https://dx.doi.org/10.4314/emj.v63 i05

Ethiopian Medical Journal 2025 63(05)
ISSN 0014-1755 eISSN 2415-2420
Rao et al.

Systematic Review

Impact of Pulmonary Rehabilitation in Lung Cancer Patients: A Systematic Review

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Abstract
Background: *Lung cancer is a malignancy originating from the bronchial mucosa. After any surgical intervention for lung cancer, patients experience hypoxemia and reduced gas exchange due to damage to the structure and physiology of the lungs. This can lead to respiratory failure in some patients. Breathing exercises consist of various respiratory techniques, including abdominal breathing, pursed-lip breathing, and thoracic breathing, which enhance the inhalation and exhalation process in lung cancer patients by enabling them to take deeper breaths and utilize more oxygen. Consequently, this systematic review aims to evaluate the impact of breathing exercises on lung cancer patients regarding reported improvements in lung function and pulmonary complications.*
Methods: *From 2019 to 2024, literature was searched in electronic databases, including Google Scholar, PubMed, and ScienceDirect. The terms "breathing exercises," "lung cancer," and "adults" were used to conduct the literature search and identify relevant studies. The methodological quality of the included studies was evaluated using the Mixed Methods Appraisal Tool (MMAT).*
Results: *Overall, six studies were included based on the selection criteria for this review. Following the quality assessment, all six studies were reported to be of high quality according to the MMAT. The studies demonstrated the impact of various breathing exercises on improving dyspnea and quality of life (QOL) in patients with lung cancer. In particular, diaphragmatic and deep breathing exercises, along with respiratory muscle training, appear promising for enhancing the QOL of these patients.*
Conclusion: *The review highlighted the positive impact of various breathing exercises on physical activity, exercise capacity, respiratory function, dyspnea, short-term recovery quality, cardiorespiratory fitness, quality of life, postoperative complications, psychological symptoms, length of hospital stay, and mortality rate. Future research studies should prioritize standardizing outcome measures, enabling more robust comparisons across studies.*

Keywords: *Pulmonary Rehabilitation, Breathing Exercises, Lung Cancer Patients, Inspiratory Muscle Training, Adults*
Citation : *Rao JB, Bansal K,. Impact of Pulmonary Rehabilitation in Lung Cancer Patients: A Systematic Review . Ethiop Med J 63 (05)*
Submission date : *17 September 2024 Accepted: 26 March 2025 Published: 1 April 2025*

Introduction

Lung cancer originates in the glands and bronchial mucosa of the lung. Based on the histological type, it is classified as either non-small cell or small cell lung cancer (1). Currently, the three major treatments for lung cancer are surgery, chemotherapy, and radiotherapy. The primary approach for treating lung cancer radically is surgical resection in conjunction with perioperative care (2,3). Following lung cancer surgery, patients have hypoxemia and decreased gas exchange as a result of the damage to the structure and physiology of the lungs.

Additionally, respiratory failure is also developed in some patients (4,5). Breathing exercises comprise a variety of respiratory techniques, such as abdominal breathing, pursed-lip breathing, and thoracic breathing. These techniques facilitate by slowing down and extending the process of inhalation and exhalation in lung cancer patients by allowing them to take deeper breaths and consume more oxygen (6).

During the rest, pursed-lip breathing reduces respiratory rate and dyspnoea while improving oxygen saturation and tidal volume. Additionally, it enhances the effective vital capacity (7,8). During inspiration, patients using abdominal breathing methods must expand their abdominal wall and reduce their upper rib cage movement. This method lowers the energy cost of breathing by enhancing ventilation distribution and mobility of the chest wall. The diaphragm, the main component of diaphragmatic respiration, is important for posture, regulating the breathing mechanism, and the respiratory pump. The inspiratory muscle training (IMT) aims to increase the strength and endurance of the muscles by increasing the inspiratory load (6,9). Therefore, this systematic review (SR) aims to assess the effect of various breathing exercises on lung cancer patients regarding improved lung function and reduced pulmonary complications (6).

