# Pulmonary Rehabilitation Compared With Brief Advice Given for Severe Chronic Obstructive Pulmonary Disease

Roger J. White, MD; Sharon T. Rudkin, MSc, RGN; Susan T. Harrison, MSCP; Karen L. Day, RGN; Ian M. Harvey, PhD


- **PURPOSE:** The objective of this study was to compare the effectiveness of a short-term pulmonary rehabilitation program with brief advice given to patients with severe ventilatory impairment due to chronic obstructive pulmonary disease (COPD).
- **METHODS:** One hundred three patients with severe COPD, defined as having forced expiratory volume in 1 second < 40% predicted, were randomly assigned to rehabilitation or to brief advice. Fifty-four patients attended a rehabilitation program twice a week for 6 weeks. Forty-nine patients attended a single session during which they were given printed educational materials and verbal advice and guidance about exercise. Subjects were reassessed at 3 months.
- **RESULTS:** The shuttle walking distance increased significantly in the rehabilitation group by 43 meters. The increase of 23 meters in the brief advice group was significantly less than in the rehabilitation group. Improvements in quality of life in the rehabilitation group were small and not clinically significant.
- **CONCLUSIONS:** In these patients with severe COPD, a short outpatient rehabilitation program of low intensity achieved small but significant improvement in shuttle walking distance, compared with brief advice. The improvements in quality of life were modest and did not reach statistical significance, although in some instances the confidence limits include differences that approach clinical significance. The relatively small effect may be due to the low intensity of the program or to the severity of the subjects' ventilatory impairment.


**KEY WORDS**

chronic obstructive pulmonary disease

rehabilitation

exercise

quality of life

From Department of Medicine, Frenchay Hospital, Bristol, UK, BS16 1LE (Dr White, Ms Rudkin, Ms Harrison, Ms Day); and the School of Medicine, Health Policy and Practice, University of East Anglia, Norwich NR4 7TJ (Prof Harvey).

Address correspondence to: Roger J. White, MD, Department of Medicine, Frenchay Hospital, Bristol, United Kingdom, BS16 1LE (e-mail: roger.white4@virgin.net).

Pulmonary rehabilitation has been shown to be effective in patients with chronic obstructive pulmonary disease (COPD). A recent meta-analysis of 14 controlled trials of pulmonary rehabilitation programs showed improvement in exercise capacity, breathlessness, sense of control over the disease.[1] Exercise is the most important element of these programs.[2,3] Education alone is less effective than comprehensive rehabilitation.[4,5]

Most studies have been in patients with widely differing degrees of severity. Few studies have looked only at patients with severe ventilatory impairment. This study was designed to compare the effectiveness of a short-term, group rehabilitation program with brief advice for improving exercise capacity and quality of life in patients with severe COPD. We have only selected patients with severe COPD as defined by forced expiratory volume in 1 second ($FEV_1$) < 40% predicted because of the uncertainty about the effects of rehabilitation in this group. The evidence for the benefits of exercise is such that some physicians feel that standard management of patients with COPD ought to include advice on exercise. For this reason, we have compared comprehensive rehabilitation with a brief (1 hour) session, giving specific advice about exercising at home.

## METHODS

Patients were recruited from a respiratory outpatient department. They were seen either as new referrals or as already under review, or had been identified after a previous hospital admission.

### Entry Criteria

All patients had COPD as defined by the criteria of the American Thoracic Society[6] and the British Thoracic Society[7] and were included if they had severe ventilatory impairment defined as $FEV_1 < 40\%$ predicted. They were excluded if there was improvement in $FEV_1$ of more than 15% or more than 200 mL after an inhaled beta agonist. They were required to be in a stable state without an exacerbation of their COPD within the last 3 weeks. Because of uncertainty about the safety of unsupervised exercise at home in severely hypoxemic patients, those with a resting oxygen saturation of 90% or less and those receiving long-term oxygen therapy were excluded. None had previously attended a pulmonary rehabilitation program or were already engaged in home exercise. Patients were excluded if there was significant locomotor disability such as arthritis or limb weakness that would limit their exercise capacity, if there was symptomatic ischemic heart disease, or if there was other significant comorbidity, such serious psychiatric problems. Current smokers were included. The local Ethics committee approved the study, and all patients gave written informed consent.

