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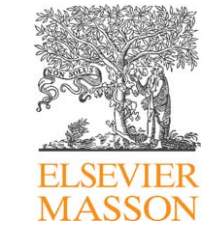

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ORIGINAL ARTICLE

Home-based pulmonary rehabilitation in idiopathic pulmonary fibrosis

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Summary
Introduction. — Idiopathic pulmonary fibrosis (IPF) is a severe chronic lung disease. Pulmonary rehabilitation could improve the quality of life of patients with this condition.
Methods. — We prospectively evaluated the impact of an 8-week home-based pulmonary rehabilitation programme over 10 months in stable patients suffering from IPF. Exercise capacity, pulmonary function, dyspnoea and quality of life were analyzed before and after the rehabilitation programme.
Results. — Seventeen patients were included and 13 completed the study. Mean functional vital capacity (FVC) was 2.15 ± 0.79 L and mean diffusing capacity for carbon monoxide (DLCO) was 7.81 ± 3.99 mL/min/mmHg. Six patients were treated with low dose oral steroids (20 mg/day of prednisone) with or without immunosuppressive treatments; six were taking part in therapeutic trials. Mean endurance time (7.4 ± 9.1 min vs. 14.1 ± 12.1 min; $P = 0.01$), number of steps per minute on a stepper (322 ± 97 vs. 456 ± 163; $P = 0.026$), six-minute walk distance relative to heart rate (HR) (11 ± 6 vs. 17 ± 12; $P = 0.006$), exercise dyspnoea ($P = 0.026$), sensation of physical limitation on the SF-36 (25% ± 26 vs. 49% ± 38; $P = 0.047$) and four out of seven visual analogue scales were significantly improved after rehabilitation. In contrast, no significant difference was observed in resting pulmonary function or in other items on quality of life questionnaires.
Conclusion. — A home-based programme of pulmonary rehabilitation is feasible in IPF patients. It significantly improved endurance parameters and physical limitation in this patient group without changing pulmonary function.
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Introduction

Idiopathic pulmonary fibrosis (IPF) is a chronic disease responsible for progressive deterioration in lung function parameters. It results in major functional disability. Its incidence is 4.6 per 100,000 in the United Kingdom [1] and varies between 6.8 and 16.3 per 100,000 in the United States [2] depending on the criteria used. Its prevalence is between 14 and 42.7 per 100,000 [2]. Current treatments [3] are ineffective, medium-term prognosis is poor, and median survival after diagnosis is approximately three years [4].

The limitations on the exercise capacity of patients with chronic lung diseases are multifactorial: pulmonary dysfunction, peripheral muscle dysfunction, and/or cardiac. In IPF, the limiting factors are abnormalities in gas exchanges (diffusion disorders, ventilation-perfusion mismatching), dysfunction of mechanical ventilation (breathing at high frequency and low tidal volume), and often impaired cardiovascular function with development of pulmonary hypertension [5]. All these anomalies result in dyspnoea, which can be worsened by peripheral muscle deconditioning, [6] and could theoretically be improved by exercise training as part of a pulmonary rehabilitation (PR) programme.

PR is recommended in chronic obstructive pulmonary disease (COPD) [7,8]. Its importance in terms of decreased use of health services [9], improved exercise tolerance, dyspnoea [10] and quality of life [11] has already been demonstrated. PR programmes are usually carried out in a centre; some teams organize home-based PR.

Few studies have addressed the issue of PR in IPF [5,12—16]. For patients with IPF, home-based PR, using an integrated approach to management, and personalized follow-up and assessment, can be very beneficial as there are currently no effective treatments for this disease that limits their independence [17].

The aim of our study was to evaluate the benefit of home-based PR in patients with IPF in terms of quality of life, dyspnoea and exercise tolerance.

Patients and methods

Patients

This prospective observational study was conducted over a period of 10 months from April 2007 to February 2008 on patients with IPF treated in the respiratory medicine department of the Calmette Hospital (part of the Lille University Hospital) in collaboration with a team trained in pulmonary rehabilitation supplied by a home health care service provider.

