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**ORIGINAL REPORT**

# SHOULD WE EXCLUDE ELDERLY PATIENTS WITH CHRONIC OBSTRUCTIVE PULMONARY DISEASE FROM A LONG-TERM AMBULATORY PULMONARY REHABILITATION PROGRAMME?

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***Objective:*** **To assess the outcomes of a 6-month comprehensive multidisciplinary outpatient pulmonary rehabilitation programme in patients with chronic obstructive pulmonary disease according to age.**

***Design:*** **Prospective cohort study.**

***Patients:*** **A total of 140 patients with chronic obstructive pulmonary disease (Global Initiative for Chronic Obstructive Lung Disease (GOLD) 3–4) admitted to our centre for pulmonary rehabilitation.**

***Methods:*** **Patients were divided into 3 groups: group A (<65 years), group B (65–74 years) and group C (≥75 years). All the patients received an education and individualized training programme. Pulmonary rehabilitation efficacy was evaluated at 6 months of treatment and 12 months post-treatment.**

***Results:*** **A total of 116 patients completed the pulmonary rehabilitation programme: 59 in group A (85.5%), 40 in group B (80%) and 17 in group C (80.9%). All the parameters studied (number of sessions, 6-min walking distance, isometric quadriceps strength, health-related quality of life, maximal load, peak oxygen uptake, maximal inspiratory and expiratory pressures) were significantly improved in each of the groups at 3 and 6 months compared with baseline. Moreover, percentage changes from baseline at 6 months for all of the parameters studied were not significantly different between age-groups.**

***Conclusion:*** **Pulmonary rehabilitation is efficient in elderly patients with severe and very severe chronic obstructive pulmonary disease, and their compliance with pulmonary rehabilitation was similar to that seen in younger groups. Therefore, elderly patients with chronic obstructive pulmonary disease should not be denied pulmonary rehabilitation.**

*Key words:* chronic obstructive pulmonary disease; elderly; pulmonary rehabilitation; treatment.

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## INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a common chronic respiratory disease amongst elderly people, the prevalence of which increases with age (1). COPD has also become a major public health problem, especially in developed countries where the proportion of elderly people is increasing. The World Health Organization (WHO) predicts that in 2020, COPD will become the third highest cause of mortality in the world, just behind cardiovascular disease, as well as being the fifth highest cause of disability (1).

Pulmonary rehabilitation (PR) has become an established part of the management of COPD (2). PR includes self-management education, maximization of drug treatment, aerobic exercise training, muscle strength training, inspiratory muscle training, nutritional intervention and psychosocial support (3). PR has proved to be effective in improving functional exercise capacity and health-related quality of life (HRQoL) of patients with COPD, and reducing exertional dyspnoea, the use of health services and health costs (3–5). However, the effect of PR has been poorly investigated in elderly patients with COPD, and there is an underlying perception amongst most clinicians, and not only general practitioners, that PR has limited benefit for patients aged 75 years or more. Moreover, older patients with similar degrees of chronic airway obstruction may have greater exercise capacity limitations than younger ones due to clinically significant loss in cardiac function, peripheral muscle strength and endurance, as well as a loss of coordination and balance (6, 7). Few studies have attempted to evaluate PR in elderly patients with COPD (8–11). PR programmes in these studies were organized as inpatient (8, 9), outpatient (8, 10) or home-based (11) settings. Furthermore, the parameters studied were limited and the studies had a short-term design with durations ranging from 2 to 12 weeks.

We performed a prospective non-controlled study to investigate, firstly, the adherence of elderly patients with COPD admitted to our centre for a 6-month comprehensive multidisciplinary outpatient PR programme, and, secondly, the efficacy of this PR programme in these patients.

## MATERIAL AND METHODS

### *Study design*

A prospective non-controlled study on patients with COPD referred to our university PR department for a 6-month outpatient programme was conducted between February 2007 and December 2008. All patients with COPD fulfilled the criteria proposed by the Global Initiative for

Chronic Obstructive Lung Disease (GOLD) guidelines (2) and were ex-smokers or current smokers. They were all classified as GOLD stage 3 or 4. Selection criteria for rehabilitation were those accepted by the National Institute for Health and Disability Insurance in Belgium. Patients over 40 years old and clinically stable at inclusion, exhibited a post-bronchodilatation forced expiratory volume in 1 s ($FEV_1$) < 50% predicted and met at least two of the following criteria: maximal workload ($W_{max}$) < 90 Watts, 6-minute walking distance (6MWD) < 70% of the predicted value, < 100 points on the Chronic Respiratory Disease Questionnaire (CRQ) or < 20 points on the dyspnoea domain (CRQd), quadriceps force (QF) < 70% of the predicted value, maximal inspiratory pressure (MIP) or maximal expiratory pressure (MEP) < 70% of the predicted value. Exclusion criteria were: a history of cardiac, neurological or orthopaedic disorder interfering with exercise, or those with active cancer. Baseline comorbid conditions were identified from the database medical file and categorized into a modified Charlson comorbidity index in which COPD was excluded from the list (12, 13).

