Long-Term Benefits of Exercise Maintenance After Outpatient Rehabilitation Program in Patients With Chronic Obstructive Pulmonary Disease

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Background. *Optimal strategies to maintain short-term benefits of an initial rehabilitation program (RP) are not known. To assess the long-term effects of exercise maintenance (EM) after an initial outpatient RP, the authors conducted a prospective study.*

Patients and Methods. *Fifty-eight patients with moderate to moderately severe chronic obstructive pulmonary disease who completed an initial 7-week outpatient RP were included. They were allocated into four groups according to the conditions of EM they self-selected: 15 patients received a structured EM session supervised by a physiotherapist twice a week (group A); 14 patients received a structured EM session supervised by a physiotherapist once a week (group B); 15 patients continued self EM daily at home (group C); and 14 patients did not continue EM (group D). Patients were evaluated before, immediately after, and 18 months after the initial outpatient RP. Measurements included exercise testing on a cycle ergometer and a visual analog scale to evaluate chronic dyspnea.*

Results. *After RP, all patients exhibited improvements in maximal workload ($P < 0.05$) and in dyspnea ($P < 0.05$). Improvements in maximal workload were maintained at 18 months in patients in groups A, B, and C but these only reached significance in groups B and C ($P < 0.05$). On the other hand, maximal workload returned to baseline values in group D ($P = 0.01$) at 18 months.*

Conclusion. *Our results indicate definite benefits of EM after an initial outpatient RP compared with no EM. Daily EM at home appears to be as efficient as structured EM sessions supervised by a physiotherapist, once or twice a week, in moderate to moderately severe chronic obstructive pulmonary disease.*

Key words: chronic obstructive pulmonary disease, exercise maintenance, exercise tolerance, respiratory rehabilitation.

Pulmonary rehabilitation is now recognized as an effective treatment option in patients with chronic obstructive pulmonary disease (COPD). Several studies have reported short-term benefits of pulmonary rehabilitation in COPD in terms of exercise tolerance and health-related quality of life, whether this rehabilitation was conducted in hospital, in outpatient structures, or at home.[1–7] However, long-term outcome of these parameters after pulmonary rehabilitation remain unclear. In fact, few studies followed patients with COPD over the long-term. Those that did tended to show that benefits of pulmonary rehabilitation were maintained partially after initial rehabilitation program (RP) over 6 to 18 months, although they tended to decrease afterward without maintenance program.[8–19]

The maintenance of short-term benefits after RP appears to be the true challenge. So far, the beneficial effect of structured postrehabilitation exercise maintenance (EM) remains unproven. Evidence for benefits of home EM after completion of an initial home-based RP have emerged recently.[20–22] However, optimal strategies to conduct EM sessions are not known in terms of frequency, intensity, and supervision (self EM at home or structured EM sessions supervised by a physiotherapist). The purposes of this study were: first, to evaluate the long-term effects (18 months) of EM after the completion of a RP in patients with COPD; second, to determine the optimal conditions of EM after RP in COPD.

To establish this, we initiated a prospective study in patients with COPD that self-selected their maintenance program. We compared four different types of long-term (18 months) follow-up after an initial outpatient RP: structured EM sessions supervised by a physiotherapist twice a week for 18 months, structured EM session supervised by a physiotherapist once a week, daily self EM at home, and no EM. We investigated the effects of EM on pulmonary function, exercise tolerance, and dyspnea.

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Patients and Methods

Patients

Seventy-one patients with COPD defined as moderate to moderately severe (according to American Thoracic Society criteria) were studied.[23–24] They all met the following criteria: dyspnea on exertion limiting activities of daily living, postbronchodilator forced expiratory volume in one second (FEV_1) less than 70% of predicted values, respiratory stable condition with optimal drug management, and no evidence of ischemic heart disease or musculoskeletal disorders. All patients gave informed consent.

Study Design

The present study was a prospective nonrandomized trial. In an initial screening visit, patients were tested for pulmonary function, gas exchanges, exercise testing, and a visual analog scale for evaluation of chronic dyspnea. Patients started a hospital-based outpatient RP for 7 consecutive weeks, 3 days a week for 2 hours each day. Toward the end of hospital outpatient respiratory rehabilitation, all patients were instructed to practice daily exercises individually for at least 30 minutes at home. In addition, structured postrehabilitation EM sessions (in the structure where initial RP took place, supervised by one physiotherapist) were available, either once a week or twice a week for 2 hours. The patients chose the conditions of postrehabilitation EM. Exercise maintenance compliance was assessed 3 months after the completion of initial RP during a visit to the chest physician in all patients. Therefore, patients were allocated into four groups according to postrehabilitation EM. Group A included patients who continued structured EM-sessions twice a week for 18 months after the initial RP. Group B included patients who continued structured EM sessions once a week for 18 months after RP. Group C included patients who only practiced daily EM individually at home for 18 months after RP. Group D included patients who did not continue EM within 3 months after RP.