One hundred sixty patients with severe COPD were initially identified as being suitable (Figure 1). After an explanation, they were invited to enter the study. One hundred sixteen patients attended for initial assessment and randomization. After further explanation of the study, 4 patients refused to be randomized and 9 did not fulfill the entry criteria. The sealed envelopes for randomization were opened after all of the baseline assessments had been completed.

One hundred three patients were randomized: 54 patients were assigned the 6-week outpatient group program, and 49 were assigned the brief advice program.

## BASELINE ASSESSMENTS

### Ventilatory Function

Forced expiratory volume in 1 second and forced vital capacity were measured using a bellows spirometer (best of three readings). If there had been no recordings of reversibility to inhaled β-agonist over the previous 3 months, then spirometry was repeated 15 minutes after inhalation of 2.5 mg nebulized salbutamol. Arterial oxygen saturation was measured by pulse oximetry at rest, breathing air.

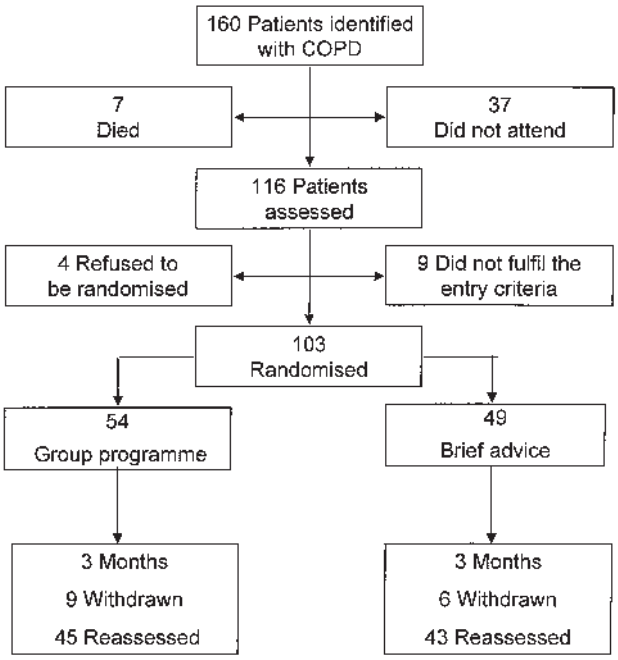


**Figure 1.** Outline of study. See text for reasons of withdrawals.

### Shuttle Walking Distance

This was performed as described by Singh et al.[8] This externally paced test was selected in preference to a self-paced test because it is less likely to be affected by encouragement and motivation. At least 30 minutes of rest was allowed after a practice walk before the walking distance was recorded. The oxygen saturation was measured before and immediately after the second shuttle test.

### Health-related Quality of Life Measurement

The disease-specific outcome instrument used was the Chronic Respiratory Disease Questionnaire (CRQ).[9] This has been widely used in assessing the effects of pulmonary rehabilitation. It is an administered questionnaire with four dimensions: dyspnea, fatigue, emotional function, and mastery (control over disease). Each of the four dimensions has between 4 and 7 items which are scored on a 7 point scale. The minimum clinically important difference is based on a score of 0.5 per item and the total is rounded up to a whole number giving a minimum clinically important difference of between 2 and 4 points for each dimension.[10]

General health was assessed using the Short-form 36 questionnaire. The SF 36[11] has been used in COPD[12] but its sensitivity to change has yet to be established. It covers 8 health dimensions including physical and mental health. An increase in score represents improvement.

The Hospital Anxiety and Depression scale examines patients' psychological well-being. Each of the two dimensions (anxiety and depression) has a range of 0-21. Scores of 10 or more are indicative of clinically significant anxiety or depression.[13]

## REASSESSMENT

Ventilatory function, shuttle walking distance and questionnaires were measured at 3 months after randomization. The shuttle walking test and the CRQ measurements were supervised by observers who were masked as to which group of the study the patients had been assigned. When administering the CRQ on each occasion the patient's previous score was given to the patient as recommended.[14]

## RANDOMIZATION

Subjects were randomized using opaque sealed envelopes prepared by a researcher not directly involved in the study. A block size of ten was used. This was unknown to those opening the randomization envelopes.

