

Reduction in hospitalisation following pulmonary rehabilitation in patients with COPD

Nola Cecins, Elizabeth Geelhoed and Sue C Jenkins

Abstract

Objectives: Pulmonary rehabilitation (PR) improves exercise capacity and health-related quality of life (HRQoL), and reduces health care utilisation. This study quantified outcomes of a PR program over a 6-year period and determined the effects of PR on hospitalisation.

Methods: Patients with chronic obstructive pulmonary disease (COPD) who entered an 8-week outpatient PR program from 1998 to 2003 were included. Functional exercise capacity (6-minute walk distance [6MWD]) and HRQoL (Chronic Respiratory Disease Questionnaire) were measured before and following PR. The number of hospital admissions and total bed-days due to a COPD exacerbation in the 12 months before and following PR were recorded.

Setting: Physiotherapy Department, Sir Charles Gairdner Hospital, Western Australia.

Results: 187 (73%) of the 256 patients who entered PR completed the program. Improvements in 6MWD (404.2 ± 114.6 m to 439.6 ± 115.0 m, $P < 0.001$) and HRQoL (4.1 ± 0.9 points per item to 4.9 ± 0.9 points per item, $P < 0.001$) occurred following PR. There was a 46% reduction in the number of patients admitted to hospital (71 to 38) with a COPD exacerbation and a 62% reduction in total bed-days (1131 to 432) following PR.

What is known about the topic?

Pulmonary rehabilitation (PR) is an effective management strategy for patients with chronic obstructive pulmonary disease (COPD) and has been shown to reduce symptoms and increase exercise capacity and health-related quality of life.

What does this paper add?

This paper describes the outcomes from a pulmonary rehabilitation program attended by 256 patients with COPD, with improvement recorded for physiological and utilisation indicators.

What are the implications for practitioners?

Appropriate COPD patients are likely to benefit from referral to pulmonary rehabilitation.

tion and a 62% reduction in total bed-days (1131 to 432) following PR.

Conclusion: Pulmonary rehabilitation provided in an Australian teaching hospital was associated with a reduction in COPD hospitalisation, and the resultant savings outweighed the costs of providing the program.

Aust Health Rev 2008; 32(3): 415–422

Nola Cecins, MSc, Physiotherapy, Curtin University of Technology; Lung Institute of Western Australia, University of WA; and Senior Physiotherapist

Sue C Jenkins, PhD, Physiotherapy, Curtin University of Technology; Lung Institute of Western Australia, University of WA; and Associate Professor
Physiotherapy Department, Sir Charles Gairdner Hospital, Perth, WA.

Elizabeth Geelhoed, PhD, Senior Lecturer
School of Population Health, The University of Western Australia, Perth, WA.

Correspondence: Mrs Nola Cecins, Physiotherapy Department, Sir Charles Gairdner Hospital, Hospital Avenue, Nedlands, Perth, WA 6009.

Nola.Cecins@health.wa.gov.au

CHRONIC OBSTRUCTIVE PULMONARY DISEASE (COPD) represents a significant economic burden in terms of health care cost. Hospitalisation due to exacerbation is consistently the greatest cost component of COPD care.^{1–3} Pulmonary rehabilitation (PR) is an effective management strategy for patients with COPD and has been shown to reduce symptoms and increase exercise capacity and health-related quality of life (HRQoL).^{4,5} There is also evidence from randomised controlled trials,^{6,7} a systematic review⁸ and clinical reports^{9–13} that PR reduces health care utilisation in COPD. Economic evaluations of PR programs have shown that the resulting reduction in health care utilisation is likely to more than offset the cost outlay in providing such programs.^{14,15}

Data collected by the Australian Lung Foundation before 2000 revealed that fewer than 1% of patients with COPD in Australia were receiving PR.¹⁶ Guidelines for the management of COPD in Australia and New Zealand were developed (COPD-X), and access to PR is strongly recommended for patients with moderate to severe disease.⁵ In response to these guidelines, more PR programs have been established across Australia in both hospital and community settings. To date, outcomes from PR programs conducted in Australia over an extended period of time have not been published.