Patients were divided into 3 groups according to age: adult group (A: age less than 65 years), a young-elderly group (B: age 65–74 years) and an old-elderly group (C: age 75 years or older).

The study was approved by the local ethics committee and all patients gave their consent to allow the use of their data.

### *Rehabilitation programme*

The 6-month comprehensive outpatient rehabilitation programme consisted of 60 tailored sessions, 3 times a week in the first 3 months, and twice weekly during the subsequent 3 months. Each session had a duration of 2 h. All patients received an education, nutritional and individualized aerobic exercise training programmes, and psychosocial assessment and counselling. Training items were: cycling, treadmill walking and peripheral muscle training. Patients started the programme at an exercise intensity between 50% and 80% of the initial maximal work load on the cycle ergometer and at 60% of their maximal walking speed during the 6-min walking test (6MWT). Isometric quadriceps strengthening was performed with loads in 3 series of 10 repetitions at 50% of the 1 repetition maximum (the weight that could be lifted once) for the quadriceps. The patients were encouraged to perform complementary exercises of inspiratory and expiratory muscle training 3 times a day with threshold devices (IMT (inspiratory muscle trainer) and PEP (positive expiratory pressure) Thresholds®, Respironics Inc, New Jersey, USA). Physiotherapists provided close supervision. Oxygen saturation, heart rate and blood pressure were measured during the training sessions. Supplemental oxygen was given to maintain oxygen saturation above 90%. The multidisciplinary medical team consisted of chest physicians specialized in PR, nurses, physiotherapists, one dietician and one psychologist.

### *Parameter measurements*

Complete assessments (6MWT, CRQ, isometric quadriceps and respiratory muscle strengths, maximal cycle ergometry) were supervised by physiotherapists (specialized in PR) blinded to the objectives of this study. Assessments were made at enrolment (T0), and at 3 (T3) and 6 months (T6) of PR, and 1 year after PR discharge (at 18 months).

All spirometric tests used in the present study were performed using a Jaeger Masterlab pneumotachograph (Erich Jaeger GmbH, Würzburg, Germany). $FEV_1$ and forced vital capacity (FVC) were measured according to the European Respiratory Society guidelines for pulmonary testing (14) and results expressed in ml and percentage of the predicted normal values. $FEV_1$/FVC was expressed as a percentage. In addition, the diffusing capacity for carbon monoxide (DLCO) was measured by the single breath method (Sensor Medics 2400 He/CO Analyzer System, Bilthoven, The Netherlands) at the initial visit.

Functional exercise performance was measured by a 6MWT. Encouragements were standardized (15). The better of two tests was used to avoid learning effects and the 6-min walk distance (6MWD) expressed in absolute value (m). A 54-m improvement was usually considered as clinically significant (16). Oxygen was administered in case of hypoxaemia at rest.

Respiratory muscle strength was assessed by measuring maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) using a portable manometer (RPM, Care Fusion®, Basingstoke, UK). We used a standardized technique (17): at least 5 attempts were realized to measure MEP from total lung capacity and MIP from residual volume. Both were determined by the pressure that could be sustained against an occluded valve for at least 1 s. Tests were repeated until the variability among the 3 best attempts was less than 5%. The highest value was chosen and was expressed as absolute value ($cmH_2O$).

Maximal exercise capacity was assessed using maximal cycle ergometry (Ergoline Acertys Health Care SA®, Aartselaar, Belgium) according to the American Thoracic Society/American College of Chest Physicians guidelines (18). After 3 min of unloaded pedalling, patients cycled at an incremental workload (10 W/min) until exhaustion. Oxygen consumption and peak oxygen uptake ($VO_{2,peak}$), carbon dioxide output and ventilation were measured breath by breath. Electrocardiogram (ECG) and oxygen saturation were monitored constantly.

