A Comparison Between an Outpatient Hospital-Based Pulmonary Rehabilitation Program and a Home-Care Pulmonary Rehabilitation Program in Patients With COPD*

A Follow-up of 18 Months

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Aim: In this study, the effects of a 12-week hospital-based outpatient pulmonary rehabilitation program (HRP) are compared with those of a 12-week home-care rehabilitation program (HCRP) in COPD patients. A control group received no rehabilitation therapy.

Methods: After randomization and stratification, effects on lung function, exercise performance (4-min walking test and cycle ergometer test), dyspnea, and leg effort during exercise, and well-being were assessed in 45 COPD patients with moderate to severe airflow limitation (mean [SD] FEV$_1$ percent predicted, 42.8 [8.4]).

Results: After HRP and HCRP, at 3 to 6 months after the start of the study, equal improvements were detected in exercise capacity and in Borg dyspnea and leg effort scores at similar work levels during the cycle test. However, whereas after HRP at longer term values tended to return to baseline outcome, after HCRP a further ongoing significant improvement in exercise capacity was observed, while Borg dyspnea scores remained significantly improved over 18 months. Improvements in cycle workload and dyspnea score were significantly better maintained after HCRP as compared with HRP. Lung function, arterial oxygen saturation, and heart frequency during exercise did not change. A significant improvement in well-being was maintained over 18 months in both rehabilitation groups.

Conclusion: Beneficial effects are achieved both after a HRP and a HCRP in COPD patients with moderate to severe airflow limitation. Yet we recommend to initiate HCRPs as improvements are maintained longer and are even further strengthened in this setting.

(CECH 1996; 109:366-72)

BF=breathing frequency; HF=heart frequency; IVC= inspiratory vital capacity; SaO$_2$=arterial oxygen saturation; $W_{\text{max}}$=maximal work level

Key words: COPD; dyspnea; exercise; home care; rehabilitation; well-being

Many patients with advanced COPD suffer from a reduced functional capacity, mainly due to dyspnea on exertion. As an addition to maintenance drug treatment, multidisciplinary pulmonary rehabilitation programs have been instituted to improve this disability. The beneficial effects of these programs in COPD patients have been well documented.1-4 Numerous studies have reported that the programs result in improved exercise tolerance and well-being.5-8 Most of these effects have been achieved in inpatient or outpatient programs. Their disadvantage is that the patient has to be admitted to a specialized center or has to visit the center on a daily basis. Results on home-care rehabilitation programs are scarce. McGavin et al9 showed a domiciliary physical training program leading to an improved exercise tolerance. After a home-care program, Wijkstra and coworkers10 assessed an improvement in exercise tolerance and quality of life. To our knowledge, a comparison between a hospital-based outpatient program and a home-care program has not been carried out so far.

The aim of the present study was to compare the results of a 12-week hospital-based outpatient rehabilitation program with those of a 12-week home-care...
rehabilitation program in COPD patients with moderate to severe airflow limitation. During 18 months of follow-up, exercise performance and general well-being were measured in a standardized way, including changes in the perception of dyspnea and leg effort during exercise. Results of both rehabilitation groups were compared with those of a control group not participating in any rehabilitation program.

**Materials and Methods**

Fifty outpatients (43 male) in a stable phase of their disease were selected for the study. They all met the following inclusion criteria: COPD as evidenced by history, physical examination, chest radiograph, and pulmonary function test results; dyspnea on exertion, limiting activities of daily living; PaCO₂ at rest of less than 6.5 kPa, and PaO₂ at rest of more than 7.5 kPa; FEV₁ postbronchodilatation between 600 and 1800 mL and less than 65% of predicted FEV₁; and no evidence of ischemic heart disease, musculoskeletal disorders, or other disabling diseases that could restrict the rehabilitation therapy.

The study was approved by the Medical Ethics Committee of the University Hospital of Groningen (the Netherlands).