Rehabilitation Program

Outpatient respiratory RP was conducted at a rehabilitation hospital. The program comprised three sessions per week over a period of 7 weeks, with as many as 6 patients per session being supervised by two physiotherapists and one pulmonary physician. Each session spanned a 2-hour period and consisted of the following components:

- Patient education about the course of the disease and optimal medications use in COPD;
- Coughing techniques;
- Progressive muscle relaxation;
- Breathing retraining to improve thoracic and abdominal synchronization; and
- Exercise reconditioning.

Exercise reconditioning incorporated lower limb exercises such as walking and cycle ergometry. Endurance training intensity on the bicycle initially was targeted at a workload corresponding with the patient's ventilatory threshold. Exercise intensity was increased gradually as tolerated and time span at this intensity level progressively extended from 30 to 45 minutes during the RP. During the sessions, oxygen saturation (SaO_2) was monitored and additional oxygen was provided if SaO_2 fell below 90%.

After the completion of the program, all patients received instructions to continue the exercises at home once a day for 30 minutes. The intensity of these exercises were individualized based on postoutpatient respiratory RP performances and progress during training sessions. Patients were instructed to adjust the training intensity on heart beat, as measured at ventilatory threshold during exercise testing at the end of RP. In addition, all patients were proposed to participate in a structured EM program, either once or twice a week. These EM sessions were supervised by one physiotherapist and spanned a 2-hour period in the structure where initial RP took place. The format of exercise training in the EM sessions was similar to initial RP, with the intensity and duration adjusted to the patients' performances toward the completion of initial RP and progress during training sessions.

Outcome Measures

Patient follow-up included three pulmonary assessments. Each assessment comprised pulmonary function (at baseline and at 18 months), gas exchanges, exercise testing, and a visual analog scale for evaluation of dyspnea. Measurements were performed during the initial screening visit, at the end of the hospital-based outpatient rehabilitation program, and at the end of the 18 month-follow up period.

Pulmonary Function Testing. FEV_1 was obtained from flow volume curves using a Medgraphics spirometer (Medical Graphics Corp., St. Paul, MN). Total lung capacity was measured using body plethysmograph (Medical Graphics Corp., St. Paul, MN). All data were expressed in absolute values or in percentage of predicted normal values.

Exercise Testing. Exercise testing was an incremental symptom-limited test and was performed on an electronically braked cycle ergometer (Ergoline 900, Sensor Medics, Bunnik, Netherlands). The patients breathed through a mouthpiece and wore a nose clip during the test. Incremental protocol was determined depending on an estimate of the patient's exercise tolerance, based on the calculation of the patient maximal voluntary ventilation,[25] with the goal that the incremental phase lasts 10 ± 2 minutes. Cycling started at a workload of 20 W. Workload was increased every minute by 5 to 10 W in 10 ± 2 minutes, until the maximum attainable load was reached. Patients were instructed to stop when they could not continue because of dyspnea or general fatigue. The maximal workload-symptom limited ($Wmax_{SL}$) was defined as the highest work level reached and maintained for a full minute. Expired minute ventilation (V_E) was measured by a pneumotachograph (Hans Rudolph, Kansas City, MO). Oxygen uptake (VO_2) and carbon dioxide production (VCO_2) were measured breath by breath by rapid analyzers (Med Graphics Desktop Diagnostics, St. Paul, MN). Ventilatory threshold was determined as previously described.[26] Electrocardiographic monitoring for heart rate (HR) was carried out continuously as was monitoring of oxygen saturation by ear oximetry (Mallinckrodt, Pleasanton, CA) and blood pressure. At rest and at maximal exercise, arterial blood samples were taken for analysis of blood gas tensions (oxygen pressure [PaO_2] and partial pressure of carbon dioxide [$PaCO_2$]).

Visual Analog Score. At each pulmonary assessment, dyspnea was evaluated. Patients rated dyspnea on a visual analog scale,[27] which was presented to the subject as a 10-cm horizontal line that was rated from 0 to 10. The subject was asked to rate the level of dyspnea (0 = none; 10 = extremely severe).

Statistical Analysis

Results were expressed as mean ± SD. First, multiple analysis of variance (MANOVA) was applied for multiple comparisons between the four groups. When a significant F test for variable was obtained, a Bonferroni-Dunn post-hoc comparisons test was carried out. Second, MANOVA was used for within-groups comparisons. When a significant F test within a group was obtained, Student's paired *t* tests were carried out. Significant level was set at $P < 0.05$.

