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ORIGINAL ARTICLE

Short- and long-term hospital and community exercise programmes for patients with chronic obstructive pulmonary disease

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Short- and long-term hospital and community exercise programmes for patients with chronic obstructive pulmonary disease
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Objective: Pulmonary rehabilitation in patients with COPD has been shown to be beneficial but the optimal setting is not known. In the present study, the efficacy of a short-term community-based exercise programme was compared with a standard hospital outpatient programme. Additionally, the usefulness of community or home programmes in maintaining improvements in the longer term was studied.
Methodology: Forty-three patients with moderate to severe COPD were randomized to one of the following three groups: a 3-month hospital programme then a 9 month home programme (Hospital/Home); a 3-month hospital programme then a 9-month community programme (Hospital/Community); or a 12-month community programme (Community/Community). The initial 3-month programme was analysed by comparing the Hospital group (Hospital/Home plus Hospital/Community) with the Community group (Community/Community). Six-minute walking distance (6MWD), quality of life (Guyatt chronic respiratory disease questionnaire, CRQ) and lung function were measured at 0, 3, 6 and 12 months and results were analysed using the Wilcoxon rank sum test.
Results: At 3 months, there was a significant improvement from baseline in 6MWD in the Hospital group (81.3 ± 18.3 m, $P < 0.05$, ANOVA) but not the Community group (14.4 ± 28.5 m, not significant). The difference between the groups was not significant ($P = 0.058$). At 3 months, there was a significant improvement in quality of life in the Hospital group (CRQ +16.3 ± 3.1, $P < 0.01$, ANOVA) and in the Community group (CRQ +10.2 ± 4.9, $P < 0.05$, ANOVA) but the difference between the groups was not significant. Following the initial 3-month programme, the dropout rate was high overall (73% by 12 months), and therefore data from the maintenance programme could not be analysed.
Conclusions: A 3-month community-based exercise programme for patients with COPD did not improve 6MWD. The long-term retention rates in the programmes were poor.

Key words: chronic obstructive pulmonary disease, community, home, hospital, pulmonary rehabilitation.

INTRODUCTION

Chronic obstructive pulmonary disease is characterized by airflow obstruction and is a common cause of dyspnoea, reduced physical capacity, reduced quality of life (QOL), and disability in the Australian community.[1] Respiratory rehabilitation programmes play a pivotal role in the overall long-term management of COPD with evidence from randomized controlled trials demonstrating an improvement in symptoms, exercise capacity and QOL,[2,3] and reduced health-care expenditure.[4,5] They have been officially endorsed in Australian and New Zealand guidelines[6] and internationally.[7]

Inpatient,[8] outpatient[9] and comprehensive home programmes[10] have all been shown to improve outcomes. These programmes vary considerably in design and resources required to run them, although

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it has been agreed that the minimum duration should be 8 weeks. Inpatient programmes are not used routinely because of cost. Hospital-based outpatient programmes usually have the resources and expertise for individualized training. They also offer the opportunity for patients to exercise with others with COPD, which can provide psychological support and allow continuity of care and easy access to medical assistance. However, places within these programmes are often limited, and transport to and from hospital can be difficult. Home programmes have been shown to help but require a significant input from staff, such as physiotherapists, who travel to the patient's home.[10,11] Community-based programmes are attractive in that they can be cheaper and more convenient for patients, and offer participants the opportunity to mix with members of their local community. Although community-based programmes are frequently less sophisticated, the homogeneity in outcome from differing studies suggests that less sophisticated rehabilitation programmes can be as effective as the more comprehensive approaches.[2] Many studies have shown that improvements gained following a short-term programme are lost over time. Various maintenance programmes have been studied, although none has demonstrated a sustained effect on outcome.[12–14]

As community-based programmes offer advantages in terms of access for patients with COPD, the present study aimed to determine their efficacy, both in the short and long term. The first aim was to study the efficacy of a 3-month community-based rehabilitation programme and compare it with a hospital-based programme, which had previously been shown to be beneficial. The second aim was to determine whether a community-based programme offered any advantage over an unsupervised home programme in terms of maintenance of exercise and QOL over a period of 12 months.

