Pulmonary rehabilitation slows the decline in forced expiratory volume in 1 second and improves body mass index in patients with Chronic Obstructive Pulmonary Disease

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Abstract Background: Chronic Obstructive Pulmonary Disease (COPD) is characterized by persistent airflow limitation that is usually progressive leading to disability with an increasing burden to the patient, his family and to the health services. Pulmonary rehabilitation (PR) is used as a complementary evidence-based effective treatment option for patients with COPD. This study was carried out to evaluate the effects of PR on the rate of forced expiratory volume in 1 second (FEV1) decline in patients with stable COPD.

Patients and methods: Eighty five COPD patients completed the study, 60 with a mean age of 63 ± 7 years underwent PR for 3 years and 25 with a mean age of 62 ± 5.4 received only pharmacological treatment according to guidelines. Pulmonary function testing and body mass index (BMI) were carried out for all patients upon enrollment and at 1 year intervals for 3 years.

Results: The FEV1 decreased from 1246.8 ml (46.9% of predicted value) to 1192.8 ml (44.8% of predicted) in the PR group, while in the control group the FEV1 decreased from 1224.6 ml (45.4% of predicted) to 1060 ml (39.3% of predicted) (i.e., FEV1 declined 54 ml versus 164.6, respectively, p = 0.008). Also, the PR group showed an improvement in BMI, while in the control group a decreased BMI was noticed (p = 0.001).

Conclusion: Pulmonary rehabilitation resulted in slowing down the decline in FEV1, as well as improving BMI in patients with stable COPD.

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leading to disability with an increasing burden to the patient, his family and to the health services [1]. The most commonly used lung function parameter is the forced expiratory volume in 1 second (FEV1), the decline of which is estimated to be 47–79 ml/year in COPD patients as compared to 30 ml/year in healthy subjects [2–7]. Smoking cessation has been shown to be the only effective intervention to alter the rate of decline in FEV1 in patients with COPD [2,8,9]. However, two recent large placebo-controlled trials have shown that such a result can be also obtained with an appropriate pharmacotherapy [10,11].

Pulmonary rehabilitation (PR) is used as a complementary evidence-based effective treatment option for patients with COPD. It has been recognized to improve symptoms, exercise tolerance and quality of life in those patients [12,13]. However, the effects of PR on lung function have been poorly investigated [14–16]. Moreover, one of the major unresolved issues is the duration of treatment. For example, outpatient exercise training with two or three weekly sessions for 4 weeks showed less benefit than similar training for 7 weeks [17–19]. Hence, the present study was carried out to evaluate the effects of three years pulmonary rehabilitation on the rate of FEV1 decline and the change of body mass index (BMI) in patients with stable COPD.

**Patients and methods**

**Patients**

This study was carried out in Respiratory and Rheumatology Departments and Outpatient Clinics during the period from August 2010 through March 2014. It included COPD patients diagnosed and under pharmacological treatment according to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines [1]; supported by spirometric evidence of airflow obstruction (forced expiratory volume in one second (FEV1)/forced vital capacity (FVC) < 0.70) when clinically stable. We excluded patients who were active smokers or had quit smoking less than 2 years prior to the onset of this study, patients with chronic respiratory failure requiring long-term oxygen therapy and those in whom there were other major medical problems such as heart failure, myocardial infarction, cerebrovascular disease, cancer, neuromuscular, or severe orthopedic disorders. Also, patients who had an acute exacerbation in the 4 weeks before the enrollment (i.e., requiring antibiotics, oral/parenteral steroids, oxygen or increased bronchodilators dosage) were excluded.

**Methods**

All patients underwent pulmonary function test according to ATS/ERS [20] recommendations, upon enrollment and at 1-year intervals up to 3 years using the Zan-100 (Flow Handy II) pulmonary function apparatus. Forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV1) were measured. The post-bronchodilator values were used for statistical analysis. BMI (kg/m2) was measured for each patient and was re-calculated at every spirometry.

PR program was carried out in groups of 6–8 patients according to Riario-Sforza et al. [21]. It involved a schedule of 12 sessions in a 6-week period and included: (1) exercise training using a treadmill for 30 min; (2) upper-limb and trunk exercise training, with warm-up and limbering exercises focused on arm, shoulder and trunk muscle groups for 30 min. Exercise intensity was graded, as the patient progressed in the PR program. In addition, patients attended a COPD education course, and were instructed on how to perform muscle exercises and respiratory training daily at home for the entire duration of the program. The PR cycle was repeated every 6 months for a duration of 3 years.