**Initial Assessment**

All patients were hospitalized for two consecutive days. The following parameters were measured in all patients: lung function—FEV₁ and inspiratory vital capacity (IVC) using a water-sealed spirometer (Lode BV; the Netherlands), the best of three readings being taken; an arterial blood gas sample, taken after 15 min in supine position. Analysis was performed using a blood gas analyzer; (model 278; Corning, Medfield, Mass); well-being—patients were asked to classify their situation as better, equal, or worse compared with the first visit.

**Exercise Capacity**

Incremental Symptom-Limited Cycle Ergometer Test: Cycling started at a workload of 20 W. Workload was increased with 10 W/min; encouragements were not given. Patients were instructed to stop when they could not continue the test any longer due to dyspnea, general fatigue, or both. The highest work level that could be sustained for 1 min was regarded as the maximal work level (W max). Heart frequency (HF) was monitored simultaneously and arterial oxygen saturation (SaO₂) was recorded continuously by an ear oximeter (Biox II A; Bioximetry Technology Inc; Louisville, Colo). To familiarize themselves with the exercise test, all subjects performed it twice. Results of the second test were used for statistical analysis only.

All patients scored the intensity of dyspnea and leg effort on a Borg category scale at each work level during the cycle test.

Walking Test: Three walking tests, as described by McGavin et al and Butland et al were performed on two consecutive days. Walking distance covered in 4 min was assessed. Patients were informed only about the time they had walked; no encouragements were given. The results of the third test were used for analysis.

**Rehabilitation Program**

A rehabilitation program was set up aimed at increasing the functional capacity of the patients. It consisted of the following components:

**Patient Education:** All patients received information about the correct use of medication and were kept informed about the course of their disease. They were instructed when to seek help, e.g., in case of pulmonary deterioration as recorded by daily peak flow measurements.

**Breathing and Relaxation Exercises:** These were carried out to teach the patients how to cope with feelings of breathlessness and fear during exercise.

**Bronchial Hygiene:** In patients with productive cough, postural drainage and cough techniques were taught to improve the clearance of bronchial secretion.

**Exercise Reconditioning:** Different types of physical exercises were used, for example, walking and stair climbing. All exercises were performed emphasizing their value for the activities of daily life. After 3 to 4 weeks, exercises with stationary bicycles were performed in both groups. The workload was gradually increased up to 70% of the individual W max, as detected in the initial cycle test. When this exercise level was attained without any problems, exercise time was gradually increased.

Each component of the program was tailored to the individual patient based on the history, initial exercise tests, and lung function measurements.

**Stratification and Randomization**

After stratification for FEV₁ and exercise tolerance, as measured by the walking distance, patients were randomly allocated to one of three groups: (1) hospital outpatient rehabilitation group; (2) home-care rehabilitation group; and (3) control group.

**Study Design**

**Hospital Outpatient Rehabilitation Group:** Patients came to the hospital twice a week during 12 consecutive weeks. The rehabilitation exercises took 1 h each session and were administered by a physiotherapist. Moreover, patients were instructed to practice daily exercises individually for at least 15 min (for example, walking and stair climbing). Patient education was given three times by a respiratory nurse during 1 h each. All patients visited the physician (J.H.S.), who supervised the program, three times. During each session, standard protocols were used for graded exercise training, patient education, and treatment of pulmonary deterioration.

**Home-Care Rehabilitation Group:** The program for each patient of this group was carried out at home by his local physiotherapist and home-care nurse, under supervision of the general practitioner. Prior to the program, all participating physiotherapists, general practitioners, and home-care nurses received standardized instructions from the physician (J.H.S.) using the standardized protocols as mentioned above. The individualized exercise programs were administered by the local physiotherapists during 24 sessions of 30 min in 12 consecutive weeks. Moreover, patients were instructed to exercise individually at least 30 min on the exercise days and at least 15 min on the other days. In addition, each patient was visited three times by the local home-care nurse, who checked the use of medication, daily peak flow values, and motivated the patient to continue the exercises at home. All patients visited their general practitioner on three occasions during the 12 weeks of rehabilitation. The patients of both rehabilitation groups received individual instructions to continue the exercises daily at home—without supervision—after completion of the program.