The main aim of this study was to quantify outcomes of a PR program provided at a teaching hospital within Australia. The secondary aim was to determine whether completion of the program was associated with a reduction in hospital admissions and length of stay for COPD exacerbations as has been reported following programs carried out in other countries.^{6-8,10-13}

Methods

Patients

All patients with a medical diagnosis of COPD (post-bronchodilator $FEV_1 < 80\%$, $FEV_1/FVC < 70\%$) who entered a PR program at a university teaching hospital (Sir Charles Gairdner Hospital [SCGH] Perth, Western Australia) over a 6-year period (1998 to 2003) entered the study. Referrals to the program were predominantly from outpatient respiratory clinics and private physicians. Patients with dyspnoea on physical activity despite optimal medical management were suitable for referral and were admitted to the program when their respiratory condition was stable and there had been no changes in their medication in the preceding 4 weeks. To be included in the program, individuals must have an absence of severe musculoskeletal impairment or uncontrolled cardiovascular disease, and a 6-minute walk distance (6MWD) > 200 m. Patients with a 6MWD < 200 m have been shown to experience difficulties completing the program due to the physical separation (140m) of the walking track and the gymnasium used for exercise training.

These patients are offered home-based rehabilitation and were not included in this study. We also excluded patients if they had undergone lung volume reduction surgery or work-up for lung transplantation.

Formal approval for undertaking this analysis was granted by the Human Research Ethics Committee of SCGH.

The pulmonary rehabilitation program

This was a continuous rolling program with each patient attending two exercise classes (75 minutes duration) each week for a period of 8 weeks. Exercise classes consisted of six to 10 patients supervised by a physiotherapist (NC or SCJ). Exercise training comprised a 20-minute walking program within an enclosed hospital corridor, flexibility and stretching exercises, and a six-station exercise circuit in a gymnasium. The 20-minute high-intensity walking program was initially prescribed at an intensity equivalent to 80% of the average walking speed achieved on the pre-PR 6-minute walk test (6MWT).¹⁷⁻¹⁹ The circuit comprised unsupported upper limb exercises and lower limb exercises aimed at improving muscle strength and endurance. Simple equipment was used to allow easy replication of the exercises in the home environment. The modalities of exercise used in the exercise circuit were based on responses to the dyspnoea domain of the Chronic Respiratory Disease Questionnaire (CRDQ),²⁰ with exercises selected for the individual with the aim of training the muscle groups involved in the activities of daily living that provoked dyspnoea. Intensity, frequency and duration of the circuit exercises were prescribed in accordance with recommendations in the Pulmonary Rehabilitation Toolkit.¹⁷ Patients prescribed long-term oxygen therapy and those who showed marked desaturation with activity used supplemental oxygen during exercise in accordance with national guidelines.²¹ The exercise intensity or duration of each exercise was increased weekly within symptom tolerance.¹⁹ In addition to the supervised classes, patients were instructed to complete a home exercise program on an additional 2 or 3 days each week.

Informal education sessions took place during the rest period (about 15 minutes) between the walking program and the exercise circuit. These sessions encouraged problem-solving and positive self-management behaviours. Topics included managing breathlessness, action plans for COPD exacerbations, maintaining regular exercise, communicating with health professionals, and oxygen therapy. A formal education session was offered to participants and their support person or carer on three occasions each year. A doctor, physiotherapist and pharmacist covered topics such as “How the lungs work in health and disease”, “Respiratory conditions and their management” and “Medications and correct inhaler technique”. Where necessary, patients were referred for nutritional advice or smoking cessation counselling. All participants were given information on local patient support groups.

At the conclusion of the 8-week program, patients were encouraged to join a community-based maintenance exercise class supervised by a physiotherapist and to continue with their home exercise program. A small number of patients (average of five each year) with severe disease and multiple comorbid conditions were offered a hospital-based maintenance exercise class.

Assessment

Before commencing PR, anthropometric data, smoking history and spirometric data were obtained. Before and immediately following the 8-week program, functional exercise capacity and HRQoL were measured.

Functional exercise capacity

The 6MWT was used to measure functional exercise capacity. The test was performed in accordance with current recommendations but modified to include standardisation of the frequency of encouragement given to patients who rested during the test and the measurement of oxygen saturation and heart rate during the test.^{17,22} All tests were supervised by a physiotherapist (N C or S C J).