Inclusion in the rehabilitation program involved:

- a diagnosis of IPF made according to the histological and/or clinical-radiological criteria of the American Thoracic Society and the European Respiratory Society [18];
- the ability to perform a walk test and use a cycle ergometer;
- the motivation and agreement of the patient for the setting up of a home-based rehabilitation programme.

Exclusion criteria were:

- the general contraindications to functional exercise testing (FEX): recent myocardial infarction, unstable angina, acute pulmonary oedema, acute myocarditis or pericarditis, severe rhythm disorders, disabling rheumatic disease;
- acute exacerbation of IPF;
- changes in therapy planned in the coming eight weeks;
- patients not requiring oxygen therapy during exercise.

Methods

All examinations were carried out as part of the usual management of patients with IPF. Examination conditions were the same before and after PR.

Resting pulmonary function testing (PFT)

Resting pulmonary function was evaluated with tests including spirometry, measurement of diffusing capacity for carbon monoxide (DLCO) and plethysmography [19].

Exercise testing

Three tests were performed to evaluate exercise capacity:

- an endurance test on a cycle ergometer breathing room air at a load of 75% of the maximum work rate on the incremental cycle ergometer exercise test (FEX) [20];
- a 6-minute walk test breathing room air [21];
- a 6-minute endurance test using a step device [22], under oxygen and counting the number of steps, performed at the patient's home. This test was repeated twice at 30 minute intervals to verify its reproducibility. The values retained were those of the second assessment. Oxygen flow rates were identical for the initial and final evaluations.

Evaluation of lower limb muscle strength included:

- a timed ''Up & Go'' test [23] during which the patient rises from an armchair, walks 3 m, turns, walks back, and sits down again. The time to perform the maneuver is recorded and provides an assessment of the patient's mobility;
- a test of 10 chair stands [24].

Dyspnoea on exertion was analyzed on a Borg scale [25], performed at the beginning and the end of the 6-minute step test, the Medical Research Council (MRC) scale [26] ranging from 0 (out of breath with intense effort) to 4 (too breathless to leave the house), and the Baseline Dyspnea Index (BDI) score [27]. This score evaluated dyspnoea using three items: functional impairment, magnitude of task, and magnitude of effort. The score ranged from 0 to 12. The higher the score, the more dyspnoea had a negative influence on daily life.

The quality of life of patients was assessed using generic and specific questionnaires:

- the Short Form-36 (SF-36) [28] provides nine subscales (physical functioning, social functioning, role limitations due to physical problems, role limitations relating to emotional problems, mental health, vitality (energy/fatigue), pain, perception of general health, perception of change in health). The higher the score, the better the quality of life;
- the St George's Respiratory Questionnaire [29] evaluates the impact of respiratory disease based on three aspects: symptoms, activity, and social and psychological impact,

as well as providing an overall score. The higher the score, the more severe the handicap;
- seven visual analogue scales [30] (VAS), ranging from 0 to 10, evaluated over the last two weeks the impact of respiratory disease on daily life, treatment constraints, anxiety, breathlessness, sleep quality, physical capabilities, and sense of well-being;
- the Hospital Anxiety and Depression (HAD) scale [31] reflects the patient's psychological state in terms of depression and anxiety. The total score is the addition of the ''depression'' and ''anxiety'' components. A state of marked anxiety or depression was defined as a score above 11 for each subscale. Major depression is characterized by a total score over 19.

Rehabilitation prescription and methods

In conformity with the *Société de pneumologie de langue française* (French Society of Pneumology) recommendations for patients with COPD [8], all patients underwent prior cardiopulmonary exercise testing to establish a personalized prescription for exercise retraining. The target heart rate (HR) corresponded to HR at ventilatory threshold.

Oxygen therapy was prescribed during exercise to improve the physical performance of the patients [32] when transcutaneous oxygen saturation (SpO_2) measured during the 6-minute walk test was less than 90%. The flow rate was adjusted depending on the exercise level to obtain a SpO_2 above or equal to 90%.