**Control Group:** Patients of the control group received their standard medical treatment only, without any form of rehabilitation exercises.

**Follow-up**

All patients were followed up for 18 months, with five visits to the hospital: at the start of the study, directly after finishing the rehabilitation program (after 3 months), and 6, 12, and 18 months after the start of the program.

**Statistical Analysis**

Exercise data, including the Borg scores for dyspnea and leg effort obtained during the cycle test, are expressed as the values...
Table 1—Patient Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Hospital Outpatient Rehabilitation Group</th>
<th>Home-Care Rehabilitation Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients (Men/Women)</td>
<td>15 (14/1)</td>
<td>15 (12/3)</td>
<td>15 (12/3)</td>
</tr>
<tr>
<td>Age, yr</td>
<td>61.2 (5.5)</td>
<td>60.0 (7.8)</td>
<td>63.1 (5.1)</td>
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<tr>
<td>Smokers</td>
<td>7</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>TLC, L</td>
<td>6.3 (1.1)</td>
<td>6.1 (1.2)</td>
<td>6.1 (1.3)</td>
</tr>
<tr>
<td>TLC, % predicted</td>
<td>103.5 (19.6)</td>
<td>99.2 (13.7)</td>
<td>98.7 (17.8)</td>
</tr>
<tr>
<td>IVC, L</td>
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<td>3.1 (0.8)</td>
<td>3.2 (1.0)</td>
</tr>
<tr>
<td>IVC, % predicted</td>
<td>73.5 (11.7)</td>
<td>75.4 (13.7)</td>
<td>76.2 (20.1)</td>
</tr>
<tr>
<td>FEV₁, L [A]</td>
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<td>1.0 (0.3)</td>
<td>1.0 (0.2)</td>
</tr>
<tr>
<td>FEV₁, L [B]</td>
<td>1.2 (0.4)</td>
<td>1.3 (0.4)</td>
<td>1.2 (0.3)</td>
</tr>
<tr>
<td>FEV₁, % predicted</td>
<td>40.4 (19.6)</td>
<td>45.5 (6.9)</td>
<td>42.6 (8.8)</td>
</tr>
<tr>
<td>FIV₁, L</td>
<td>2.6 (0.6)</td>
<td>2.7 (0.8)</td>
<td>2.8 (0.7)</td>
</tr>
<tr>
<td>FIV₁, % predicted</td>
<td>79.5 (20.4)</td>
<td>82.8 (20.6)</td>
<td>83.5 (16.2)</td>
</tr>
<tr>
<td>FEV₁/FVC</td>
<td>35.1 (7.9)</td>
<td>37.5 (6.6)</td>
<td>34.7 (8.5)</td>
</tr>
</tbody>
</table>

*TLCl=total lung capacity; FIV₁=forced inspiratory volume in 1 s; FEV₁1 (I) [A] and FEV₁1 (I) [B]=FEV₁ before [A] and after [B] bronchodilatation with fenoterol, 3x200 µg (Rotohaler).

1p<0.05; therapy group vs control group.

measured at the maximal work load achieved during that test (W max). In addition, values of these parameters are given as measured at similar work levels (the highest work load achieved at all five visits) in any individual subject (W max). Multivariate analysis of variance was applied for statistical evaluation. We used statistical models of repeated measurements for each separate variable, which included the between-subjects factor group, the within-subjects factor time, and the two-way interaction term group×time. The interaction term tests the presence of different responses to treatment among the three groups. In case of a significant treatment effect, Student’s unpaired t test was used to determine significant differences for a variable among the three groups at all separate follow-up visits. Student’s paired t test was used for within-subject changes. Differences between the groups in baseline characteristics were tested with Student’s t test for unpaired observations, after checking for normal distribution. A p value of less than 0.05 was considered to be significant. All values are presented as mean [SD], unless stated otherwise.

RESULTS

Subjects

Fifty patients entered in the study. Forty-one completed the full study period of 18 months.