## SAMPLE SIZE AND STATISTICAL ANALYSIS

We calculated the sample size using the CRQ, because this is a patient-related measure of health status for which clinically important differences have been determined. For shuttle distance and for the other outcome measures there is no consensus as to what constitutes a clinically important difference. We used the mastery and emotional subscales of the CRQ as the primary outcome measures. In this questionnaire, a score on each of the subscales of between 2 and 4 points is considered clinically significant. This study considered a change of 3 points on the emotional state or mastery subscales as clinically significant. Data from Wijkstra et al[15] indicate that the SD of scores on these subscales among COPD patients is approximately 5.7. For 80% power to detect this minimum clinically significant difference (0.53 SD) requires 60 subjects in each group (two-tailed $P = .05$).

Analyses were performed on an intention-to-treat basis. Differences between the two groups were assessed by analysis of covariance, with adjustment for the baseline value of the relevant outcome measure, as well as age and sex. In addition, changes in the physical measurements and quality-of-life scores within individuals were examined using paired *t* tests.

## INTERVENTIONS

### Group Program

Patients attended the hospital twice a week for a 2-hour session for 6 weeks. Patients' partners or caregivers were encouraged to attend. Where there were difficulties with attendance at the hospital, transport was provided in the form of a minibus using volunteer drivers. Between 8 and 12 patients attended as a group. The first part of the program was a 45-minute period of exercise supervised by a physiotherapist. The exercise was a combination of general endurance and muscle strengthening.

Walking exercise was performed on a 30-meter rectangular indoor circuit and was symptom limited. Subjects were asked to walk at a pace sufficient to cause moderate shortness of breath. Subjects were allowed to have short rests when breathlessness became more severe (4 or more on the Borg scale ) and then asked to resume walking as soon as able. They ceased walking after 4 minutes and recorded the number of laps achieved during that time. At subsequent attendances, as their ability improved, they were advised to increase their walking speed to achieve more laps of the circuit. If and when they were able to achieve 8 or more laps they progressed to a self-powered treadmill set at a 10° incline. At their first attempt on this treadmill they only completed 1-minute of walking. At subsequent attendances they walked at a pace sufficient to cause breathlessness to 4 on the Borg scale and aimed to gradually build up the time to complete 4 minutes.

Step exercise was performed on a single step with a handrail for support. The number of step-ups over 4 minutes was recorded. A simple exercise bicycle with variable resistance was used. The subjects started at low or no resistance and cycled for as long as possible, aiming to reach 4 on the Borg scale up to a maximum of 4 minutes. At subsequent visits the patients described the difficulty of this exercise and the resistance was adjusted accordingly.

A variety of limb and thoracic cage exercises also were performed. For arm exercise they passed a rubber ring from hand to hand over their head. Wall press-ups were done standing approximately at arm's length from the wall and they used an elasticized band for thoracic cage and arm stretching. Bands with three different resistances were used based on their initial ability, and they progressed to higher resistance where able.

For leg exercises, subjects did sit-to-stand from an upright chair. They were encouraged to do this without arm support if possible. Leg extension exercises were performed from a sitting position with weights of up to 0.5 kg on each ankle. Specific respiratory muscle training was not included.

For the muscle strengthening exercises, the number of repetitions over 4 minutes was recorded. At each visit they were asked about any problems arising from previous sessions such as persistent pain or stiffness in the limbs, shoulders, or neck, and the presence of any other adverse symptoms such as symptoms of chest infection that might affect their ability to exercise. If no problem was identified, patients were encouraged to

increase the number of repetitions of individual exercises. Patients kept a record of their achievements and were asked to bring this for inspection at each attendance. Modification of the exercise prescription was made on the basis of this record and on discussion with each patient. Where possible patients were encouraged to increase the repetitions by 10%.