Quality of life was assessed with the disease-specific CRQ (19). This 20-item questionnaire is widely used to measure the effect of PR. It rates the quality of life in 4 domains (dyspnoea, mastery, emotional functioning and fatigue) and has been validated in the French language (20). Each item is graded on a 7-point Likert scale. A global CRQ score was obtained from the sum of the 4 domains (20–140-point scale). The minimum change indicating a clinically important benefit was 10 points for the total CRQ score and 0.5 points per item (21). The CRQ was administered by a psychologist.

Isometric quadriceps strength was evaluated using a handheld dynamometer (MicroFET 2, Hoggan Health Industry®, West West Jordan, Utah, USA). Extension peak torque was evaluated at 60º of knee flexion. The best of at least 5 attempts was chosen and the value was expressed in Newton metre (Nm).

Compliance was assessed by both the number of withdrawals and the number of sessions followed by the patients.

The French version of a free dedicated Internet search engine (http://www.mappy.be) was used for the distance calculation with a precision of 0.1 km between patient residences and PR centre.

### *Statistical analysis*

The data are presented as mean and standard deviation (SD) or mean ± standard error of the mean (SEM) for clarity of presentation. One-way measures analyses of variance (ANOVA) with *post-hoc* test (Tukey) were used to compare the 3 groups of subjects. The $\chi^2$ test was used to compare the proportion of dropouts in each group and comorbidities. Repeated measures ANOVA were used for paired data with *post-hoc* test if $p < 0.05$. Statistical significance was set at $p < 0.05$.

## RESULTS

### *Population*

During the period of study 140 consecutive patients with COPD were admitted to our PR centre. Table I represents all baseline characteristics of the population studied divided into 3 groups according to age. The youngest group (A) consisted of 42 men and 27 women with a mean age of 57.6 years (SD 5.2 years), the intermediate group (B) included 36 men and 14 women with a mean age of 69.9 years (SD 2.6 years), while the oldest group (C) included 17 men and 4 women with a mean age of 77.4 years (SD 2.5 years). All patients had severe or very severe airflow obstruction (GOLD 3 and 4) and there were no differences between the 3 groups of patients with COPD with respect to $FEV_1$ and $FEV_1$/FVC. Each group showed a great deterioration in exercise capacity, but only the $VO_{2,peak}$ had deteriorated significantly in the oldest patients. There was no

Table I. *Baseline characteristics of patients with chronic obstructive pulmonary disease according to age*

| | <65 years<br>A<br>*n*=69 | 65–74 years<br>B<br>*n*=50 | ≥75 years<br>C<br>*n*=21 | A vs B | A vs C | B vs C |
|---|---|---|---|---|---|---|
| Age, years, mean (SD) | 57.6 (5.2) | 69.5 (2.6) | 77.4 (2.5) | $p<0.001$ | $p<0.001$ | $p<0.001$ |
| Men/woman, *n* | 42/27 | 36/14 | 17/4 | ns | ns | ns |
| Current smokers, % | 42.0 | 32.0 | 19.1 | ns | ns | ns |
| Pack years, *n* | 39.0 (15.7) | 45.7 (20.6) | 46.7 (17.0) | $p<0.05$ | ns | ns |
| Charlson score, mean (SD) | 1.6 (1.1) | 1.9 (0.9) | 2.2 (1.8) | $p<0.05$ | ns | ns |
| Body mass index, kg/m$^2$, mean (SD) | 25.7 (5.6) | 25.8 (4.0) | 25.8 (5.4) | ns | ns | ns |
| LTOT, *n* (%) | 8 (11.6) | 6 (12.0) | 3 (14.3) | ns | ns | ns |
| FEV1 (% predicted), mean (SD) | 38.1 (10.8) | 39.5 (11.7) | 39.9 (9.2) | ns | ns | ns |
| FEV1/VC, % | 46.1 (10.4) | 48.5 (11.0) | 46.8 (10.2) | ns | ns | ns |
| 6-minute walk distance, m, mean (SD) | 371.0 (99.5) | 340.4 (101.1) | 321 (122.9) | ns | ns | ns |
| Maximum work load, W, mean (SD) | 47.6 (16.3) | 41.8 (16.9) | 40.4 (13.5) | ns | ns | ns |
| $VO_{2,peak}$, ml.kg$^{-1}$.min$^{-1}$, mean (SD) | 9.3 (2.9) | 8.4 (2.5) | 7.7 (2.3) | ns | $p<0.05$ | ns |
| MIP, cm$H_2O$, mean (SD) | 61.1 (23.1) | 54.2 (20.3) | 49.2 (15.9) | ns | $p<0.05$ | ns |
| MEP, cm$H_2O$, mean (SD) | 70.4 (24.2) | 69.7 (26.7) | 61.9 (19.0) | ns | ns | ns |
| Quadriceps strength, Nm, mean (SD) | 116.2 (40.2) | 108.2 (45.3) | 104.8 (37.4) | ns | ns | ns |
| CRQ score (20–140), mean (SD) | 67.1 (16.7) | 74.1 (13.9) | 73.6 (14.7) | $p<0.05$ | ns | ns |
| Dyspnoea CRQ score (7–35), mean (SD) | 14.2 (3.7) | 15.6 (4.3) | 15.8 (2.9) | ns | ns | ns |
| Distance: home/PR centre, km[a], mean (SD) | 15.2 (9.8) | 14.4 (8.3) | 12.2 (4.3) | ns | ns | ns |