The 6MWT was performed over a 45m straight course within a level, enclosed corridor. Before

each test standardised instructions were read aloud to the patient.¹⁷ Each minute patients were informed of the number of minutes remaining and were given standardised encouragement. In the event that a patient rested during the test, encouragement to recommence walking was given at 15 second intervals. The 6MWT was performed twice at baseline (pre-PR) assessment, with a 20–30 minute rest period separating the two tests, and the greatest distance was recorded. A single 6MWT was performed at the post-PR assessment.

Health-related quality of life

The CRDQ, using the interview format with informed responses at post-PR assessment, was used to measure HRQoL.^{20,23} This questionnaire quantifies the four domains of: dyspnoea, fatigue, emotional function and mastery.

Hospitalisation

The number of hospital admissions for a COPD exacerbation and total bed-days (calculated by adding bed-days from all admissions) in the 12-month period before PR and the 12-month period following PR were recorded. Data were collected by patient report and verified by searching hospital databases for patients' admissions to hospital for a COPD exacerbation and the days spent in hospital. Patients who completed PR but died in the 12 months following the program were excluded from this analysis.

Statistical analysis

Distribution of the data was examined and data were transformed for statistical analyses where necessary. The 6MWD and CRDQ data pre- and post-PR were compared using paired *t*-tests. Unpaired *t*-tests were used to compare baseline data on patients who completed and those who did not complete PR, and the magnitude of change between the men and women who completed the program. The number of hospital admissions before and after the program were compared using unpaired *t*-tests (continuous variables) and χ^2 tests (discrete variables). The numbers of patients admitted to hospital before and

I Baseline anthropometric characteristics and lung function of 187 patients who completed pulmonary rehabilitation

Characteristic	Patients (n=187)*
Male : female	65 : 35
Age (years)	67.5±8.4
FEV ₁ (L)	1.04±0.50
FEV ₁ % predicted ²⁴	41.4%±19.3%
Disease severity ^{5†}	
Mild	15%
Moderate	32%
Severe	53%
Body mass index (kg/m ²)	25.0±5.6
< 20	17%
20–24.9	39%
25–29.9	28%
≥ 30	16%
6-minute walk distance (m)	399±119

* Mean ±SD unless otherwise indicated. FEV₁ = forced expiratory volume in one second. † Disease severity defined on basis of FEV₁: mild = FEV₁ ≥ 60% of predicted value; moderate = FEV₁ 40%–59% of predicted value; severe = FEV₁ < 40% of predicted value.

after the program were compared using the proportions admitted. Analyses were performed using SPSS, Version 11 (SPSS Inc, Chicago, Ill, USA). An alpha value of ≤ 0.05 was considered

to be significant. Data are presented as mean ±SD unless otherwise stated.

Results

Two hundred and fifty-six patients with COPD who entered PR over the 6-year period were included in this study. Twenty-nine patients were excluded, as they had undergone lung volume reduction surgery or work-up for lung transplantation. Patients were considered to have completed the program if they attended at least 10 exercise classes (ie, at least 60% of their scheduled classes) and completed the reassessment. One hundred and eighty-seven patients (73%) completed PR. Reasons for non-completion were mostly due to medical problems, COPD and non-COPD related, and other issues including transport difficulties, relocation and poor attendance. Forty-five (24%) of the program graduates attended formal education sessions. At the completion of the program, 42% of the graduates commenced a maintenance exercise program either at the hospital (17%) or in the community (25%).

