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Pulmonary Rehabilitation and Outcomes in Chronic Obstructive Pulmonary Disease: A Prospective Interventional Study

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Abstract

Background: Chronic obstructive pulmonary disease (COPD) can limit exercise capacity and quality of life despite medical treatment. This study examined changes in symptoms, physical performance, pulmonary function, and health-related quality of life during a 12-week pulmonary rehabilitation program.

Methods: In this prospective, single-arm study, 40 adults with COPD completed a 12-week pulmonary rehabilitation program. During the first six weeks, participants attended one supervised session and performed two home-based exercise sessions each week; the remaining six weeks were home-based. Outcomes were assessed at baseline, week 6, and week 12 using the six-minute walk test, 30 s sit-to-stand test, modified Medical Research Council (mMRC) dyspnea scale, spirometry, Clinical COPD Questionnaire (CCQ), St George's Respiratory Questionnaire (SGRQ), and RAND 36-Item Health Survey 1.0 (RAND-36).

Results: Mean six-minute walk distance increased from 326.50 ± 50.82 m at baseline to 401.80 ± 46.86 m at week 12, while mean sit-to-stand repetitions increased from 8.50 ± 1.93 to 12.50 ± 2.08. Mean mMRC grade decreased from 2.65 to 1.35. Mean CCQ and SGRQ scores decreased from 3.00 ± 0.60 to 1.85 ± 0.67 and from 63.15 ± 7.91 to 44.50 ± 7.93, respectively. Overall changes across the three assessments were statistically significant for these outcomes (all $P < 0.0001$). Mean forced expiratory volume in 1 s (FEV_1) increased by 0.05 L, while the FEV_1/forced vital capacity (FVC) ratio decreased slightly.

Conclusions: Over 12 weeks, participants experienced reduced dyspnea, improved health-related quality of life, and better exercise performance. These consistent gains reinforce the value of pulmonary rehabilitation as an essential component of COPD care.

Categories: Sports Medicine, Physical Medicine & Rehabilitation, Orthopedics
Keywords: chronic obstructive pulmonary disease, dyspnoea, health-related quality of life, pulmonary rehabilitation, six-minute walk test

Introduction

Chronic obstructive pulmonary disease (COPD) represents a substantial global health burden [1]. Patients often experience exertional dyspnea and reduced functional capacity, and exercise-based interventions can improve these outcomes [2]. Pulmonary function alone may not adequately reflect the impact of COPD on everyday activity.

Pulmonary rehabilitation (PR) combines individualized exercise training, education, and self-management support [3]. Systematic evidence supports improvements in exercise capacity and health-related quality of life [4]. Nevertheless, delivery models vary in the amount of center-based supervision and home exercise. Evaluating outcomes during a transition to home-based exercise may therefore provide useful clinical information, although a single-arm study cannot determine comparative efficacy.

The primary objective was to assess change in six-minute walk distance in adults aged 30-70 years with COPD undergoing a 12-week PR program consisting of six weeks of one supervised session and two recommended home sessions per week, followed by six weeks of home-based exercise. Secondary objectives were to assess changes in 30 s sit-to-stand performance, modified Medical Research Council (mMRC) dyspnea grades, spirometry, Clinical COPD Questionnaire (CCQ), St George's Respiratory Questionnaire (SGRQ), and RAND 36-Item Health Survey 1.0 (RAND-36) outcomes at baseline, week 6, and week 12.

Materials And Methods

Study design and participants

This prospective, single-arm interventional study was conducted from April 10, 2024, to October 9, 2025 (18 months), in the Department of Physical Medicine and Rehabilitation at Employees' State Insurance

Corporation (ESIC) Medical College and Hospital, Faridabad. Patients with an established diagnosis of COPD were referred from the Department of Respiratory Medicine. Written informed consent was obtained before enrolment.