[a]Distance (km) between pulmonary rehabilitation (PR) centre and patient's residence, as assessed by Mappy (http://www.mappy.be).
PR: pulmonary rehabilitation; SD: standard deviation; ns: non-significant; LTOT: long-term oxygen therapy; FEV1: forced expiratory volume in 1 s; FVC: forced vital capacity; MIP: maximal inspiratory pressure; MEP: maximal expiratory pressure; CRQ: Chronic Respiratory Disease Questionnaire.

significant difference in terms of peripheral and respiratory muscle strength, except for the MIP, which was significantly reduced in the oldest patients with COPD in comparison with the youngest group. There was no difference in body mass index (BMI) between the groups. Quality of life was altered, but it displayed a significantly greater alteration in the youngest group. The Charlson score was higher in group B by comparison with group A, and there was a trend for an increased score in group C. However, the prevalences of the most common comorbidities associated with COPD were not different between groups, except for cardiovascular diseases, which increased with age (Table II).

*Compliance*

On the 140 patients included in the study 116 completed the PR programme: 59 in group A (85.5%), 40 in group B (80%) and 17 in group C (80.9%). The withdrawal rate did not differ significantly between the 3 groups. Baseline characteristics of patients who did not complete the programme (non-completers) and those who completed (completers) their programme of rehabilitation were not significantly different, except for 6MWD in group B, which was significantly lower in patients who stopped PR prematurely (278.9 ± 92.2 vs 352.3 ± 100.3 m, $p<0.05$), and for Charlson score, which was higher in non-completers of group A (1.4 ± 0.7 vs 3.0 ± 2.1, $p<0.01$). In addition, the mean distance between the residence of the patient and the PR centre was not significantly different between completer and non-completer patients with COPD in each group.

The number of sessions per patient was not significantly different between groups (A: 54.7 ± 8.3; B: 56.1 ± 5.9; C: 54.0 ± 9.2).

Reasons for withdrawals were classical: acute exacerbation ($n=10$), loss of motivation ($n=7$), problems associated with transport ($n=3$: cost, distance), arthropathy ($n=2$), and death ($n=2$; one in group A and one in group B).

Table II. *Prevalence of most common comorbidities associated with chronic obstructive pulmonary disease according to age*

| | A<br><65 years<br>*n*=69<br>*n* (%) | B<br>65–74 years<br>*n*=50<br>*n* (%) | C<br>≥75 years<br>*n*=21<br>*n* (%) | A vs B | A vs C | B vs C |
|---|---|---|---|---|---|---|
| Osteoporosis | 8 (11.6) | 7 (14.0) | 2 (9.5) | ns | ns | ns |
| Diabetes | 5 (7.2) | 6 (12.0) | 2 (9.5) | ns | ns | ns |
| BMI <21 kg/m$^2$ | 14 (20.3) | 5 (10.0) | 4 (19.0) | ns | ns | ns |
| Cardiovascular diseases | 19 (27.5) | 23 (46.0) | 14 (66.6) | $p<0.05$ | $p<0.01$ | ns |
| GERD | 12 (17.4) | 6 (12.0) | 5 (23.8) | ns | ns | ns |
| Depression | 18 (26.1) | 11 (22.0) | 5 (23.8) | ns | ns | ns |
| Lung cancer | 1 (1.4) | 3 (6.0) | 0 (0.0) | ns | ns | ns |

GERD: gastroesophageal reflux disease; BMI: body mass index.

*Efficacy*

All the studied parameters (6MWD, isometric quadriceps strength, HRQoL evaluated by CRQ, maximal load work, maximal oxygen uptake, maximal inspiratory and expiratory pressures) were significantly improved in each group at 3 and 6 months compared with baseline (Figs 1 and 2).