METHODS

Patients

Forty-three patients with moderate to severe COPD (FEV_1 34–70% of predicted) were studied.[7] They were recruited from inpatients and outpatients in the Respiratory Medicine Departments at Royal Perth Hospital (RPH) and Sir Charles Gairdner Hospital (SCGH). At the time patients participated in the study, they had stable breathlessness on exertion. Patients were excluded from the study if they had significant cardiac or other disease, musculoskeletal problems precluding exercise, significant arterial oxygen desaturation during exercise ($SaO_2 \leq 85\%$), psychiatric or cognitive problems, difficulty with communication, or recent respiratory infections. Patients received their usual medical care for the duration of the study. The study protocol was approved by the Human Ethics Committees at RPH, SCGH and the University of Western Australia and conformed to the provisions of the World Health Organization Declaration of Helsinki. Informed consent was obtained from all participants.

Study design

Patients were randomly assigned to one of three rehabilitation groups: Hospital/Home, a 3-month hospital-based outpatient programme followed by a 9-month home programme; Hospital/Community, a 3-month hospital-based programme followed by a 9-month community-based programme; and Community/Community, a 12-month community programme. To assess the benefits of a hospital versus a community programme in the initial 3 months, the Hospital/Home and Hospital/Community groups (Hospital group) were combined and compared with the Community/Community group (Community group). A Home/Home group was not included as we did not have the resources to provide the kind of supervised home programme that had previously been shown to be beneficial.[10] To determine the benefit of maintenance programmes, all three groups were compared.

Intervention

All patients received education regarding their condition, their medication and the benefits of the programme. Patients were instructed to use their bronchodilators prior to the hospital or community sessions and prior to exercise at home. If required, transport was arranged for patients to attend the groups.

The hospital-based programme was conducted at the Outpatient Physiotherapy Departments of RPH and SCGH and was run specifically for respiratory patients. The exercise programme was 1.5 h in duration and was run twice a week. The programme consisted of warm-up and stretch, circuit strength training, aerobic training and cool-down and stretch, with 30 min spent on circuit and aerobic training, respectively. The circuit included upper and lower limb exercises, and abdominal strengthening exercises. The aerobic component included treadmill and corridor walking, and cycling. On average, there were 10–12 patients per class. Exercise programmes were individually prescribed based on the initial assessment, and targets were updated continually after review by the physiotherapist.

Patients in the community programme were integrated into local exercise groups run by Community Physiotherapy Services of the Health Department of Western Australia. The programme selected for each patient depended on proximity to the home, suitability of class times and level of fitness. Depending on their capabilities, patients participated in either a general fitness class, run for members of the community over 60 years of age (22 patients), or a class for individuals with a medical condition and more specific mobility requirements (four patients). One patient attended one of each type of class each week. The programme was 1.5 h in duration and was run

twice a week. It consisted of warm-up and stretch, walking, and general exercises or low-intensity circuit routines with weights, and cool-down and stretch. The exercises focussed on function and mobility. For one patient, the session was run as 'aquarobics'. The physical demands in the specific mobility requirement group were less than in the general fitness class. There were between 15 and 25 participants per group; these programmes were not individualized and the demands did not change over time.

The home programme was unsupervised and consisted of a written exercise programme provided by the physiotherapist after completion of the 3-month hospital or community-based programmes. The home programme involved twice weekly exercise for 1.5 h and consisted of a warm up, stretch, walking and circuit exercises and cool down. The patients were familiar with the exercises from their previous involvement. In addition, daily exercise was encouraged. Compliance was discussed at 3-month intervals and a log book was kept. Patients could contact the physiotherapist regarding problems at any time.

Assessment

Demographic details and a medical assessment, which included smoking history, weight and ventilatory function tests, were obtained prior to commencement in a programme. FEV_1 and FVC were measured with a spirometer (PK Morgan spiroflow and Vitalograph; PK Morgan, Rainham, Kent, UK).[15] The highest of three reproducible measurements was used and expressed as percentage predicted for age, height and sex according to standardized tables.[16] Lung volumes were measured by helium dilution analysis (PK Morgan helium dilution analyser), and the transfer factor (single breath diffusing capacity) was also measured (PK Morgan autolink breath system).

