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COPD

Maintaining Gains Following Pulmonary Rehabilitation

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Abstract
Purpose Pulmonary rehabilitation (PR) is an accepted intervention for individuals with chronic obstructive pulmonary disease. Despite initial improvements following PR, many patients eventually return to baseline function or decline even further. The aim of this study is to look at long-term (>1 year) outcomes following PR.
Methods This was a prospective cohort study of patients who had completed PR. Participants were invited for an assessment consisting of participant interviews and clinical assessments using standardised instruments.
Results 129 patients between 2003 and 2012 completed rehabilitation and were eligible. 88 patients were included in the analysis. The mean time of the long-term assessment was 22 months following PR. The mean age was 71 years. Mean FEV1 was 46 %. There was a statistically significant ($p < 0.001$) increase in the incremental shuttle walk test distance of 29.0 m following PR but this gain was lost at the long-term reassessment. Chronic Respiratory Questionnaire (CRQ) scores showed a statistically significant ($p < 0.001$) increase in all four domains but only the domains of dyspnoea and fatigue remained statistically significant ($p < 0.001$, $p < 0.01$, respectively) at the long-term reassessment. Hospital Anxiety and Depression Scale scores reduced following rehabilitation but only the anxiety component was statistically significant ($p < 0.01$). These improvements persisted at the long-term reassessment but were not statically significant.
Conclusions This study confirms that many of the functional gains achieved in PR are lost in the longer term. Regular surveillance or monitoring of these patients post-PR is important to identify those requiring further intervention.

Keywords Pulmonary disease · Chronic obstructive · Pulmonary rehabilitation · Exercise

Introduction

Patients with chronic obstructive pulmonary disease (COPD) often experience ongoing impairments with their day-to-day life despite optimal pharmacological management. Whilst COPD is known to affect the lungs, the associated physical deconditioning and the emotional responses to chronic respiratory disease contribute greatly to the resulting morbidity [1]. It has been difficult to determine whether these changes relate to the disease itself or reduced activity levels as a consequence of progressive lung disease [2]. Skeletal muscle dysfunction beyond deconditioning has been identified and recognised as a major target for treatment [3]. In spite of optimal pharmacological treatment, many COPD patients experience substantial functional impairment limiting their normal activities of daily living and affecting their quality of life (QOL) [4, 5]. The medical treatment of COPD has been well established, yet very little is known about how the disease progresses to disability [6].

Pulmonary rehabilitation (PR) is an accepted non-pharmacological intervention for individuals with COPD [7]. This consists of an interdisciplinary approach to

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patients with chronic respiratory impairment that is individually tailored and designed to optimise physical and social performance and autonomy [1]. The minimum duration of an effective rehabilitation program is 6 weeks [8]. PR should be offered to patients with moderate to severe COPD [9].

Unlike neurological and orthopaedic rehabilitation in which therapy acts as an adjuvant treatment in enhancing recovery, the primary aim of PR is not to improve lung function, but rather to improve self-coping or management of COPD.

Following successful completion of PR, some patients deteriorate further and require repeat stints of PR. Studies that have monitored patients beyond 12 months following PR have shown differing results. Some have shown that benefits such as QOL persist beyond 12 months [10–14]. Others have shown that patients often return to baseline or even deteriorate further [15–17]. Some studies had small sample sizes with only 16 and 21 patients [14, 18]. Many studies included patients in a hospital outpatient setting or patients with less severe COPD. The aim of this study is to look at long-term outcomes of patients with moderate to severe COPD attending PR in a community setting. Secondary aims include comparing the demographics and changes in mobility and function following PR.

Methods

Participants and Setting

This was a prospective cohort study of patients who had completed PR conducted at Royal Melbourne Hospital (RMH) and Merri Community Health Service (MCHS). This study was approved by the Human Research Ethics Committee of Melbourne Health.