Table III shows the major effects of PR according to age. All studied parameters increased significantly after the 6-month PR programme. Changes (% from baseline) at 6 months for all the parameters studied were not significantly different between the 3 age groups. The proportion of patients with a clinically significant improvement from baseline (≥54 m) in the 6MWD were similar in each age group (A: 84.7%; B: 70%; C: 82.4%). Similarly, the proportion of patients with a significant improvement in total CRQ score (≥10 points) were not significantly different between age groups (A: 76.3%; B: 80%; C: 88.2%).

At 18 months, the proportion of patients who agreed to be reassessed after a telephone call was not significantly different ($p=0.31$). Improvement for most of the studied parameters compared with baseline value were maintained 1 year after PR discharge (Table IV), but to a lesser extent than at 6 months. Improvement in quality of life and functional parameters were not different between age groups (Table IV).

Table III. *Effects of pulmonary rehabilitation according to age. Results are expressed as percentage improvement at 6 months compared with baseline*

| | <65 years<br>*n*=59<br>Mean±SEM | 65–74 years<br>*n*=40<br>Mean±SEM | ≥75 years<br>*n*=17<br>Mean±SEM | *p* |
|---|---|---|---|---|
| 6-min walk distance | 36.0±4.3 | 32.9±4.8 | 49.6±13.9 | ns |
| Maximum work load | 60.5±7.7 | 72.6±17.0 | 55.1±8.2 | ns |
| $VO_{2,peak}$ | 41.2±6.9 | 42.5±5.8 | 42.4±9.5 | ns |
| MIP | 42.8±5.3 | 40.3±8.6 | 34.4±7.2 | ns |
| MEP | 35.6±6.1 | 33.8±6.0 | 35.1±12.3 | ns |
| Quadriceps strength | 53.7±4.9 | 47.1±5.5 | 66.7±14.7 | ns |
| CRQ | 42.1±4.9 | 31.2±4.4 | 39.3±7.3 | ns |
| Dyspnoea CRQ score | 55.3±6.6 | 50.9±10.9 | 45.8±7.0 | ns |

MIP: maximal inspiratory pressure; MEP: maximal expiratory pressure; CRQ: Chronic Respiratory Disease Questionnaire; ns: non-significant; SEM: standard error of the mean.