Table 1. ***Baseline Characteristics***

	Group A	*Group B*	*Group C*	*Group D*	*ANOVA**
No. of patients	15	14	15	14	NS
Age (years)	60.8 ± 6.9	62.1 ± 5.9	62.7 ± 6.1	63.2 ± 6.6	NS
Gender (F/M)	4/11	4/10	1/14	2/12	NS
BMI	25.9 ± 4.1	27.8 ± 5.7	25.9 ± 5.2	24.9 ± 3.3	NS
Pulmonary function					
FEV_1 (L)	1.33 ± 0.7	1.43 ± 0.4	1.43 ± 0.4	1.44 ± 0.5	NS
FEV_1 (% predicted)	48.9 ± 21	48.5 ± 15	49.7 ± 15.8	49.3 ± 17.8	NS
TLC (% predicted)	111.9 ± 25.3	112 ± 17.7	114.3 ± 18.5	107 ± 28.3	NS
Resting values					
PaO_2 (mm Hg)	72.0 ± 7.2	76.3 ± 9.4	82.1 ± 7.5†	76.4 ± 9.7	0.003
$PaCO_2$ (mm Hg)	41.9 ± 4.3	40.1 ± 2.9	38.6 ± 3.2	40.8 ± 7.3	NS
VO_2 (ml/kg/mn)	4.5 ± 0.9	4.4 ± 0.8	4.3 ± 1.2	4.7 ± 0.9	NS
VE (L/mn)	13.5 ± 3	14.2 ± 3.8	15.0 ± 3.1	14.9 ± 2.6	NS
RR (cycles/min)	16.6 ± 3.8	18.8 ± 4.2	17.5 ± 4	18.6 ± 5.6	NS
VT (L)	0.84 ± 0.2	0.78 ± 0.2	0.89 ± 0.2	0.86 ± 0.3	NS
HR (beat/min)	91.3 ± 13.4	88.1 ± 12.3	90.4 ± 16.8	93.0 ± 13.6	NS
VAS					
Dyspnea	6.3 ± 3.1	5.1 ± 2.7	3.8 ± 2.8	3.6 ± 1.9	NS

Values are expressed as mean ± SD.
ANOVA: analysis of variance; BMI: body mass index; EM: exercise maintenance; RP: rehabilitation program; FEV_1: forced expiratory volume in one second; TLC: total lung capacity; VO_2: oxygen uptake; VE: expired minute ventilation; RR: respiratory rate; VT: tidal volume; HR: heart rate; VAS: visual analog scale.
Group A: structured EM-session supervised by a physiotherapist twice a week after RP. Group B: structured EM-session supervised by a physiotherapist once a week after RP. Group C: daily EM at home after RP. Group D: no EM after RP.
*Value of ANOVA for between-group analysis.
†$P < 0.05$, statistically different from group A.

Results

Baseline Characteristics

Seventy-one patients completed the hospital-based outpatient RP. Thirteen (18%) dropped out during follow-up. Thus, 58 patients were available for analysis: 15 in group A (structured EM sessions twice a week after RP); 14 in group B (structured EM sessions once a week after RP); 15 in group C (daily self-EM at home after RP); and 14 in group D (no EM after RP). Baseline characteristics of the 58 patients are summarized in Table 1. There were no significant differences between the four groups in terms of age, sex, and body mass index.

Characteristics of the 13 patients who dropped out during the 18-month follow-up are disclosed in Table 2. They withdrew for the following reasons:

- Five patients died (3 of respiratory failure, 2 of bronchial carcinoma: 1 in group A, 2 in group B, 1 in group C, and 1 in group D);
- Four withdrew because of lack of motivation to continue (1 patient in each group); and
- Four dropped out because of unrelated diseases (1 car accident in group A, 1 ischemic heart disease in group B, 1 nasopharyngeal carcinoma in group C, and 1 bladder carcinoma in group D). Clinical data, baseline function, gas exchange, and exercise tolerance did not differ between the dropouts and the four other groups of patients under study at baseline and after the initial outpatient RP (Table 2).

Gas Exchanges and Pulmonary Function

At baseline, there was no significant difference in pulmonary function (FEV_1 and total lung capacity) between the four groups (Tables 1 and 3). PaO_2 was significantly higher in group C than in group A. $PaCO_2$ was not different between the four groups.

Within group analyses showed a significant decrease in FEV_1 ($P = 0.01$) in group D at 18 months, whereas it remained unchanged in the three remaining groups. PaO_2 remained stable in the four groups at all time points of the follow-up. Moderate decrease of $PaCO_2$ was observed in group A after RP, which

Table 2. ***Characteristics of the 13 Drop-out Patients at Baseline and After Rehabilitation Program***

	*Baseline**	*After Rehabilitation Program**	*F Test†*	*P†*
Age (years)	65.6 ± 5.5			
Sex (F/M)	3/11			
BMI	25.2 ± 3.7			
FEV_1 (L)	1.36 ± 0.25			
FEV_1 (%)	48.1 ± 9.1			
TLC (%)	113.1 ± 20.9			
PaO_2 (mm Hg)	76.0 ± 7.0	76.2 ± 7.0	0.48	0.53
$PaCO_2$ (mm Hg)	39.5 ± 3.9	39.5 ± 3.6	0.88	0.93
Ventilatory threshold				
Watts	44.9 ± 13.3	56.2 ± 19.6	11.6	0.007
VO_2 (ml/kg/mn)	11.1 ± 2.1	12.3 ± 0.8	3.7	0.08
VE (L/mn)	26.3 ± 7.6	28.9 ± 7.3	3.2	0.10
HR (beat/mn)	103.3 ± 11.3	105.7 ± 14.2	1.0	0.35
Maximal workload				
Watts	85.1 ± 20.5	100.2 ± 21.4	14.9	0.003
VO_2 (ml/kg/mn)	15.9 ± 3.8	17.8 ± 3.7	7.5	0.019
VE (L/mn)	45.6 ± 14.3	50.1 ± 15.1	4.1	0.07
HR (beat/mn)	128.1 ± 17.3	130.4 ± 18.2	1.7	0.20
Dyspnea score	4.0 ± 1.2	3.5 ± 1.1	2.84	0.14

Values are expressed as mean ± SD.

