Original Article

Systematic review and meta-analysis of breathing exercises effects on lung function and quality of life in postoperative lung cancer patients

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Background: Postoperative recovery in lung cancer patients is a complex process, where breathing exercises may play a crucial role in enhancing pulmonary function and quality of life (QoL). This study systematically reviews and meta-analyzes the impact of breathing exercises on post-surgical lung function and QoL in lung cancer patients.

Methods: An extensive literature search was conducted across PubMed, Cochrane, Web of Science, and Embase databases using terms like "Lung Neoplasms", "breathing exercises", and "randomized controlled trial", supplemented by Medical Subject Headings (MeSH) and free words. The Cochrane risk of bias tool was used for quality assessment. A systematic review and meta-analysis on the effects of breathing exercises post-lung cancer surgery followed by data extraction and quality evaluation.

Results: From 384 retrieved studies, 10 met the inclusion criteria and were selected for detailed analysis. The main outcomes assessed were postoperative pulmonary function indices and QoL measures. The majority of studies were deemed 'low risk' for random sequence generation and allocation concealment. However, due to the nature of the interventions, blinding was a 'high risk' in most cases. The meta-analysis revealed significant improvements in key pulmonary function indices: forced vital capacity (FVC%) increased by an average of 1.73%, maximal voluntary ventilation (MVV) improved by 7.58 L/min, and maximal inspiratory pressure (MIP) enhanced by 0.95 cmH_2O. Additionally, there was a notable alleviation of postoperative dyspnea and an enhancement in QoL, with anxiety scores decreasing by an average of 3.42 points and complication rates reducing correspondingly. However, the interventions did not significantly affect physical activity levels or performance on the 6-minute walk test (6WMT), with effect sizes for these outcomes being non-significant.

Conclusions: This study indicates that breathing exercises significantly improve postoperative pulmonary function and QoL in lung cancer patients. Future research should delve into the mechanisms behind these exercises and evaluate their long-term rehabilitation effects. Customized programs could further optimize recovery and enhance patient QoL.

Keywords: Lung cancer; postoperative rehabilitation; breathing exercises; pulmonary function; quality of life (QoL)

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Introduction

Lung cancer remains a prominent public health challenge, with its incidence and mortality rates on the rise globally. This disease profoundly affects patients' physical well-being and significantly diminishes their quality of life (QoL), as noted in several studies (1-3). The journey through lung cancer treatment is fraught with numerous hurdles, among which postoperative recovery is a pivotal phase that substantially influences patient outcomes and long-term survival (4-6). The decline in respiratory function postoperatively is a significant issue, often leading to restricted daily activities, worsening of health status, and extended recovery periods (7,8). While a range of rehabilitation strategies has been proposed and adopted in clinical settings, their effectiveness needs continuous assessment and improvement (4,9).

The postoperative period for lung cancer patients is characterized by an array of complications. Surgical procedures often lead to damage in pulmonary tissues and a weakening of respiratory muscles, which manifests as reduced respiratory capacity (7,8). These physical impairments, along with prevalent fatigue and dyspnea, contribute to a decrease in QoL (10-12). Moreover, surgery can trigger psychological distress, such as anxiety or depression, further complicating the recovery trajectory. The psychological burden can adversely affect both the rehabilitation process and its outcomes. Although current rehabilitation methodologies offer some relief, their inconsistent effectiveness and patient adherence leave much to be desired (4,9).

Non-pharmacological interventions such as breathing exercises have shown promise in mitigating these postoperative challenges (13-15). Such training is designed to increase the strength of respiratory muscles, enhance pulmonary efficiency, ease breathing difficulties, and promote the restoration of lung function (16,17). Beyond the physical improvements, breathing exercises have been associated with psychological relief, increased patient motivation, and improved adherence to rehabilitation protocols (18). Consequently, integrating breathing exercises into postoperative care should benefit lung cancer patients.