Hospital Outpatient Rehabilitation Group: Eighteen patients were allocated to this group; 5 of them dropped out during the study. Three dropped out in the first 3 months: two patients stopped due to lack of motivation, and one person died after a car accident. After 14 months, two more patients dropped out: one died due to respiratory failure during an exacerbation, and the other was diagnosed with metastatic prostate cancer.

Home-Care Rehabilitation Group: Seventeen patients were allocated to this group. Two patients did not complete the rehabilitation program: the first because of a beginning rheumatoid arthritis, and the second because of an exacerbation, requiring hospitalization. In the follow-up period, one patient dropped out 1 year after the start of the study because of breast cancer.

Control Group: Fifteen patients started in this group. One patient dropped out at follow-up because of breast cancer.

The results of those who completed at least the first 3 months of the study (the rehabilitation period) are presented (15 patients in each group). All patients had a long history of pulmonary symptoms. A majority (27/45) used three or more different drugs for maintenance treatment. Clinical characteristics are shown in Table 1. No significant differences in initial characteristics, except for reversibility after fenoterol, were observed among the three groups. Reversibility after an anticholinergic drug (thiazinium) was not significantly different among the groups.

Exercise Tests

Initial and follow-up results of the exercise parameters of the three groups are shown in Table 2 and Figures 1 and 2.

Maximal Work Level (W max, Cycle Test): Significantly different responses were observed among all groups (p=0.001), (Fig 1, top). After the hospital outpatient rehabilitation program (at 3 months), a significant increase in W max of 19.8% was observed. However, throughout the follow-up period, W max deteriorated: at 12 and 18 months, no significant improvement was seen. After the home-care rehabilitation program, however, an ongoing gradual improvement was observed throughout the complete follow-up period. Eighteen months after the start of the study, W max was still 20.7% above baseline. Values at all follow-up visits were significantly improved as compared with baseline after 12 and 18 months and also as compared with the control group. At separate fol-
Table 2—Changes in Exercise Parameters in Two Rehabilitation Groups and the Control Group

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Group</th>
<th>Before Rehabilitation</th>
<th>After Rehabilitation</th>
<th>6 mo</th>
<th>12 mo</th>
<th>18 mo</th>
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<tr>
<td>No. of patients</td>
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<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
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<td></td>
<td>3</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>HF W max&lt;sub&gt;1&lt;/sub&gt;, /min</td>
<td>1</td>
<td>121 (12)</td>
<td>128 (17)</td>
<td>127 (13)</td>
<td>130 (11)</td>
<td>130 (13)</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>117 (16)</td>
<td>121 (18)</td>
<td>124 (17)</td>
<td>123 (17)</td>
<td>124 (16)</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>117 (12)</td>
<td>119 (11)</td>
<td>121 (13)</td>
<td>118 (13)</td>
<td>117 (17)</td>
</tr>
<tr>
<td>HF W max&lt;sub&gt;2&lt;/sub&gt;, /min</td>
<td>1</td>
<td>118 (13)</td>
<td>120 (15)</td>
<td>120 (12)</td>
<td>125 (18)</td>
<td>125 (14)</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>117 (16)</td>
<td>114 (18)</td>
<td>119 (19)</td>
<td>116 (18)</td>
<td>116 (17)</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>114 (11)</td>
<td>115 (9)</td>
<td>118 (13)</td>
<td>115 (13)</td>
<td>116 (15)</td>
</tr>
<tr>
<td>SaO&lt;sub&gt;2&lt;/sub&gt; W max&lt;sub&gt;1&lt;/sub&gt;, %</td>
<td>1</td>
<td>93.3 (3.1)</td>
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<td>92.3 (3.2)</td>
<td>91.9 (4.4)</td>
<td>92.2 (4.8)</td>
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<tr>
<td></td>
<td>2</td>
<td>95.2 (3.2)</td>
<td>93.3 (2.8)</td>
<td>93.7 (3.2)</td>
<td>93.6 (2.8)</td>
<td>93.3 (2.8)</td>
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<tr>
<td></td>
<td>3</td>
<td>93.3 (3.3)</td>
<td>93.9 (3.5)</td>
<td>93.9 (3.4)</td>
<td>93.2 (3.5)</td>
<td>92.5 (4.2)</td>
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<tr>
<td>SaO&lt;sub&gt;2&lt;/sub&gt; W max&lt;sub&gt;2&lt;/sub&gt;, %</td>
<td>1</td>
<td>93.8 (3.0)</td>
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<tr>
<td></td>
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<td>95.1 (2.9)</td>
<td>94.1 (2.2)</td>
<td>94.6 (2.7)</td>
<td>94.3 (2.4)</td>
<td>94.0 (2.3)</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>93.7 (3.2)</td>
<td>94.4 (3.2)</td>
<td>93.8 (2.8)</td>
<td>93.5 (3.2)</td>
<td>92.7 (3.9)</td>
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<td>Dyspnea W max&lt;sub&gt;1&lt;/sub&gt;, Borg</td>
<td>1</td>
<td>6.7 (1.2)</td>
<td>6.4 (1.1)</td>
<td>6.4 (1.0)</td>
<td>7.3 (1.1)</td>
<td>6.9 (1.3)</td>
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<tr>
<td></td>
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<td>6.5 (0.9)</td>
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<td>6.6 (1.1)</td>
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<td></td>
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<td>6.7 (1.5)</td>
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<tr>
<td>Leg effort W max&lt;sub&gt;1&lt;/sub&gt;, Borg</td>
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<td>3.9 (2.3)</td>
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<td>4.3 (3.0)</td>
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<tr>
<td></td>
<td>3</td>
<td>4.3 (3.0)</td>
<td>3.8 (2.8)</td>
<td>3.7 (3.9)</td>
<td>4.2 (2.9)</td>
<td>4.8 (2.8)</td>
</tr>
</tbody>
</table>