Methods

This SR followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (10).

Data sources and search strategy

From 2019 to 2024, a literature search was conducted using the Science Direct, PubMed, and Google Scholar databases. The search terms "breathing exercises," "lung cancer," and "adults" were utilized for the literature review.

Study screening and selection

Studies involving lung cancer patients that observed the effect of breathing exercises were included. These studies were published between 2019 and 2024 and included randomized controlled trials, as well as cross-sectional and observational studies, including retroactive studies that were available in English with full text. However, studies that provided irrelevant information, those consisting of book chapters, editorials, commentaries, guidelines, case reports, letters to editors, and studies not available in full-text English were excluded.

Two reviewers independently assessed each article to determine whether or not the study should be included in the review. To eliminate duplicate articles, the titles and abstracts were reviewed. Secondly, further screening was performed on the selected articles to exclude those not meeting the eligibility requirements. Finally, to establish eligibility, the screening was performed for the full text of the selected articles. The conflicts were sorted among the reviewers through discussions.

Data extraction

The authors independently retrieved and examined the data, which was then combined based on consensus. The data included study design, number of lung cancer patients, mean age, timeline of the intervention, interventions performed, outcome measures, results, and conclusion.

Quality assessment

The Mixed Methods Appraisal Tool (MMAT) is frequently used to assess mixed method, non-randomized, cross-sectional, qualitative, and quantitative descriptive research (11,12) and therefore, was utilized to evaluate the methodological quality of the included studies. The quality was described as low, moderate, or high.

Data synthesis

Critical narrative technique was utilized to integrate the findings from the studies. The implication of figures, tables, and text to demonstrate study findings is known as narrative synthesis (11). The factors such as incorporated study limitations, potential biases, higher methodological quality studies, and others were analyzed to provide a critical opinion for the evaluation. The included studies showed considerable variability since different research procedures and outcome measures were present.

Results

Initially, a total of 17,645 articles were screened, which included 25 from the PubMed database, 17,000 from Google Scholar, and 620 studies from the ScienceDirect database. After eliminating duplicate articles totaling 9,934 studies, 7,711 studies remained and underwent a retrieval evaluation process, out of which 1,138 studies were not retrieved. Furthermore, an eligibility screening process was conducted for 6,573 articles, resulting in 914 articles providing irrelevant data, 4,721 articles lacking full-text availability, 745 studies being other types aside from original research articles, and 187 studies not written in English, which were therefore not included in the review. Consequently, based on this strategy, a total of six studies were included in this systematic review, as illustrated in Figure 1.

