Benefits of a 7-week outpatient pulmonary rehabilitation program in COPD patients

Alina Croitoru¹, Diana Ioniţă², Carmen Stroescu¹, Irina Pele¹, Daniela Gologanu¹, Andreea Dumitrescu¹, Lucia Marinescu¹, Dana Anghelieșcu¹, Miron Alexandru Bogdan¹

Abstract

Background: Respiratory rehabilitation programs (RR) are essential tools in the management of COPD. Aim: We present the results of a 7-week outpatient rehabilitation program in terms of dyspnea, exercise tolerance and quality of life.

Material and method: The following parameters were evaluated before and after RR: dyspnea (mMRC scale), pulmonary function (FEV₁, RV - residual volume), exercise tolerance (6MWT - 6 minutes walk test, CPET - cardiopulmonary exercise test), quality of life (SGRQ questionnaire). The RR program was outpatient, hospital based (7 weeks, 3 sessions/week) and included: exercise training, therapeutic education, and psychological support.

Results: 25 patients, COPD stage II-IV GOLD (mean FEV₁ 44.5 ± 13% predicted), mean age 60.4 ± 12 years, 7 females, average BMI 27.14±4 kg/m², average RV residual volume 221.55±86% predicted. Mean 6MWT distance: 407.48 ± 84 m and mean maximum power (Pmax) obtained on CPET: 75.67±30 Watts. All patients were symptomatic with significant dyspnea (3.06±0.7 on mMRC scale) and showed a significant impairment of quality of life: SGRQ score 46.23±14.

At the end of RR program: dyspnea decreased with 0.67 points on mMRC scale (p = 0.000), 6MWT distance increased with 58.5 m (p = 0.001), Pmax obtained during CPET increased with 11.2 W, without reaching statistical significance (p>0.05). SGRQ score decreased by 5.59 points (p = 0.02). There were no significant improvements in FEV₁ and RV values (p>0.05).

Conclusion: In our COPD patients, the 7 week outpatient rehabilitation program was effective, leading to improvement of symptoms, exercise tolerance and quality of life.

Keywords: COPD, rehabilitation, exercise tolerance

Rezumat

Beneficiile unui program ambulatoriu de 7 săptămâni de reabilitare respiratorie la pacienţii cu BPOC.

Scop: Prezentăm rezultatele unui program ambulatoriu, de 7 săptămâni, de reabilitare respiratorie, asupra dispneei, toleranţei la efort şi calităţii vieţii.

Material şi metode: Parametrile urmărite, înainte şi după RR, au fost: dispnea (scala mMRC), funcţia pulmonară (VEMS, VR volum residual), toleranţa la efort (TM6M - Test de mers 6 minute, CPET - test de efort standardizat cardio-respirator), calitatea vieţii (chestionar SGRQ). Programul de RR s-a desfăşurat în regim ambulator (7 săptămâni, 3 şedinţe/ săptămână) şi a cuprins: reantrenament la efort, educaţie terapeutică, consiliere psihologică.

Rezultate: 25 de pacienţi, BPOC std. II-IV GOLD (VEMS mediu 44.5±13% din prezis); vârsta medie: 60,4±12 ani; 7 femei; IMC mediu 27,14±4 kg/m²; VR mediu 221,55±86% din prezis. Distanţa medie la TM6M: 407,48±84 m şi puterea maximă (Pmax) obţinută la testul de efort 75,67±30 Watts în medie. Toti pacienţii erau simptomatice cu dispnee semnificativă (3,06±0,7 pe scala mMRC) şi prezentau o afectare importantă a calităţii vieţii: scor SGRQ 46,23±14.

La finalul programului de RR am constatat: scăderea dispneei cu 0.67 puncte pe scala mMRC (p=0.000), creșterea distanței la TM6M cu 58.5 m (p=0.001) şi a Pmax obținută în cursul CPET cu 11.2 W, fără a atinge semnificația statistică (p>0.05), scăderea SGRQ cu 5,59 puncte (p=0.02). Fără ameliorări semnificative ale valorilor VEWS şi VR (p>0.05).

Concluzie: La pacienţii noştri cu BPOC, programul de reabilitare în ambulator de 7 săptămâni s-a dovedit eficient, ducând la ameliorarea simptomelor, îmbunătăţirea toleranţei la efort şi a calităţii vieţii.

Cuvinte-cheie: BPOC, reabilitare, toleranţă la efort

Introduction

COPD patients have exertional dyspnea, which may lead to decreased physical activity and impaired quality of life.

The main factors involved in this vicious cycle of inactivity are: muscle dysfunction (peripheral and respiratory muscles), breathlessness, decreased exercise tolerance and physical deconditioning. Pulmonary rehabilitation (PR) aims to interrupt this circle through a series of specific measures (exercise training, physical therapy, therapeutic education), in order to give the patient a chance to a social reintegration.