Box 1 shows the baseline characteristics of the 187 patients who completed the program. The majority of patients (85%) had moderate or severe COPD.⁵ The 69 patients who did not complete PR had a lower FEV₁ (0.86±0.36 v 1.04±0.50 L, $P=0.005$) and 6MWD (328±114 v 399±119 m, $P<0.001$) compared with the patients who completed the program. The mean

2 Functional exercise capacity and health-related quality of life measured pre and post pulmonary rehabilitation (PR) in the 187 patients who completed PR

Outcome measure	Pre PR	Post PR	P
Functional exercise capacity			
6-minute walk distance (m)	404.2±114.6	439.6±115.0	< 0.05
Health-related quality of life — Chronic Respiratory Disease Questionnaire (CRDQ) (n = 144)			
Total score	4.1±0.9	4.9±0.9*	< 0.001
Dyspnoea	3.3±1.0	4.3±1.1*	< 0.001
Emotional function	4.6±1.1	5.3±1.1*	< 0.001
Fatigue	3.4±1.2	4.4±1.1*	< 0.001
Mastery	4.7±1.2	5.5±1.1*	< 0.001

All values are mean±SD. CRDQ data reported as points per item with higher scores indicating less impairment. *Improvements exceed the minimum clinically important difference.

3 Hospitalisation data for the patients who completed pulmonary rehabilitation (PR) excluding deceased patients (n = 177)

	Pre PR (12 months)	Post PR (12 months)	P
Patients admitted (no., %)	71 (40%)	38 (21%)	< 0.001
Total no. admissions	127	61	< 0.001
Total bed-days	1131	432	< 0.001
Average LOS per admission (days)	11.1 ± 15.0	7.3 ± 4.7	ns
Total hospitalisation cost (A\$)	642 408	245 376	na

LOS = length of stay. ns = not significant. na = not applicable. Hospitalisation cost based on an average per day cost for a chronic obstructive pulmonary disease admission (A\$568)²⁶ multiplied by total bed-days.

body mass index for the patients who did not complete was also lower, however this did not reach significance ($23.4 \pm 0.5 \text{ kg/m}^2$ v $25.0 \pm 0.5 \text{ kg/m}^2$, $P = 0.12$).

Functional exercise capacity and HRQoL

Box 2 shows the 6MWD and CRDQ data for the patients who completed PR. The CRDQ data are not reported for 44 patients who experienced difficulties completing the questionnaire due to visual impairment or language problems. Improvements in 6MWD ($P < 0.001$) and all domains of the CRDQ ($P < 0.001$) were found following PR. The magnitude of improvement in each domain of the CRDQ exceeded the minimum clinically important difference.²⁵ The magnitude of change in 6MWD and each domain of the CRDQ were similar in men and women ($P > 0.05$).

COPD-related hospitalisations for patients completing PR

In the 12 months following PR, 10 of the 187 patients (6%) who completed the program died and were excluded from further analysis. Box 3 shows the number of admissions for COPD exacerbations and total bed-days for the remaining 177 patients in the 12 months before and following PR. Seventy-one patients had at least one COPD-related admission in the 12 months before PR and 38 patients had an admission in the 12 months following PR. This represents a 46% reduction in the number of patients admitted to hospital for a COPD exacerbation and a 51% reduction in total hospital admissions (127

to 61) following PR. There was a 62% reduction (1131 to 432 days) in the total bed-days in the 12 months following PR. Although there was a strong trend towards a decrease in the average length of stay for admissions following PR compared with pre PR (11.1 ± 15.0 to 7.3 ± 4.7 days), this did not reach statistical significance.

The average per-day cost for a COPD admission was A\$568²⁶ (corrected by a health index deflator to reflect 2003 cost²⁷). Based on this figure, hospitalisation costs for COPD exacerbations in the 12 months before and following PR were A\$642 408 and A\$245 376 respectively (Box 3). This represents a net saving of A\$397 032 in hospitalisation costs in the 12 months following PR.

Of the 71 patients who were admitted to hospital in the 12 months before PR, 28 patients (40%) had an admission for a COPD exacerbation in the 12 months following PR. Eight patients who did not have an admission in the 12 months before PR were admitted in the 12 months following PR for a COPD exacerbation. Twenty eight patients had two or more admissions (total of 95 admissions) in the 12 months before PR. Of these 28 patients, 13 had no admissions, 9 had one admission and 6 patients had two or more admissions (total of 35 admissions) in the 12 months following PR.