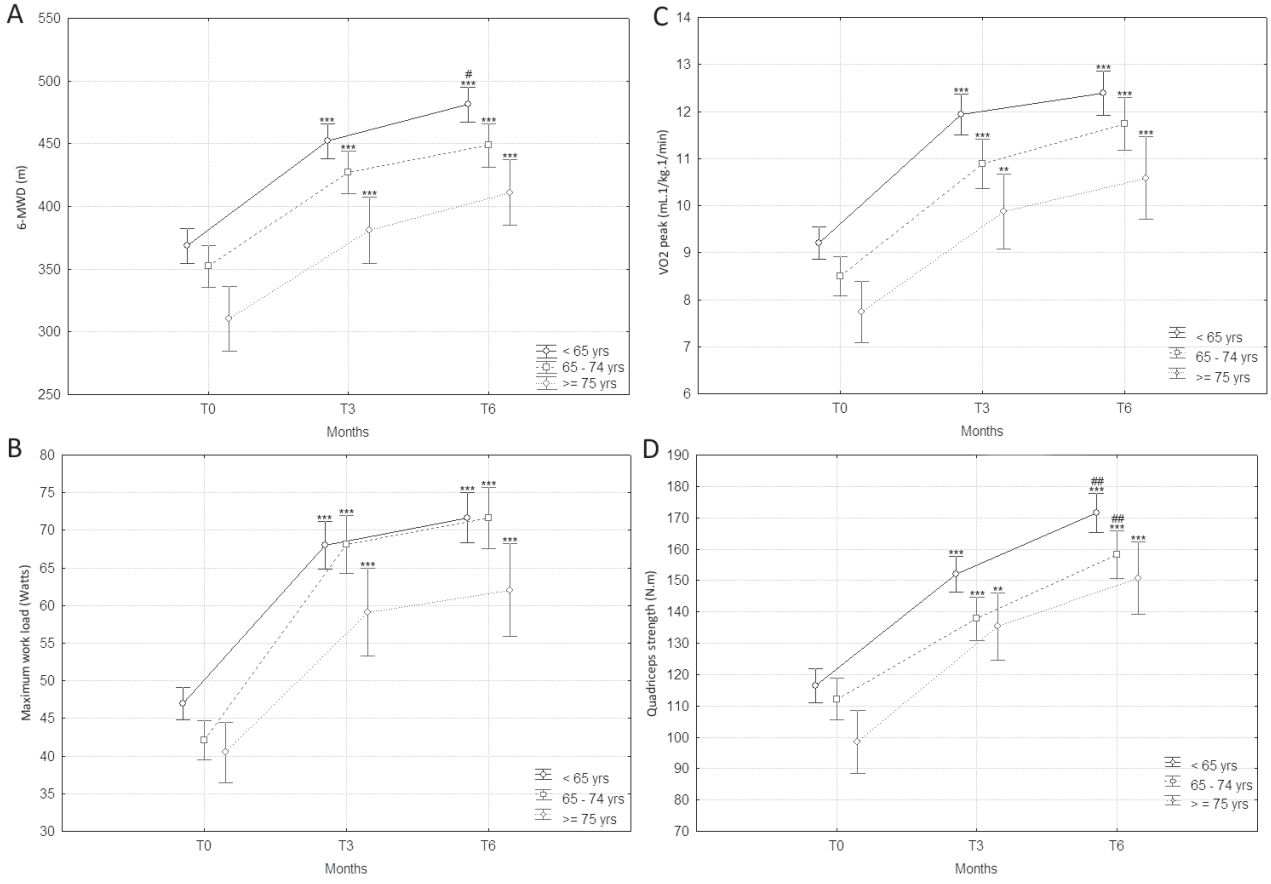


*Fig. 1.* Effects of a 6-month comprehensive outpatient pulmonary rehabilitation programme on (A) 6-minute walk distance, (B) maximal load work, (C) $VO_{2,peak}$, and (D) isometric quadriceps strength according to age in patients with chronic obstructive pulmonary disease (COPD). Lines and marks represent mean values for each group and time. Vertical bars represent standard errors of the mean. ***$p<0.0001$ (T0/3 or 6), **$p<0.005$ (T0/3 or 6), *$p<0.05$ (T0/3 or 6), #$p<0.05$ (T3/T6), ##$p<0.005$ (T3/T6).