After the period of exercise, there was an interval for refreshment followed by an education and discussion session covering topics related to respiratory problems and their management (Figure 2). These talks were given with the aid of illustrated material and by a variety of health professionals, including physicians, respiratory nurses, physiotherapists, lung function technicians, and dietitians. Intermittently during the program patients were seen in groups of 3 or 4 by the respiratory nurse for discussion of goal setting. During this session, their change in activity over the last year or two was discussed and the patients were asked to identify specific goals that they hoped to achieve as a result of the program. The nurse assisted in helping them to identify goals that were both specific and achievable. Goal setting was regarded as part of the process of rehabilitation rather than as an outcome measure.

Subjects were required to attend at least 10 of the 12 sessions. On the days when they were not attending the program, they were advised to continue exercising at home, aiming to do 30 minutes daily on at least 2 days.

### Brief Advice

After randomization, these patients visited the hospital on a single occasion and attended for approximately 1 hour. This session was designed to be one that could be replicated in primary care or in a respiratory outpatient department. The patients were seen individually by the respiratory nurse and by the physiotherapist and were given a booklet that contained the same educational material given to those attending the supervised program. They were advised about the benefits of exercise and were reassured about its safety. It was explained to them that breathlessness is an expected result of the exercise that they would be asked to do, and that it would not have an adverse effect on their heart or lungs. They were then shown exercises that could be performed at home: walking, sit-to-stand, steps, and arm exercises were demonstrated and a chart illustrating these exercises was issued. Advice on the timing and frequency of exercise was individualized but was broadly similar to that given to the rehabilitation group. They were recommended to attempt 30 minutes of exercise at least 4 days of each week. They were encouraged to increase their exercise over the subsequent 6-week period and to maintain this thereafter.

To determine if home exercise was being done as recommended, all patients were given a diary sheet and asked to record their exercise. Although the patients were aware that the diaries would be inspected, it was apparent that even in those who were thought to be complying well with home exercise this was not being well recorded. Because we were unable to rely on the accuracy of their recording of exercise, they were not analyzed.

- How our lungs work
- The benefits of exercise
- Chest clearance techniques
- Healthy eating
- Stress, breathlessness, and relaxation
- Medication and inhalers
- When to call the general practitioner
- Chronic bronchitis and emphysema
- Steroids
- Nebulizers and oxygen
- Lung function tests
- How to recognize infections

**Figure 2.** Education topics.

## RESULTS

Due to recruitment difficulties, we were unable to enter 60 patients into each group of the study. The actual number of subjects recruited confers 74% power to detect the difference specified in the sample size calculation. Table 1 shows the baseline demographic and lung function data. The groups were similar on these key potential confounding variables. Table 2 shows the major within-subject comparisons. Differences between the two groups after adjustment for age, sex, and the relevant baseline values are shown in Table 3.

Attendance at the group program was on the whole good, and we attribute this partly to the provision of transport. Five of the 54 patients failed to attend enough sessions because of lack of interest. One dropped out because of troublesome arthritis and 3 patients died. None dropped out because of COPD exacerbation.

**Table 1** • BASELINE DEMOGRAPHIC AND VENTILATORY FUNCTION DATA: MEAN (SD)

| | Group Program n = 54 | Brief Advice n = 49 |
|---|---|---|
| Age, y | 67 (9) | 67 (9) |
| Male/female | 36/18 | 35/14 |
| $FEV_1$, L | 0.82 (0.3) | 0.84 (0.3) |
| FVC, L | 2.09 (0.8) | 2.05 (0.8) |
| $FEV_1$, % predicted | 26.6 (8.0) | 27.2 (7.6) |

$FEV_1$, forced expiratory volume in 1 second; FVC, forced vital capacity.