Eligible patients were adults aged 30-70 years with an established COPD diagnosis who were referred from Respiratory Medicine and were able to participate in the prescribed exercise program. Exclusion criteria were symptomatic ischemic heart disease, chronic kidney disease, cognitive impairment, symptomatic psychiatric illness, active cancer treatment, pregnancy, Global Initiative for Chronic Obstructive Lung Disease (GOLD) stage IV disease, and inability to adhere to the exercise program. COPD diagnosis and GOLD staging were based on the GOLD criteria [5]. Forty eligible participants who completed the scheduled assessments were included. The sample size was calculated using change in six-minute walk distance as the primary outcome. Based on previous PR research, the standard deviation of the within-patient change was assumed to be 57 m [6]. To detect a mean improvement of 30 m with 80% power and a two-sided significance level of 5%, 31 evaluable participants were required using a paired t-test calculation. Allowing for 15% dropout increased the required sample size to 37, which was rounded up to a recruitment target of 40 participants.

PR program

Participants followed a 12-week rehabilitation program comprising exercise training and patient education. The exercise prescription was individualized according to each participant's tolerance and incorporated breathing exercises, flexibility exercises, aerobic activity, and low-resistance strengthening of the upper and lower limbs. Airway-clearance techniques were included when clinically indicated. Aerobic activities included walking, treadmill exercise, marching, stair climbing, leg exercises, and rope jumping according to individual ability. Resistance training was performed using dumbbells or elastic resistance bands.

During the first six weeks, participants attended one supervised 45-60-minute session each week and were advised to complete two additional exercise sessions at home. Supervised visits were used to demonstrate and correct exercise technique and to monitor symptoms and vital parameters. From weeks 7-12, participants continued the prescribed exercises at home without routine weekly supervised sessions. Educational components addressed regular physical activity, energy-conservation strategies, COPD self-management, and smoking cessation when applicable.

Exercise was discontinued during supervised sessions if clinically concerning symptoms developed, including chest pain, marked breathlessness, dizziness, syncope, palpitations, visual disturbance, excessive sweating, gait instability, severe cough, acute exacerbation, or persistent fatigue despite rest. Exercise intensity, progression, and adherence to the home program were not quantified using predefined numerical measures.

Outcome measures

Assessments were performed at baseline, week 6, and week 12. Dyspnea was measured with the mMRC scale using the original MRC breathlessness framework [7]. The grades were defined as follows: grade 0, breathless only with strenuous exercise; grade 1, short of breath when hurrying on level ground or walking up a slight hill; grade 2, walks slower than people of the same age on level ground because of breathlessness or has to stop for breath when walking at own pace; grade 3, stops for breath after walking about 100 yards or after a few minutes on level ground; and grade 4, too breathless to leave the house or breathless when dressing or undressing. Disease-specific health status was assessed with the CCQ [8] and SGRQ [9]. Spirometry recorded forced expiratory volume in 1 s (FEV_1), forced vital capacity (FVC), and the FEV_1/FVC ratio [10].

Exercise capacity was assessed using the six-minute walk test along a 30 m corridor according to the American Thoracic Society (ATS) guideline [11]. The 30 s sit-to-stand test recorded the number of chair rises completed using a chair approximately 43 cm high without armrests, in accordance with the original 30 s chair-stand test description [12]. Generic health-related quality of life was assessed using the RAND-36 [13].

The RAND-36 contains 36 items covering eight domains: physical functioning, role limitations due to physical health, role limitations due to emotional problems, energy/fatigue, emotional well-being, social functioning, bodily pain, and general health. The questionnaire and scoring approach were based on the RAND Health Surveys and Tools resource. Item responses were recoded and aggregated within their respective domains using the RAND-36 scoring approach; domain scores range from 0 to 100, with higher scores indicating better health status [13]. SGRQ comprises symptoms, activity, and impacts components and a total score ranging from 0 to 100, with higher scores indicating greater health impairment. CCQ comprises 10 items across symptoms, functional state, and mental state; total and domain scores range from 0 to 6, with lower scores indicating better health status. RAND Health Care confirmed in writing that the RAND survey is available for use without permission; permission for academic use of SGRQ-C and CCQ was obtained from the respective instrument holders. Supporting correspondence was provided to the journal for editorial review.