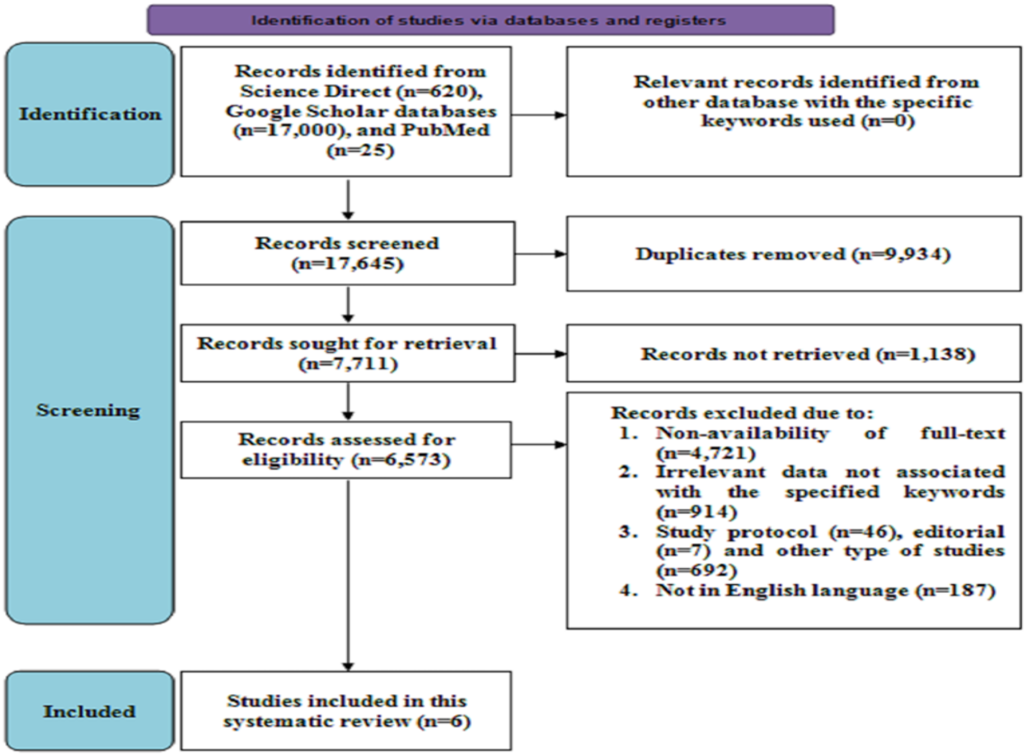

Figure 1: Search strategy

Moreover, the characteristics of the studies included are described in Table 1.

Table 1: Characteristic of the included studies

Sr. No.	Author and year	Study design	Sample size	Mean age	Time of inter-vention
1.	Jonsson M et al. (2019) (13)	RCT	94	IG = 69±8 years, CG = 68±8 years	Preoperative
2.	Şahin H et al. (2022) (14)	RCT	66	IG = 66 (55-72) years, CG = 64 (62-69) years	Postoperative
3.	Liu Z et al. (2020) (15)	RCT	73	IG = 56.2±10.3 years, CG = 56.2±8.7 years	Preoperative
4.	Qiu Q-X et al. (2023) (16)	RCT	80	IG = 62.76±10.43 years, CG = 62.18±10.39 years	Postoperative
5.	Saetan P et al. (2020) (17)	Quasi-experimental	28	IG = 65.80±8.80 years, CG = 73±7.60 years	Not specified
6.	Gravier F-E et al. (2022) (18)	RCT	36	IG = 68±8 years, CG = 65±8 years	Preoperative

CG = Control group, IG = Interventional group, RCT = Randomized controlled trial

Table 2 describes the summary of the studies, which includes the intervention, outcome measurements, results, conclusion, and quality evaluation.

Table 2: Summary of the included studies

Sr. No.	Author and year	Intervention	Outcome measures	Results	Conclusion	Quality assessment
1.	Jonsson M et al. (2019) (13)	IG = breathing exercises, mobilization, shoulder exercises, and ambulation. CG = no treatment.	Dyspnoea scores, 6MWT, accelerometer, and spirometry.	Spirometry, dyspnea, and the 6MWT showed no significant changes between the groups. However, for the first three post-operative days, in comparison to the CG, the IG recorded considerably more accelerometer steps and counts per hour.	In comparison to the CG who did not receive any treatment, patients undergoing in-hospital physical therapy had a higher degree of physical activity following lung cancer surgery.	High
2.	Şahin H et al. (2022) (14)	IG = Breathing exercises (thoracic expansion exercises, diaphragmatic breathing, and pursed-lip breathing), aerobic exercises, peripheral muscle strengthening, stretching exercises, and relaxation. In addition, dyspnoea reduction positions, and bronchial hygiene techniques were taught. The intervention involved a total duration of eight weeks and was performed for two days a week, and each session was of two hours.	The body plethysmograph was used to measure respiratory functions, the mMRC dyspnoea scale was used to assess dyspnoea, the 6MWT was used to assess exercise capacity, the SGRQ (disease specific) was used to assess QOL, and the SF-36 was used to assess overall QOL. Using the HAD scale, the psychological symptoms were assessed.	When the comparison was made between the groups for post-PR changes, the PR group showed higher decrease in dyspnoea perception with significant results. In the PR group, there was increase in the physical function, mental health, SF-36, FVC, 6MWT, and vitality scores with significant results. Whereas the scores of dyspnoea, SGRQ, and anxiety score decreased significantly. The only symptoms that decreased in the group that received breathing exercise were dyspnoea and SGRQ symptom scores.	PR program increases exercise capacity, reduces dyspnoea and psychological symptoms and improves QOL. It is important to make sure that lung cancer patients should be directed to the PR program.	High

