"Impact of Pulmonary Rehabilitation on Pulmonary Function in Patients with Chronic Obstructive Pulmonary Disease: A Quasi-Experimental Pilot Study"

Dayana. B. A. A[1*], Prof. Dr.Shruthi Kamal[2], Dr. P. Thenmozhi[3]

*[1]*Assistant Professor, Department of Medical and Surgical Nursing,Saveetha College of Nursing, SIMATS, Thandalam, Chennai, Tamil Nadu, India.*
[2] Professor, Department of General Surgery, Saveetha Medical College and hospital, SIMATS, Chennai, India
[3] Professor, Department of Medical and Surgical Nursing, Saveetha College of Nursing, SIMATS, Thandalam, Chennai, Tamil Nadu, India

Corresponding Author*
Dayana. B. A. A
Email Id: diana.joann@gmail.com, dayana.scon@saveetha.com
Orchid ID: 0000-0003-0185-3753

Received: 18th Oct, 2025; Revised: 14th Dec, 2025; Accepted: 15th Jan, 2026; Available Online: 15th Feb, 2026

ABSTRACT
Background: Chronic obstructive pulmonary disease (COPD) is a progressive respiratory condition characterized by airflow limitation, chronic inflammation, and impaired gas exchange, significantly impacting patient morbidity and mortality worldwide. Pulmonary rehabilitation (PR) has emerged as an essential component of COPD management, aiming to enhance lung function, exercise capacity, and quality of life.
Objective: This pilot study aimed to evaluate the impact of pulmonary rehabilitation on physiological outcomes in patients with COPD.
Methods: A quasi-experimental pretest-post-test design was employed involving 20 COPD patients divided into experimental (PR intervention) and control groups. The intervention consisted of a 3-month intensive PR program including breathing exercises, training, psychoeducation, social and emotional support, and nutritional counselling. Pulmonary function tests (PFTs) including FVC, FEV1, FEV1/FVC ratio, PEFR, and FEF25-75% were measured pre- and post-intervention. Demographic and clinical variables were also collected.
Results: The experimental group demonstrated statistically significant improvements in all pulmonary parameters after the PR program ($p < 0.005$). In contrast, the control group showed no significant changes. Notably, FEV1 increased from 1.4 ± 0.2 L to 1.8 ± 0.2 L, and FVC from 2.1 ± 0.3 L to 2.5 ± 0.3 L in the intervention group. Between-group comparisons post-intervention showed a reduction in the baseline functional gap. The study further found that demographic variables such as age, educational status, and smoking habits did not significantly influence the PR effectiveness.
Conclusion: Pulmonary rehabilitation significantly improves pulmonary function in COPD patients, enhancing key respiratory parameters and potentially reducing exacerbation risks. This study supports the integration of PR as a vital element in comprehensive COPD care to improve patient outcomes and quality of life..
Keywords: Pulmonary Rehabilitation, Chronic Obstructive Pulmonary Disease, COPD, Pulmonary Function Test, PFT, Spirometry
How to cite this article: Dayana BAA, Kamal S, Thenmozhi P.., "Impact of Pulmonary Rehabilitation on Pulmonary Function in Patients with Chronic Obstructive Pulmonary Disease: A Quasi-Experimental Pilot Study"..Int J Drug Deliv Technol. 2026; 16(2): 180-185; DOI: 10.25258/ijddt.16.2.22
Source of support: Nil.
Conflict of interest: None

INTRODUCTION
The respiratory condition termed COPD is marked by inadequate pulmonary gas exchange, hyperinflation, and restriction of airflow. Exposure to harmful substances, usually cigarette smoke, causes it to develop over many decades. [1] It is characterized as chronic inflammation of the lung tissue and airways that results in decreased elastic rebound and increased airway resistance. [2] Among non-communicable diseases, chronic obstructive pulmonary disease (COPD) is the third largest cause of disability-adjusted life years (DALY) worldwide and a substantial contributor to chronic morbidity and mortality. [3] The primary respiratory symptoms associated with COPD are coughing, sputum production, and dyspnoea. The most significant impact on healthcare systems arises from exacerbations, which are sudden worsening of symptoms that occur alongside ongoing symptom management. [4] Lung function is the main pulmonary indicators that is greatly impacted by COPD. Reduced airflow, higher respiratory effort, and possible effects on gas exchange and cardiovascular function are important physiological