The diagnosis and severity of COPD was graded according to the Global Initiative for COPD (GOLD) criteria [19] by respiratory and rehabilitation physicians at RMH. Patients who are treated by the respiratory service are referred for ongoing pulmonary management and rehabilitation.

The 8-week PR program consists of multidisciplinary management including medical, nursing and allied health using standardised therapy protocols. Following patient assessment including goal setting, an individualised exercise plan was created. Each week, participants undertook two 2-hourly sessions consisting of group physical therapy and general education sessions. The 45 min exercise session consists of 15 min treadmill/walking, 15 min cycling, and 15 min circuit exercises. Treadmill speeds were set at 80 % of the initial incremental shuttle walk test (ISWT) speed. Patients were educated and monitored to ensure they spend most of their time on the treadmill or bike at a high level of intensity as per current American Thoracic Society guidelines [20]. This correlated to a rating of perceived exertion (RPE) of 4–6 on the modified Borg scale. In subsequent sessions, patients were encouraged to either increase treadmill speed or bike resistance provided they remained in the 4–6 on the RPE. Each group contained a maximum of 15 patients. Patients were supervised during the program by their key worker and physician. Group education included topics such as how the lungs work and medication management.

Eligible patients were identified from a centralised database at MCHS. The inclusion criteria were patients with a confirmed diagnosis of COPD and have completed PR between 2003 and 2012. This allowed a minimum period of 12 months follow-up. Patients were excluded if they had severe cognitive impairment or were medically unwell for further assessment and testing.

Procedure

Following consent, eligible patients were invited to attend the community centre for assessment (long-term assessment).

The long-term assessment participant interviews and clinical assessments were completed using a structured format. The assessors completed demographic, functional, and QOL assessments using standardised instruments (see measures). Standardised instructions were given to patients to complete questionnaires. Any additional queries were answered.

Data Collection

Patient data were extracted from a centralised database. Information was collected at several time points, from pre-PR, post-PR and at 3 monthly intervals post-PR until they were discharged from case management. Basic demographic information was collected at the first visit. The main outcome measures including ISWT, CRQ and Hospital Anxiety and Depression Scale (HADS) were recorded at pre-PR, post-PR and repeated at the long-term assessment.

Main Outcome Measures

Activity was assessed with the ISWT [21], whilst participation and QOL was measured with the Chronic Respiratory Questionnaire (CRQ) [22] and HADS [23]. COPD-related measures were obtained from the medical record which include socio-demographic, clinical and treatment data, such as spirometry and severity of COPD.

The primary outcome measure in this study is the CRQ. The CRQ consists of a 20-item questionnaire with four major domains which patients self-administer. This

measures the health-related Quality of Life in respiratory patients. CRQ has been widely used in the respiratory and COPD contexts [20]. The Minimal Clinically Important Difference (MCID) is reflected by a change in score of 0.5 on a 7-point scale [24].

Secondary Outcome Measures Include

ISWT This is a field-based test that progressively increases walking speed and measures the functional capacity of COPD patients [21]. ISWT is a true symptom-limited maximal exercise capacity test, and distance walked relates strongly to peak aerobic capacity [20]. Normal health subjects are able to complete 810 m [25]. The MCID for COPD is 47.5 m [26]. Patients were asked to complete ISWT twice at each timepoint with the best result recorded.

HADS The HADS is a fourteen-item scale that measures levels of anxiety and depression. Each item is rated on a scale of 0–3. Each domain is totalled; scores 8–10 indicate possible case and greater than 10 indicate probable case [27]. HADS is the current recommended screen tool in COPD patients [9]. The MCID is 1.5 [28].

Statistical Analyses

The data were keyed into Microsoft Excel (Microsoft, WA USA) and exported into Stata12 (StataCorp, TX USA) for data analysis and reporting. Descriptive analysis of study cohort was undertaken and results were reported as *N*(%) for categorical data (e.g. gender, living arrangements, etc.) and mean for continuous data (FEV1, FVC, BMI, etc.).

