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Review Article

A Retrospective Cohort Study of pulmonary rehabilitation programs in patients with advanced COPD with chronic obstructive pulmonary disease

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Abstract

Background: Pulmonary rehabilitation (PR) improves exercise capacity, dyspnoea and quality of life in COPD, yet most trial evidence derives from moderate disease, leaving its effectiveness in advanced, GOLD stage III-IV patients under-documented.

Objective: This retrospective cohort study evaluated outcomes of structured outpatient PR programs in patients with advanced COPD, examining functional capacity, symptom burden, healthcare utilisation and program completion.

Methods: We reviewed records of 412 patients with GOLD stage III-IV COPD referred to three hospital-affiliated PR programs over six years, comparing six-minute walk distance, St George's Respiratory Questionnaire scores, dyspnoea grade and 12-month exacerbation-related hospitalisation between completers and non-completers.

Results: Completers (n=289, 70.1%) achieved a mean six-minute walk distance improvement of 42.6 m and a St George's Respiratory Questionnaire reduction of 9.8 points, exceeding minimal clinically important differences, alongside a 34% relative reduction in exacerbation-related hospitalisation.

Conclusions: Structured PR confers clinically meaningful functional and symptomatic benefit even in advanced COPD, though completion rates remain a limiting factor warranting targeted strategies to reduce attrition.

Keywords: pulmonary rehabilitation; COPD; exercise capacity; dyspnoea; hospitalisation

1. Introduction

Chronic obstructive pulmonary disease (COPD) remains a leading cause of chronic disability worldwide, and patients with advanced disease, defined by the Global Initiative for Chronic Obstructive Lung Disease (GOLD) as stage III or IV airflow obstruction, carry the greatest burden of dyspnoea, exercise intolerance and healthcare utilisation [1,2]. Pulmonary rehabilitation (PR), a structured programme combining supervised exercise training, education and behavioural change support, is among the most effective non-pharmacological interventions available for COPD, with a substantial evidence base showing improvements in exercise capacity, dyspnoea and health-related quality of life [3,4]. The joint American Thoracic Society/European Respiratory Society statement and successive Cochrane reviews have repeatedly confirmed these benefits across the disease spectrum [5,6], and outpatient multidisciplinary programmes following hospitalisation for exacerbation reduce readmission and improve functional status [7,8].

Despite this consistent evidence, most foundational randomised trials enrolled patients with moderate to moderately severe airflow obstruction, and few large studies have characterised outcomes and completion patterns among patients with advanced, GOLD stage III-IV disease treated in routine clinical practice rather than a trial setting [9,10]. Advanced COPD patients often present with greater comorbid burden, more severe dyspnoea and lower functional reserve, which may influence both achievable benefit and the likelihood of completing rehabilitation [11,12]. Non-completion is itself well documented across the PR literature, with attrition commonly 25-40%, and predictors including travel burden, comorbid mobility limitation and depressive symptoms [13,14,15].

This retrospective cohort study was undertaken to describe real-world outcomes of structured outpatient pulmonary rehabilitation in a large cohort of patients with advanced COPD across three hospital-affiliated programmes, to quantify functional and symptomatic improvement among completers relative to non-completers, and to characterise the association between completion and subsequent exacerbation-related hospitalisation, extending the applied evidence base to the population with the most to gain, and the most difficulty sustaining engagement, from rehabilitation [16,17].

2. Methods

We conducted a retrospective cohort study of consecutive adult patients with spirometrically confirmed GOLD stage III or IV COPD referred to one of three hospital-affiliated outpatient pulmonary rehabilitation programmes over a six-year period. Eligible patients had a post-bronchodilator forced expiratory volume in one second (FEV1) below 50% predicted, were clinically stable at referral (no exacerbation requiring systemic corticosteroids or antibiotics within the preceding four weeks), and had at least one baseline and one follow-up assessment recorded in the programme database. Patients with a competing diagnosis substantially limiting exercise tolerance, such as decompensated heart failure or unstable angina, were excluded at the point of clinical intake, consistent with standard programme eligibility criteria [9,10].