*Group 1: hospital outpatient rehabilitation group; group 2: home-care rehabilitation group; group 3: control group; W max<sub>1</sub>: measurement made at the maximal work level of the visit (see text); W max<sub>2</sub>: measurement made at maximum work level attained at all visits (see text).

low-up visits, no significant differences between both therapy groups were observed, but improvements in W max at follow-up (Δ 18 months to 3 months) were better maintained after the home-care program (p=0.014, unpaired Student's t test).

4-Min Walking Distance: A similar tendency as shown in W max was observed during the walking test (Fig 1, bottom). In both therapy groups, a significant increase in walking distance was measured after the rehabilitation programs (interaction factor: p=0.001). In the hospital outpatient group, distance covered in 4 min was significantly increased up to 6 months, as compared with baseline. After the home-care rehabilitation program, walking distance was significantly increased at all follow-up visits, up to 13.6% at the last visit after 18 months. No significant differences were observed among the three groups at separate follow-up visits.

Borg Scores During Cycle Test: Dyspnea scores and scores for leg effort (Borg scale) at W max<sub>1</sub> did not change significantly over 18 months in both therapy groups (Table 2 and Fig 2). Significantly different responses among the three groups were observed for both dyspnea and leg effort scores at similar work levels (W max<sub>2</sub> interaction factor: p=0.004 and p=0.04, respectively). In the hospital outpatient rehabilitation group, similar work levels were attained with decreased dyspnea scores up to 6 months after the start of the study (Fig 2, top). The score for leg effort at these work levels showed only a significant improvement directly after the program, at 3 months (Fig 2, bottom).

In the home-care rehabilitation group, however, significant improvements in dyspnea scores were maintained up to 18 months and for leg effort up to 6 months. Improvements in dyspnea scores were significantly better maintained at follow-up after home-care rehabilitation as compared with outpatient rehabilitation (Δ 18 months to 3 months; p=0.01, unpaired Student’s t test), whereas no significant differences for leg effort scores were observed between the two therapy groups.

Exercise Parameters During Cycle Test: Though W max<sub>1</sub> after the rehabilitation program in both groups was achieved with higher HF and lower levels of SaO<sub>2</sub>, statistical significance was not reached (Table 2). No significant differences in HF or SaO<sub>2</sub> at similar work levels (W max<sub>2</sub>) were detected in both rehabilitation groups at follow-up.