The change in outcomes of interest between pre- and post-PR was calculated based on the score at end of PR minus the score at baseline. The long-term change was calculated based on the score at the long-term assessment visit minus the score at baseline. The differences were assessed for normality using Shapiro–Wilk test. An one-sample *t* test was used in scores with normal distribution to determine the significance of the change and its magnitude. Multivariate regression analysis was then undertaken to determine the predictors of the change. Level of significance for the study was set at $p < 0.05$. Accounting for multiple comparison and subscale analysis, the change for CRQ subscales was defined as significant if p was < 0.01.

Results

A total of 217 patients commenced PR between 2003 and 2012. 129 patients actually completed rehabilitation and were eligible. 88 patients were included in the analysis. 21 patients were deceased and 20 patients declined participation or could not be contacted.

Table 1 shows the basic demographics of the cohort. There was a similar ratio of males to females with a mean age of 71 years. A mean FEV1 of 46 % correlates with severe COPD according to the GOLD criteria [29]. 94 % were either a past or present smoker. 26 % of patients were on Long-Term Oxygen Therapy (LTOT).

The prevalence of medical comorbidities ranged from 13 to 29 %. 8 % had previously diagnosed anxiety and 19 % had previously diagnosed depression.

Table 2 reflects the scores of patients at baseline, end of rehabilitation and their reassessment (long-term reassessment). Graph 1 illustrates the mean time between the end of PR and the long-term reassessment was 22 months (standard deviation 16 months, range 12–84 months). At the time of reassessment, some of these patients were already discharged from case management. Baseline scores revealed 39 % of patients had probable anxiety and 28 % had probable depression on the HADS (Table 1).

Table 3 shows the mean change of outcome measures immediately following rehabilitation and at the long-term reassessment. In the walk test, this showed a statistically significant ($p < 0.001$) increase in the ISWT distance of 29.0 m following rehabilitation but this gain was lost at the long-term reassessment and in fact worsened. CRQ scores showed a statistically significant ($p < 0.001$) improvement in all four domains but only dyspnoea and fatigue remained statistically significant ($p < 0.001$ and $p < 0.01$, respectively) at the long-term reassessment. The mean improvements in dyspnoea and fatigue scores were maintained at the long-term reassessment. The other domains of emotion and mastery maintained some of their gains following rehabilitation but not statically significant.

Both the anxiety and depression component of the HADS scores reduced following rehabilitation but only the anxiety component was statistically significant ($p < 0.01$). Some of these improvements persisted at the long-term reassessment but was not statically significant.

Multivariate regression analysis was performed to see whether any baseline variables could predict maintenance of gains in the long term. No predictors were seen. Mild to moderate correlation was observed between the change in ISWT and the change in total CRQ ($r = 0.27$, $p = 0.014$) and emotional CRQ ($r = 0.26$, $p = 0.018$). Other domains in the CRQ showed no correlation.

Discussion

This study showed that patients showed improvements immediately following PR but these gains are not maintained in the longer term. At the long-term assessment, only the dyspnoea domain of the CRQ showed sustained gains that were both statistically significant and exceeding