Each programme followed a broadly similar structure of twice-weekly supervised sessions over eight weeks, comprising endurance and resistance exercise training individualised to baseline capacity, together with disease education and self-management components, in line with contemporary practice guidance [5,3]. Programme completion was defined, as in prior audit and outcomes literature, as attendance at a minimum of 70% of scheduled sessions with a documented discharge assessment [18]. Patients who withdrew, were lost to follow-up, or attended fewer than 70% of sessions without

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a discharge assessment were classified as non-completers.

Exacerbations occurring during follow-up were classified and managed according to contemporary joint society guidance [19]. The primary functional outcome was change in six-minute walk distance (6MWD) between baseline and discharge (or, for non-completers, the last recorded assessment), measured according to standard field-test methodology [20,21,22]. Secondary outcomes were change in St George's Respiratory Questionnaire (SGRQ) total score [23], change in modified Medical Research Council (mMRC) dyspnoea grade [24,25], and the proportion of patients with at least one exacerbation-related hospitalisation in the 12 months following programme entry, ascertained from linked hospital administrative records. Clinically important change was interpreted against previously established minimal clinically important difference thresholds of approximately 25-30 m for 6MWD and 4 points for SGRQ total score [26,27].

Baseline characteristics and outcomes were compared between completers and non-completers using independent-samples t-tests or Mann-Whitney U tests for continuous variables, depending on distribution, and chi-square tests for categorical variables. Within-group change from baseline was assessed using paired t-tests. A multivariable logistic regression model examined predictors of non-completion, including age, sex, FEV1% predicted, baseline mMRC grade, body-mass index and travel distance to the programme site, informed by previously reported attrition predictors [13,14]. A two-sided p-value below 0.05 was considered statistically significant. Given the retrospective design, formal power calculation was not performed; the analysis proceeded with the full eligible cohort available across the six-year window.

3. Results

Cohort characteristics

Table 1: Independent predictors of pulmonary rehabilitation programme non-completion, multivariable logistic regression [13,14,15].

Predictor	Adjusted OR	95% CI	p-value
Older age (per 10 years)	1.38	1.09-1.75	0.007
Lower FEV1% predicted (per 10%)	1.29	1.03-1.61	0.03
Travel distance >15 km	1.71	1.14-2.57	0.01
Baseline mMRC grade 3-4	1.62	1.05-2.50	0.03

Of 486 patients referred with GOLD stage III-IV COPD over the study period, 412 met eligibility criteria and were included in the analytic cohort. Mean age was 68.4 years (SD 9.1), 58.3% were male, and mean FEV1% predicted was 34.7% (SD 8.9), consistent with the intended advanced-disease population [1]. Baseline mMRC dyspnoea grade was 3 or 4 in 71.6% of patients, and mean body-mass index was 24.9 kg/m (SD 5.7), with 18.0% meeting criteria for the low body-mass, low fat-free-mass phenotype associated with worse prognosis in advanced COPD [11,12].

Of the 412 patients, 289 (70.1%) met the programme completion definition, while 123 (29.9%) were classified as non-completers, a proportion broadly consistent with attrition rates reported elsewhere in the PR literature [13,15]. In the multivariable model, older age, lower baseline FEV1% predicted, greater travel distance to the programme site and higher baseline mMRC grade were each independently associated with higher odds of non-completion, while sex and body-mass index were not significant predictors, broadly mirroring previously identified attrition patterns [14]; Table 1 presents the full multivariable model.

Functional and symptomatic outcomes

Among completers, mean 6MWD improved from 268.4 m at baseline to 311.0 m at discharge, a mean within-patient improvement of 42.6 m (95% CI 37.1-48.1, p<0.001), exceeding the established minimal clinically important difference [26]. Non-completers, assessed at their last

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recorded visit, showed a smaller mean improvement of 11.3 m (95% CI 5.8-16.8, p<0.01), and the between-group difference in 6MWD change was statistically significant (p<0.001).