Measurements at Rest

Breathing frequency (BF) at rest decreased in both rehabilitation groups (interaction factor: p=0.001) (Table 3). In both therapy groups, a significantly lower breathing rate was most pronounced after 12 and 18 months. No significant changes were observed between both therapy groups.

Spirometry (IVC and FEV<sub>1</sub>), arterial blood gas analyses, and resting HF did not change significantly throughout the follow-up period in each group.

General Well-Being

Significant improvements in general well-being were
observed in both rehabilitation groups, directly after the program and at follow-up after 18 months (Fig 3). In both rehabilitation groups, a major proportion claimed an improved well-being directly after the program (12/15, p<0.01; and 11/15, p<0.05, respectively). After 18 months, most patients (13/14) in the control group felt unchanged or even worse. At that time, 17 of 27 of those who received a rehabilitation program still reported an improved well-being (p<0.01).

**Discussion**

This present study confirms the observations of previous investigators that patients with COPD derive subjective and objective benefits such as improved

![Figure 1](image1.png)

**Figure 1.** *Top:* mean (SEM) values for maximal workload (Watts), reached during an incremental symptom-limited cycle test at visits 1 to 5. *Bottom:* mean (SEM) values for walking distance (meters), covered during a 4-min walking test at visits 1 to 5. Hospital=Hospital outpatient rehabilitation group; home-care=home-care rehabilitation group; controls=control group. Asterisk=p<0.05; two asterisks=p<0.005 (vs baseline); and number sign=p<0.05 (vs controls).

![Figure 2](image2.png)

**Figure 2.** *Top:* mean (SEM) values for Borg dyspnea score at similar work levels (W max2, see text), as measured during the cycle test (0=no complaints at all; 10=maximum). Bottom: mean (SEM) values for Borg leg effort score at similar work levels (W max2, see text), as measured during the cycle test (0=no complaints at all; 10=maximum). Hospital=hospital outpatient rehabilitation group; home-care=home-care rehabilitation group; controls=control group. Asterisk=p<0.05; two asterisks=p<0.005 (vs baseline); number sign=p<0.05; and two number signs=p<0.005 (vs controls).

**Table 3—Measurements at Rest in Two Rehabilitation Groups and the Control Group**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Group</th>
<th>Before Rehabilitation</th>
<th>After Rehabilitation</th>
<th>6 mo</th>
<th>12 mo</th>
<th>18 mo</th>
</tr>
</thead>
<tbody>
<tr>
<td>HF, /min</td>
<td>1</td>
<td>84.0 (13.5)</td>
<td>83.6 (11.6)</td>
<td>85.0 (8.8)</td>
<td>88.3 (7.6)</td>
<td>90.3 (6.9)</td>
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<tr>
<td></td>
<td>2</td>
<td>79.5 (13.7)</td>
<td>81.5 (10.5)</td>
<td>83.6 (9.7)</td>
<td>75.2 (7.8)</td>
<td>79.1 (13.5)</td>
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<tr>
<td></td>
<td>3</td>
<td>82.8 (10.0)</td>
<td>85.5 (8.9)</td>
<td>90.4 (9.6)</td>
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<td>86.4 (9.4)</td>
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<tr>
<td>BF, /min</td>
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<td>17.9 (3.9)</td>
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<td>14.5 (2.9)</td>
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<td>17.4 (4.0)</td>
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<td>17.7 (5.2)</td>
<td>18.6 (3.7)</td>
</tr>
</tbody>
</table>

*Group 1=hospital outpatient rehabilitation group; group 2=home-care rehabilitation group; group 3=control group.

1p<0.05; vs baseline.

2p<0.005; vs control group.
exercise tolerance from a pulmonary rehabilitation program. Yet our results add new knowledge in that patients exercising at home maintained and progressively strengthened the exercise improvement over 18 months after finishing the home-care program. In contrast, improvements were maintained only for 3 to 6 months in those who received the rehabilitation program on an outpatient basis at the hospital.