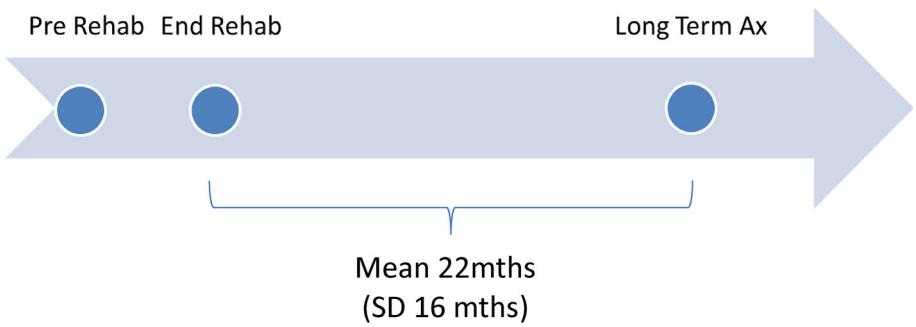
Table 1 Baseline Demographics

	($n = 88$)
Sex	
Male	41 (47 %)
Female	47 (53 %)
Age	70.7 (SD 7)
Body mass index (BMI—kg/m^2)	26.9 (SD 6)
Lung function	
FEV1	46 % (SD 16)
Modified Medical Research Council Scale (MMRC)	1.98
Current/past smoker	83 (94 %)
Smoking (pack years)	55 (SD31)
Long-term oxygen therapy (LTOT)	23 (26 %)
Ischaemic heart disease (IHD)	26 (29 %)
Congestive cardiac failure (CCF)	12 (13 %)
Diabetes mellitus (DM)	14 (16 %)
Previously diagnosed anxiety	7 (8 %)
Previously diagnosed depression	17 (19 %)

Table 2 Results at pre-PR, post-PR and at long-term assessment

Outcome measure (SD)	Pre-PR	Post-PR	Long-term post-assessment
Incremental shuttle walk test (ISWT) (m)	234.5 (99.4)	263.6 (104.8)	215.2 (116.6)
CRQ scores			
Total (range 20–140)	85.6 (18.9)	98.4 (17.1)	92.6 (21.6)
Dyspnoea (range 5–35)	16.3 (4.5)	20.1 (5.9)	19.7 (6.9)
Fatigue (range 4–28)	15.2 (5.5)	18.2 (4.4)	16.7 (5.9)
Emotion (range 7–49	33.6 (9.1)	37.3 (7.8)	34.2 (9.8)
Mastery (range 4–28)	20.4 (5.3)	22.9 (4.3)	21.3 (5.3)
HADS	($n = 54$)	($n = 54$)	($n = 40$)
anxiety score	6 (4–10)	6 (2–8)	7 (4–9)
Depression score	4 (2–8)	3 (2–5)	4 (2–7)
Prob anxiety	21 (39 %)	14 (26 %)	16 (40 %)
Prob depression	15 (28 %)	9 (16 %)	8 (20 %)

Graph 1 Data collection time points



the MCID. An improvement in fatigue was statistically significant but did not reach MCID. The other domains of the CRQ, ISWT and HADS returned to previous level of function. Previously, Griffiths et al. demonstrated sustained improvements in CRQ exceeding MCID [17], whilst another showed all improvements following PR were lost at 1 year [30]. Two other studies which monitored patients 1 year post-PR have shown patients returning to baseline in the walk test [17, 30]. In HADS, Ige et al. did confirm a significant difference three months' post-rehabilitation

Table 3 Immediate and long-term assessment changes in functional exercise capacity and quality of life following pulmonary rehabilitation (PR)

Outcome measure (SD)	Mean change from pre-PR to post-PR	Mean change from pre-PR to long-term assessment
ISWT (m)	29.0 (64.5)***	−18.5 (100.9)
CRQ scores		
Dyspnoea (range 5–35)	3.7 (4.6)***	3.3 (7.4)***
Fatigue (range 4–28)	3.0 (4.5)***	1.5 (5.5)*
Emotion (range 7–49)	3.6 (6.6)***	0.4 (7.9)
Mastery (range 4–28)	2.5 (3.8)***	0.8 (5.8)
HADS		
Anxiety	−1.6 (3.7)**	−0.9 (3.5)
Depression	−0.7 (2.8)	−0.3 (2.9)

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

(Anxiety −0.8, Depression −0.69) [31]. The demographics such as age and severity of COPD and outcomes following rehabilitation were similar to other cohort studies conducted in Australia and New Zealand [14, 18, 32].

In relation to QOL, statistically significant and exceeding MCID increases were seen in all four domains. These results were similar to a systematic review of PR. Its meta-analysis confirmed improvements exceeding MCID in all four CRQ domains [33]. In the longer term, however, only improvements in one of the four CRQ domains were sustained post-PR.