Discussion

To our knowledge, this is the first reported study of outcomes and hospitalisation data following PR in an Australian cohort of COPD patients over an extended period of time (6 years). The results

show our PR program improves functional exercise capacity and HRQoL in the short-term, and is associated with a reduction in hospitalisation for COPD exacerbations in the 12 months following rehabilitation. Of the patients entering PR, 73% completed the program. This high attrition rate is similar to that reported by others.^{9,28}

Hospitalisation

Following PR, the reduction in total bed-days was due to a decrease in the number of patients being admitted to hospital and a reduction in the length of stay. This differs to the findings of a study carried out in the United Kingdom⁶ that reported an overall reduction in days spent in hospital following PR due to a decrease in the frequency and duration of admissions but not the number of patients admitted. Although there is a historic decline in average length of stay in public acute hospitals within Australia, during the 6-year period of this analysis the average length of stay in public acute hospitals did not vary.²⁹ There is some evidence of a trend towards a decline in length of stay for COPD admissions during the period of the study, however, this does not account for the change observed following the PR intervention.³⁰

Costs

The reduction in hospitalisation related to COPD exacerbations following our PR program would result in significant savings to the health care system. The cost of our PR program was A\$292 (2003) per patient based on previously reported data³¹ and corrected using a health index deflator.²⁷ The inclusion of equipment and overhead costs (an additional 25% consistent with Griffiths et al¹⁴) gives rise to an overall program cost of A\$93 440 for 256 patients. This figure is modest and compares favourably with the costs of programs in the UK²⁸ and in Canada.¹⁵ The reduction in hospitalisation in the 12 months following PR resulted in a net saving of A\$397 032 (Box 3). Hence the cost of providing PR at SCGH to the 256 patients who entered over the 6-year period represents only 23% of the total savings from the subsequent reduction in bed-days.

These findings are consistent with studies undertaken elsewhere. Evidence of cost-effectiveness of PR in the UK has been reported. Griffiths and colleagues¹⁴ performed a cost/utility analysis in conjunction with their randomised-controlled trial of PR versus standard care.⁶ This comprehensive analysis included quality-adjusted life years, direct and indirect costs. Their findings showed that the savings from the downstream reduction in health care utilisation more than offset the cost of providing PR, and thus PR resulted in financial benefits to the health service. An economic evaluation of community-based PR in Canada reported a reduction of total costs of C\$344 per person per year.¹⁵ Regardless of COPD severity, PR was associated with decreased health care utilisation, reduced direct costs and improved health status. The magnitude of the cost savings following PR in Australia that arise due to a reduction in hospitalisation for COPD exacerbations is similar to that reported following PR in other countries.^{14,15} Further, these savings far outweigh the cost of providing such a program.

Factors affecting hospitalisation

The increased levels of physical activity promoted in our PR program possibly contributed to the reduction in hospitalisation. Garcia-Aymerich et al³² showed that patients with COPD who reported high levels of physical activity (equivalent to greater than 60 minutes of walking per day) had a 46% reduction in hospital readmission for COPD. Our program has a large component of walking and emphasises the importance of walking in functional activities. Functional exercise capacity, as measured by the 6MWD, is a strong correlate of walking and standing time during daily life in COPD patients³³ and a 6MWD of less than 367m has been reported to increase the risk of hospitalisation in this population.³⁴ Before PR, 43% of our patients achieved a 6MWD of less than 367m, and this decreased to 26% of patients following PR. This improvement in 6MWD may have reduced the risk of hospitalisation and contributed to the decrease in the number of patients admitted to hospital for an exacerbation of COPD.

The improvements in HRQoL following our program may also have contributed to the reduction in hospitalisation. Patients with COPD who have poor HRQoL have been shown to be at greater risk of hospital readmission.³⁵ In particular, improvements in the mastery domain of the CRDQ following our program may reflect improved coping strategies that in turn may have contributed to the patient's confidence in managing an exacerbation. In a study of the effects of early treatment on COPD exacerbations, patients who did not seek early treatment were more likely to be hospitalised for the management of an exacerbation and had poorer HRQoL.³⁶ Education sessions in our program, both formal and informal, may have contributed to the reduction in hospitalisation as a result of improved adherence with medications and oxygen therapy and earlier recognition and management of exacerbations.