3.	**Liu Z et al. (2020) (15)**	**IG = Before surgery, a 2-week multimodal program comprising aerobic and respiratory training, resistance training, dietary counseling, supplementation with whey protein, and psychological counseling was implemented. CG = received the standard care.**	**Perioperative functional capacity (6MWT), lung function, psychometric evaluations, disability, quality of short-term recovery, mortality, postoperative complications, and length of stay.**	**In comparison to the CG, the average 6MWT was greater in the prehabilitation group following surgery. Except for FVC, there were no changes in the other parameters involved**	**Patients with lung cancer may experience clinically beneficial improvement in their perioperative functional capacity after the intervention.**	**High**
4.	Qiu Q-X et al. (2023) (16)	CG = conventional nursing care. IG = respiratory exercise nursing combined with continuous nursing.	Between the two groups before and after 3 months of intervention the blood gas analysis, pulmonary function parameters, occurrence rate of pulmonary complications, Morisky compliance scores, MDASI-LC scores were compared.	In comparison to the CG, the IG group demonstrated higher PaO2, pulmonary function parameters, nursing satisfaction, and treatment compliance with statistically significant differences. Additionally, the occurrence rate of pulmonary complications, PaCO2, the MDASI score, were significantly lower.	The integration of respiratory exercise training along with continuous nursing care can provide notable benefits for postoperative lung cancer patients, including increased respiratory function recovery, decreased rate of complications, and increased patient adherence to therapy.	High
5.	Saetan P et al. (2020) (17)	CG = routine nursing care IG = dyspnoea education, respiratory strengthening training, effective coughing, breathing exercise, and follow-up.	Perceived self-efficacy and dyspnoea by using cancer dyspnoea scale was assessed.	Between the IG and the CG, the perceived self-efficacy and dyspnoea scores showed significant difference.	Lung cancer patients should benefit from the PR program to alleviate dyspnoea and improve their self-efficacy.	High

6.	**Gravier F-E et al. (2022) (18)**	**Inspiratory muscle training, peripheral muscle strengthening, aerobic endurance training, and education and support. IG = Prehabilitation dense regimen for three weeks consisting of five sessions/ week for 90 minutes. CG = a non-dense regimen for five weeks consisting of three sessions/week for 90 minutes.**	**Post-training change in cardiorespiratory fitness (VO2peak), maximal inspiratory pressure, cardiopulmonary exercise testing, quadriceps maximal voluntary isometric contractions, non-invasive nutritional markers, QOL, postoperative complications, and adherence.**	**Similar effects were observed on V̇O2 at ventilatory threshold, body mass index, maximal inspiratory pressure, and peak work rate. Whereas, for QOL, quadriceps maximal voluntary isometric contractions, and postoperative complications the relative effect was uncertain. The changes in the IG were superior or similar to the CG.**	**Reducing the sessions of prehabilitation led to comparable or enhanced cardiorespiratory fitness and had no effect on adherence or increased adverse events. As a result, even with brief preoperative times, this may enable more individuals to be recommended for prehabilitation.**	**High**

IG = Interventional group, CG = Control group, mMRC = Modified Medical Research Council, 6MWT = six-minute walk test, QOL = Quality of life, HAD = Hospital Anxiety and Depression scale, SF-36 = Short Form-36, SGRQ = St. George's Respiratory Questionnaire, PR = Pulmonary rehabilitation, FEV1 = Forced expiratory volume in 1 second, FVC = Forced vital capacity, MDASI-LC =

