory Pressure*

P_{Emax} *- Maximum Expiratory Pressure; SGRQ - St George's Respiratory Questionnaire;* FEV_1 *- Forced Expiratory Volume in 1 s; FVC - Forced Vital Capacity*; *HRQOL - Health-Related Quality of Life*

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