The 6-min walking distance (6MWD)[17] was measured in an indoor corridor using standardized instructions and encouragement.[18] Patients performed one practice 6MWD 30 min prior to the test. SaO_2 was measured continuously during the test by pulse oximetry (Criticare 504; Criticare Systems Inc.) with the investigator following the patient.[12] QOL was assessed by the chronic respiratory disease questionnaire (CRQ) of Guyatt *et al.*, which examined four dimensions: dyspnoea (five items) and fatigue (four items), both reflecting physical function, and emotion (seven items) and mastery (four items), both reflecting emotional function.[19] During subsequent administration of the CRQ, the patients were told their previous answers.[20]

Repeat assessment was performed after 3, 6 and 12 months using the following measurements: FEV_1 and FVC using the Vitalograph (Vitalograph, Buckingham, UK),[15] 6MWD, CRQ and weight. Repeat assessments were completed at the same time of day.

Class attendance (%) for the 3 months was calculated by dividing the number of classes the patient attended by the number of classes that would have been attended if the patient had attended two classes per week for 12 weeks.

Statistical analysis

Baseline data from the 43 patients were compared between groups using Student's *t*-test. Two-way repeated-measures ANOVA using the generalized linear model on SPSS was used to compare data obtained before and after training, within the groups and between the groups. Data was analysed both for patients with complete data and on an intention-to-treat basis. A P-value < 0.05 was considered significant.

RESULTS

Demographics

Forty-three patients were enrolled in the study: 12 in the Hospital/Home group, 18 in the Hospital/Community group and 13 in the Community/Community group (Table 1). There were no differences between the groups at baseline with respect to age and ventilatory function. All patients had irreversible airflow limitation because of emphysema and chronic bronchitis; three patients had pre-existing stable asthma

Table 1 Baseline demographics and lung function (mean ± SEM)

	Groups		
	Hospital/Home	Hospital/Community	Community/Community
Subjects ($n = 43$)	12	18	13
Subjects remaining at 3 months	8	14	9
Age (years)	66.4 ± 2.1	68.7 ± 2.1	62.5 ± 2.1
Sex (n, male/female)	3/9	11/7	9/4
Married (n (%))	6 (50)	12 (67)	7 (54)
Current smoker /former smoker (n (%))	12 (100)	16 (89)	10 (77)
FEV_1 (% predicted)	46.0 ± 3.9	46.3 ± 4.4	42.7 ± 5.9
TLC (% predicted)	120 ± 3.2	121.5 ± 4.9	116.2 ± 5.4
KCO (% predicted)	61.5 ± 4.6	61.3 ± 6.0	65.5 ± 9.1

KCO, lung carbon monoxide transfer factor corrected for effective alveolar volume.

with no significant reversibility; and one patient had coexistent bronchiectasis.

Short-term programme: Hospital versus community

Thirty patients entered the hospital-based programme (Hospital group) and 13 patients entered the community programme (Community group). The patients were similar with respect to initial FEV_1 and CRQ, and although there was a trend towards a greater initial 6MWD in the Community group, this was not significant. Twenty-two of the 30 patients (73%) in the Hospital group and nine of the 13 patients (69%) in the Community group completed the 3-month programme (Table 2). Class attendance was similar in the two groups (78 and 76%, respectively). Ventilatory function and weight did not change over the 3 months.

There was a significant improvement in 6MWD over the 3 months in the Hospital group (mean ± SEM: 81.3 ± 18.3 m; 19%; ANOVA $P < 0.01$), but not in the Community group (14.4 ± 28.6 m; 3%; ANOVA not significant) (Table 2; Fig. 1). The improvement in the Hospital group was not significantly greater than that in the Community group ($P = 0.058$). The mean change in the total score for QOL (CRQ) before and after training, was +16.3 ± 3.1 (19%) for the Hospital group ($P < 0.01$) and +10.2 ± 4.9 (13%) for the Community group ($P < 0.05$) (Fig. 2). Thirteen of 22 (59%) and five of nine (55%) patients who completed the Hospital and Community programmes, respectively, had a clinically meaningful improvement of 10 points in the total CRQ score. In the Hospital group, there were significant improvements in all components of the CRQ ($P < 0.01$–0.05), whereas in the Community group, there were significant improvements only in the dyspnoea and mastery domains ($P < 0.05$) (Table 2). There was no significant difference in the improvement in CRQ between the two groups (Table 2).

When the data were analysed for the three groups separately, without pooling groups Hospital/Community and Hospital/Home, the findings were similar. At the 3-month review, there was a greater improvement in 6MWD in the Hospital/Home (94.0 ± 30.2 m) and Hospital/Community groups (76.3 ± 22.1 m) than in the Community/Community group (14.4 ± 28.5 m) ($P < 0.05$). CRQ improved in all three groups, with no differences between the groups. When the effect of a programme was reviewed on an intention-to-treat basis, the results were the same.