**Table 2** • BASELINE VALUES AND CHANGES FROM BASELINE IN REHABILITATION AND ADVICE GROUPS WITHIN SUBJECTS

| Patients | No. at Baseline | No. at 3 months |
|---|---|---|
| Group program | 54 | 45 |
| Brief advice | 49 | 43 |
| | Scores Mean(SD) | Changes from baseline (95%CI) |
| **Shuttle distance, m** | | |
| Group program | 223.5 (118.3) | +42.9 (20.5 – 65.3)* |
| Brief advice | 192.5 (134.5) | +23.3 (4.7 – 41.9)‡ |
| **Dyspnea** | | |
| Group program | 15.8 (5.3) | +2.13 (1.28 – 2.98)* |
| Brief advice | 16.5 (4.3) | +1.72 (0.65 – 2.79)† |
| **Fatigue** | | |
| Group program | 14.9 (4.8) | +2.02 (0.71 – 3.33)† |
| Brief advice | 14.7 (4.9) | +1.05 (-0.2 – 2.12) |
| **Emotional Function** | | |
| Group program | 31.9 (8.9) | +2.24 (0.58 – 3.9)† |
| Brief advice | 32.9 (8.2) | +1.28 (-0.40 – 2.96) |
| **Mastery** | | |
| Group program | 18.5 (4.6) | +1.56 (0.65 – 2.47)* |
| Brief advice | 18.4 (5.3) | +0.51 (–0.40 – 1.42) |
| **CRQ total** | | |
| Group program | 81.1 (15.9) | 8.0 (4.2 – 11.8)* |
| Brief advice | 82.5 (17.6) | 4.6 (1.1 – 8.3) ‡ |
| **HAD anxiety** | | |
| Group program | 7.5 (4.5) | –0.80 (–1.75 – 0.15) |
| Brief advice | 7.1 (4.2) | –0.67 (–1.50 – 0.16) |
| **HAD depression** | | |
| Group program | 6.2 (3.5) | –0.67 (–1.34 – 0.00)‡ |
| Brief advice | 6.3 (3.4) | –0.51 (–1.46 – 0.44) |
| **SF-36 social functioning** | | |
| Group program | 64.2 (27.7) | +8.52 (1.00 – 16.04)‡ |
| Brief advice | 64.3 (30.5) | 0 (–8.45 – 8.45) |
| **SF-36 physical functioning** | | |
| Group program | 35.3 (20.5) | +2.4 (–3.2 – 8.0) |
| Brief advice | 34.4 (25.7) | + 2.6 (–4.0 – 9.1) |

CI, confidence interval; CRQ, Chronic Respiratory Disease Questionnaire; HAD, Hospital Anxiety and Depression Scale; SF-36, MOS 36-item Short Form Health Survey.
*$P < .001$; †$P < .01$; ‡$P < .05$ (by paired $t$ test compared with baseline).

Although compliance with exercise prescription was monitored, we did not analyze this. However, the nurse and the physiotherapist were confident that subjects were doing their best to comply with advice given.

In the brief advice group, 6 were lost at 3 months (2 had died). Three refused to attend or had lost interest, and one was too unwell to attend.

Table 2 shows statistically significant improvements within subjects in some of the outcome measures (notably the shuttle distance, CRQ dyspnea, and total score) across both groups of the study. In the subjects attending the group program there were improvements in fatigue, emotional function, and mastery and in the Hospital Anxiety and Depression scale depression scores but none of these reached clinical significance. There was substantial and significant improvement in social functioning (SF-36 Health Survey).

Table 3 directly compares the study groups and apart from the shuttle distance at 3 months, differences are not statistically significant. The shuttle distance at 3 months shows an (unadjusted) increase of 42.9 meters (19%) in the rehabilitation group compared with 23.3 meters (12%) in the brief advice group. However, it is acknowledged that the confidence limits for some measures, including the total CRQ and the SF-36 social functioning subscale, are relatively wide and include differences that are at the margins of clinical significance.

## DISCUSSION

The subjects in our rehabilitation group improved their shuttle walking distance after 3 months. There was a small improvement in the brief advice group, which

**Table 3** • DIFFERENCES BETWEEN GROUP REHABILITATION PROGRAM AND BRIEF ADVICE GROUPS (GROUP PROGRAM MINUS BRIEF ADVICE) AT 3 MONTHS*

| Instrument | 3 Months (95% Confidence Interval) |
|---|---|
| Shuttle distance, m | 34.1 (3.0, 65.3)† |
| CRQ dyspnea | 0.4 (–0.9, 1.7) |
| CRQ fatigue | 0.1 (–2.1, 2.3) |
| CRQ emotional function | 0.7 (–1.5, 2.9) |
| CRQ mastery | 0.9 (–0.3, 2.1) |
| CRQ total | 3.1 (–1.9, 8.0) |
| HAD anxiety | –0.07 (–1.3, 1.1) |
| HAD depression | –0.1 (–1.2, 0.9) |
| SF-36 social functioning | 7.7 (–1.8, 17.2) |
| SF-36 physical functioning | 0.6 (–7.0, 8.2) |