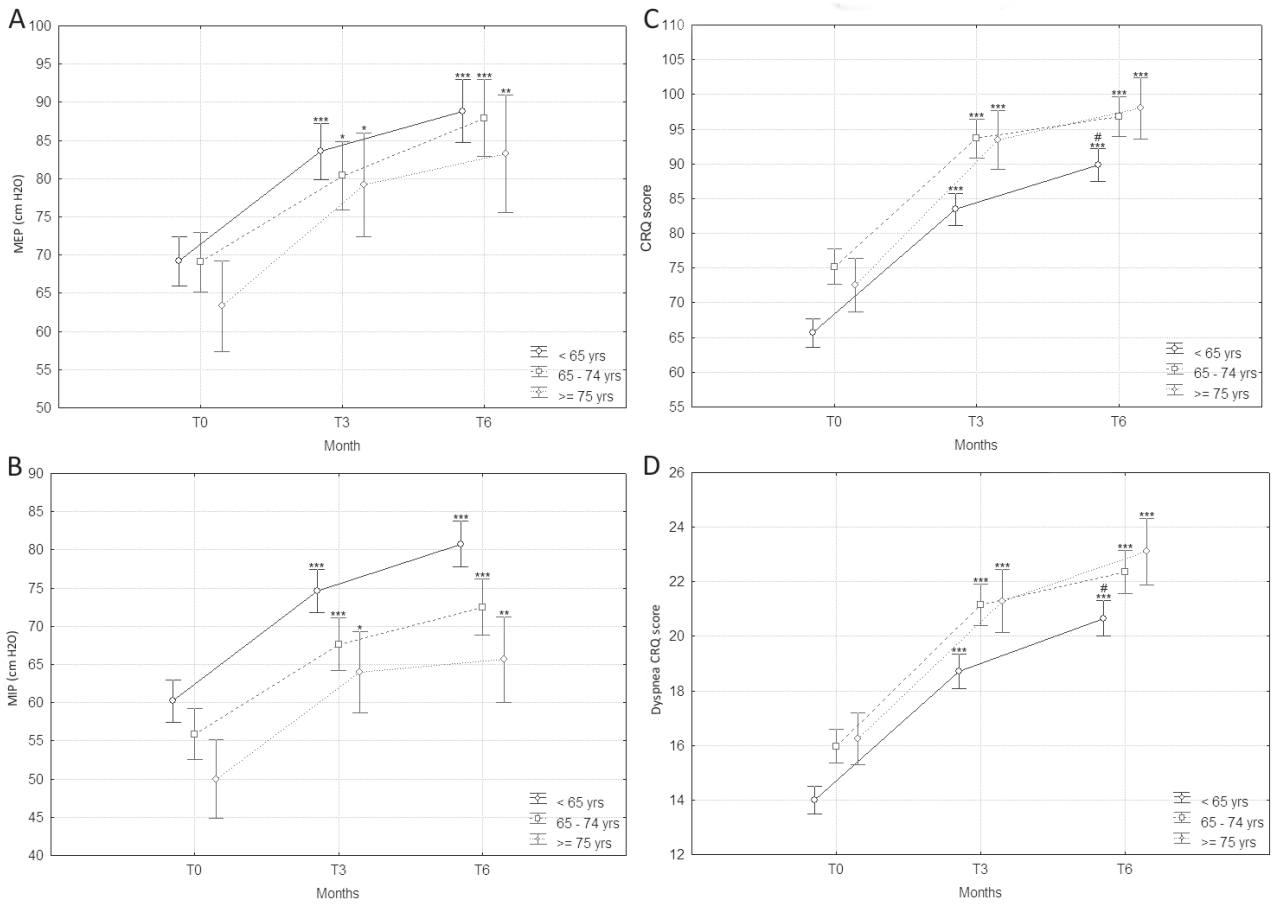


*Fig. 2.* Effects of a 6-month comprehensive outpatient pulmonary rehabilitation programme on: (A) maximal expiratory pressure (MEP), (B) maximal inspiratory pressure (MIP), (C) Total Chronic Respiratory Disease Questionnaire (CRQ) score, and (D) Dyspnoea CRQ score according to age in patients with chronic obstructive pulmonary disease. Lines and marks represent mean values for each group and time. Vertical bars represent standard errors of the mean. ***$p<0.0001$ (T0/3 or 6), **$p<0.005$ (T0/3 or 6),*$p<0.05$ (T0/3 or 6), #$p<0.05$ (T3/T6), ##$p<0.005$ (T3/T6).

Table IV. *Long-term effects of pulmonary rehabilitation one year after discharge according to age. Results are expressed as percentage improvement at 18 months compared with baseline. Parameters significantly (*p < 0.05; **p < 0.01; ***p < 0.001) improved by comparison with baseline. Between-group comparisons were all non-significant*

| | <65 years<br>*n*=38<br>Mean±SEM | 65–74 years<br>*n*=27<br>Mean±SEM | ≥75 years<br>*n*=8<br>Mean±SEM |
|---|---|---|---|
| 6-min walk distance | 10.8±9.0* | 9.9±7,2 | 22.9±15.3 |
| Maximum work load | 24.0±8.2*** | 28.3±8.0*** | 18.3±7.2 |
| $VO_{2,peak}$ | 14.3±6.4* | 17.7±7.2** | 27.1±6,7 |
| MIP | 26.7±9.7** | 14.2±12.9 | 36.4±4.3* |
| MEP | 15.4±10.2 | 5.0±12.8 | 18.9±9.5 |
| Quadriceps strength | 5.1±11.0 | 6.1±10.9 | 8.9±7.2 |
| CRQ | 22.2±5.9*** | 14.2±6.6** | 21.3±6.3* |
| Dyspnoea CRQ score | 23.3±7.8** | 11.1±7.8** | 19.4±9.5 |

MIP: Maximal inspiratory pressure; MEP: maximal expiratory pressure; CRQ: Chronic Respiratory Disease Questionnaire; SEM: standard error of the mean.

*Adverse events*

There were no serious adverse events reported during exercise interventions or testing.

## DISCUSSION

The data from this study suggest that 6-month comprehensive outpatient PR programmes are as beneficial in elderly patients with severe or very severe COPD as they are in younger patients with similar lung function and major exercise limitation. These benefits are significant in terms of sub-maximal and maximal exercise capacity, peripheral and respiratory muscular strength and quality of life. Older patients with COPD were also found to be as adherent to the programme as the youngest ones. Therefore, these patients with COPD could be appropriate candidates for an ambulatory PR with duration of as long as 6 months.

Most PR studies have focused mainly on patients under 75 years of age, or sometimes even excluded patients older than 75 years (22–26). The rationale for age exclusion was not given in these studies. These patients with COPD may have been considered inappropriate for PR because they were supposed to be "too old" to tolerate such treatment. Moreover, they are known to often present co-morbid illnesses that would limit their ability to improve exercise capacity, and are also known to have more difficulty in moving around outside their home. Finally, the criteria used to define which patients are most likely to benefit from PR are controversial (3–5, 27, 28).