In the first 3 months, 27% of the Hospital group and 31% of the Community group withdrew. Withdrawals were a result of illness ($n = 5$), lack of interest ($n = 4$), transport difficulty ($n = 1$), preference for an alternative exercise group ($n = 1$) or being too well ($n = 1$). Similar reasons for withdrawal were given in each group.

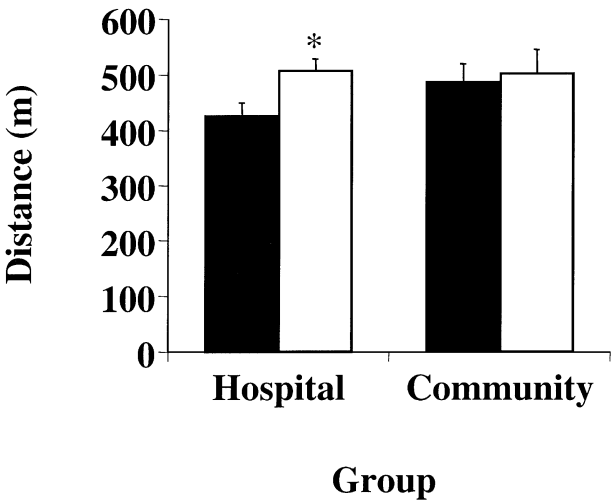

Figure 1 Six-minute walking distance at 0 (■) and 3 months (□) in the Hospital and Community groups. Values are mean ± SEM. *$P < 0.01$, ANOVA.

Table 2 Outcome measures before and after 3 months' training (mean ± SEM)

	Groups†			
	Hospital ($n = 22$)		Community ($n = 9$)	
	Before	After	Before	After
Six-minute walking distance (m)	426.5 ± 23.0	507.8 ± 20.7*	487.8 ± 31.5	502.2 ± 43.0
SaO_2 during exercise (min %)	91.9 ± 1.1	91.0 ± 4.4	93.3 ± 1.4	95.0 ± 0.3
Peak heart rate	106.7 ± 3.3	110.3 ± 4.1	100.4 ± 6.3	116.1 ± 8.0
Chronic respiratory disease questionnaire				
Dyspnoea	15.8 ± 3.5	20.7 ± 1.4**	14.5 ± 1.3	18.7 ± 2.4**
Fatigue	16.0 ± 1.3	20.1 ± 0.9*	16.4 ± 1.6	18.1 ± 1.5
Emotional	33.5 ± 1.6	38.3 ± 1.3*	30.8 ± 1.3	32.7 ± 1.8
Mastery	20.5 ± 1.0	23.1 ± 0.9*	17.9 ± 1.4	20.5 ± 1.6**
Total score	85.9 ± 3.5	102.1 ± 3.7*	79.7 ± 3.4	89.9 ± 4.5**
FEV_1 (L)	0.96 ± 0.06	0.91 ± 0.05	0.95 ± 0.12	0.91 ± 0.06
Weight (kg)	66.4 ± 3.3	66.8 ± 3.3	60.3 ± 4.0	59.4 ± 3.7
Attendance (%)		78.3		75.7

*Change for 0–3 months, $P < 0.01$, ANOVA; **change 0 to 3 months, $P < 0.05$, ANOVA; †Hospital group comprised Hospital/Home and Hospital/Community groups and Community group consisted of the Community/Community group.

Long-term maintenance programme: Home versus community

Of the 31 patients (of a total of 43 patients) who continued in the study after 3 months, eight patients were in the Hospital/Home group, 14 patients were in the Hospital/Community group, and nine patients were in the Community/Community group (Table 3). Of those 31 patients, 22 completed 6 months and 16 completed 12 months in the study (Table 3).