**Author for Correspondence: diana.joann@gmail.com, dayana.scon@saveetha.com*

alterations. [5] The Pulmonary parameters like Pulmonary Function Test (PFT) more specifically Forced expiratory Volume (FEV1) in one sec vs Forced vital capacity (FVC) changes may help in evaluating the improvement in the health status. In order to alleviate dyspnea symptoms and lower the likelihood of exacerbations, first-line treatment consists of respiratory medication to lessen airflow restriction and hyperinflation as well as preventive measures like quitting smoking and becoming vaccinated. [1] For COPD patients, drug interventions involving antibiotics, bronchodilators, inhaled corticosteroids, and other medications are often utilized in clinical settings [6]. In addition to pharmacologic treatments, pulmonary rehabilitation (PR) ought to be regarded as a crucial part of integrated patient management [7]. Numerous chronic respiratory disorders, including COPD have been demonstrated to benefit from PR programs, which usually involve fitness training, education, and psychological support. [8] Through its impact on peripheral muscle and heart function, as well as through patient education and behavioral changes, pulmonary rehabilitation enhances health-related quality of life and exercise capacity. It can also lower readmission rates and increase survival. [9] Improving adherence to a PR program requires an early, customized, patient-centered approach [10]. The present use of telemedicine offers the chance for direct one-on-one training, and a supervised home-based program may increase engagement [11, 12]. Thus, the study aimed to assess the impact of pulmonary rehabilitation on Pulmonary function in Patients with Chronic Obstructive Pulmonary Disease.

Materials And Methods

A Pilot study was conducted to evaluate the impact of Pulmonary Rehabilitation on Pulmonary Outcomes in Patients with Chronic Obstructive Pulmonary Disease (COPD). A quasi-experimental pretest and post-test research design was used to evaluate the 10% of estimated main sample size of 200 COPD patients using convenient sampling technique at Saveetha Medical College and Hospital in Chennai. The samples were divided into 2 groups as experimental and control with 10 samples in each group. The inclusion criteria included were age group from 40 years, both male and female patients, patients with decreased exercise tolerance, patients with exertional dyspnoea or fatigue, patients with or without Oxygen support, patients diagnosed based on GOLD criteria grades from 2 to 4, patients with hyperinflation, patients with mild to moderate impairment of activities of daily living, patients who were willing to participate in the study and those who could read, write or speak Tamil, English or Hindi.

Ethical Approval:

Institutional Ethics Committee granted a research study approval on 01.10.2024 and the reference number (002/10/2024/IEC/SMCH) for the same was obtained to proceed with Pilot study. The same has been registered in the Clinical Trials Registry – India (CTRI) and obtained the reference number (REF/2025/10/115579) for the further proceedings.

Intervention:

Intervention called Pulmonary Rehabilitation (PR) was given intensively to the experimental group for 3 months period. It consists of Breathing exercises, Exercise training, Psycho education, social activities, Emotional strengthening and Nutritional education. A semi-structured questionnaire was used to collect information on demographic and clinical variables. Both the groups control and experimental group receive routine care, whereas the experimental group additionally received Pulmonary Rehabilitation (PR) program. This included Breathing exercises like deep breathing, Pursed lip breathing and diaphragmatic exercises, Physical exercises and patient education on coping with disease. Manoharan et al. (2025) The diaphragmatic strengthening regimen significantly enhanced diaphragm thickness and contraction velocity in people with elevated BMI. These findings endorse the execution of targeted exercise treatments to enhance diaphragm function in this population. [13]

Data Analysis:

Section A: Demographic and Clinical Variables of the Experimental and Control Group.