RP: rehabilitation program; BMI: body mass index; FEV_1 forced expiratory volume in one second; TLC: total lung capacity; VO_2: oxygen uptake; VE: expired minute ventilation; HR: heart rate.

*ANOVA between groups analysis (between drop-out patients and groups A, B, C, and D whom results are disclosed in Tables 1,3,4,5,6) showed no significant difference at baseline and after RP.

†Value of MANOVA for comparisons between baseline and after RP.

Table 3. ***Lung Function and Gas Exchanges***

	Baseline	After Rehabilitation Program	18 Months	F-Test*	P*
Group A					
FEV_1 (%)	48.9 ± 21	ND	44.4 ± 20.1	—	0.540
PaO_2 (mm Hg)	72.2 ± 7.2	72.0 ± 6.9	74.1 ± 10.1	1.124	0.349
$PaCO_2$ (mm Hg)	41.9 ± 4.3	40.4 ± 4.7†	43.4 ± 4.7	4.082	0.050
Group B					
FEV_1 (%)	48.5 ± 15	ND	49.0 ± 12.6	—	0.690
PaO_2 (mm Hg)	76.3 ± 9.4	75.7 ± 10.7	77.0 ± 13.2	0.149	0.862
$PaCO_2$ (mm Hg)	40.1 ± 2.9	40.5 ± 1.7	41.9 ± 3.5	0.268	0.768
Group C					
FEV_1 (%)	49.7 ± 15.8	ND	54.8 ± 20.3	—	0.710
PaO_2 (mm Hg)	82.1 ± 7.5§	82.4 ± 7.0	84.3 ± 8.3	0.617	0.553
$PaCO_2$ (mm Hg)	38.6 ± 3.2	38.5 ± 3.7	40.4 ± 4.6	1.779	0.218
Group D					
FEV_1 (%)	49.3 ± 17.8	ND	38.8 ± 12.7‡	—	0.010‡
PaO_2 (mm Hg)	76.4 ± 9.7	75.1 ± 11.3	75.8 ± 11.2	0.233	0.794
$PaCO_2$ (mm Hg)	40.8 ± 7.3	42.0 ± 7.9	40.3 ± 9.7	0.513	0.609

Values are expressed as means ± SD.
ND: no difference; EM: exercise maintenance; RP: rehabilitation program; T18: values after 18 months of follow-up.
Group A: structured EM-session supervised by a physiotherapist twice a week after RP. Group B: structured EM-session supervised by a physiotherapist once a week after RP. Group C: daily EM at home after RP. Group D: no EM after RP.
*Value of MANOVA repeated measures for within-groups comparisons.
†$P < 0.05$, difference between after RP and baseline.
‡P value of Student's paired t test between FEV_1 at baseline and FEV_1 at 18 months.
ANOVA between groups analysis showed no significant difference between groups after RP and at 18 months.
§$P < 0.05$, different from group A.

returned to baseline value at 18 months. $PaCO_2$ did not change in the other groups.

Between-group analyses showed that FEV_1, PaO_2, and $PaCO_2$ were not significantly different between the four groups after RP and at 18 months.

Bicycle Ergometer Test

Resting Values. VO_2, V_E, respiratory rate, tidal volume, and heart rate at rest were not different between the four groups at baseline (Table 1), after RP and at 18 months (data not shown).

Ventilatory Threshold. At baseline, workload, VO_2, V_E, respiratory rate, and heart rate at ventilatory threshold were similar in the four groups (Table 4).

Within-group analyses showed a significant increase of workload value in group C and in group D after RP. In group A and in group B, the improvement of workload value after RP did not reach statistical significance. At 18 months, workload value moderately decreased in comparison with after RP value in groups A, B, and C but remained slightly higher than at baseline (not significant). Workload at ventilatory threshold significantly decreased at 18 months in group D in comparison with baseline and after RP values.

Between-group comparisons showed no significant difference between the four groups after RP. At 18 months, between-group analysis demonstrated that workload was lower in group D than in group B and that V_E was lower in group D than in group C.

Maximal Workload. At baseline, the patients exhibited a ventilatory limitation in their exercise capacity (Table 5), as assessed by the ventilation at maximal workload, which was close to maximal voluntary ventilation ($37.5 \times FEV_1$).[25] All measurements at $Wmax_{SL}$ were comparable in the four groups at baseline.