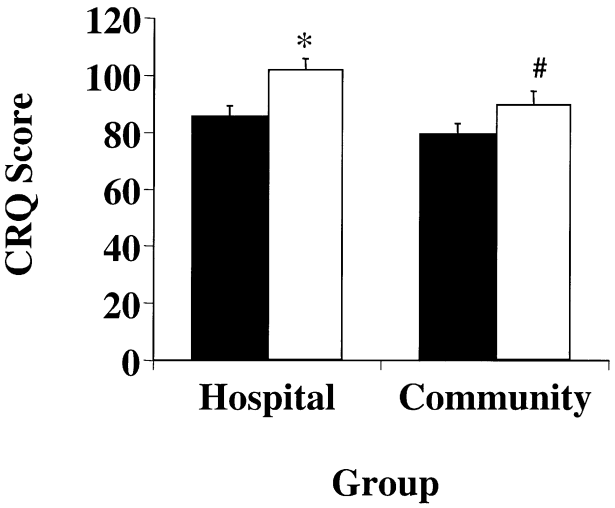

Figure 2 Quality of life (chronic respiratory disease questionnaire) at 0 (■) and 3 months (□) in the Hospital and Community groups. Values are mean ± SEM. $^{*}P < 0.01$, ANOVA; $^{**}P < 0.05$, ANOVA.

Most of the withdrawals were in the Hospital/Home and Hospital/Community groups (Table 4), and were the result of illness or a preference for the hospital programme over the home or community programmes to which they were changed at 3 months. It was noted that those that withdrew after 3 months because they preferred the hospital programme (five patients) had experienced a large improvement in 6MWD (178.0 ± 33.9 m vs 81.3 ± 18.3 m in the total group) in the first 3 months.

Because of the small numbers of subjects participating in the exercise programmes at the end of the study, data could not be analysed at 6, 9 or 12 months.

DISCUSSION

The present study demonstrates that a generic community-based exercise programme for patients with COPD does not result in an improvement in 6MWD. Although some improvement was seen in QOL, as measured by CRQ, this was only in the domains of mastery and dyspnoea. Second, it is clear that continued participation in formal exercise programmes in the long term is poor.

The minimum clinically important difference needs to be determined for an intervention, which for the 6MWD is between 30 and 50 m (95% confidence interval 37–71 m).[8,21] The improvement in 6MWD of 81.3 m in the Hospital group was clinically significant and was similar to improvements demonstrated in other studies,[2,9,12] but the marginal gain of 14.4 m in the Community group was not significant. Small numbers and unbalanced group sizes—the latter resulting from combining the Hospital/Home and

Table 3 Patients remaining in the study over the 12-month period (*n* (%))

	Group			
	Hospital/Home	Hospital/Community	Community/Community	Total
0 months	12 (100)	18 (100)	13 (100)	43 (100)
3 months	8 (67)	14 (78)	9 (69)	31 (81)
6 months	5 (42)	8 (44)	9 (69)	22 (51)
12 months	3 (25)	5 (28)	8 (61)	16 (37)

Table 4 Reason for withdrawal during the 12 months

	Group			
	Hospital/Home	Hospital/Community	Community/Community	Total (*n* (%))
Illness	2	6	2	10 (37)
Preferred hospital programme	1	5	NA	6 (22)
Orthopaedic	2	1	—	3 (11)
Surgery	1	—	—	1 (4)
Deceased	1	—	—	1 (4)
Lack of interest	1	1	2	4 (15)
Transport difficulty	1	—	—	1 (4)
Too well	—	—	1	1 (4)
Total	9	13	5	27 (63)

NA, not applicable.

Hospital/Community groups for comparison with the Community/Community group—might have influenced the result, but it is more likely the poor results in the community programme related to its lower intensity. Although the frequency and duration of exercise were the same for both programmes, the extent of aerobic exercise and strength training differed. In addition to corridor walking, the hospital-based programmes included treadmill walking and cycling, whereas the community programme emphasized mobility and balance. In addition, the hospital programmes continually reviewed and reset exercise targets. The fact that in the Hospital group all those exercising had COPD and that medical assistance was close may have engendered confidence to work at higher levels. Motivation and enthusiasm might have been important, although the low dropout rate over the long term in the Community group suggests good motivation in the participants.

The Community group had a higher starting 6MWD (487.8 m vs 426.5 m in the Hospital group), and although not significantly different from the Hospital group, this might have influenced the results. There are mixed reports in the available published reports regarding the influence of initial 6MWD on the potential for improvement in functional capacity with exercise training in both healthy adults[22] and patients with COPD.[23–25] It is likely that initial 6MWD is determined by both severity of airway disease and level of fitness resulting from an individual's habitual exercise.