The research participants' demographic profiles in the experimental and control groups showed significant similarities with small variations in age distribution and occupational position. Male participants made up the majority, female subjects made up a lesser percentage, and neither category included any transsexual people. Ubhi et al. (2025) Whereas Ubhi's study conducted in California stated that female participants were more than male.[14,15] Tasrufoon et al. (2025) In addition this study had selected patients had respiratory diseases like COPD due to silicosis.[16] In contrast, the control group included a larger proportion of older persons aged 61 and beyond, the experimental group was predominantly composed of people between the ages of 51 and 60. The most common religion among both populations was Hinduism, which was followed by Islam and Christianity. The participants' educational backgrounds varied; the majority had earned graduate-level degrees, while a few had professional degrees or were illiterate, the latter of which was only seen in the experimental group.

Occupational backgrounds included professionals, skilled, and semi-skilled workers, and the experimental cohort had a higher percentage of jobless or homemakers. In addition to non-industrial exposures including biomass smoke and passive smoking, most participants worked in industrial environments, reporting exposures to chemicals, fumes, the cotton and iron industries. A significant percentage of participants reported monthly salaries between ₹27,883 and ₹92,950, with income levels spanning many categories and none in the lowest income group. Assaf et al. (2022) in contrast states that lower income people were the highest participants.[17] The sample was primarily urban, semi-urban and rural living coming in second and third, respectively. Jebaraj et al. (2025) this study did only in urban sector. [18]

Clinical Variable:

Clinically, both groups showed similar traits with regard to the length of time they had had chronic obstructive pulmonary disease (COPD), with the majority reporting one to three years and a small percentage reporting more than six years. Smoking was frequent, however significantly more common in the experimental group, with daily cigarette or bidi intake ranging. The most common symptom was a productive cough, with mucoid or purulent sputum; hemoptysis was rare but observed in the experimental group. Although a small percentage reported having a family history of TB, this information was mostly lacking. With durations usually ranging from one to nine years, common comorbidities included coronary artery disease, diabetes mellitus, hypertension, and gastro-esophageal reflux disease. Gueçamburu et al. (2024) However in univariate analysis, those who did not have PR had a lot more comorbidities than those who did.[19]

Exacerbation-related hospitalizations were uncommon, usually occurring only once or twice a year. Corticosteroids, combination treatments, and bronchodilator inhalers were often used in medication regimens. Breathing activities were preferred above aerobic, stretching, agility, and anaerobic workouts in physical activity patterns. The average daily dietary protein intake for each group was between 1.1 and 1.2 grammes per kilogram of body weight. The validity of comparative analyses within the research design is supported by the findings, which collectively imply that the experimental and control groups were well matched across demographic and clinical factors.

Section B: Effect of Pulmonary Rehabilitation on Pulmonary Function test in COPD patients

Table 1: Pre- and post-test pulmonary parameters value in COPD patients within both groups and between groups.

Variable	**Exp. Pre (Mean±SD)**	**Exp. Post (Mean±SD)**	**p (paired t-test)**	**Ctrl Pre (Mean±SD)**	**Ctrl Post (Mean±SD)**	**p (paired t-test)**	**p (Exp vs Ctrl Pre)**	**p (Exp vs Ctrl Post)**
FVC (L)	2.1 ± 0.3	2.5 ± 0.3	<0.001*	2.7 ± 0.4	2.7 ± 0.3	0.75	<0.001	<0.001
FEV1 (L)	1.4 ± 0.2	1.8 ± 0.2	<0.001*	1.9 ± 0.3	1.9 ± 0.3	0.81	<0.001	<0.001
FEV1/FVC (%)	67 ± 5	69 ± 4	0.03*	70 ± 4	70 ± 3	0.89	0.12	0.01*
PEFR (L/min)	230 ± 40	265 ± 38	0.001*	280 ± 35	282 ± 33	0.68	0.006	0.001
FEF25-75% (L/s)	1.1 ± 0.3	1.4 ± 0.3	0.002*	1.5 ± 0.4	1.5 ± 0.4	0.92	0.004	0.003