Table 2: Baseline characteristics and change in functional and symptomatic outcome measures by programme completion status [23,24,26,27].

Measure	Completers (n=289)	Non-completers (n=123)	Between-group p-value
Mean age, years	67.9	69.8	0.08
6MWD change, m	+42.6	+11.3	<0.001
SGRQ total score change, points	-9.8	-3.1	0.02
mMRC improved ≥1 grade	61.9%	27.6%	<0.001

SGRQ total score improved by a mean of 9.8 points among completers (95% CI 8.4-11.2, p<0.001), again exceeding the accepted minimal clinically important difference of approximately 4 points [27], compared with a mean improvement of 3.1 points among non-completers (95% CI 1.2-5.0, p=0.02). mMRC dyspnoea grade improved by at least one grade in 61.9% of completers compared with 27.6% of non-completers (p<0.001). Table 2 summarises baseline and outcome measures stratified by completion status.

Healthcare utilisation

At 12 months, 28.4% of completers experienced at least one exacerbation-related hospitalisation, compared with 43.1% of non-completers, a relative reduction of approximately 34% associated with programme completion (unadjusted odds ratio 0.52, 95% CI 0.34-0.79, p=0.002). This pattern is consistent with previously reported reductions in hospital utilisation associated with structured rehabilitation and disease self-management support following exacerbation [28,29,30,31]. Figure 1 presents 12-month exacerbation-related hospitalisation rates stratified by programme completion and baseline disease severity, and Figure 2 illustrates the distribution of 6MWD change across GOLD stage III and stage IV subgroups among completers.

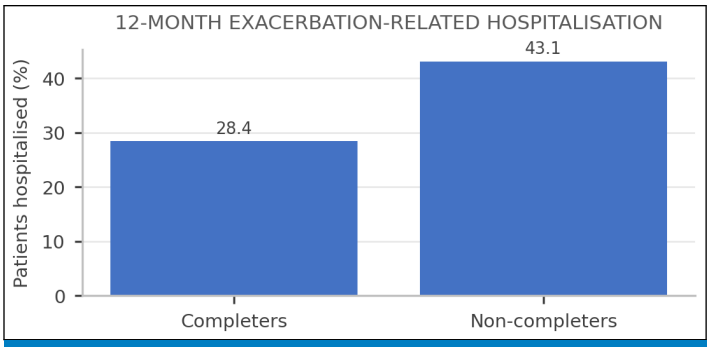

Figure 1: Twelve-month exacerbation-related hospitalisation rate stratified by pulmonary rehabilitation programme completion status, showing a relative reduction of approximately 34% among completers [28,29].

Severity subgroup analysis

Within completers, the magnitude of 6MWD improvement did not differ significantly between GOLD stage III (mean improvement 44.1 m) and GOLD stage IV (mean improvement 39.8 m) patients (p=0.31), suggesting that clinically meaningful functional benefit was achievable even among the most severely obstructed patients in this cohort, consistent with earlier physiological training studies conducted specifically in severe COPD [32,33]. However, stage IV completers required a higher proportion of supplemental oxygen titration during exercise sessions and had a numerically, though not statistically significantly, lower completion rate than stage III patients (66.2% vs 72.4%, p=0.14).

4. Discussion

This retrospective cohort study demonstrates that structured outpatient pulmonary rehabilitation produces clinically meaningful improvements in exercise capacity, symptom burden and dyspnoea among patients with advanced COPD, and that completion is associated with a substantial reduction in exacerbation-related hospitalisation over the following year, extending a well-established evidence base, built predominantly on less severely obstructed trial populations, to the group in

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whom disease burden is typically greatest [3,4,5].