Within-group comparisons showed a significant increase in $Wmax_{SL}$ value after RP in the four groups. This improvement remained sustained at 18 months in groups A, B, and C. Long-term improvements of

Table 4. ***Results of Bicycle Ergometer Test at Ventilatory Threshold***

	Baseline	*After Rehabilitation Program*	*18 Months*	*F Test**	*P**
Group A					
Watts	50.6 ± 12.4	53.2 ± 21.5	50.9 ± 19.7	0.869	0.434
VO_2 (ml/kg/mn)	11.0 ± 2.4	11.0 ± 3.3	11.5 ± 3.0	0.967	0.397
VE (L/mn)	27.2 ± 5.6	27.6 ± 9.0	26.4 ± 5.5	1.817	0.188
RR (cycles/mn)	24.5 ± 4.7	24.4 ± 6.4	23.7 ± 6.8	0.036	0.964
HR (beat/mn)	105.8 ± 12.9	110.9 ± 10.3†	105.8 ± 9.7	3.748	0.041
Group B					
Watts	59.2 ± 25.1	67.1 ± 32.5	64.7 ± 32.1	1.238	0.309
VO_2 (ml/kg/mn)	12.1 ± 2.9	12.8 ± 3.7	12.6 ± 3.6	0.397	0.677
VE (L/mn)	27.8 ± 8.3	30.2 ± 9.2	27.8 ± 5.4	0.777	0.471
RR (cycles/mn)	23.6 ± 6.7	23.6 ± 6.2	24.7 ± 4.8	1.082	0.356
HR (beat/mn)	109.0 ± 10.7	107.9 ± 13.2	105.0 ± 14.9	0.241	0.787
Group C					
Watts	51.6 ± 16.2	60.5 ± 14.5†	53.6 ± 13.7	4.070	0.030
VO_2 (ml/kg/mn)	11.8 ± 3.1	12.7 ± 3.2	13.3 ± 3.5	2.136	0.140
VE (L/mn)	29.4 ± 6.4	30.6 ± 7.9	30.8 ± 5.3	0.065	0.937
RR (cycles/mn)	22.6 ± 7.0	20.5 ± 6.8	20.0 ± 5.7	1.264	0.302
HR (beat/mn)	104.3 ± 15.8	106.6 ± 15.9	106.1 ± 8.3	0.324	0.726
Group D					
Watts	43.2 ± 14.7	57.1 ± 18.1†	40.0 ± 10.6‡	5.100	0.017
VO_2 (ml/kg/mn)	10.9 ± 2.8	11.6 ± 2.8	11.0 ± 2.2	0.702	0.508
VE (L/mn)	28.0 ± 6.0	29.7 ± 6.9	24.4 ± 2.6‡§	4.723	0.022
RR (cycles/mn)	21.4 ± 6.6	21.0 ± 5.6	22.3 ± 4.7	0.111	0.895
HR (beat/mn)	107.8 ± 18.5	108.9 ± 20.7	107.0 ± 8.7	1.109	0.351

EM: exercise maintenance; RP: rehabilitation program; T18: values after 18 months of follow-up; VO_2: oxygen uptake; VE: expired minute ventilation; RR: respiratory rate; HR: heart rate.
Group A: structured EM-session supervised by a physiotherapist twice a week after RP. Group B: structured EM-session supervised by a physiotherapist once a week after RP. Group C: daily EM at home after RP; Group D: no EM after RP.
*Value of MANOVA repeated measures for within-groups comparisons.
†$P < 0.05$, difference between after RP and baseline.
‡$P < 0.05$, difference between 18 months and baseline.
§$P < 0.05$, difference between 18 months and after RP.
ANOVA between groups analysis showed no significant difference between groups at baseline and after RP.
ANOVA between groups analysis at 18 months disclosed the following differences. Watts: $F = 3.272$; $P < 0.05$ (Bonferroni post-hoc comparison between group B and group D < 0.005); VE: $F = 4.496$, $P < 0.01$ (Bonferroni post-hoc comparison between group C and group D < 0.001).

$Wmax_{SL}$ reach statistical significance only in group B and group C ($P < 0.05$). In group A, $Wmax_{SL}$ moderately decreased at 18 months in comparison with after RP value, but this value remained higher than at baseline (nonsignificant). $Wmax_{SL}$ significantly decreased at 18 months in group D in comparison with after RP values and was lower than at baseline, although this difference was not statistically significant. VO_2 tended to improve in the four groups after RP. It reached statistical significance only in group C. Improvements of VO_2 tended to remain improved in groups A, B, and C, whereas it tended to decrease in group D. In addition, V_E significantly increased in group A and in group D after RP. V_E returned to baseline values in group A at 18 months, whereas it significantly decreased in group D in comparison with after RP values.

Between-group analysis showed no difference between the four groups after RP. At 18 months, maximal workload was significantly lower in group D than in group B ($P < 0.005$). At 18 months, V_E was lower in group D than in group C. VO_2, respiratory rate, and heart rate were similar in the four groups at 18 months.