The CRQ as a measure of QOL showed a significant improvement after 3 months' training in both groups. An increase in total CRQ score of at least 10 points and increases in the subscores of 2.5 for dyspnoea, 2.0 for fatigue, 3.5 for emotional and 2.0 for mastery are considered to be associated with clinically meaningful improvements in QOL.[26] We noted a mean improvement in the Hospital group of 16 points and in the Community group of 10 points, with improvements in all dimensions in the Hospital group but only in mastery and dyspnoea in the Community group. The improvement in CRQ in the Hospital group but not in the Community group was similar to the findings of a meta-analysis of 14 trials, which showed that respiratory rehabilitation significantly improved dyspnoea, fatigue and mastery.[2]

Successful exercise programmes for patients with COPD have been reported in a number of settings,[2] including inpatient,[8] outpatient[8] and in the home.[10,11] Home programmes require a significant amount of resources, with home visits by physiotherapists or other personnel, or monthly trips to a hospital programme. The only reports relating to community settings were an uncontrolled study in a community hospital,[27] where improvements in exercise capacity were observed, and a pilot study in a general practice.[28] The latter study was too small to be analysed but did demonstrate that one medical practice was insufficient to sustain a programme because of insufficient numbers. As our community programmes were already established and used limited resources, we felt it appropriate to evaluate the possible benefits of these programmes for patients with COPD. However, it is clear that neither the Community programme as currently run nor an unsupervised home programme were beneficial.

After the initial 3-month programme, the numbers in the present study were too small to allow interpretation of long-term outcomes. Most previous studies have shown that performance returns to baseline after the programme has been completed, despite the provision of instructions for an unsupervised home programme, attempts to maintain exercise with monthly visits to the hospital or home, repeat programmes at 1 year, or telephone support.[13–15] The important finding in the present study and in many others[13,29] is the large dropout rate, with few people interested in participating in the long term. Foglio *et al.* found a 50% dropout from participation in an outpatient programme run yearly,[29] and Brooks *et al.* reported a 50% dropout after enhanced follow up.[13] In the present study, the dropout rate in the community programme was only 33% over the full 12 months, which suggests patients found the setting acceptable.

A large number of dropouts among those participating in the community programmes were those who were initially involved in the hospital programme. The five patients who withdrew under these circumstances had shown a substantially greater improvement in 6MWD from 0 to 3 months compared with that seen in the group overall. This suggests patients were unwilling to risk the great gains they had made in the hospital programme by changing to another programme.

It appears a variety of programmes need to be offered to patients to cater for individual needs and to make use of the resources of hospitals and communities. Long-term compliance with programmes is poor and needs to be considered in planning. Increasing the intensity of community-based programmes could improve the outcomes in this setting and further study of this is warranted.

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REFERENCES

1 Australian Institute of Health and Welfare. *Australia's Health* [Internet]. Australian Institute of Health and Welfare, Canberra, 2000. [Cited 9 August 2004]. Available from URL: http://www.aihw.gov.au

2 Lacasse Y, Brosseau L, Milne S *et al.* Pulmonary rehabilitation for chronic obstructive pulmonary disease. Cochrane Database Syst. Rev. 2003; 1: CD003793.

