Research Paper

Impact of Pulmonary Rehabilitation in Coal Miners: An Interventional Study

Samana Sayed[1], Komal KB[2*], Shaima Farheen Mohammed Saleem[3], Nidhi Sharma[4], Krishna Kumar Singh[4], Anvita Shiggavi[5]

1. Department of Physiotherapy, You360 Healthcare and Academy, Mumbai, India.
2. Department of Physiotherapy, KLE College of Physiotherapy, Hubli, India.
3. Department of Physiotherapy, Dr.Shaima Clinic, Nagpur, India.
4. Department of Physiotherapy, Ojas College of Physiotherapy, Jalna, India.
5. Department of Physiotherapy, Bethel Medical Mission College, Bangalore, India.

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ABSTRACT

Purpose: Progressive airflow restriction and hyperinflation, accompanied by dyspnoea or shortness of breath and changed respiratory patterns, are characteristic symptoms of chronic obstructive pulmonary disease (COPD). Evidence indicates that one of the pulmonary risks associated with coal mining is that coal miners are more likely to develop lung diseases, such as COPD, due to coal mine dust. Thus, the purpose of this study was to determine the impact of pulmonary rehabilitation on coal miners with COPD.

Methods: An interventional study was carried out among 76 coal miners aged 18 to 35 years from May to November 2023, based on the selection criteria. The outcome measures assessed at baseline and after the intervention involved incentive spirometry and chest expansion for vital capacity, while the 6-minute walk test (6MWT) was used to determine functional capacity.

Results: The majority of COPD patients were between 24 and 29 years of age. The pre- and post-intervention vital capacities measured on the incentive spirometer, along with chest expansion values, demonstrated statistically significant improvements post-intervention. Furthermore, functional capacity, assessed by the 6MWT, also showed significant improvement post-intervention.

Conclusion: The study concluded that diaphragmatic breathing, thoracic expansion exercises, and active cycle of breathing technique (ACBT) provided beneficial effects in improving vital capacity, as measured by the incentive spirometer and chest expansion as outcome measures, along with enhanced functional capacity, which showed statistically significant results on the 6MWT.

*** Corresponding Author:**
Komal KB, PhD.
Address: *Department of Physiotherapy, KLE College of Physiotherapy, Hubli, India.*
Phone: *+91 (962) 0645934*
E-mail: *drkomalkb24@kledeemeduniversity.edu.in*

Highlights

- Vital capacity improved from 2.79±38.25 to 3.45±31.23 litres (P<0.001).
- The chest expansion reported a statistically significant improvement at all levels.
- The submaximal capacity improved from 292.43±67.24 to 327.71±76.52 (P<0.001).

Plain Language Summary

The study focused on the occupational hazard coal miners come across following the exposure to dust and small particles of coal. It often leads to chronic obstructive pulmonary disease (COPD) in coal miners. Pulmonary rehabilitation refers to the exercises of the lungs which improves the functional capacity of the lungs and leads to improvement in quality of life and working capacity of these miners. The study used outcome measures to evaluate the differences in the vital capacity, airway clearance, and submaximal capacity and reported the results. This study thus, highlighted the impact and necessity of including the pulmonary rehabilitation for miners to prevent the occupational hazards as well as to increase the longevity of working years of the miners.

Introduction

Chronic obstructive pulmonary disease (COPD) is the most prevalent condition that causes limitations in airflow and hyperinflation, which is associated with altered respiratory patterns and dyspnoea and is progressive in nature. Although the aforementioned symptoms are manageable and preventable, they have the potential to worsen and become the primary cause of morbidity and mortality globally [1, 2]. Evidence indicates that one of the pulmonary risks associated with coal mining is that coal miners are more likely to develop lung diseases, such as COPD, due to coal mine dust exposure. A higher risk of airway restriction is linked to prolonged coal dust exposure [1, 3, 4], consequently resulting in dyspnoea and limitation in physical activity due to fatigue on exertion, adversely affecting activities of daily living and quality of life [5–7]. Despite being a respiratory issue, dyspnoea [7] is thought to be the main cause of reduced activity among coal miners [8].

Pulmonary rehabilitation is a comprehensive intervention that combines behavior modification, education, and exercise training to assist individuals with COPD in regaining their physical and mental well-being [9]. In patients with COPD, diaphragmatic breathing improves breathing patterns and respiratory efficiency while causing a decrease in the rate of respiration and an increase in tidal volume [10]. Furthermore, the active cycle of breathing technique (ACBT) appears to be beneficial for individuals with a variety of respiratory disorders [11]. Pulmonary rehabilitation is therefore crucial for enhancing exercise tolerance in COPD patients. Hence, the goal of this research was to determine the impact of pulmonary rehabilitation on coal miners with COPD.