Statistical analysis

Continuous variables were summarized using means and standard deviations or medians and ranges, as appropriate. Categorical variables were reported as counts and percentages. Normality was assessed with the Shapiro-Wilk test. Changes across the three assessment points were analyzed using repeated-measures analysis of variance (ANOVA) for normally distributed continuous outcomes and the Friedman test for mMRC scores and other non-normally distributed outcomes. Pairwise comparisons, where applicable, used Bonferroni adjustment after repeated-measures ANOVA and Wilcoxon signed-rank tests after the Friedman test. Reported P-values represent overall comparisons across the three time points. Analyses were performed using SPSS version 25 (IBM Corp., Armonk, NY, USA), with a two-sided P-value < 0.05 considered statistically significant.

Results

Forty participants completed the scheduled assessments. Their mean age was 55.6 ± 7.4 years; 31 (77.5%) were men, and 27 (67.5%) reported a history of smoking (Table *1*).

Characteristic	Category or value	n (%)
Age, mean ± SD	55.6 ± 7.4 years	-
Age	31-40 years	1 (2.5)
	41-50 years	10 (25.0)
	51-60 years	14 (35.0)
	61-70 years	15 (37.5)
Sex	Men	31 (77.5)
	Women	9 (22.5)
Smoking history	Present	27 (67.5)
	Absent	13 (32.5)
Socioeconomic status	Upper lower	18 (45.0)
	Lower middle	13 (32.5)
	Upper middle	9 (22.5)

TABLE 1: Participant characteristics

n = 40.

SD: standard deviation

Mean six-minute walk distance increased from 326.50 ± 50.82 m at baseline to 366.50 ± 49.42 m at week 6 and 401.80 ± 46.86 m at week 12, a baseline-to-week-12 increase of 75.30 m. Mean 30 s sit-to-stand performance increased from 8.50 ± 1.93 to 10.03 ± 2.03 and 12.50 ± 2.08 repetitions, respectively. The overall changes across assessment points were statistically significant for both measures (P < 0.0001; Table *2*).

Outcome, mean ± SD	Baseline	Week 6	Week 12	Test statistic	Overall P-value
Six-minute walk distance (m)	326.50 ± 50.82	366.50 ± 49.42	401.80 ± 46.86	F(2, 78) = 1,069.83	<0.0001
30 s sit-to-stand (repetitions)	8.50 ± 1.93	10.03 ± 2.03	12.50 ± 2.08	F(2, 78) = 867.89	<0.0001

TABLE 2: Functional exercise outcomes

n = 40. Repeated-measures ANOVA was used. P-values compare the three assessment points overall.

SD: standard deviation; ANOVA: analysis of variance

Dyspnea also decreased over the study period. At baseline, 26 participants (65%) had an mMRC grade of 3; at

week 12, 22 (55%) had a grade of 1. Mean mMRC grade decreased from 2.65 ± 0.48 at baseline to 2.05 ± 0.60 at week 6 and 1.35 ± 0.80 at week 12 (P < 0.0001; Table 3).