Peripheral muscle impairment in COPD is characterized by atrophy, weakness and poor aerobic capacity and it is the main cause of reduced daily life activities. Skeletal muscle dysfunction in COPD is caused by several factors: patients have a reduced level of activity; because of exertional dyspnea, they will adopt a sedentary lifestyle; early occurrence of lactic acidosis during exercise; the presence of lactic acidosis generates additional CO₂, where elimination requires increased ventilation, causing exertional dyspnea; the number of capillaries surrounding each muscle is lower in COPD patients than in normal subjects; the peripheral muscles’ oxidative capacity is reduced by a decrease in proportion of type I fibers with high oxidative potential and increase of type 2 fiber;
• oxidative enzyme activity is also diminished. Therefore, muscle metabolism at rest and during exercise will be altered;
• the involvement of pro-inflammatory cytokines such as TNF can activate muscle proteolysis and result in a loss of muscle through a chronic inflammatory mechanism;
• malnutrition: BMI has a prognostic value in COPD. The causes are varied: hypercatabolism (systemic inflammation), reduced intake (dyspnea, anorexigenic effect of TNF), increased energy consumption, hormonal changes, depression;
• systemic corticosteroids, that induce peripheral myopathy;
Muscle impairment in COPD is reversible and is one of the main targets of respiratory rehabilitation. In most COPD patients, exercise training partially reverses the morphologic and structural abnormalities of peripheral muscle fibers.

These physiological benefits apply to all COPD patients, independently of the degree of disease severity, and are associated with improved exercise tolerance, functional capacity and quality of life.

Pulmonary rehabilitation is an evidence-based treatment developed by a multidisciplinary team, customized for the carrier of a chronic respiratory disease, who has reduced its daily activities. It is an individualized program based on the patient’s needs and on the impact of the disease on quality of life and symptoms.

The main components of rehabilitation programs are exercise training, physiotherapy, education, and psychosocial and nutritional support.

Exercise training is the cornerstone of respiratory rehabilitation, and the efficacy of which is expressed by the improvement in physical capacity, dyspnea, quality of life and need for medical care.

The effects of exercise training in skeletal muscle dysfunction include:
• improved peripheral muscle oxidative capacity. This response is characterized among other things by a reduction of lactic acidosis and hyperventilation for a given effort. The reduced hyperventilation will move the threshold of dyspnea to a much greater load of exercise.
• a normalization in the type I and IIa fibers;
• a decreased exercise-induced quadriceps fatigue.

The most recommended is aerobic endurance training, although there are studies that report similar effects of endurance and resistance training on peripheral muscle force, exercise capacity and health-related quality of life.

The tools that can be used are cycling, treadmill, stepping and walking. Training should involve all muscle groups and should not neglect the upper limbs and, in selected cases, the respiratory muscles. In order to be effective, the exercise must be adapted to each patient.

A meta-analysis concluded that the programs that used at least lower-extremity training did significantly improve walking test results and shortness of breath.

The intensity of training must be at least 60% of the maximal power obtained during cardiopulmonary exercise testing in order to be effective. According to Casaburi, the endurance training must be situated at high metabolic level in order to reduce the lactate production and ventilation at a given level of exercise.

Each candidate to a rehabilitation program must first receive an initial assessment of his/her pulmonary and physical abilities. The most frequently used tests to assess exercise tolerance are walking tests and CPET.

Respiratory rehabilitation is a therapeutic process continuously evolving and never completely. It consists of two distinct and complementary parts: the initial stage and maintaining the effects obtained.

The benefits of pulmonary rehabilitation have a level evidence (GOLD 2013) on exercise capacity, perceived intensity of breathlessness, health related quality of life, number of hospitalizations and days in the hospital, anxiety and depression.

The rehabilitation programs can be conducted inpatient, outpatient or home-based settings.

Materials and method

Subjects
The study was conducted in the Pulmonary Rehabilitation Center of “Marius Nasta” National Institute of Pulmonology, Bucharest, Romania.

All COPD patients were addressed to our rehabilitation center by their pulmonologists. The diagnostic was made accordingly to GOLD guidelines: symptoms and spirometric evidence of obstruction: FEV1/FVC ratio < 0.7. They were clinically stable (no exacerbation) in the last 3 months; all were on optimal medical therapy. Before the rehabilitation program was started, all patients signed an informed consent.

Parameters evaluated
All tests were performed before and after the 7-week rehabilitation program.

Lung function testing: FEV1 and residual volume (RV) were measured by using a Jaeger body plethysmograph, 15-30 minutes after inhalation of 400 mcg salbutamol. Three acceptable and repeatable tests were performed. The highest value for FEV1 and the average value for RV were reported.