Materials and Methods

Male coal miners who were non-smokers and aged 18 to 35 years, with moderate to severe stable COPD confirmed by a physician and meeting the global initiative for obstructive lung disease (GOLD) criteria, were included in the study. The GOLD criteria involved unassisted walking, stability for three months prior to enrollment, clinically assessed post-bronchodilator FEV1 of less than 80% predicted, and a forced expiratory volume in 1 second (FEV1)/forced vital capacity (FVC) ratio of <0.7. Participants were required to provide informed consent and be able to complete all study assessments.

Individuals were excluded if they had unstable angina, experienced a recent exacerbation of their COPD, had a resting heart rate of more than 120 beats per minute, or had a respiratory tract infection within one month prior to the study commencement. Also, those with a basal blood pressure of more than 180/100 mmHg, a body mass index of more than 35 kg/m^2, a history of angioplasty, heart surgery, myocardial infarction within the preceding three months, any neuromuscular conditions interfering with exercise tests, hospitalization, or a smoking history—including both current and former smokers—were also excluded.

For baseline evaluation, the participants were assessed for vital lung capacity using incentive spirometry and chest expansion, and the six-minute walk test (6MWT) was performed to determine functional capacity [12]. Before the commencement of the intervention, each participant provided written informed consent and received comprehensive information about the study. The intervention involved diaphragmatic breathing exercises [13] and thoracic expansion exercises, consisting of five repetitions of each and three cycles of the ACBT [11]. Each session lasted for 45 minutes and was carried out once per day, six days a week, for four weeks. The exercises were taught to all participants using handouts with pictorial diagrams along with live demonstrations. After four weeks of intervention, the participants were reassessed for vital lung capacity and functional capacity.

SPSS software, version 26.0 was used to analyze the data (IBM-SPSS Inc, Chicago, IL, USA). Main effect comparisons and repeated measures ANOVA were utilized to examine how the variables changed over time. To compare pre and post-intervention results, a paired t-test using Bonferroni correction was employed, and post-hoc analysis was performed through independent t-tests. For every test, $P<0.05$ was considered the level of statistical significance.

Results

A total of 76 coal miners aged 18 to 35 years were recruited for the study. The age-wise distribution of the miners showed that the maximum number of participants were in the age group of 24-29 years, consisting of 42 participants (55.26%), followed by the age group of 30 to 35 years, which included 26 participants (34.21%), and the age group of 18 to 23 years, which involved 8 participants (10.52%). The pre- and post-intervention vital capacities measured using the incentive spirometer are demonstrated in Table 1, which reports statistically significant results. Additionally, the pre- and post-intervention values of chest expansion are demonstrated in Table 2, also reporting statistically significant results. Moreover, Table 3 presents statistically significant results for the functional capacity determined by the 6MWT performed before and after the intervention.

Discussion

The present study evaluated the effects of cardio-respiratory physiotherapy on coal miners, during which a four-week intervention was conducted. The 6MWT was performed to determine the functional capacity, and the vital lung capacity was measured using incentive spirometry and chest expansion parameters assessed at the axillary, nipple, and xiphisternum levels. The exercise intervention consisted of diaphragmatic breathing exercises and thoracic expansion exercises, with five repetitions of each and three cycles of ACBT, which reported statistically significant results in terms of increased vital and functional lung capacities.

Decreased parenchymal elasticity is a consequence of COPD [14]. As a result, there is an increase in the workload on the respiratory muscles, which must contract for longer periods to meet the higher ventilatory flow requirements. The correlation between elevated respiratory demands and hyperinflation decreases the contractile range of the sarcomeres in the respiratory muscles, thereby inducing mechanoreceptor stimulation of the respiratory centers and increasing ventilation, culminating in the exacerbation of dyspnea. This vicious cycle continues, as rising dyspnea demands higher ventilatory efforts as well [14, 15].