Table 5. ***Results of Bicycle Ergometer Test at Maximal Workload***

	Baseline	*After Rehabilitation Program*	*18 Months*	*F Test**	*P**
Group A					
$Wmax_{SL}$	83.7 ± 25.9	101.3 ± 33.3†	91.5 ± 29.5	5.080	0.013
VO_2 (ml/kg/mn)	16.4 ± 5.1	17.9 ± 5.7	18.0 ± 5.2	2.025	0.150
VE (L/mn)	42.5 ± 15.1	49.6 ± 17.4†	46.1 ± 16.4	4.007	0.029
RR (cycles/mn)	34.0 ± 8.0	37.0 ± 6.4	36.0 ± 9.3	1.072	0.356
HR (beat/mn)	127.5 ± 12.8	134.0 ± 9.9	128.1 ± 15.4	1.600	0.219
Group B					
$Wmax_{SL}$	96.9 ± 38.9	111.7 ± 51.7†	117.4 ± 50.2‡	6.572	0.005
VO_2 (ml/kg/mn)	17.7 ± 5.8	18.3 ± 6.4	19.4 ± 6.1	1.483	0.247
VE (L/mn)	48.0 ± 13.1	50.2 ± 16.2	52.2 ± 12.3	1.747	0.195
RR (cycles/mn)	33.0 ± 6.0	35.0 ± 8.0	38.0 ± 7.4‡§	6.690	0.005
HR (beat/mn)	129.6 ± 20.8	135.7 ± 21.4	138.1 ± 20.0	1.341	0.280
Group C					
$Wmax_{SL}$	86.6 ± 26.7	101.0 ± 28.3†	104.0 ± 24.7‡	4.722	0.017
VO_2 (ml/kg/mn)	16.7 ± 5.2	18.6 ± 4.9†	20.2 ± 4.4‡	6.243	0.006
VE (L/mn)	48.0 ± 16.8	52.0 ± 16.1	58.8 ± 15.7	1.878	0.173
RR (cycles/mn)	31.0 ± 10.2	29.0 ± 8.7	30.0 ± 7.0	0.696	0.509
HR (beat/mn)	127.0 ± 15.8	129.9 ± 12.8	131.9 ± 13.7	0.618	0.546
Group D					
$Wmax_{SL}$	82.0 ± 22.9	98.6 ± 29.9†	76.8 ± 25.4§	7.985	0.002
VO_2 (ml/kg/mn)	16.1 ± 3.1	17.2 ± 4.9	16.5 ± 4.4	0.508	0.608
VE (L/mn)	44.4 ± 11.8	52.7 ± 17.6†	39.4 ± 12.5§	6.962	0.004
RR (cycles/mn)	28.0 ± 6.0	33.0 ± 8.9	32.0 ± 7.0	2.682	0.092
HR (beat/mn)	129.0 ± 18.1	132.8 ± 17.2	125.7 ± 14.9	1.101	0.378

EM: exercise maintenance; RP: rehabilitation program; T18: values after 18 months of follow-up; $Wmax_{SL}$: maximal workload symptom limited; VO_2: oxygen uptake; VE: expired minute ventilation; RR: respiratory rate; HR: heart rate.
Group A: structured EM-session supervised by a physiotherapist twice a week after RP. Group B: structured EM-session supervised by a physiotherapist once a week after RP. Group C: daily EM at home after RP. Group D: no EM after RP.
*Value of MANOVA repeated measures for within-groups comparisons.
†$P < 0.05$, difference between after RP and baseline.
‡$P < 0.05$, difference between 18 months and baseline.
§$P < 0.05$, difference between 18 months and after RP.
ANOVA between groups analysis showed no significant difference between groups at baseline and after RP.
ANOVA between groups analysis at 18 months disclosed the following differences. Watts: F = 3.698; $P < 0.05$ (Bonferroni post-hoc comparison between group B and group D < 0.005); VE: F = 4.782, $P < 0.005$ (Bonferroni post-hoc comparison between group C and group D < 0.001).

Visual Analog Scales

At baseline, chronic dyspnea tended to be higher in group A than in groups C and D, but this difference did not reach significance (Table 1). Chronic dyspnea significantly decreased after RP in all patients (Figure 1) ($P < 0.05$) and remained improved at 18 months.

Within-group analyses showed no significant changes in chronic dyspnea in the four groups (Table 6), although it tended to be lower after RP. Between-group analyses showed no significant differences in dyspnea between the four groups at all time points.