Considering the aforementioned background, this study aims to meticulously evaluate the impact of different breathing exercises, including breathing exercises and lung capacity measurements, on postoperative lung function and QoL in lung cancer patients. In contrast to the focus on respiratory muscle training (RMT) using resistance threshold or flow resistance loads, our systematic review and meta-analysis seek to explore the more widely utilized resistance-free breathing practices in postoperative care. A comprehensive literature search was conducted across four major databases, and study quality was rigorously assessed using the Cochrane risk of bias tool. By synthesizing data from various lung function and QoL indicators, our study strives to provide a more scientifically sound and personalized approach to respiratory exercise interventions for clinical practice, ultimately aiming to enhance postoperative prognosis and QoL for lung cancer patients. Recent research on breathing exercises (19,20) further corroborates the significance of our findings, which we believe will contribute to advancing postoperative recovery and improving QoL for lung cancer patients. The relevance of this study lies in addressing the current gap in understanding the specific benefits of postoperative breathing exercises, an area that remains inadequately acknowledged or standardized globally. The necessity of this research is underscored by the lack of sufficient evidence regarding the effectiveness of various breathing exercises compared to traditional postoperative care, particularly for thoracic surgical patients. We are confident that the results

Highlight box

Key findings

- Breathing exercises significantly improved forced vital capacity, maximal voluntary ventilation, and maximal inspiratory pressure in postoperative lung cancer patients.
- Notable reduction in postoperative dyspnea and anxiety, with improved quality of life (QoL), though no significant impact on physical activity levels or 6-minute walk test performance.

What is known and what is new?

- Postoperative recovery in lung cancer patients can benefit from pulmonary rehabilitation, with breathing exercises being potentially beneficial.
- This study provides systematic evidence that specific breathing exercises yield measurable improvements in pulmonary function and QoL post lung cancer surgery.

What is the implication, and what should change now?

- Breathing exercises should be considered an integral part of postoperative care for lung cancer patients to enhance pulmonary recovery and improve QoL.
- Healthcare providers should integrate targeted breathing exercises into the standard postoperative rehabilitation protocol for lung cancer patients to optimize recovery outcomes and reduce complication rates.

of this study will hold significant clinical implications in promoting postoperative recovery and enhancing the QoL for lung cancer patients. We present this article in accordance with the PRISMA reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-1733/rc).

Methods

Literature search strategy

This study comprehensively searched four English databases: PubMed, Web of Science, Embase, and Cochrane Library. The databases are retrieved separately by two researchers. To investigate the impact of postoperative breathing exercises on lung cancer recovery, we employed medical subject headings (MeSH) such as "lung neoplasms" and "breathing exercises", along with terms like "randomized controlled trials", for literature retrieval in four databases: PubMed, Cochrane Library, Web of Science, and Embase (see search strategy in the appendix). Across these databases, we identified a total of 28 articles from PubMed, 271 from Cochrane, 77 from Web of Science, and 8 from Embase, amounting to 384 relevant publications. To ensure research quality, we explicitly excluded non-randomized controlled trials (non-RCTs) from the literature review.

Literature management and screening

The inclusion criteria for literature are as follows: peer review; conduct clinical randomized trials; use English literature; the minimum number of research subjects is 10; the research focuses on lung cancer patients who undergo breathing exercises after surgery.

The exclusion criteria are as follows: non-original research, such as methodological studies, reviews, meta-analyses, or case reports. The study included lung cancer patients who underwent preoperative breathing exercises. The research focuses specifically on breathing exercises, encompassing various techniques such as inspiratory muscle training (IMT), device-assisted breathing exercises, and yoga breathing techniques.

Even if two studies employ overlapping samples but different outcome measures, they should be included in the systematic review. Additionally, we manually screened the list of references included in the study to obtain articles that met additional criteria.

Visualization

A flow chart the literature search process was created using the PRISMA template in Microsoft Visio. It was done to enhance transparency and reproducibility in the study (21).

Using the obtained literature, we used the "word cloud" package in the R language to generate a word cloud focused on breathing exercises. This word cloud visually presents the most frequently used vocabulary in the literature (22).

System evaluation overview

Standardized data extraction tables are utilized to ensure each study's consistent and accurate recording of key data. We extracted several pieces of information from the selected literature. These include the study authors, publication year, country, research design type (e.g., RCT, observational study), study groups and treatments given to the patients, baseline characteristics of participants (e.g., age, gender, body mass index, smoking status, chronic non-obstructive comorbidities), specific breathing exercises methods and protocols, and the primary and secondary outcome measures results. Double data checking was implemented to ensure the accuracy of data extraction. Two researchers independently extracted the literature's data, which was then compared and assessed for consistency. If there are any objections, the arbitration will be conducted by a third-party researcher.