Home-based pulmonary rehabilitation methods

Home-based PR was carried out for 8 consecutive weeks. A cycle ergometer was made available to the patient. A member of the rehabilitation team (nurse, physiotherapist, professor of adapted physical activity) provided personalized follow-up of the patient once a week at his home for 90 minutes, after performing a training diagnostic assessment. The retraining program lasted 30 to 45 minutes a day and included:
- endurance retraining on the cycle ergometer (Domyos VM 630): the resistance level was raised until the prescribed target HR was reached while giving preference to exercise duration. A HR monitor was used daily by the patients and weekly oximetry monitoring was performed by the team;
- muscle strengthening exercises using weights and elastic resistance bands;
- activities of daily living, walking and learning to climb stairs.

The patients learnt to recognize their dyspnoea threshold and were encouraged to carry out this daily exercise program independently. Compliance with the rehabilitation program was evaluated every week by a team member; a patient education program was also implemented with a picture folder and fact sheets.

Statistical analysis

The results are expressed as mean ± standard deviation (SD) for normally distributed quantitative variables, as medians (minimum and maximum) for abnormally distributed quantitative variables, and as numbers (%) for qualitative variables. Comparison of matched groups was performed with StatView version 4.0 software using nonparametric tests (Wilcoxon). The difference was considered to be statistically significant when $P \leq 0.05$.

Table 1 Characteristics of the population that completed the programme of pulmonary rehabilitation.

Characteristics of the population ($n = 13$)	Mean ± SD; number (%)
Age (years)	67 ± 13
Male gender	9(62%)
BMI (kg/m^2)	29 ± 5
Ischemic heart disease	2 (15%)
Diabetes	2 (15%)
Treatment with β-blockers	2 (15%)
Long-term corticosteroid therapy	6 (45%)
Dose > 20 mg prednisone	1
Dose ≤ 20 mg prednisone	5
Immunosuppressants	6 (45%)
Treatment trials	6 (45%)

Mean ± SD; number (%); Body mass index (BMI).

Results

Characteristics of the population

Seventeen patients were included during the study period. The rehabilitation programme was completed by 14 patients: three presented exacerbation of fibrosis during the study (two died), and one patient developed a gluteal abscess. No complications attributable to the PR activities were observed. The characteristics of the 13 patients that could be evaluated are summarized in Table 1. The diagnosis of IPF had been made on average 31 ± 23 months previously. All patients received oxygen therapy during exercise: the average oxygen flow rate prescribed during PR was 4 L/min. Compliance with the exercise-retraining programme was considered to be excellent.

Resting pulmonary function

Respiratory parameters did not change between the beginning and end of PR (Table 2).

Functional evaluation with exercise

Using the cycle ergometer while breathing room air, the patients showed a significantly higher endurance time after PR (7.4 ± 9.1 versus 14.1 ± 12 minutes) ($P = 0.008$) with identical SpO_2 and HR. The number of steps counted on the 6-minute test with the step device was significantly higher after PR (322 ± 97 vs. 456 ± 163) with a lower maximum HR (not significant). The distance in metres on the 6-minute walk test was identical after PR with a significant decrease in maximum HR. Thus, the same distance was covered with less increase in HR: the distance relative to the variation in HR (maximal HR with exercise less resting HR), was significantly higher after PR (11 ± 6 vs. 17 ± 12). (Table 3).

Table 2 Resting pulmonary function values.

Functional parameters	Before PR	After PR
FEV1 (L)	1.78 ± 0.63	1.81 ± 0.64
FEV1 (%)	70 ± 15	71 ± 16
DLCO (mL/min/mmHg)	7.81 ± 3.99	8.31 ± 3.86
DLCO (%)	32 ± 13	35 ± 13
FVC (L)	2.15 ± 0.79	2.19 ± 0.81
FVC (%)	67 ± 14	68 ± 15

Mean ± SD; functional vital capacity (FVC); diffusing capacity for carbon monoxide (DLCO); forced expiratory volume in one second (FEV1); pulmonary rehabilitation (PR).

After PR, there were no significant changes in the timed Up & Go test or the 10 chair stands.

Evaluation of dyspnoea

The MRC dyspnoea score was 1 for six patients, 2 for five patients, and 3 for two patients before rehabilitation. The median MRC score before PR was 1.5 (1—3) and 2 (1—3) afterwards ($P = 0.18$). The Borg dyspnoea scale evaluated during the step test was 4 (2—8) before and 3 (2—9) after PR ($P = 0.78$). Perceived dyspnoea at equal effort was lower after PR: the Borg scale relative to the number of steps using the step device revealed a significant difference before and after PR (0.017 ± 0.015 vs. 0.008 ± 0.005; $P = 0.026$). There was no significant improvement in the BDI score before or after PR (5.8 ± 1.9 and 6.0 ± 1.7; $P = 0.23$).