Discussion

The present systematic review highlighted the positive impact of various breathing exercises on physical activity, exercise capacity, respiratory function, dyspnoea, cardiorespiratory fitness, short term recovery quality, hospital stay duration, psychological symptoms, quality of life (QOL), postoperative complications, and mortality rate. During the hospital stay, patients who got physiotherapy in the initial postoperative days engaged in much greater physical activity than those who did not received such treatment (13). Similarly, Agostini et al. in their study reported a low physical activity level [17], whereas, a remarkably high physical activity during hospitalization was stated by Esteban et al. (19,20). The walking distance and FVC% value was considerably higher in the patients who had lung cancer resection following pulmonary rehabilitation (PR), while their anxiety and dyspnoea perception scores were significantly lower. Apart from parenchymal resection, a reduction in the postoperative forced expiratory volume in 1 second (FEV1) is brought about by impairments in the diaphragm and chest wall motility. Poor tolerance to exercises, dyspnoea, and lower QOL are consequences of decline in pulmonary functioning (21–23).

The primary aim of the PR despite the condition is lung function optimization and consequently, the functional capacity of the patient (24). The thoracic-surgery related functional deterioration can be decreased by the PR program (25). According to some research, FEV1 and FVC values increase during PR (21), although other research revealed that only FEV1 levels increase (26) or the vital capacity and FVC values increase (27). Furthermore, it has been demonstrated in several studies that the exercise capacity following lung resection increases after implementation of the PR program (21,22,28). It is reported that in lung cancer patients the perception of dyspnea is decreased by both the PR program (26) and respiratory exercises (28) which correlates well with a study in the present systematic review that demonstrated significant decrease in the perception of dyspnea in both the groups.

Improving QOL is considerably more essential along with achieving other therapy goals when treating patients with lung cancer, even though it is not often the obvious outcome (29). The results of earlier studies, which indicated that lung cancer patients who engaged in PR following lung resection had increased QOL, were supportive of the findings of the current systematic review (28,30).

Furthermore, regardless of the kind of therapy, lung cancer patients experience greater rates of psychosocial problems than patients with other cancers (30).

Except for the depression score, the anxiety scores of the experimental group significantly decreased, according to the current systematic review. PR performance in groups may have improved the psychological condition and physical and functional abilities. However, individual psychological support should be considered necessary for patients with more serious psychological issues. This was found to be congruous with a prior study that found that patients' perceptions of their dyspnoea diminished following the PR program, leading to an increase in their self-efficacy and capacity for exercise and a decrease in psychological symptoms (31).

Many studies provided preoperative rehabilitation in this systematic review as it improves the patient's functional and physiological abilities before surgery, reduces surgical stress, maintains perioperative homeostasis, and speeds up recovery after surgery (15). Reduced functional capacity and fatigue are frequent and persistent adverse effects that affect activities of daily living and QOL postoperatively. As these exercise interventions can enhance functional capacity, preoperative exercise has been recommended to reverse adverse effects and improve QOL and functional capacity (15). In addition, prehabilitation may aid in improving lung function following thoracic surgery by strengthening the respiratory muscles that impact functional capacity (32).

Limitations

The limitations included the absence of meta-analyses, as few studies were incorporated that covered a wide range of breathing techniques but showed a lack of standardized outcome measures. Additionally, a narrative method was employed to synthesize the information, which constrained the ability to provide quantitative evaluations of the treatments' outcomes. Furthermore, research studies from databases outside those considered and published in other languages were not included, which may have limited the number of relevant articles.

Conclusion

This systematic review indicates that various breathing exercises improve dyspnea and quality of life (QOL) in patients with lung cancer, highlighting the significance of pulmonary rehabilitation. Even perioperative prehabilitation has shown beneficial improvements in lung functional capacity. Particularly, diaphragmatic and deep breathing exercises, along with respiratory muscle training, appear promising in enhancing the QOL of these patients. Standardizing outcome measurements will assist future research in this area, facilitating more reliable comparisons between studies. Comparative effectiveness studies may provide important insights into the relative benefits of different breathing techniques, but longer follow-up periods are necessary to evaluate the sustainability of these effects. Additionally, exploring multidisciplinary approaches and incorporating patient-centered outcomes are essential steps towards enhancing the comprehensive care of lung cancer patients.

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