CRQ, Chronic Respiratory Disease Questionnaire; HAD, Hospital Anxiety and Depression Scale; SF-36, MOS 36-item Short Form Health Survey.
*Adjusted for age, sex, and baseline value of relevant variable.
†$P < .05$.

was significantly less than in the rehabilitation group and that was not large enough to be of clinical importance. In neither group were there clinically significant changes in quality of life.

The improvement of 43 meters in shuttle distance in the rehabilitation group is smaller than that recorded in some previous studies, but these generally have been in patients with less severe disease who, in some instances, have undergone a more intensive program. Singh et al[16] found an increase of 56 meters in 110 patients with mean $FEV_1$ 1.1 liters attending twice weekly for 7 weeks, although in a later study using the same program this unit measured the same increase as we did (42 meters) in 97 patients with $FEV_1$ 1.06 liters.[17] After a 6-week program with thrice weekly attendance, Griffiths et al achieved a 71-meter increase in 99 patients (mean $FEV_1$ 0.91 L).[18] In these studies, walking exercise was tailored to the peak oxygen uptake as determined by the shuttle walking test, and the intensity of exercise was therefore likely to have been greater. However, the importance of this degree of standardization is uncertain because increases in exercise capacity can be achieved without such standardization. For example, the 33 patients studied by Wedzicha et al[5] (mean $FEV_1$ 0.95 liters) attending twice weekly for 8 weeks increased their shuttle distance by 88 meters.[5] Our program was very similar to theirs with exercise intensity being related to development of breathlessness rather than to estimated oxygen uptake.

A number of factors apart from the degree of exercise can affect the improvement in exercise capacity; these include motivation and home support. In our study we believe that the smaller effect was probably due to our program being less intensive and of shorter duration than others. The severity of their disease also may have been an important factor because our subjects' ventilatory impairment (mean $FEV_1$ 0.82 liters) was more marked than in other studies. We included patients who were very severely disabled and it is probable that the most severely affected were unable to achieve anything more than minimal improvement. The inclusion of these patients may possibly have masked the effects of rehabilitation in the less disabled subjects. The importance of disease severity is supported by the study of Wedzicha et al who found no improvement in shuttle distance after rehabilitation in a group of patients virtually housebound by severe COPD (mean $FEV_1$ 0.87 L).[5]

Social functioning improved in the rehabilitation group, but this was not significantly different from the advice group. The improvements in CRQ also were statistically significant for each of the dimensions in the rehabilitation group, but these increases did not reach clinical significance and were no greater on a direct comparison than in the brief advice group. These results contrast with those in the studies mentioned above where clinically important improvements were seen in each of the dimensions.[5,15,16]

Our results are similar to those of Goldstein and colleagues.[19] This is the only other study we have identified where patients were recruited specifically according to the severity of their ventilatory impairment. This was an inpatient program lasting 8 weeks and as in the present study the main inclusion criterion was an $FEV_1$ of less than 40% of predicted. Using the CRQ, they observed significant improvement but as in the present study the changes were small and just exceeded the minimum clinically important difference for dyspnea and mastery only. They observed a small improvement in the 6-minute walking distance of 40 meters (10%), which is less than the accepted minimum clinically important difference.

The key result of our study is that following a 6-week program of symptom-limited exercise, education, and goal setting patients with severe ventilatory impairment produced a small improvement in shuttle walking distance but only modest improvement in quality of life. The benefits might have been greater with a more intensive or a longer program, but many patients with this degree of ventilatory impairment would encounter difficulty with this. There were no apparent benefits of simply giving brief advice.

Although our subjects were well defined with regard to the degree of ventilatory impairment, they were in fact a heterogeneous group with widely differing degrees of disability, and inclusion of extremely disabled subjects may have obscured the effects on those with less disability. Uncertainty remains as to the benefits of rehabilitation in patients with severe disease and future studies comparing different interventions should be conducted in patients defined according to their disability, as well as to the impairment of lung function.