Evaluation of publication bias risk

This study aims to assess the risk of bias in clinical RCTs using the risk of bias assessment tool recommended by the Cochrane Handbook. The assessment considers the following elements: (I) verification of randomization methods and their accuracy; (II) correct allocation concealment; (III) proper blinding of participants and personnel; (IV) completeness of outcome data; (V) absence of selective reporting of study outcomes; (VI) identification of any other sources of bias. Two independent appraisers evaluate this section for bias risk assessment, and the results are verified through cross-checking. In case of any disagreement, it will be addressed and resolved, or a third appraiser will have the final say (23).

Meta-analysis

In this study, we employed the "meta" package in R software to conduct a meta-analysis focusing on continuous data. Due to the inconsistent detection methods and unit variations among the data used in this study, the standard mean difference (SMD) and 95% confidence interval (CI) will be employed to evaluate the combined effect. The objective of heterogeneity testing, also known as the test of homogeneity of statistics, is to determine the combinability of independent studies. The Q-test and I^2 are employed to assess the extent and significance of heterogeneity. Suppose the studies have no statistical heterogeneity ($P>0.05$ and $I^2<50\%$). In that case, the differences among the studies are not statistically significant, and the results could be combined using a fixed-effects model. This result implies that the observed study variations are likely due to sampling error. However, if statistical heterogeneity exists among the studies ($P<0.05$ and $I^2>50\%$), a random-effects model should be employed for the meta-analysis. Subgroup analysis is employed to analyze the heterogeneity between the data of the control and intervention groups, while one-by-one exclusion sensitivity analysis is utilized to assess the stability of the results (24).

Statistical analysis

In this study, we analyzed bioinformatics results using R 4.3.1, while statistical analysis of other results was performed using SPSS 26.0 (IBM, USA). The mean value represents the average value of measurement data, indicated as the mean plus or minus the standard deviation. A P value of less than 0.05 indicates statistical significance.

Results

Impact of postoperative breathing exercises on lung cancer rehabilitation: a comprehensive literature review

To investigate the efficacy of breathing exercises in the postoperative recovery of lung cancer patients, a total of 384 relevant publications were retrieved. During the literature screening process, we utilized EndNote software to eliminate 71 duplicate papers. Subsequently, following our pre-defined inclusion and exclusion criteria, 307 publications were further excluded due to either not employing an RCT design, not assessing our primary outcome of interest, or not being conducted within the context of postoperative lung cancer recovery. Ultimately, 10 studies meeting the criteria were selected for in-depth analysis. These studies primarily examined the impact of breathing exercises on postoperative lung function and their potential benefits in enhancing QoL. The PRISMA flowchart in *Figure 1* provides a detailed overview of the specific steps and reasons involved in the literature screening process.

Furthermore, a word cloud was generated to illustrate the content of the 10 articles about breathing exercises. The words such as "lung cancer", "postoperative", "exercise", "surgery", and "effect" are prominently highlighted, indicating the primary focus of current research (*Figure 2A*). Meanwhile, we have summarized the classification and characteristics of the breathing exercises methods used in these 10 pieces of literature (*Figure 2B*).

In conclusion, breathing exercises are the primary area of focus in postoperative rehabilitation research for patients with lung cancer.

Evaluation and outcomes of breathing exercises in postoperative lung cancer recovery: a detailed analysis of RCTs

After screening, we included 10 relevant studies that explored the effects of breathing exercises on postoperative recovery in patients with lung cancer. Table S1 presents the basic information in the literature, consisting of 10 RCTs. Table S2 displays the clinical feature information of the participants who were enrolled. Among the participants, the age range was between 46 and 73 years, with males accounting for 59.6% and females accounting for 40.4%. Details on the breathing exercise methods are available in Table S3. Three studies utilized IMT as a methodology (25-27). One study utilized a breathing exercises device, while another study employed yoga breathing techniques for training (28). Different breathing exercise techniques were utilized in the remaining studies (29-32). Cohen's kappa value for the consistency of all data extraction processes is 0.92, indicating a high level of agreement among researchers.