Few studies have been devoted to the impact of age on the benefits of a PR programme (8–11). One of the strengths of our study is the long duration of the ambulatory rehabilitation treatment, which lasted 6 months with a maximum of 60 sessions. Couser et al. (8) proposed in their study a 2-month ambulatory rehabilitation programme, while Di Meo et al. (10) reported a 4-week ambulatory training. In our study we found that in elderly patients with COPD the benefits were observed throughout the whole programme duration and beyond 12 weeks. In other words, these patients still progressed until 6 months of PR, but to a lesser extent than after 3 months. This is in line with data reported by Troosters et al. (24), who demonstrated significant and clinically relevant improvement in functional and maximal exercise capacity, peripheral and respiratory muscle strength and quality of life in patients with severe COPD after a long-term rehabilitation programme. Furthermore, we know that obtaining changes in lifestyle and behaviour requires much longer programmes (28).

Another strength of our study is the comprehensive functional assessment. Several studies in old (> 75 years) patients with COPD measured sub-maximal exercise capacity using the well-standardized 6MWT or 12MWT (8, 10). We found a significant improvement in the 6MWD, which was above the commonly admitted minimal important difference (MID) of 54 metres (16) and obviously clearly above the lower MID of 25 m recently considered as more appropriate for moderate-to-severe COPD (29). Moreover, we also found a significant increase in the $VO_{2max}$ and the maximal work load after rehabilitation in the 3 groups of patients. Corriveau and colleagues (30) demonstrated that patients aged 60 years or younger and patients older than 60 years were able to increase exercise levels and $VO_{2max}$ after an inpatient rehabilitation programme and that there was no relationship between age and change in $VO_{2max}$. In our study, we found, in all patient groups, a significant increase in the maximal load work, largely greater than 8.4 watts, which is the mean increase reported by Lacasse et al. (31) in their systematic review. Moreover, there was a significant improvement in the isometric quadriceps strength in our older patients. We know that lower extremity muscle weakness is a major independent contributor to falls (32). Reinforcing the quadriceps force is likely to improve the balance disorders in elderly patients with COPD. Furthermore, we found a significant improvement in the MIP and MEP of our population after the comprehensive PR programme, which also comprises home-based respiratory muscle training. One study seems to demonstrate that both leg muscle strength and respiratory muscle strength are independently associated with the rate of mobility decline in community-dwelling elderly (33). The quality of life was evaluated by the CRQ questionnaire. Improvement in each group of patients with COPD was greater than the 10-point threshold of the total score considered as the minimal clinically significant difference (19, 21). This may be related to improvement in exercise capacity, dyspnoea, psychological status and autonomy. Finally, most of the benefits of PR were maintained in patients reassessed at 18-months (1 year after ending PR), but to a lesser extent than those seen at 6 months.

In this prospective study, we found that older patients with COPD are also as compliant to this programme as younger ones. There was an overall mean drop-out rate of 18%, with no significant difference between the 3 groups. In previous studies, the reported rate of withdrawal ranged from 10% to 31% (24, 34). Our value was, however, lower than that reported by Troosters et al. (24), who found a dropout rate of 30% in their study with a similar programme in term of components and duration (6 months). However, it should be noted that our programme had a lower intensity training regimen. Indeed, our patients rarely reached 80% of the initial maximal work load after the first 3 months.

The major limitation of our study is that the third group contains a limited number of patients relative to other groups. However, as we recruited consecutive patients, we can argue that our proportion of elderly COPD reflects the true figure of that kind of patients referred to a university hospital and eligible for a long-term PR programme. We hope that this study will convince physicians to send more elderly patients with COPD to PR centres. Moreover, the risk of having more co-morbidity in elderly patients with COPD ≥ 75 years of age is higher than in younger ones. However, in our study, except for the prevalence of cardiovascular diseases, we did not find an increase in Charlson score and prevalence of most common comorbidities associated with COPD in elderly patients. Thus, it is conceivable that physicians sent the more valid and motivated elderly patients with COPD to a PR centre, therefore creating a selection bias favouring good response to PR in these patients. However, all patients in this study, including the oldest, met the inclusion criteria selecting the patients with severe or very severe COPD who were particularly disabled and affected in their quality of life.

In conclusion, elderly and very elderly patients with severe COPD could be good candidates for a 6-month ambulatory multidisciplinary PR, although they can present some co-morbid illnesses. Adherence of elderly patients with COPD to this long duration comprehensive PR programme and their benefits are in the same range as those seen younger patients. Although our results do not justify systematically referring all older patients with COPD, physicians should not be reluctant to include these patients in long-term and comprehensive ambulatory PR programmes.

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