*Significant p value <0.005

According to the analysis of pulmonary function parameters, the experimental group experienced significant improvements after the intervention. For example, forced expiratory volume in 1 second (FEV1) increased from 1.4 ± 0.2 L to 1.8 ± 0.2 L ($p < 0.001$), forced vital capacity (FVC) increased from 2.1 ± 0.3 L to 2.5 ± 0.3 L ($p < 0.001$), and the FEV1/FVC ratio ($p = 0.03$), peak expiratory flow rate (PEFR) ($p = 0.001$), and forced expiratory flow at 25-75% (FEF25-75%) ($p = 0.002$). However, with all p-values over 0.05, the control group did not exhibit any statistically significant changes in any of the pulmonary measurements. The experimental group may have been at risk from the beginning because baseline comparisons showed that the control group had considerably better lung function than the experimental group for the majority of variables (FVC, FEV1, PEFR, and FEF25-75%). In spite of this, the experimental group showed significant improvements that reduced the functional gap after the intervention. This was especially noticeable in the FEV1/FVC ratio, PEFR, and FEF25-75%, where comparisons with controls revealed either no significant difference or a significant improvement.

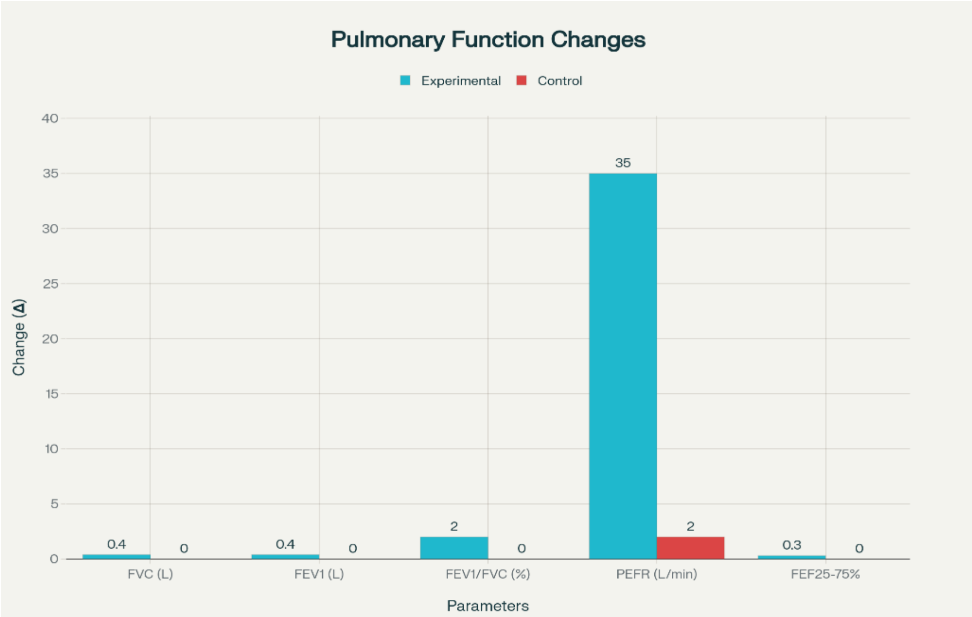

Figure 1: Changes in pulmonary function parameters comparing Experimental and Control groups