In this study, exercise capacity improved following PR. Other studies of PR showed improvement between 33 and 88 m in the ISWT [11, 17, 30, 34]. This study showed a 29 m improvement following PR. This is statistically significant ($p < 0.001$) but did not reach the MCID of 47.5 m [26].However, when patients were reassessed at the long-term assessment their ISWT scores actually worsened though not statistically significant. Whilst our centre's PR program was developed around current lung foundation guidelines, some patient's programs could not be uptitrated due to their medical comorbidities or deterioration of their respiratory status [35]. This may have contributed to the lower improvement of exercise capacity. Higher intensity of exercise is likely to provide greater benefit, but the exact amount or type remains unknown [34].

Significant underreporting of psychological disorders was noted in this study. Screening of patients showed 39 % of patients had probable anxiety and 28 % had probable depression. In contrast, only 8 % self-reported anxiety and 19 % self-reported depression. This highlights the importance of screening psychological disorders in patients with COPD and has been recognised in the COPD-X guidelines produced conjointly by the Thoracic Society of Australia and New Zealand and the Lung Foundation [8]. Additional support from their key worker including referral to a psychologist as well as informing their general practitioner was provided where anxiety and depression had been identified. The scores obtained from this centre are similar to that obtained from another study of patients in the same metropolitan region [36]. Depression has been shown to influence the adherence to PR program [37] and may impact on effectiveness of PR. A recent systematic review on the effect of comorbidities confirms that patients with anxiety and/or depression are less likely to improve in dyspnoea scales [38].

Ideally, PR would target the significant psychological (anxiety and depression) burden in this group. Following PR, both anxiety and depression scores reduced but only the anxiety component was statistically significant. MCID was not reached. Two studies (Bentsen et al. and Ige et al.) using the HADS as an outcome measure in PR have shown differing results. Bentsen et al. showed no significant difference in anxiety or depression following PR but the baseline scores were within the normal range [39]. In another study, Ige et al. showed significant difference in both anxiety and depression (−0.7 and −0.5, respectively) immediately following rehabilitation [31].

The loss of physical gains (as seen in the ISWT) is likely due to patients not maintaining either the intensity or frequency of exercise following PR. The major focus of PR is increasingly focused on changing patients' behaviour or perception of their disease long term. This has been confirmed in this study as two of the four domains in CRQ did maintain their gains. Only the emotional domain of CRQ correlated with exercise capacity. The three other domains had no correlation. Other studies have shown that improvements in QOL were not necessarily related to increases in exercise capacity [34].

This study illustrates the performance of the PR program in this health service and in particular rehabilitation conducted in a community health service rather than a hospital outpatient department. In this particular centre, there was 59 % (129/217) completion rate. This is within the 9.7–31.8 % range identified in a systematic review [37]. Patients who smoke or have depression have been identified as factors affecting PR completion rate. The rate of depression in this particular cohort was 28 % and may have contributed to the high dropout rate [37]. Recruitment bias may be possible given that all patients were recruited from this single service. Another limitation is that only those who completed PR were analysed. Those that were initially enrolled but did not commence or did not complete the program were not included. In addition, analysis of a patient's activity levels following PR was not recorded. As all of these patients received case management, most patients would have been encouraged to participate in either a specialised respiratory maintenance program or

other structured activity. Patients who repeated PR during the analysis period were excluded from this study which could potentially bias results. A longer follow-up period would have provided more information. Lastly, hospital readmissions or frequency of exacerbations were not recorded. Further progression of COPD may explain why patient's function may deteriorate.

Conclusions

This study confirms that many of the functional gains achieved in PR are lost in the longer term. Further studies are required to determine which factors affect the longevity of gains following PR. Regular surveillance or monitoring of these patients post-PR is important to identify those requiring further intervention.

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Conflict of interest None.

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