Subsequently, the Cochrane Risk of Bias tool should be employed to evaluate the quality of the literature that has been included. The results indicate that most studies are categorized as having a "low risk" regarding random sequence generation and allocation concealment. Regarding blinding, most studies were rated as "high risk" due to the nature of breath training, while the remaining were marked as "unclear". The specific assessment results are presented in *Figure 3A,3B*, which comprehensively depicts the distribution of different risk biases.

We assessed key parameters, including pulmonary

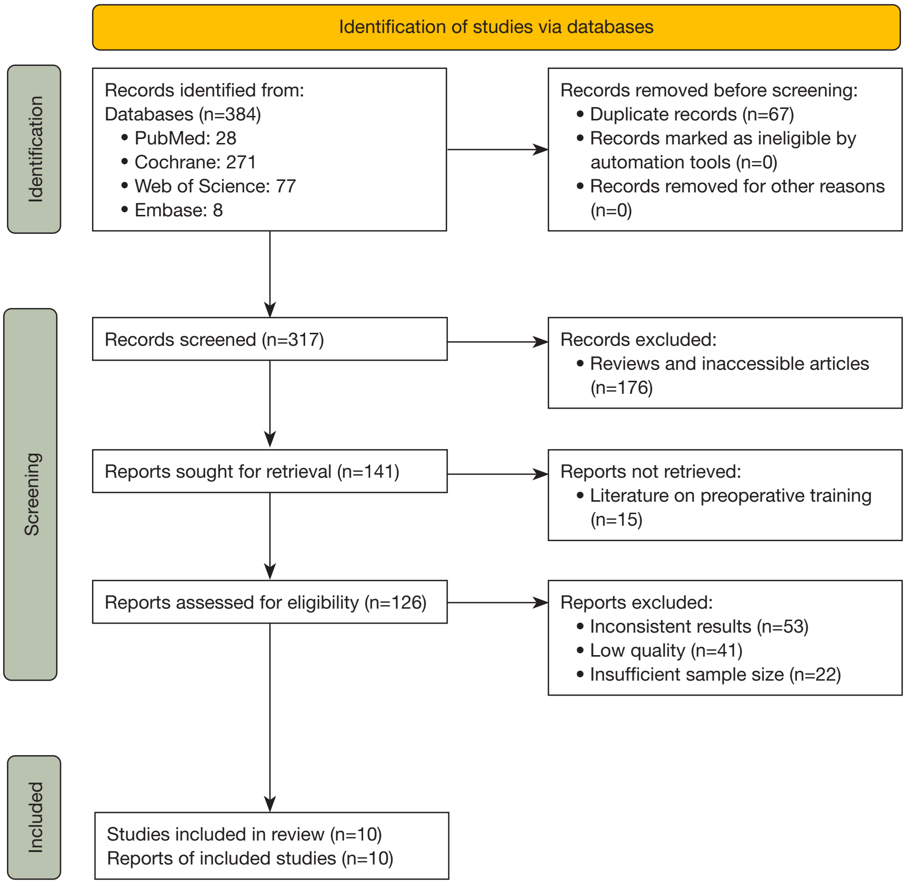

Figure 1 Flowchart of literature screening.

function test (PFT) indicators—forced vital capacity (FVC%), forced expiratory volume in one second (FEV1%), maximum voluntary ventilation (MVV), maximal inspiratory pressure (MIP), as well as QoL-related measures such as anxiety score, depression score, daily sedentary time (SEDP), low-intensity physical activity time (LIGPA), and moderate-intensity physical activity time (MVPA). Based on the extracted data, we found that breathing exercises can facilitate postoperative lung function recovery and enhancement of QoL in lung cancer patients (Table S4). When discussing the impact of breathing exercises on PFT indicators and QOL in postoperative lung cancer patients, we observed that 1% to 2% increases in postoperative PFTs may appear clinically insignificant. Nonetheless, our data revealed that breathing exercises not only led to slight improvements in FVC% and FEV1% by 1.73% and 2.15%, respectively, but more importantly, these enhancements in pulmonary function indicators were accompanied by a significant improvement in patients' QoL. Decreases in anxiety and depression scores by 3.42 and 2.14, along with changes in daily physical activity patterns such as increased sedentary time and heightened light physical activity time, reflected an overall enhancement in QoL. Furthermore, the increases in MVV value by 7.58 L/min and MIP value by 0.95 cmH_2O further substantiated the effectiveness of breathing exercises in postoperative recovery. While these improvements in the indicators were statistically significant ($P<0.05$), we also recognize the limitations of the study, particularly the lack of long-term follow-up data in most studies, which restricts our understanding of the long-term effects of breathing exercises.