Evaluation of quality of life

Perceived physical limitation during exercise as described in the SF-36 decreased after PR ($P = 0.047$). No significant differences were observed for the other SF-36 parameters, the St George's Respiratory Questionnaire, or the HAD scale.

Analysis of the various VAS (Table 4) showed that patients felt less dyspnoeic and noted less impact of their respiratory disease on their daily lives. There were also improvements in the quality of their sleep and their physical abilities after PR. There were no significant differences in the VAS assessing treatment constraints, anxiety and sense of well-being. The total sum of the VAS had significantly improved after PR (38 ± 8 vs. 42 ± 12) ($P = 0.004$).

Table 3 Exercise test results ($n = 13$) before and after pulmonary rehabilitation.

Tests	Before	After	P
Cycle endurance breathing room air			
Duration (min)	7.4 ± 9.1	14.1 ± 12.1	0.008
Nadir SpO_2 (%)	86 ± 5	86 ± 7	0.400
Maximum HR (/min)	127 ± 20	129 ± 15	0.374
Endurance/ΔHR	0.149 ± 0.121	0.415 ± 0.309	0.005
6-minute walk test breathing room air			
Distance (m)	383 ± 115	375 ± 101	0.505
Nadir SpO_2 (%)	84 ± 5	84 ± 5	0.756
Maximum HR (/min)	120 ± 19	101 ± 12	0.008
Distance (m) /ΔHR	11 ± 6	17 ± 12	0.006
6-minute step test under O_2			
Borg dyspnoea	4.5 ± 1.9	3.8 ± 2.2	0.780
Borg lower limbs	3.0 ± 2.3	2.9 ± 2.1	0.594
Nadir SpO_2 (%)	90 ± 4	89 ± 4	0.097
Maximum HR (/min)	114 ± 19	106 ± 17	0.060
Number of steps	322 ± 97	456 ± 163	0.026
Number of stops	0.7 ± 1.2	0	0.109
Timed Up & Go under O_2			
Duration (min)	7.2 ± 3	6.5 ± 2	0.328
Borg dyspnoea	0.7 ± 1.2	0.6 ± 0.8	0.272
Borg lower limbs	0.2 ± 0.4	0.03 ± 0.1	0.285
Nadir SpO_2 (%)	96 ± 2	95 ± 2	0.579
Maximum HR (/min)	88 ± 17	81 ± 11	0.060
Chair stands under O_2			
Duration (s)	25 ± 7	23 ± 7	0.075
Borg dyspnoea	1.8 ± 1.7	1.8 ± 1.6	0.906
Borg lower limbs	0.3 ± 0.6	0.8 ± 1.2	0.237
Nadir SpO_2 (%)	94 ± 2	94 ± 5	0.875
Maximum HR (/min)	95 ± 16	89 ± 15	0.065

Mean ± SD; transcutaneous oxygen saturation (SpO_2); heart rate (HR).

Table 4 Quality of life questionnaires.

Questionnaires	Before	After	*P*
VAS			
Impact on everyday life	5.1 ± 2.0	4.1 ± 2.7	0.002
Treatment constraints	4.4 ± 2.3	3.9 ± 2.7	0.095
Anxiety	3.3 ± 1.8	3.9 ± 3.1	0.680
Breathlessness	5.8 ± 1.8	5.1 ± 2.4	0.025
Quality of sleep	6.2 ± 2.4	7.2 ± 1.5	0.035
Physical capabilities	5.2 ± 1.7	6.3 ± 1.6	0.028
Sense of well-being	6.2 ± 1.9	6.0 ± 1.8	0.593
Total of the VAS	38 ± 8	42 ± 12	0.004

Mean ± SD.

Discussion

This was the first prospective study on entirely home-based PR in patients with IPF. The improvement in endurance and quality of life was consistent with the few studies that have approached the issue of PR for patients with interstitial diseases [5,12–16].