Limitations

The main limitation of this study is the lack of a randomised control group, and thus we are unable to account for confounding factors such as changes in medications in the 12 months following PR, the impact of influenza epidemics or improvements in general practice and management during hospital admissions. To the best of the authors' knowledge, no structured programs aimed at improving inpatient management of COPD were implemented during the period of the study. However, for this group of patients there was a reduction in hospitalisation compared with the previous 12 months and this is consistent with the findings of randomised-controlled trials.^{6,7} Finally, these findings are not able to be generalised to patients with severe functional limitation (6MWD < 200 m) as they were not included in the study due to their inability to manage an outpatient program in this setting.

Conclusion

This study suggests that an outpatient PR program conducted in Australia results in significant improvements in functional exercise capacity and HRQoL, and a reduction in hospitalisation due to

COPD exacerbations. The savings incurred from the reduction in hospitalisation far outweigh the costs of providing such a program.

Acknowledgements

We would like to acknowledge the staff at Sir Charles Gairdner Hospital who were involved in the formal education sessions, and the Department of Respiratory Medicine.

Competing interests

The authors declare that they have no competing interests.

References

- 1 Strassels SA, Smith DH, Sullivan SD, Mahajan PS. The costs of treating COPD in the United States. *Chest* 2001; 119: 344-52.
- 2 Novak D, Berger K, Lippert B, et al. Epidemiology and health economics of COPD across Europe: a critical analysis. *Treat Respir Med* 2005; 4: 381-95.
- 3 Chapman KR, Mannino DM, Soriano JB, et al. Epidemiology and costs of chronic obstructive pulmonary disease. *Eur Respir J* 2006; 27: 188-207.
- 4 Lacasse Y, Goldstein R, Lasserson TJ, Martin S. Pulmonary rehabilitation for chronic obstructive pulmonary disease. *Cochrane Database Syst Rev* 2006; (4): CD003793. DOI: 10.1002/14651858.CD003793.pub2.
- 5 McKenzie DK, Abramson M, Crockett AJ, et al. The COPDX Plan: Australian and New Zealand Guidelines for the Management of COPD 2007. Available at: http://www.copdx.org.au/guidelines/a_copd_guidelines.asp (accessed Mar 2007).
- 6 Griffiths TL, Burr ML, Campbell IA, et al. Results at 1 year of outpatient multidisciplinary pulmonary rehabilitation: a randomised controlled trial. *Lancet* 2000; 355: 362-8.
- 7 Man WD-C, Polkey MI, Donaldson N, et al. Community pulmonary rehabilitation after hospitalisation for acute exacerbations of chronic obstructive pulmonary disease: randomised controlled study. *BMJ* 2004; 329: 1209. doi: 10.1136/bmj.38258.662720.3A.
- 8 Puhan MA, Scharplatz M, Troosters T, Steurer J. Respiratory rehabilitation after acute exacerbation of COPD may reduce risk for readmission and mortality — a systematic review. *Respir Res* 2005; 6: 54. doi: 10.1186/1465-9921-6-54.
- 9 Hui KP, Hewitt AB. A simple pulmonary rehabilitation program improves health outcomes and reduces