These results highlight how well the intervention worked to enhance lung function in the experimental group, as demonstrated by both between-group comparisons and substantial within-group pre-post improvements. Instead of being a temporal or measurement artefact, the intervention-specific impact is further supported by the control group's lack of change. All of these findings support the intervention's potential use in clinical or occupational health settings by confirming that it improved pulmonary function in a way that was both clinically and statistically significant. Puhan et al (2016) Evidence indicates that pulmonary rehabilitation (PR) effectively enhances outcomes during chronic obstructive pulmonary disease (COPD) flare-ups, markedly improving pulmonary function, exercise capacity, and quality of life. Successful PR programs include physical activity, patient education, and lifestyle modifications.[14] Given the results, it is reasonable to assume that most patients will see improvements following the PR regimen. Additional oxygen assistance and non-invasive ventilation increased exercise tolerance or other functional measures. Tonga et al (2023)As a result of the PR program, the patient will have more personal autonomy and be able to participate fully in society.[20]

Section C: To associate the selected demographic variables with the effectiveness of Pulmonary Rehabilitation on pulmonary function among Chronic Obstructive Pulmonary Disease (COPD) patients in the study group.

Table 2: Effectiveness in the Pulmonary function test parameters with demographic variables.

Demographic Variable	**Parameter**	**Groups (n)**	**Mean Improvement ± SD**	**F-value**	**p-value**
Age Group (years)	FEV1 (L)	40-50 (4)	0.35 ± 0.10	1.15	0.36
		51-60 (3)	0.37 ± 0.15		
		61+ (3)	0.42 ± 0.08		
Educational Status	FEV1 (L)	Illiterate (2)	0.30 ± 0.07	1.78	0.23
		Primary/High School (4)	0.40 ± 0.10		
		Graduate/Professional (4)	0.38 ± 0.12		
Smoking Habit	FEV1 (L)	Smokers (6)	0.38 ± 0.09	0.49	0.50
		Non-smokers (4)	0.36 ± 0.12		

The observed gains in pulmonary function seem to be predominantly due to the intervention rather than baseline characteristics, even though there were minor demographic differences between the experimental and control groups. Given that ageing is linked to decreased pulmonary plasticity, the control group's larger percentage of older people (≥61 years) may help to explain why their PFT values did not change. The control group also showed marginally higher incomes and somewhat greater educational attainment, but these benefits did not result in any appreciable changes in lung function after the intervention. It's interesting to note that the experimental group had a higher proportion of manual and industrial occupations, which may indicate a higher baseline exposure to respiratory risks such dust, chemicals, and fumes. The experimental group demonstrated notable gains in every

PFT metric despite these risk factors. Ma et al. (2022) The same kind of result was also obtained in the global spirometry measurements of forced vital capacity (FVC), forced expiratory volume in the first second (FEV1), FEV1 predicted percentage (%pred), and peak expiratory flow (PEF) shown considerable improvement compared to pre-rehabilitation levels.[21] This disparity implies that the intervention was successful in enhancing pulmonary function, even in those with more exposure to the environment and their jobs, and that demographic variations did not obscure the benefits that were seen.

The effectiveness of a focused intervention in enhancing pulmonary function in individuals with Chronic Obstructive Pulmonary Disease (COPD) was assessed in this comparative research. A total of twenty individuals were split evenly between the Experimental and Control groups. A well-matched sample was indicated by the statistical similarity of baseline characteristics between the two groups, which included smoking history, length of COPD, comorbidities, medication usage, exercise routines, and protein consumption.

Spirometry results after the intervention showed that the Experimental group significantly improved on all important parameters, including FVC, FEV1, FEV1/FVC ratio, PEFR, and FEF25–75%, whereas the Control group did not significantly alter. Since no characteristic from the baseline dataset (Table 1) indicated a substantial advantage for the Experimental group, these gains in lung function are unlikely to be attributable to baseline differences. The results imply that the intervention, which may have included dietary changes, increased physical therapy, or medication assistance, was successful in enhancing respiratory function in individuals with COPD. Tasrufoon et al. (2024) Pulmonary rehabilitation, encompassing pranayama and nutritional education, demonstrated a considerable enhancement in lung capacity and pulmonary functions, with a statistically significant improvement in quality of life ($P < 0.001$).[22] These findings provide credence to the inclusion of such therapies in standard COPD therapy procedures. Feng et al (2025) However, this report states that Patients with clinically stable COPD have a low PR benefit rate, which is mostly influenced by the family care index, chronic pain, sarcopenia, baseline 6MWD, and financial status.[23]