Discussion

The current study confirms the previous findings that patients with COPD derived short-term benefits from outpatient RP in terms of exercise tolerance, dyspnea, and physical performances. In addition, our findings indicate definite benefits of exercise maintenance after initial RP. Indeed, we demonstrated that short-term benefits of initial RP were maintained at 18 months in terms of exercise tolerance and maximum exercise capacity in patients receiving EM after RP,

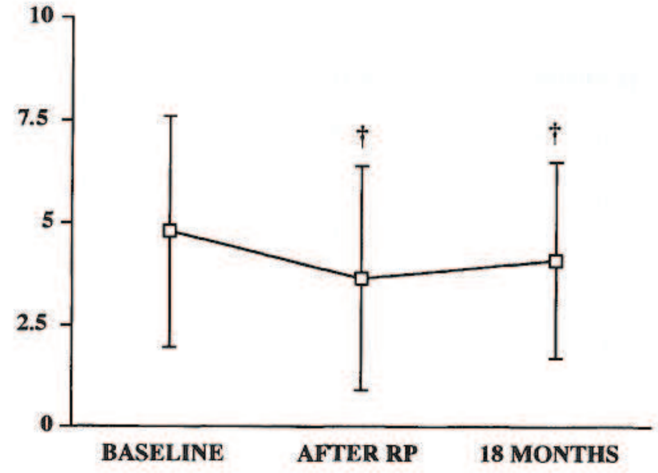

Figure 1. Chronic dyspnea in the 58 patients. Chronic dyspnea was assessed on a visual analog scale (0 = none; 10 = extremely severe). RP: rehabilitation program. $P < 0.05$, when compared with baseline values.

whether EM was conducted daily at home or was supervised once or twice a week by a physiotherapist. On the other hand, we displayed a deterioration in exercise tolerance at 18 months in patients who did not continue EM after initial RP.

Our results concerning short-term benefits of outpatient RP on dyspnea and on objective parameters as measured during exercise testing are in accordance with previous studies.[1–7] A recent meta-analysis of 14 randomized controlled trials of respiratory rehabilitation in patients with COPD concluded that the overall short-term effects of RP (either inpatient, outpatient, or home-based RP) were positive in terms of increased maximal exercise capacity.[28] In the same line, all the randomized studies that have evaluated dyspnea as an outcome have shown a significant improvement in perceived dyspnea in treated patients after RP.[29,30]

At 18 months, our findings are in favor of post-RP EM in comparison with no EM. Both objective and subjective criteria tended to remain improved in the groups of patients who continued EM (groups A, B, and C), whereas they tended to worsen in the group of patients with no EM (group D). Our results concerning long-term benefits of post-RP EM are of importance because the majority of previous studies demonstrated that improvement of exercise tolerance after RP tended to diminish over 6 to 18 months without treatment maintenance. Few prospective studies have evaluated the long-term effects of EM after RP on objective parameters, especially after outpatient RP. Vale et al.[20] failed to demonstrate difference in exercise tolerance between patients who participated in a weekly post-RP EM-session and patients who did not approximately 11 months after a 6-week outpatient RP. However, in this study, there was a large dropout rate in the group of patients who chose not to receive EM after initial RP. More recently, Wijkstra et al.[21,22] conducted two randomized controlled studies to assess long-term benefits of home rehabilitation in patients with COPD. Their results were clearly in favor of long-term EM. They showed a sustained improvement in quality of life at 18 months in patients receiving once monthly or once weekly physiotherapy session after a 12-week home-based RP in comparison with patients who did not receive rehabilitation. On the other hand, they demonstrated a significant decrease in walking distance as well as a deterioration in maximal workload at 18 months in patients who did not receive rehabilitation at all. In the present study, we found that the improvement of maximum exercise capacity after initial RP was maintained and even tended to improve at 18 months, especially in group B and C. In addition, oxygen uptake at maximal workload was increased at 18 months compared with baseline in patients who continued daily EM at home. At ventilatory threshold, improvement in workload level after RP tended to wane over 18 months; however, it remained higher than at baseline in patients receiving EM. On the other hand, we displayed a marked deterioration in exercise parameters at maximal workload as well as at ventilatory threshold at 18 months in patients who did not continue EM. These findings support the concept that exercise performances are directly related to daily activities and that a reduction of training level is associated with a progressive loss of maximal oxygen uptake, suggesting that daily activities are of crucial importance to maintain or improve exercise performance.[31–33]

In our prospective study, the patients were allowed to choose the conditions of EM after the initial outpatient RP, which was similar in the four groups. Self-selection of EM may represent a bias, especially regarding patients' levels of motivation, but it is a more realistic picture of what patients do. We cannot exclude the fact that patients with the least motivation for EM have stopped EM quickly (group D), whereas the others may have opted for long-term EM. On the other hand, it is of interest to notice that patients who declined to participate in EM tended to demonstrate at baseline a more severe impairment of exercise testing parameters, both at ventilatory threshold and at maximal workload. Although between-group comparisons did not show statistical difference, it may be hypothesized that this more severe impairment of exercise capacities in patients in group D have affected their choice of EM regimen, toward no EM. However, although our study is not strictly comparable with previous studies, we reached similar results and drew the same conclusions: first, in the way that EM may help maintaining short-term benefits of initial