Exercise capacity was assessed by the 6 minutes walking test (6MWT) and standardized cardiopulmonary exercise test (CPET).

6MWT is a constant load exercise test that measures the distance that a patient can quickly walk on a flat surface in a period of 6 minutes (6MWD). The parameters evaluated are SaO2, heart rate, dyspnea (Borg scale), distance traveled, number and cause of potential stops.

For 6MWT we used a 50 m corridor and the patients were instructed to walk as fast as possible, under the supervision of a healthcare professional. The tests were performed 2 times, 30 minutes apart, and the greatest distance traveled was chosen.

Cardiopulmonary exercise testing (CPET) is a fundamental examination in the initial assessment before rehabilitation. This test has several purposes:
• objective measurement of exercise capacity, as the maximal power and maximal oxygen uptake (VO2 max);
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- search for undiscovered pathologies associated with COPD;
- analysis of gas exchange and the need for oxygen;
- establishing the appropriate level of training 26,32.

This test, as opposed to 6MWT, is performed with an increasing load. The main information extracted from this test was the maximal power, which we used to model the training intensity.

**Dyspnea** during activities of daily living was assessed by the modified Medical Research Council (mMRC) dyspnea scale. The scores range from 0 to 4, 4 being the greatest level of breathlessness. The patients were asked to choose an appropriate level of their status.

**Quality of life** was assessed using the Romanian version of St George Respiratory Questionnaire (SGRQ). It has 50 items and 3 domains: symptoms, activity (disturbances in the patient’s daily physical activity) and impact (social functioning, psychological disturbances secondary to airway disease). Scores range from 0 to 100, with higher scores indicating more limitation7. The patients completed the questionnaire themselves. The 3 partial scores and the total score were calculated by introducing the answers in the SGRQ calculator (an Excel spreadsheet).

**Pulmonary rehabilitation program design:**

The pulmonary rehabilitation program took place in an outpatient setting, and consisted in 21 sessions (3 session/week) during approximately 7 weeks. It included peripheral muscle training (legs and arms muscles), physical therapy, education and psychological support.

**Training protocol:** for the lower extremities we performed endurance training. We used cycling on a cyclogermeter. The workload was established by using the maximal power obtained during the CPET. Thus, in the first session the power was 20 watts and was subsequently increased with 5-10 watts /week, in order to reach 60-80% of maximal power obtained at CPET. The patients learned in the first week under the supervision of a physiotherapist how to set up the load of the cycle, and in the following sessions they piloted themselves the program.

Every session included 20-30 minutes cycling, 15 minutes of arm muscles exercise, and 10 minutes of physiotherapy. Each session of cycling included a warm-up period and a resting period of recovery (5 minutes each, Figure 1). The vital signs (SaO₂, blood pressure, heart rate) were followed up for safety.

Training of upper limb musculature was not standardized. We used series of 10 repetitions with free weights or at a multifunctional device with elastic bands (Figure 2). The exercises were synchronized with the breathing cycle: expiration and inspiration.

**Physical therapy** consisted in breathing exercises (pursed lip breathing, abdominal breathing) and relaxation techniques.

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**Figure 1. Structure of a training session**

<table>
<thead>
<tr>
<th>Table I</th>
<th>Baseline characteristics of COPD patients</th>
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<tbody>
<tr>
<td>Patients characteristics</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>60.4 ± 12</td>
</tr>
<tr>
<td>Sex</td>
<td>7 females / 18 males</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>27.14 ± 4</td>
</tr>
<tr>
<td>FEV₁ (l)</td>
<td>1.27 ± 0.4</td>
</tr>
<tr>
<td>FEV₁ (% predicted)</td>
<td>44.50 ± 13</td>
</tr>
<tr>
<td>RV (% predicted)</td>
<td>221.55 ± 86</td>
</tr>
<tr>
<td>P max (watts)</td>
<td>75.67 ± 30</td>
</tr>
<tr>
<td>6MWD (m)</td>
<td>407.48 ± 84</td>
</tr>
<tr>
<td>Dyspnea (mMRC)</td>
<td>3.06 ± 0.7</td>
</tr>
<tr>
<td>SGRQ score</td>
<td>46.23 ± 14</td>
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Therapeutic education: The patients received explanations about the nature of the disease, of its causes, symptoms and management. They were taught how to properly manage medications, recognize exacerbations, and adapt their lifestyle to their illness.

Psychological support: a psychologist organized meeting groups (maximum 8 patients) once per week, discussing about the disease’s impact on the mental status and the ways to deal with stress, anxiety and depression.

Statistical analysis:
The values of the parameters of interest were compared before and after 7 weeks of rehabilitation program. Statistical analysis was performed using SPSS version 18.0. A p value <0.05 was considered significant.