Grade or summary	Baseline	Week 6	Week 12	Test statistic	Overall P-value
Grade 0, n (%)	0 (0)	0 (0)	4 (10)		
Grade 1, n (%)	0 (0)	6 (15)	22 (55)		
Grade 2, n (%)	14 (35)	26 (65)	10 (25)		
Grade 3, n (%)	26 (65)	8 (20)	4 (10)		
Grade 4, n (%)	0 (0)	0 (0)	0 (0)		
Mean ± SD	2.65 ± 0.48	2.05 ± 0.60	1.35 ± 0.80	Friedman $\chi^2(2) = 62.19$	<0.0001

TABLE 3: mMRC dyspnea grades

n = 40. The overall P-value represents the global comparison of mMRC grades across baseline, week 6, and week 12 using the Friedman test.

mMRC: modified Medical Research Council; SD: standard deviation

Mean FEV_1 increased from 1.31 ± 0.27 L to 1.36 ± 0.27 L, and mean FVC increased from 2.44 ± 0.62 L to 2.58 ± 0.64 L between baseline and week 12. The mean FEV_1/FVC ratio decreased from 54.57 ± 5.78% to 53.63 ± 5.96% (Table 4).

Parameter, mean ± SD	Baseline	Week 6	Week 12	Test statistic	Overall P-value
FEV_1 (L)	1.31 ± 0.27	1.34 ± 0.27	1.36 ± 0.27	F(2, 78) = 189.01	<0.0001
FVC (L)	2.44 ± 0.62	2.51 ± 0.63	2.58 ± 0.64	F(2, 78) = 316.34	<0.0001
FEV_1/FVC (%)	54.57 ± 5.78	54.22 ± 5.72	53.63 ± 5.96	F(2, 78) = 19.17	<0.0001

TABLE 4: Spirometric outcomes

n = 40. Repeated-measures ANOVA was used.

FEV_1: forced expiratory volume in 1 s; FVC: forced vital capacity; SD: standard deviation; ANOVA: analysis of variance

Disease-specific health status scores improved. Mean CCQ score decreased from 3.00 ± 0.60 at baseline to 1.85 ± 0.67 at week 12, while mean SGRQ total score decreased from 63.15 ± 7.91 to 44.50 ± 7.93. The overall changes were statistically significant for both measures (P < 0.0001; Table 5).

Measure, mean ± SD	Baseline	Week 6	Week 12	Test statistic	Overall P-value
CCQ total score	3.00 ± 0.60	2.35 ± 0.65	1.85 ± 0.67	F(2, 78) = 844.46	<0.0001
SGRQ total score	63.15 ± 7.91	54.83 ± 7.90	44.50 ± 7.93	F(2, 78) = 2,080.80	<0.0001

TABLE 5: Disease-specific health status

n = 40. Lower scores indicate better health status. Repeated-measures ANOVA was used.

CCQ: Clinical COPD Questionnaire; SGRQ: St George's Respiratory Questionnaire; SD: standard deviation; ANOVA: analysis of variance

Scores improved across all eight RAND-36 domains (Table 6).

Domain, mean ± SD	Baseline	Week 6	Week 12	Test statistic	Overall P-value
Physical functioning	36.90 ± 11.35	52.02 ± 8.65	65.67 ± 9.01	F(2, 78) = 100.21	<0.001
Role limitation: physical	29.15 ± 11.73	46.77 ± 9.93	63.65 ± 11.49	F(2, 78) = 97.12	<0.001
Role limitation: emotional	57.62 ± 12.01	73.12 ± 10.23	83.42 ± 9.86	F(2, 78) = 74.80	<0.001
Energy/fatigue	32.67 ± 10.98	44.38 ± 9.36	56.60 ± 10.20	F(2, 78) = 80.62	<0.001
Emotional well-being	66.30 ± 11.52	81.72 ± 8.55	88.17 ± 8.57	F(2, 78) = 84.11	<0.001
Social functioning	55.92 ± 13.30	68.20 ± 11.16	77.40 ± 9.71	F(2, 78) = 51.95	<0.001
Pain	49.38 ± 11.42	59.25 ± 11.33	66.47 ± 10.18	F(2, 78) = 130.80	<0.001
General health	47.02 ± 12.51	58.08 ± 10.04	63.60 ± 10.27	F(2, 78) = 37.97	<0.001

TABLE 6: RAND-36 domain outcomes

n = 40. Higher scores indicate better health status. Repeated-measures ANOVA was used.