Table 6. *Dyspnea Scores (Visual Analogic Scale)*

	Baseline	*After Rehabilitation Program*	*18 Months*	*F Test**	*P**
Group A	6.3 ± 3.1	3.7 ± 3.1	4.6 ± 2.4	2.438	0.119
Group B	5.1 ± 2.7	4.6 ± 3.5	5.2 ± 2.9	0.495	0.617
Group C	3.8 ± 2.8	2.9 ± 2.1	3.0 ± 2.0	1.085	0.357
Group D	3.6 ± 1.9	3.3 ± 1.8	3.5 ± 1.8	1.084	0.369

EM: exercise maintenance; RP: rehabilitation program.
Values are expressed as means ± SD.
Group A: structured EM-session supervised by a physiotherapist twice a week after RP. Group B: structured EM-session supervised by a physiotherapist once a week after RP. Group C: daily EM at home after RP. Group D: no EM after RP.
*Value of MANOVA repeated measures for within-groups comparisons.
ANOVA between groups analysis showed no significant difference between groups at baseline, after RP and at 18 months.

RP, second that no EM is associated with a rapid deterioration of exercise testing parameters.

The long-term benefits of respiratory rehabilitation on subjective parameters such as dyspnea are more controversial. Recent studies have evaluated the outcome of quality of life (QOL) or dyspnea over 6 to 18 months after RP without a post-RP maintenance program. They demonstrated that benefits of initial RP were maintained partially over 6 to 18 months after discharge and tended to diminish later on.[12,14] In addition, Ketelaars et al.[15] suggested that RP had differential effects on QOL, regarding patients' QOL scores before RP. The author demonstrated that the patients with initial poor QOL showed little improvement during RP and remained severely impaired in long-term, whereas patients with moderate QOL impairments exhibited the greatest declines on long-term follow-up, despite substantial QOL gains after RP.[15] Alternatively, Strijbos et al.[16] showed that a 12-week home-based RP and a 12-week outpatient hospital-based RP, which were not followed by a supervised EM program, were both associated with a sustained improvement in general well-being at 18 months, whereas sustained improvement in maximal workload level was only achieved in the first group. The effects of post-RP EM on QOL or dyspnea also are unclear. Vale et al.[20] did not display significant difference in terms of QOL between patients participating weekly to post-RP EM and patients who did not follow post-RP EM. Nevertheless, Wijkstra[21] showed long-term improvements at 18 months in QOL in patients who received once monthly physiotherapy session after a 12-week home-based RP.

In the current study, considering our 58 patients, dyspnea on daily activities remained improved at 18 months. However, considering each group, the improvement of dyspnea after initial RP tended to wane over the 18-month period, especially in group A and group B (patients who participated in a structured EM). In contrast, daily self-EM at home (group C) was not associated with a deterioration in dyspnea score at 18 months as it remained almost unchanged at 18 months. It may be anticipated that this result concerning long-term outcome of dyspnea after RP is related directly to the patients' motivation level for EM. Patients who were highly motivated may have chosen daily unsupervised EM and patients with low motivation may have opted for no EM, whereas patients with intermediate level of motivation may have chosen the supervised EM. Patients in group C have perhaps trained more than did patients in groups A and B. This finding was noted by Strijbos:[16] he reported that patients who received an initial home-care rehabilitation spent more time performing the unsupervised exercise after the completion of the program, as reported in their diary cards, than those who received an initial hospital outpatient rehabilitation. It is of interest to notice that patients in group D exhibited the lowest score in dyspnea at baseline and that this score remained stable during follow-up, even after RP. Thus, we raised the hypothesis that patients in whom dyspnea was low initially and did not improve after RP discontinue EM, as they did not derive benefits over RP.

Similar to other studies, we reported no change in gas exchanges and lung function in patients who continued EM after an initial RP. However, we observed a significant decrease in FEV_1 in patients who did not continue post-RP EM. Such decline of FEV_1 may not be attributable solely to physiological decrease in FEV_1 in patients with COPD. Wijkstra previously reported a significant decrease in FEV_1 and in inspiratory vital capacity after 12 weeks in patients who did not receive rehabilitation, whereas FEV_1 remained stable in patients receiving a 12-week home-based RP.[30] However, the explanation of this decrease is questionable and has to be monitored closely in further longer-term studies.

In summary, we demonstrated definite long-term benefits of postoutpatient RP EM, in terms of exercise tolerance and maximum exercise capacity. Daily self-EM at home appears to be as efficient as structured-EM, with regard to exercise testing parameters and chronic dyspnea. We cannot propose a definite conclusion concerning the optimal type of EM after RP, taking into account the possible bias of EM conditions of self-selection. However, we do suggest that EM is needed after an initial outpatient RP, and that it may be anticipated that patients with less motivation will need prolonged supervision to maintain benefits that are obtained after initial outpatient RP. Structured EM may be helpful in patients who need supervision to be motivated in continuing exercise training and in patients with severe COPD or cardiopulmonary disease. Given the expense of structured EM in comparison with self-home EM, daily unsupervised EM at home after an initial outpatient RP may be recommended in patients with moderate to moderately severe COPD and high motivation level.

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