CONCLUSION:

This study unequivocally shows that individuals with chronic obstructive pulmonary disease (COPD) benefit greatly from pulmonary rehabilitation. Vital parameters such as forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), FEV1/FVC ratio, peak expiratory flow rate (PEFR), and forced expiratory flow at 25-75% (FEF25-75%) all significantly improved in the intervention group when compared to the control group. These enhancements, which indicate improved lung capacity, airway patency, and general respiratory function, are clinically significant. The intervention's robustness was demonstrated by the fact that its impact was noticeable even in the face of baseline inequities and possible occupational exposures.

REFERENCE

1.Singh, D., Donohue, J. F., Boucot, I. H., Barnes, N. C., Compton, C., & Martinez, F. J. (2021). Future concepts in bronchodilation for COPD: dual-versus monotherapy. European Respiratory Review, 30(160).

2. Mowery, N. T. (2017). Ventilator strategies for chronic obstructive pulmonary disease and acute respiratory distress syndrome. Surgical Clinics, 97(6), 1381-1397.

3. Kyu, H. H., Abate, D., Abate, K. H., Abay, S. M., Abbafati, C., Abbasi, N., ... & Breitborde, N. J. (2018). Global, regional, and national disability-adjusted life-years (DALYs) for 359 diseases and injuries and healthy life expectancy (HALE) for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. The Lancet, 392(10159), 1859-1922.

4. Katzenberg, G., Deacon, A., Aigbirior, J., & Vestbo, J. (2021). Management of chronic obstructive pulmonary disease. British Journal of Hospital Medicine, 82(7), 1-10.

5. Maestri, R., Bruschi, C., Fracchia, C., Pinna, G. D., Fanfulla, F., & Ambrosino, N. (2019). Physiological and clinical characteristics of patients with COPD admitted to an inpatient pulmonary rehabilitation program: A real-life study. Pulmonology, 25(2), 71-78.

6. Guo, P., Li, R., Piao, T. H., Wang, C. L., Wu, X. L., & Cai, H. Y. (2022). Pathological mechanism and targeted drugs of COPD. International Journal of Chronic Obstructive Pulmonary Disease, 1565-1575.

7. Li, J., Li, H., Wang, D., Guo, Y., Zhang, X., Ran, M., ... & Dong, H. (2019). Orexin activated emergence from isoflurane anaesthesia involves excitation of ventral tegmental area dopaminergic neurones in rats. British journal of anaesthesia, 123(4), 497-505.

8. Wouters, E. F., Posthuma, R., Koopman, M., Liu, W. Y., Sillen, M. J., Hajian, B., ... & Franssen, F. M. (2020). An update on pulmonary rehabilitation techniques for patients with chronic obstructive pulmonary disease. Expert review of respiratory medicine, 14(2), 149-161.

9. Jaitovich, A., & Barreiro, E. (2018). Skeletal muscle dysfunction in chronic obstructive pulmonary disease. What we know and can do for our patients. American journal of respiratory and critical care medicine, 198(2), 175-186.

10. Pacheco, V. A., Masa, M. P., Fernández, A. P. G. B., Rodríguez, A. M. M., Moreno, R. T., & Rubio, T. M. (2017). Patient profile of drop-outs from a pulmonary rehabilitation program. Archivos de Bronconeumología (English Edition), 53(5), 257-262.

11. Bernocchi, P., Vitacca, M., La Rovere, M. T., Volterrani, M., Galli, T., Baratti, D., ... & Scalvini, S. (2018). Home-based telerehabilitation in older patients with chronic obstructive pulmonary disease and heart failure: a randomised controlled trial. Age and ageing, 47(1), 82-88.