3 Pulmonary rehabilitation. Joint ACCP/AACVPR evidence-based guidelines. *Chest* 1997; **112**: 1363–96.

4 Griffiths TL, Burr ML, Campbell IA *et al.* Results at 1 year of outpatient multidisciplinary pulmonary rehabilita-

tion: a randomised controlled trial. *Lancet* 2000; **355**: 362–8.
5 Ries AL, Kaplan RM, Limberg TM, Prewitt LM. Effects of pulmonary rehabilitation on physiologic and psychosocial outcomes in patients with chronic obstructive pulmonary disease. *Ann. Intern. Med.* 1995; **122**: 823–32.
6 McKenzie DK, Frith PA, Burdon JG, Town GI, Australian Lung Foundation, Thoracic Society of Australia and New Zealand. The COPDX Plan: Australian and New Zealand Guidelines for the management of Chronic Obstructive Pulmonary Disease 2003. *Med. J. Aust.* 2003; **178** (Suppl.): S7–39.
7 NHLBI/WHO Workshop Report. *Global Initiative for Chronic Obstructive Lung Disease (GOLD): Global Strategies for the Diagnosis, Management, and Prevention of Chronic Obstructive Lung Disease.* National Institutes of Health–National Heart, Lung and. Blood Institute, Bethesda, MD, 2001.
8 Goldstein RS, Gort EH, Stubbing D, Avendano MA, Guyatt GH. Randomised controlled trial of respiratory rehabilitation. *Lancet* 1994; **344**: 1394–7.
9 Lake FR, Henderson K, Briffa T, Openshaw J, Musk AW. Upper-limb and lower-limb exercise training in patients with chronic airflow obstruction. *Chest* 1990; **97**: 1077–82.
10 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**: 269–73.
11 Strijbos JH, Postma DS, van Altena R., Gimeno F, Koeter GH. 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. *Chest* 1996; **109**: 366–72.
12 Troosters T, Gosselink R., Decramer M. Short- and long-term effects of outpatient rehabilitation in patients with chronic obstructive pulmonary disease: a randomized trial. *Am. J. Med.* 2000; **109**: 207–12.
13 Brooks D, Krip B, Mangovski-Alzamora S, Goldstein RS. The effect of post-rehabilitation programmes among individuals with chronic obstructive pulmonary disease. *Eur. Respir. J.* 2002; **20**: 20–29.
14 Ries AL, Kaplan RM, Myers R., Prewitt LM. Maintenance after pulmonary rehabilitation in chronic lung disease: a randomized trial. *Am. J. Respir. Crit. Care Med.* 2003; **167**: 880–88.
15 American Thoracic Society. Standardization of spirometry—1987 update. *Am. Rev. Respir. Dis.* 1987; **136**: 1285–98.
16 Cotes JE. *Lung Function. Assessment and Application in Medicine*, 5th edn. Blackwell, Oxford, 1993.
17 Butland RJA, Pang J, Gross ER, Woodcock AA, Geddes DM. Two-, six-, and 12-minute walking tests in respiratory disease. *Br. Med. J.* 1982; **284**: 1607–8.
18 Guyatt GH, Pugsley SO, Sullivan MJ *et al.* Effect of encouragement on walking test performance. *Thorax* 1984; **39**: 818–22.
19 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**: 773–8.
20 Guyatt GH, Townsend M, Keller JL, Singer J. Should study subjects see their previous responses: data from a randomized control trial. *J. Clin. Epidemiol.* 1989; **42**: 913–20.
21 Goldstein RS, Redelmeier DA, Baksh L, Guyatt GH. Subjective comparison ratings of walking ability in patients with COPD. *Proceedings of the 5th International Conference on Pulmonary Rehabilitation and Home Ventilation*, Denver, CO, 1995; 99.
22 Pollock ML, Wilmore JH. *Exercise in Health and Disease*, 2nd edn. W.B. Saunders Co., Philadelphia, PA, 1990.
23 Zu Wallack RL, Patel K, Reardon JZ, Clark BA, Normandin EA. Predictors of improvement in the 12-minute walking distance following a six-week outpatient pulmonary rehabilitation program. *Chest* 1991; **99**: 805–8.
24 Niederman MS, Clemente PH, Fein AM *et al.* Benefits of a multidisciplinary pulmonary rehabilitation program. Improvements are independent of lung function. *Chest* 1991; **99**: 798–804.
25 Moser KM, Bokinsky GE, Savage RT, Archibald CJ, Hansen PR. Results of a comprehensive rehabilitation program. Physiologic and functional effects on patients with chronic obstructive pulmonary disease. *Arch. Intern. Med.* 1980; **140**: 1596–601.
26 Jaeschke R, Singer J, Guyatt GH. Measurement of health status: ascertaining the minimal clinically important difference. *Control. Clin. Trials* 1989; **10**: 407–15.
27 Ward JA, Akers G, Ward DG *et al.* Feasibility and effectiveness of a pulmonary rehabilitation programme in a community hospital setting. *Br. J. Gen. Pract.* 2002; **52**: 539–42.
28 Jones RC, Copper S, Riley O, Dobbs F. A pilot study of pulmonary rehabilitation in primary care. *Br. J. Gen. Pract.* 2002; **52**: 567–8.
29 Foglio K, Bianchi L, Ambrosino N. Is it really useful to repeat outpatient pulmonary rehabilitation programs in patients with chronic airway obstruction? A 2-year controlled study. *Chest* 2001; **119**: 1696–704.