- hospital utilization in patients with COPD. *Chest* 2003; 124: 94-7.
- 10 Cote CG, Celli BR. Pulmonary rehabilitation and the BODE index in COPD. *Eur Respir J* 2005; 26: 630-6.
- 11 Young P, Fergusson W, Dewse M, Kolbe J. Improvements in outcomes for chronic obstructive pulmonary disease attributable to a hospital-based respiratory rehabilitation programme. *Aust N Z J Med* 1999; 29: 59-65.
- 12 Foglio K, Bianchi L, Brulletti G, et al. Long-term effectiveness of pulmonary rehabilitation in patients with chronic airway obstruction. *Eur Respir J* 1999; 13: 125-32.
- 13 California Pulmonary Rehabilitation Collaborative Group. Effects of pulmonary rehabilitation on dyspnea, quality of life, and healthcare costs in California. *J Cardiopulm Rehabil* 2004; 24: 52-62.
- 14 Griffiths TL, Phillips CJ, Davies S, et al. Cost effectiveness of an outpatient multidisciplinary pulmonary rehabilitation program. *Thorax* 2001; 56: 779-84.
- 15 Golmohammadi K, Jacobs P, Sin DD. Economic evaluation of a community-based pulmonary rehabilitation program for chronic obstructive pulmonary disease. *Lung* 2004; 182: 187-96.
- 16 The Australian Lung Foundation. Case statement: chronic obstructive pulmonary disease — Australia and New Zealand. ALF, 2001. Available at: <http://www.lungnet.com.au/content/view/118/142/> (accessed Mar 2007).
- 17 The Australian Lung Foundation and Australian Physiotherapy Association. Pulmonary rehabilitation toolkit. ALF & APA, 2006. Available at: <http://www.pulmonaryrehab.com.au> (accessed Mar 2007).
- 18 American Thoracic Society. Pulmonary rehabilitation — 1999. *Am J Respir Crit Care Med* 1999; 159: 1666-82.
- 19 American Thoracic Society/European Respiratory Society. ATS/ERS statement on pulmonary rehabilitation. *Am J Respir Crit Care Med* 2006; 173: 1390-1413.
- 20 Guyatt GH, Berman LB, Townsend M, et al. A measure of quality of life for clinical trials in chronic lung disease. *Thorax* 1987; 42: 773-8.
- 21 McDonald CF, Crockett AJ, Young IH. Adult domiciliary oxygen therapy. Position statement of the Thoracic Society of Australia and New Zealand. *Med J Aust* 2005; 182: 621-6.
- 22 American Thoracic Society. ATS Statement: guidelines for the six-minute walk test. *Am J Respir Crit Care Med* 2002; 166: 111-7.
- 23 Guyatt GH, Berman LB, Townsend M, Taylor DW. Should study subjects see their previous responses? *J Chronic Dis* 1985; 38: 1003-7.
- 24 Hankinson JL, Odencrantz JR, Fedan KB. Spirometric reference values from a sample of the general US population. *Am J Respir Crit Care Med* 1999; 159: 179-87.
- 25 Jaeschke R, Singer J, Guyatt GH. Measurement of health status. Ascertaining the minimal clinically important difference. *Control Clin Trials* 1989; 10: 407-15.
- 26 Australian Institute of Health and Welfare. Australian hospital statistics 2002-03. Health Services Series No. 22. Canberra: AIHW, 2004. (AIHW Cat. No. HSE 32.)
- 27 Australian Institute of Health and Welfare. Health expenditure Australia 2003-04. Health and Welfare Expenditure Series No. 25. Canberra: AIHW, 2005. (AIHW Cat. No. HWE 32.)
- 28 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: 1146-54.
- 29 Australian Institute of Health and Welfare. Hospitals at a glance. Available at: <http://www.aihw.gov.au/hospitals/ata glance/2004/index.cfm#s01> (accessed Sep 2006).
- 30 Australian Institute of Health and Welfare. COPD data cubes. <http://www.aihw.gov.au/cognos/cgi-bin/ppd-scgi?DC=Q&E=/ahs/principaldiagnosis9899-0405> (accessed Jul 2007).
- 31 Jenkins SC, Cecins NM, Collins GB. Outcomes and direct costs of a pulmonary rehabilitation service. *Physiother Theory Pract* 2001; 17: 67-76.
- 32 Garcia-Aymerich J, Farrero E, Felez MA, et al. Risk factors of readmission to hospital for a COPD exacerbation: a prospective study. *Thorax* 2003; 58: 100-5.
- 33 Pitta F, Troosters T, Spruit MA, et al. Characteristics of physical activities in daily life in chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 2005; 171: 972-7.
- 34 Kessler R, Faller M, Fourgaut G, et al. Predictive factors of hospitalization for acute exacerbation in a series of 64 patients with chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 1999; 159: 158-64.
- 35 Osman LM, Godden DJ, Friend JAR, et al. Quality of life and hospital re-admission in patients with chronic obstructive pulmonary disease. *Thorax* 1997; 52: 67-71.
- 36 Wilkinson TMA, Donaldson GC, Hurst JR, et al. Early therapy improves outcomes of exacerbations of chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 2004; 169: 1298-1303.

(Received 30/04/07, revised 30/07/07, accepted 29/01/08) □