Our study had limitations. The cohort was small because the study took place over a period of 10 months and the disease prevalence in the population and its severity made inclusion of patients difficult. However, conducting the study over a short period allowed homogeneous patient management. Twenty-three percent of the patients dropped out of the study because of worsening of their IPF, or concomitant events making continuation of PR impossible. Despite this, there were no complications directly related to the PR. The relationship between exacerbation of IPF (observed in three of the 17 patients) and PR requires further study even though currently available data cannot establish causality. The incidence of exacerbations did not appear to be higher than that described in the literature: 18 to 37% of the patients dropped out of the studies [5,12–16] due to death, acute exacerbation of their lung disease, or non-compliance.

Generalizing the results to other centers would be difficult as ours was a single-center study and our patients were managed by a PR team with extensive experience in home-based care. Finally, our cohort requires follow-up beyond the 8 weeks of PR. Indeed, the benefits of PR in terms of endurance and quality of life were not maintained at 6 months in the study by Holland et al. [15], and it is known that benefits are maintained for 12 to 18 months in patients with COPD [8].

In patients whose resting pulmonary function remained stable for the 8 weeks of PR, cycle ergometer endurance time, number of steps, and 6-minute walk test distance relative to HR were significantly improved after PR. HR during the walk test was lower after PR indicating improved cardiovascular adaptation to exercise. Our results were consistent with those of Holland et al. [15]: analysis of the subgroup of patients with IPF showed the improvement in walk test distance compared with control patients was not significant (25 m vs. 43 m; $P = 0.34$). But Novitch et al. [12] noted an improvement in cycle ergometer time and doubling of the walk test distance after 4 weeks of PR in a rehabilitation centre (with five 45–minute sessions per week). However, we should be careful with comparisons as these studies were mostly carried out in PR centres and none specifically concentrated on patients with IPF.

Indisputably, rehabilitation has an impact on dyspnoea on exertion, evidenced by the decrease on the Borg scale relative to the number of steps on the step device. In the study by Jastrzebski et al. [13], the authors observed a significant improvement in perceived dyspnoea on the Borg scale after PR. However, in keeping with this study [13] the MRC dyspnoea score had not changed after PR. In patients with IPF, the MRC score was correlated with disease severity [26] assessed by resting functional pulmonary parameters. But resting pulmonary function was stable after PR. MRC was thus probably not the best questionnaire to evaluate the benefits of PR on dyspnoea in patients with IPF. In a randomized controlled trial in two PR centres in Australia [15], 57 patients with restrictive disease (34 patients with IPF) had either undergone 8 weeks of PR (two sessions per week) in a center, or had telephone follow-up once a week. At the end of 8 weeks, MRC had significantly improved after PR in the retrained group versus the control group, but this was a comparison of unmatched groups.

The SF-36 and St George's Respiratory questionnaires showed a strong correlation with pulmonary function parameters in patients with interstitial diseases [33]; the SF-36 has been validated in IPF [34]. In our study, these questionnaires as well as the HAD did not reflect an improvement in quality of life. Only perceived physical limitation during exercise, a parameter from the SF-36, had improved. On the one hand, this could be due to our small cohort. On the other hand, these assessment tools were probably not all appropriate in the context of PR for patients with IPF. In studies that used the same questionnaires, only a few parameters had significantly improved. Thus, in the study by Jastrzebski et al. [13], some items from the St George's Respiratory Questionnaire (activity, social and psychological impact and total score), and the SF-36 (physical impact, vitality, mental health, social impact) had significantly improved. In the study by Naji et al. [14], only the depression component of the HAD improved, without modifications in the St George's Respiratory Questionnaire after PR. In our study the VAS showed significant improvements in some parameters of everyday life. Simple tools such as VAS

offer an alternative to ''standard'' questionnaires because they are easily understood by patients and quickly implemented.

In conclusion, entirely home-based PR is feasible and provides short-term benefits in patients with IPF, subject to compliance with the contraindications, in particular cardiovascular, and preparation of a personalized prescription for an exercise-retraining programme. Home-based PR is as safe as in a centre. The absence of complications due to PR, the gain in quality of life and improved exercise tolerance are arguments for including PR early in the treatment armamentarium and in the overall management of patients with IPF.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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