RAND-36: RAND 36-Item Health Survey 1.0; SD: standard deviation; ANOVA: analysis of variance

No major adverse events were reported during the intervention.

Discussion

Clinical and functional outcomes

Participants demonstrated improvements in exercise performance, dyspnea, and health-related quality of life during the 12-week PR program, consistent with previous reviews [2,4]. SGRQ total score decreased by 18.65 points, exceeding the commonly cited four-point minimal clinically important difference [14]. Six-minute walk distance increased by 75.30 m, exceeding the published minimal important difference of approximately 25 m [15]. The four-repetition improvement in the 30 s sit-to-stand test exceeded the reported two-repetition threshold [16]. These changes suggest clinically relevant improvements in group-level functional performance, but without a control group they cannot be attributed solely to PR.

Changes in spirometric parameters were modest: FEV_1 increased by 0.05 L, and the FEV_1/FVC ratio decreased slightly. Improved exercise tolerance and dyspnea therefore occurred without evidence of reversal of airflow obstruction. Improved conditioning may have contributed to functional gains [3], but physiological mechanisms and independent muscle-strength changes were not measured.

Health-related quality of life

CCQ scores also decreased, and all eight RAND-36 domain scores increased. The concordant changes across performance-based and patient-reported measures support a favorable pattern of outcomes during follow-up, consistent with established PR evidence [4]. However, repeated testing, concurrent care, and other time-related influences cannot be excluded.

Comparison with established rehabilitation protocols

The ATS/European Respiratory Society (ERS) statement describes PR as a comprehensive intervention involving exercise training, education, and behavior change [3]. Our program incorporated aerobic activity, low-resistance strengthening, breathing exercises, and education, broadly consistent with these core components. Unlike programs with ongoing center-based supervision, it provided one supervised session weekly alongside two recommended home sessions during weeks 1-6 and subsequently transitioned to home exercise alone during weeks 7-12. Holland et al. reported equivalent outcomes for a structured home-based versus center-based program in a randomized trial [17]. Our findings are compatible with the feasibility of observing improvements during home-based delivery, but our study did not compare models and cannot demonstrate equivalence. Exercise intensity, progression, and adherence were not objectively measured, limiting comparisons of exercise dose.

The 2023 ATS clinical practice guideline recommends PR for adults with stable COPD [18]. A program requiring limited supervised visits may be relevant in settings where frequent center attendance is difficult, but accessibility, costs, safety, comparative effectiveness, and longer-term maintenance were not evaluated here.

Limitations

This was a single-center study involving 40 participants and did not include a concurrent control group. The observed changes therefore cannot establish an independent treatment effect of the rehabilitation program. Repeated exposure to outcome assessments, changes in routine clinical care, and other events occurring during follow-up may also have influenced the findings.

Adherence to home exercise and changes in COPD medication were not systematically documented. Follow-up was limited to 12 weeks, restricting assessment of the persistence of the observed improvements. These factors limit causal interpretation and generalizability of the findings. Future controlled studies incorporating objective adherence measures and longer follow-up would help determine the magnitude and durability of the benefits.

Conclusions

In this prospective single-arm study, a 12-week PR program combining limited supervised and home-based exercise was associated with clinically meaningful improvements in exercise performance, dyspnea, and health-related quality of life in adults with COPD. These preliminary findings support further controlled evaluation of such delivery models with objective adherence monitoring and longer follow-up.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Vineet Bharti, Anand K. Kaushal, Bhawna Khorwal, Rajendra Sharma

Acquisition, analysis, or interpretation of data: Vineet Bharti, Anand K. Kaushal, Bhawna Khorwal, Rajendra Sharma

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Supervision: Vineet Bharti, Rajendra Sharma

Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. Institutional Ethics Committee, ESIC Medical College and Hospital, Faridabad, Haryana, India issued approval 134X/11/13/2024-IEC/DHR/62. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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