Results
Initially, 34 patients with COPD were addressed to us and 29 were considered eligible for the program. The exclusion criteria were: the presence of unstable cardiac disease, poor adherence, the onset of an exacerbation, and difficult accessibility to the center.

29 patients started the rehabilitation program. During the program 4 patients withdrew from the study: one because of a COPD exacerbation, one because of home occurrence of a leg fracture due to osteoporosis and two quitted the program after the first sessions.

We report the results for the 25 patients who finished the program. The patients’ characteristics are presented in Table I. The distribution according to GOLD classification was: 8 patients in stage IV, 9 in stage III and 8 in stage II. The mean FEV1 value was 1.27±0.41 (44.5±13% predicted). Only two patients had BMI smaller than 20 kg/m². At baseline, 6MWT distance significantly correlated with SGRQ score (p=0.01) and mMRC dyspnea score (p=0.03).

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Lung function tests
Although we noticed a slight increase in FEV1 values after rehabilitation (from 1.27 to 1.34 l), it did not reach statistical significance. The thoracic hyperinflation, present in 20 cases, has a non-significant change: residual volume decreased from 221.55±86% to 197.08±78% (Table II).

Exercise tolerance
Following the training period there was a significant increase in 6MWT distance, from 407.48±84 to 466.05±88 m (p=0.001). The difference of 58.5 m is greater than the clinically significant distance of 54 m found in a previous study on 112 patients44. Maximal power obtained during CPET increased by 11.21 watts but it failed to reach statistical signification (p=0.6).

Dyspnea
We noticed a statistically significant decrease of mMRC dyspnea score: from 3.06 to 2.39 (p=0.000). Pulmonary rehabilitation clearly improved this symptom.

Quality of life
When the SGRQ results were analyzed (Table III), we found that SGRQ total score significantly decreased by 5.59 points (p=0.02), which is above the clinically signifi-
Looking at the 3 components of SGRQ, we noticed that the greatest improvement was in the symptoms (-6.1 points) and in the impact domain (-6.94 points).

**Discussion**

This study shows that a 7-week outpatient, hospital based rehabilitation program including muscular training, education and psychological support can bring benefits to COPD patients. Its efficacy is expressed by significant improvement of exercise tolerance, dyspnea and quality of life, without significant changes in functional status.

We noticed the fact that improvement in shortness of breath was reflected by decreases in both mMRC scores and the symptoms domain of SGRQ scores. The decrease in perception of dyspnea may be related to physiological changes, such as a lower level of lactic acidosis and reduced ventilatory requirements, but also to other factors where rehabilitation may play a role, such as mood and lifestyle.

The improvement in exercise tolerance and dyspnea was not accompanied by significant changes in FEV1 and thoracic hyperinflation. That may be related to the fact that rehabilitation intervenes on other outcomes of COPD patients, as muscle dysfunction, reduced physical activities, depression.

Other measures can be used to act on respiratory function, such as lung volume reduction surgery (LVRS), bronchodilators. However, the functional status is not the main selection criterion for pulmonary rehabilitation.

We obtained a significant improvement in walking distance of 58.5 m. This was accompanied by an increase of maximal power obtained during CPET, although it did not reach statistical significance. However, the maximal power provided by CPET was useful to adjust cycle training protocol.

Improvement in quality of life is an expected outcome of pulmonary rehabilitation and appears even when there is no improvement in exercise capacity.

A meta-analysis of 20 randomized trials concluded that while for mild/moderate COPD short and long term rehabilitation programs bring benefits on walking test and shortness of breath, severe COPD patients may benefit from at least 6-month rehabilitation programs.

The Troosters team reported one randomized trial of a 6-month outpatient rehabilitation program, showing improvements in "6-minute walking distance, maximal exercise performance, peripheral and respiratory muscle strength, and quality of life. Most of these effects persisted 18 months after starting the program." However, it seems that 20 sessions or 6-8 weeks are sufficient to obtain a benefit. The optimal frequency of the sessions is three per week.

There is also a discussion about the right period of time for training sessions, between 20 and 30 minutes. If the period is too short, the patient’s level of dyspnea would not increase enough. If the period is too long, the patient may not be able to sustain the exercise.

An alternative to continuous exercise is interval training, as demonstrated in a study conducted by Vogiatzis.

In our study we tried to set up a convenient period of minimum 20 minutes. If the patients felt, after first week, that they were able to increase the period of training, we prolonged it to 30 minutes.

Our study group was relatively homogenous, containing 8 to 9 patients of every GOLD stage (II to IV). This study has, however, some limitations: the absence of a control group and the small number of subjects.

We also need to follow up these patients after the end of the program, in order to see if the benefits are maintained on long term, knowing that stopping the training may lead to deconditioning. Therefore, it may be important to maintain daily physical activity to improve or maintain the effects of a respiratory rehabilitation program.

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