**Statistical analysis**

Statistical analysis was performed with Epi Info™ version 7 and SPSS version 19 statistical software package (SPSS Inc., Chicago, IL, USA). Data are presented as mean ± SD. Analysis of variance (ANOVA) was used to compare between the groups for the analysis of the entire 3 year period. For time point differences, a two-sample t test was used. p-Value < 0.05 was considered significant.

**Results**

First, this study included 95 COPD patients, 67 of them agreed to receive PR (PR group) and 28 did not require and received pharmacotherapy only (control group). Ten patients, 10.5% withdrew during the observation period (7 in the PR group and 3 in the control group). So, finally 85 patients completed the present study (60 in the PR group with a mean age of 63 ± 7 and 25 in the control group with a mean age of 62 ± 5.4) and their demographic data are shown in Table 1. Table 2 shows body mass index (BMI) changes in the studied groups over 3 years. The PR group showed an improvement in BMI, while in the control group a decreased BMI was noticed (p = 0.001).

Table 3 & Fig. 1 shows FEV1 values over 3 years in the studied population. In the PR group, the FEV1 decreased from 1246.8 ml (46.9% of predicted value) to 1192.8 ml (44.8% of predicted), while in the control group the FEV1 decreased from 1224.6 ml (45.4% of predicted) to 1060 ml (39.3% of predicted) (i.e., FEV1 decline of 54 ml versus 164.6, respectively, p = 0.008).

**Discussion**

To date, none of the existing medications for COPD has been shown conclusively to modify the long-term decline in lung function that is the hallmark of this disease [1]. Pulmonary rehabilitation (PR) is used as a complementary treatment option for these patients [16]. The American Thoracic Society (ATS) and the European Respiratory Society (ERS) published a statement, in which PR was recognized as an evidence-based, multidisciplinary and comprehensive intervention for patients with chronic respiratory diseases who are symptomatic and often have decreased daily life activities [12]. However, little data are available about the effects of PR on pulmonary function in patients with stable COPD. So, the aim of the current work was to investigate the effects of PR over 3 years on lung function of COPD patients.

Results of the present study illustrated that three years of PR program for COPD patients resulted in a significant lower decline in FEV1 compared to patients in the control group who...
received pharmacotherapy only (54 ml versus 164.4 ml, respectively, \( p = 0.008 \)), as the FEV\(_1\) decreased from 1246.8 ml (46.9% of predicted value) to 1192.8 ml (44.8% of predicted) in the PR group, whereas in the control group the FEV\(_1\) decreased from 1224.6 ml (45.4% of predicted) to 1060 ml (39.3% of predicted). Also, the PR group showed an improvement in BMI, while in the control group a decreased BMI was noticed (\( p = 0.001 \)). The above mentioned results are in accordance with that obtained by Stav et al.\[16\] who studied 80 patients with moderate to severe COPD and also found a lower decline in FEV\(_1\) after 3 years in the patients who received PR compared to controls (74 ml versus 149 ml), but a mild improvement in BMI was noticed in the PR group versus decrease in the control group.

In contrary, Incorvaia et al.\[22\] studied 257 COPD patients and found that FEV\(_1\) in the PR group, increased from 1240 ml (57.3% of predicted) to 1252.4 ml (60.8%) after 3 years, whereas in the controls the values were 1367 ml (55% of

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Demographics of all studied patients.</th>
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<tbody>
<tr>
<td>Parameter</td>
<td>PR (no = 60)</td>
</tr>
<tr>
<td>Age, mean ± SD</td>
<td>63 ± 7</td>
</tr>
<tr>
<td>Sex: M/F</td>
<td>47/13</td>
</tr>
<tr>
<td>Smoking history (pack/year)</td>
<td>49 ± 27</td>
</tr>
<tr>
<td>BMI, kg/m(^2)</td>
<td>24.5 ± 0.9</td>
</tr>
<tr>
<td>Exacerbations (no in year before study)</td>
<td>1.2 ± 1.5</td>
</tr>
<tr>
<td>FEV(_1)/FVC</td>
<td>0.57 ± 0.08</td>
</tr>
<tr>
<td>FEV(_1) % pred.</td>
<td>47 ± 6</td>
</tr>
<tr>
<td>Medications, no (%)</td>
<td></td>
</tr>
<tr>
<td>Inhaled glucocorticoids</td>
<td>41 (68.3%)</td>
</tr>
<tr>
<td>Long acting beta agonist</td>
<td>46 (76.7%)</td>
</tr>
<tr>
<td>Tiotropium</td>
<td>23 (38.3%)</td>
</tr>
</tbody>
</table>

PR: pulmonary rehabilitation; M: male; F: female; BMI: body mass index; FVC: forced vital capacity; FEV\(_1\): forced expiratory volume in 1 second.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Effect of pulmonary rehabilitation on body mass index.</th>
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<tbody>
<tr>
<td>BMI</td>
<td>PR (no = 60)</td>
</tr>
<tr>
<td>Basal BMI</td>
<td>24.5 ± 0.9</td>
</tr>
<tr>
<td>BMI after 1 year</td>
<td>24.9 ± 1.1</td>
</tr>
<tr>
<td>BMI after 2 years</td>
<td>25.3 ± 1.1</td>
</tr>
<tr>
<td>BMI after 3 years</td>
<td>25.2 ± 1.3</td>
</tr>
</tbody>
</table>

PR: pulmonary rehabilitation; BMI: body mass index.