***Acknowledgments***

*The study was funded by the Frenchay Respiratory Fund. In addition, STR was in receipt of a grant from the Sir Halley Stewart Trust.*

## References

1. Lacasse Y, Wong E, Guyatt GH, King D, Cook DJ, Goldstein RS. Meta-analysis of respiratory rehabilitation in chronic obstructive pulmonary disease. *Lancet*. 1996;348:1115-1119.
2. Lacasse Y, Guyatt GH, Goldstein RS. The components of a respiratory rehabilitation program: a systematic overview. *Chest*. 1997;111:1077-1088.
3. ACCP/AACVPR Pulmonary Rehabilitation Guidelines Panel. Pulmonary rehabilitation: joint ACCP/AACVPR evidence-based guidelines. *Chest*. 1997;112:1363-1396.
4. Ries AL, Kaplan RM, Limberg TM, Prewitt LM. Effects of pulmonary rehabilitation on physiologic and psychological outcomes in patients with COPD. *Ann Intern Med*. 1995;122:823-832.
5. Wedzicha JA, Bestall JC, Garrod R, Garnham R, Paul EA, Jones PW. Randomised controlled trial of pulmonary rehabilitation in severe chronic obstructive pulmonary disease patients, stratified with the MRC dyspnoea scale. *Eur Respir J*. 1998;12:363-369.
6. Statement for the diagnosis and care of patients with chronic obstructive pulmonary disease. American Thoracic Society. *Am J Respir Crit Care Med*. 1995;152(5 pt 2):S77-S170.
7. BTS Guidelines for the Management of Chronic Obstructive Pulmonary Disease. *Thorax*. 1997;52(suppl 5):S1-S28.
8. Singh SJ, Morgan MDL, Scott S, Walters DA, Hardman AE. A shuttle walking test of disability in patients with chronic airways obstruction: description and comparison with the 6-minute walking test. *Thorax*. 1992;47:1019-1024.
9. Guyatt GH, Berman LB, Townsend M, Pugsley SO, Chambers LW. A measure of quality of life for clinical trials in chronic lung disease. *Thorax*. 1987;42:773-778.
10. Jaeschke R, Singer J, Guyatt GH. Measurement of health status: ascertaining the minimal clinically important difference. *Control Clin Trials*. 1989;10:407-415.
11. Ware JE, Sherbourne CD. The MOS 36-item short-form health survey. *Med Care*. 1992;30:473-481.
12. Mahler DA, Mackowiak JL. Evaluation of the short-form 36-item questionnaire to measure health- related quality of life in patients with COPD. *Chest*. 1995;107:1585-1589.
13. Zigmond AS, Snaith RP. The hospital anxiety and depression scale. *Acta Psychiatr Scand*. 1983;67:361-370.
14. Guyatt GH, Towsend M, Keller JL, Singer J. Should study subjects see their previous responses: data from a randomised control trial. *J Clin Epidemiol*. 1989;42:913-920.
15. Wijkstra PJ, Van Altena R, Kraan J, Otten V, Postma DS, Koeter GH. Quality of life in patients with chronic obstructive pulmonary disease improves after rehabilitation at home. *Eur Respir J*. 1994;7:369-273.
16. Singh SJ, Smith DL, Hyland ME, Morgan MDL. A short outpatient pulmonary rehabilitation programme: immediate and longer term effects on exercise performance and quality of life. *Respir Med*. 1998;92:1146-1154.
17. Singh SJ, Sodergren SC, Hyland ME, Williams J, Morgan MDL. A comparison of three disease specific and two generic health status measures to evaluate the outcome of pulmonary rehabilitation in COPD. *Respir Med*. 2001;95:71-77.
18. Griffiths TL, Burr ML, Campbell IA, et al. Results at 1 year of outpatient multidisciplinary pulmonary rehabilitation: a randomised controlled trial. *Lancet*. 2000;355:362-368.
19. Goldstein RS, Gort EH, Stubbing D, Avendano MA. Randomised controlled trial of respiratory rehabilitation. *Lancet*. 1994;344: 1394-1397.