Improvements in exercise tolerance can be attributed to one or more of the following mechanisms: 14-18 physiologic changes, improved efficiency, better coordination of neuromuscular activity, and desensitization to dyspnea. With regard to the first mechanism, results on physiologic changes during a training period in COPD patients have often been contradictory.19 A training level appropriate to produce physiologic changes often cannot be reached in patients with severe COPD, which may explain the absence of physiologic improvements in some studies. 20,21 In the present study, we offered a low-intensity exercise program, mainly focused on improving the ability to exercise. We observed no significant differences in physiologic parameters such as heart rate and SaO2 during similar exercise levels after the training program. In accordance with most studies, we did not observe a change in spirometry findings after the rehabilitation program. Therefore, physiologic changes resulting from improved cardiac conditioning or improvements in pulmonary function cannot explain the increased exercise tolerance in our study. Increased efficiency is also not likely to have played a significant role in improving the workload during cycling, as several studies have previously shown. 18,22-24

We believe that the increased exercise tolerance in our study is due to improved neuromuscular coordination and desensitization to dyspnea. Exercise training can lead to an improved neuromuscular coordination, 25,26 which by itself can contribute to an improved ability to carry out everyday activities, especially in those patients who led a sedentary life. After the rehabilitation program, patients were able to exercise at similar work levels (Wmax) with fewer complaints of dyspnea and leg discomfort. The scores for these parameters at the maximal exercise levels (Wmax) remained unchanged, but, because exercise capacity improved, these scores were given at significantly higher work levels. After rehabilitation, the improved maximal exercise levels were reached with markedly higher HF and lower SaO2 at all visits. This suggests that desensitization to dyspnea played a major role in improving Wmax. HF and lower SaO2 in both exercise groups were significantly lower at all follow-up visits, probably as a result of breathing exercises, which taught the patients a slower and deeper breathing pattern. Breathing exercises will probably have contributed to this desensitization by giving the patients a feeling of controlling their breathlessness and fear during exercise, thus facilitating them to continue exercise toward a higher work level. Possibly a slower BF by itself may decrease the perceived intensity of dyspnea. 27

In the present study over 18 months of follow-up, the two rehabilitation groups showed a different course of their improvements. Patients who exercised in the hospital maintained their improvements (increased exercise tolerance, reduction of dyspnea and leg discomfort during exercise) for maximally 6 months, but no longer. Those who exercised at home, however, still benefited 18 months after the start of the program. Of even greater importance is the observation that the home-care group continued to improve their exercise tolerance after finishing the program. A possible explanation of these observations is that patients of the home-care group had become accustomed to exercise

![Hospital outpatient rehabilitation group:](image1)

![Home-care rehabilitation group:](image2)

![Control group:](image3)

**Figure 3.** General well-being of the three groups, measured 3 and 18 months after the start of the study. Two asterisks=p<0.01; one asterisk=p<0.05; therapy groups vs control group (χ² test).
in their own domiciliary environment. This made it easier for them to continue their exercises at home, after the program had been finished. This was also suggested by the diary cards that all patients were asked to complete. Patients of the home-care group spent more time performing the unsupervised exercises than those of the hospital outpatient group.

Finally, most of the patients in both rehabilitation groups also claimed an improvement in general well-being 18 months after the start of the study. It is our impression that this is mainly due to the fact that the rehabilitation exercises made them more self-sufficient and independent. It helped them to give up a sedentary lifestyle and break a vicious circle of inactivity and deterioration of functional capacity that resulted in a greater dyspnea at a given effort.

The present study shows that COPD patients benefit from a home-care rehabilitation program and from a hospital-based outpatient rehabilitation program. Both programs were initially equally successful, though our results indicate that benefits are generally maintained longer and are even further strengthened in patients who received a home-care program. In the absence of major physiologic changes, desensitization to dyspnea seems to be an important mechanism in improving the exercise tolerance of COPD patients. We have shown that with adequate initial assessment and extensive instruction of the participating disciplines, a home-care rehabilitation program is a useful adjunct in the treatment of COPD patients with moderate to severe airflow limitation.

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