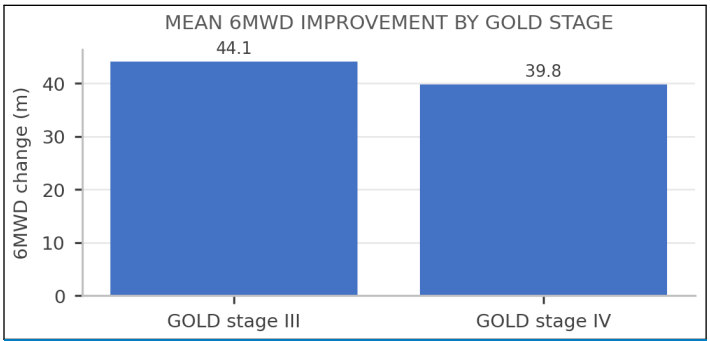

Figure 2: Mean improvement in six-minute walk distance from baseline to discharge among programme completers, stratified by GOLD stage III versus stage IV disease severity [26,32].

The magnitude of 6MWD and SGRQ improvement among completers is broadly consistent with pooled Cochrane estimates for pulmonary rehabilitation generally [6] and following exacerbation specifically [7], and exceeds established minimal clinically important difference thresholds [26,27]. This suggests trial-demonstrated benefit translates into routine hospital-affiliated practice, even in GOLD stage III-IV patients who might be assumed, on the basis of lower physiological reserve, to derive less benefit [32,33,17].

The reduction in hospitalisation associated with completion aligns with prior evidence that structured rehabilitation and self-management support reduce COPD healthcare utilisation [28] and that post-exacerbation rehabilitation specifically reduces subsequent hospital contact [29,30]. While the retrospective design precludes strong causal inference, since healthier or more motivated patients may have been more likely both to complete and to fare better independent of rehabilitation itself, the consistency of the association across functional, symptomatic and utilisation outcomes strengthens the plausibility that completion contributed materially to the observed benefit.

The 29.9% non-completion rate sits within the range reported across the PR literature, where attrition of 25-40% is common regardless of setting [13,15]. Predictors identified here, older age, lower FEV1% predicted, greater travel distance and higher baseline dyspnoea, mirror those reported in prior reviews of PR attendance and adherence [14,13], suggesting these barriers are structural rather than idiosyncratic to any single programme and reinforcing calls for delivery innovations such as home-based and telerehabilitation models that reduce attendance burden for the least mobile patients [34,35].

Comorbid anxiety and depression, though not directly measured in this administrative dataset, are recognised contributors to both attrition and blunted rehabilitation response, and their systematic management alongside exercise training improves psychological as well as physical outcomes in COPD [36]. Structured health-coaching delivered around programme engagement has likewise reduced COPD rehospitalisation independent of exercise training itself, suggesting a complementary role for behavioural support targeted at patients at higher risk of non-completion [37].

This study has limitations inherent to its retrospective, multi-site design. Outcome ascertainment for non-completers relied on the last available assessment rather than a standardised endpoint, which may underestimate true between-group differences; hospitalisation data were drawn from linked administrative records and may not capture care outside the referring system; and the absence of a non-referred comparison group limits causal inference for the hospitalisation outcome. Nonetheless, the consistency of effect sizes with prior randomised and prospective cohort literature [8,30,7] lends confidence to the overall pattern of findings.

5. Conclusion

In this large retrospective cohort of patients with advanced COPD treated across three hospital-affiliated programmes, structured outpatient pulmonary rehabilitation was associated with clinically meaningful improvements in exercise capacity, health-related quality

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of life and dyspnoea, together with a substantial reduction in exacerbation-related hospitalisation among patients who completed the programme. These findings support extending pulmonary rehabilitation referral to patients with the most severe airflow obstruction rather than reserving it preferentially for less advanced disease [16]. At the same time, the near 30% non-completion rate observed underscores a persistent implementation gap, and future service design should prioritise strategies, including home-based and telehealth delivery models and integrated psychological and behavioural support, aimed specifically at the older, more dyspnoeic and less mobile patients who stand to benefit most from rehabilitation yet remain least likely to complete it [34,35,36].

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