12. Benzo, R. P., Kramer, K. M., Hoult, J. P., Anderson, P. M., Begue, I. M., & Seifert, S. J. (2018). Development and feasibility of a home pulmonary rehabilitation program with health coaching. Respiratory care, 63(2), 131-140.

13. Manoharan, V. S., Subramaniam, R., K, K., & Rahman, S. A. (2025). Effect of diaphragmatic strengthening on muscle thickness and velocity of diaphram excursion in high body mass index individuals. Research Journal of Pharmacy and Technology, 3191–3195. https://doi.org/10.52711/0974-360x.2025.00459

14. Puhan, M. A., Gimeno-Santos, E., Scharplatz, M., Troosters, T., Walters, E. H., & Steurer, J. (2016). Pulmonary rehabilitation following exacerbations of chronic obstructive pulmonary disease. Cochrane Database of Systematic Reviews, 12(12), CD005305.

15. Ubhi, B., Shaheen, R., Ireland, K., & Alismail, A. (2025). Effects of pulmonary rehabilitation program in a community based hospital in California. BMC Pulmonary Medicine, 25(1), 249. https://doi.org/10.1186/s12890-025-03714-w

16. Tasrufoon, K., Bhuvaneswari, G., Rao, K. S., & Vijayaraghavan, R. (2025). Effectiveness of pulmonary rehabilitation using spirometry, and breathing and walking exercises on quality of life among occupationally exposed silica workers. International Journal of Nutrition Pharmacology Neurological Diseases, 15(3), 266–273. https://doi.org/10.4103/ijnpnd.ijnpnd_11_25

17. Assaf, E. A., Badarneh, A., Saifan, A., & Al-Yateem, N. (2022). Chronic obstructive pulmonary disease patients' quality of life and its related factors: A cross-sectional study of the Jordanian population. F1000Research, 11, 581. https://doi.org/10.12688/f1000research.121783.1

18. Jebaraj, P., Paul, B., Isaac, R., Reddy, S. R., Kumar, R., Vikas, B., Das, D., Norrie, J., Weller, D., Pinnock, H., & RESPIRE Collaboration (2025). Optimising participation in a pulmonary rehabilitation programme for people living with chronic respiratory diseases in rural India: a feasibility study. Journal of global health, 15, 04143. https://doi.org/10.7189/jogh.15.04143

19. Gueçamburu, M., Verdy, G., Cuadros, J., Nocent-Ejnaini, C., Macey, J., Portel, L., Rapin, A., & Zysman, M. (2024). Insufficient pulmonary rehabilitation uptake after severe exacerbation of COPD: a multicentre study in the South West region of France. International Journal of COPD, Volume 19, 1579–1589. https://doi.org/10.2147/copd.s460991

20. Tonga, K. O., & Oliver, B. G. (2023). Effectiveness of Pulmonary Rehabilitation for Chronic Obstructive Pulmonary Disease Therapy: Focusing on Traditional Medical Practices. Journal of clinical medicine, 12(14), 4815.

21. Ma, H., Dai, M., Wu, S., Zhao, Z., Zhang, Y., Zhao, F., Yang, L., Ti, X., & Qu, S. (2022). Pulmonary rehabilitation ameliorates regional lung function in chronic obstructive pulmonary disease: a prospective single-arm clinical trial. Annals of Translational Medicine, 10(16), 891. https://doi.org/10.21037/atm-22-3597

22. Tasrufoon, K., Bhuvaneswari, G., Rao, K., & Vijayaraghavan, R. (2024). Pulmonary Rehabilitation Effect on Physiological and Biochemical Parameters occupationally Exposed to Silica Workers: A Quasi-Experimental Study. International Journal of Nutrition Pharmacology Neurological Diseases, 14(4), 468–471. https://doi.org/10.4103/ijnpnd.ijnpnd_123_24

23. Feng, L., Yang, Q., & Liang, M. (2025). Factors influencing the benefits of pulmonary rehabilitation in older adults with chronic obstructive pulmonary disease: a prospective study. Frontiers in Public Health, 13, 1644607.