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Effect of pulmonary rehabilitation on FEV(_1).</th>
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<tbody>
<tr>
<td>FEV(_1) (ml)</td>
<td>PR (no = 60)</td>
</tr>
<tr>
<td>Basal FEV(_1)</td>
<td>1246.8 ± 149</td>
</tr>
<tr>
<td>FEV(_1) after 1 year</td>
<td>1226.5 ± 148.4</td>
</tr>
<tr>
<td>FEV(_1) after 2 years</td>
<td>1210.1 ± 141.5</td>
</tr>
<tr>
<td>FEV(_1) after 3 years</td>
<td>1192.8 ± 136.3</td>
</tr>
</tbody>
</table>

FEV\(_1\): forced expiratory volume in 1 second; PR: pulmonary rehabilitation.

Figure 1  Evolution of forced expiratory volume in 1second (FEV\(_1\)) over 3 years in COPD patients who received pulmonary rehabilitation (PR) compared to patients on pharmacological treatment only (control).

received pharmacotherapy only (54 ml versus 164.4 ml, respectively, \( p = 0.008 \)), as the FEV\(_1\) decreased from 1246.8 ml (46.9% of predicted value) to 1192.8 ml (44.8% of predicted) in the PR group, whereas in the control group the FEV\(_1\) decreased from 1224.6 ml (45.4% of predicted) to 1060 ml (39.3% of predicted). Also, the PR group showed an improvement in BMI, while in the control group a decreased BMI was noticed (\( p = 0.001 \)). The above mentioned results are in accordance with that obtained by Stav et al.\[16\] who studied 80 patients with moderate to severe COPD and also found a lower decline in FEV\(_1\) after 3 years in the patients who received PR compared to controls (74 ml versus 149 ml), but a mild improvement in BMI was noticed in the PR group versus decrease in the control group.

Also, in accordance PR was shown able to slow down the FEV\(_1\) decline in previous studies [14,15]. Cote and Celli [14] found in a group of 116 patients who received PR a mean decline of 20 ml over 2 years compared to 160 ml decline in 130 controls. Such patients were defined as assuming optimal medical therapy, but the treatment details were not described [16]. In 2007, another study showed a mean FEV\(_1\) decline of 18 ml/year in 48 PR treated patients over 7 years, but without a control group [15].

In contrary, Incorvaia et al. [22] studied 257 COPD patients and found that FEV\(_1\) in the PR group, increased from 1240 ml (57.3% of predicted) to 1252.4 ml (60.8%) after 3 years, whereas in the controls the values were 1367 ml (55% of
predicted at baseline and 1150 ml (51%) after 3 years. This discrepancy in results between the present study and that of Incorvaia et al. could be attributed to the selection criteria of the studied patients being with more severe airflow limitation in this study (FEV1 47% of predicted in the PR group and 45% in the controls) compared to their study (57.3% and 55%).

It was speculated that participating in the pulmonary rehabilitation program, over a considerably long period, increased in incremental stages small airways function and/or recruitment. In addition, the exercise regimen likely improves secretion evacuation, which can reduce airway infection/inflammation and decrease COPD exacerbations [16]. Moreover, Petersen and Pedersen [23] noted that regular exercise protected against diseases associated with chronic inflammation, which is crucial in the pathogenesis of COPD. The contribution of PR in the slowing of FEV1 decline adds an additional beneficial effect of pulmonary rehabilitation for COPD patients. FEV1 decline may serve as a predictor of death from COPD, and therefore PR could be considered as a disease modifier [16, 24].

Regarding BMI, it was previously described to be an effective indicator of prognosis in COPD, with a clear association between decreasing body mass and increasing mortality [25–28], whereas available data indicate that those patients able to gain weight improve their prognosis [27, 29]. In the current work, the significant improvement in BMI which was observed among COPD patients who received PR, may affect the prognosis of those patients, a point that needs further study.

In conclusion, three years of pulmonary rehabilitation was able to slow down the decline in FEV1 and to improve BMI in patients with stable COPD.

Conflict of interest

None.

References