A vital component of the treatment for COPD is pulmonary rehabilitation, which includes physical activity stimulation, exercise training, self-management interventions, behavioral modification encouragement, and patient education. Research has shown that pulmonary rehabilitation enhances exercise tolerance, improves symptoms, and health-related quality of life (QOL), which consequently reduces hospitalization rates [9, 16, 17]. Diaphragmatic and pursed-lip breathing techniques can be used in combination or individually to treat dyspnoea in COPD patients. Individuals who are unable to engage in exercise training can also perform these techniques. The goals of these treatments include enhancing gas exchange and ventilation, improving chest wall motion, reducing dyspnea, and decreasing hyperinflation [18]. Significant gains in respiratory function were noted in a prior study conducted by Mendes et al. following diaphragmatic breathing training [19]. Similarly, Chukwu et al. revealed improved results for forced expiratory volume and capacity in patients treated with diaphragmatic breathing and cervical mobilization using an incentive spirometer [20].

To assess functional capacity, the most common submaximal exercise test used is the 6MWT [21]. In patients with COPD, moderate levels of exercise are comparable to many everyday activities; therefore, regular administration of the 6MWT may provide a more accurate description of the exercise capacity required to engage in physical activity. These results are consistent with those of previous research [9]. In the present study, the average rise in 6MWT was 35.28 m, which is similar to the value

Table 1. Pre- and post-intervention values of incentive spirometry

Variable	Mean±SD		P
	Pre-intervention	Post-intervention	
Vital capacity (litres)	2.79±38.25	3.45±31.23	<0.001

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Table 2. Pre- and post-intervention values of chest expansion

Levels of Assessment	Mean±SD		P
	Pre-intervention	Post-intervention	
Axillary	3.39±1.02	3.69±0.88	<0.001
Nipple	3.08±1.12	3.36±1.05	<0.001
Xiphisternum	3.12±1.23	3.52±1.17	<0.001

PHYSICAL TREATMENTS

of 36.94 m reported in a study by Camillo et al., and exceeds the clinically significant minimum difference of 30 m [22]. These findings suggest that individuals with COPD can perform breathing exercises more effectively at home, and these changes were found clinically significant. The rationale behind this is that breathing exercises enhance the patient's everyday activity and ventilation.

As part of an airway clearance procedure, the ACBT helps in loosening secretions through a series of techniques, such as breathing control, thoracic expansion exercises, and forced expiratory techniques [23]. It is more effective than most other therapies for secretion clearance in the short term for individuals with chronic sputum production [24]. Exercise with ACBT is easy to control and does not require the use of any other external power or force. It is recommended that patients with COPD utilize ACBT because it can efficiently clear sputum, increase the discharge of secretions, boost oxygen partial pressure, and shorten treatment times [23].

The research demonstrated the beneficial effects of diaphragmatic breathing, thoracic expansion exercises, and ACBT on the vital signs and functional capacities of COPD patients. However, certain limitations of the study should also be considered, primarily involving the small sample size. Therefore, studies focusing on a large number of population should be performed. The study also excluded patients who had recently experienced a COPD exacerbation and included only those who had been clinically stable for at least three months prior to enrolment, which may have limited the reliability of the findings. Moreover, the intervention period of the present study was short, consisting of only four weeks, and it lacked a follow-up. Therefore, it is important to consider future research that focuses on efficacy and long-term impacts.

Conclusion

The study concluded that diaphragmatic breathing, thoracic expansion exercises, and ACBT provided beneficial effects in improving vital capacity, as measured with an incentive spirometer, and chest expansion as outcome measures, along with enhanced functional capacity, evidenced by statistically significant results on the 6MWT. To effectively manage COPD, physiotherapy must address issues related to breathing, promote airway clearance, increase mobility, encourage rehabilitation, and support the provision of non-invasive ventilation services. The treatment approach should be tailored based on whether a patient

Table 3. Pre- and post-intervention values of the 6MWT

Variable	Mean±SD		P
	Pre-intervention	Post-intervention)	
6MWT (meters)	292.43±67.24	327.71±76.52	<0.001

PHYSICAL TREATMENTS

is experiencing an acute exacerbation of COPD or is in a stable phase, taking into account how each patient's clinical presentation changes over time. Furthermore, to maximize and encourage self-management, achieving agreement between patients and clinical staff on a treatment plan should be the primary goal of treatment.

Ethical Considerations

Compliance with ethical guidelines

An interventional study was carried out among 76 coal miners aged 18 to 35 years from May 2023 to November 2023, and approved by the Ethics Committee of Hosmat Hospital Educational Institutes (Code: HHEIEC/REV/387/2023).

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Authors' contributions

All authors contributed equally to the conception and design of the study, data collection and analysis, interpretation of the results, and drafting of the manuscript. Each author approved the final version of the manuscript for submission.

Conflict of interest

The authors declared no conflicts of interest.

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