Meta-analysis of breathing exercises' impact on lung function recovery and alleviation of respiratory difficulties in postoperative lung cancer patients

To comprehensively understand the impact of breathing exercises on postoperative lung function in lung cancer

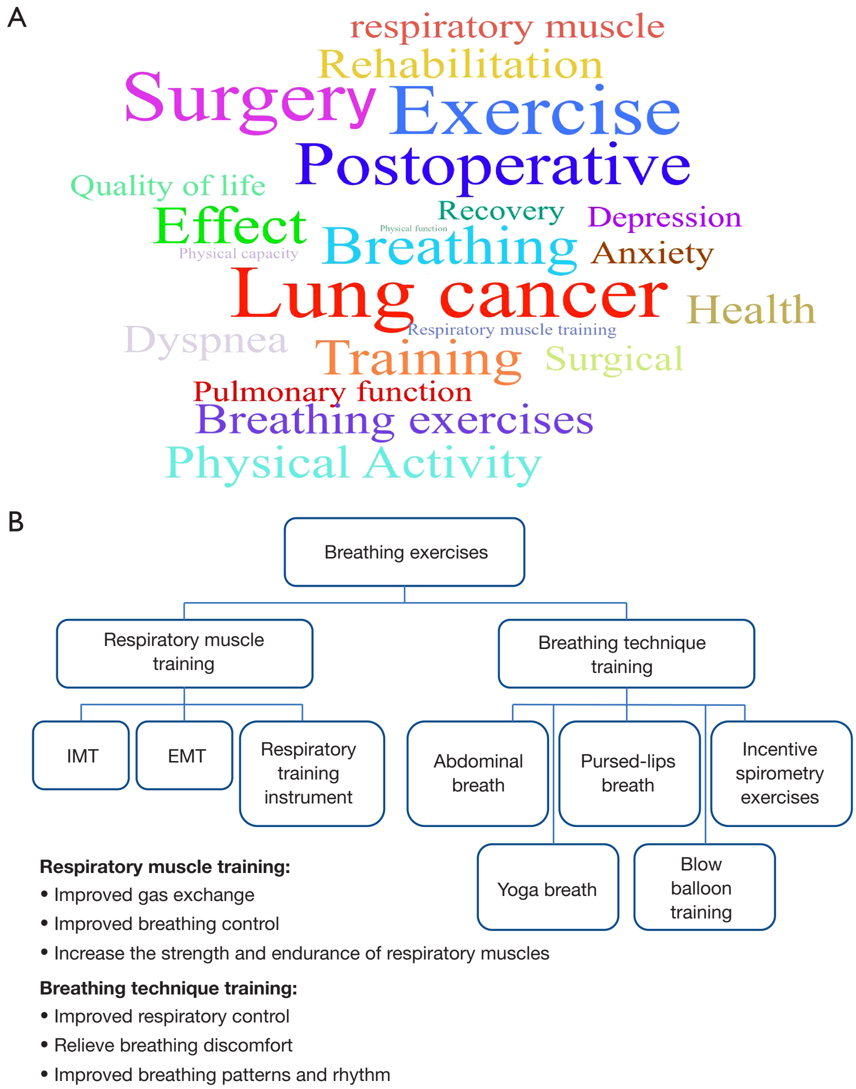

Figure 2 Summary of breathing exercises methods. (A) Word cloud of breathing exercises in the included literature. The size of each word represents its prominence in the source text: the larger the word in the cloud, the higher the frequency of its appearance in the text. (B) Summary graph of the breathing methods used in the included literature. IMT, inspiratory muscle training; EMT, expiratory muscle training.

patients, we conducted a meta-analysis on the heterogeneity of the FVC% data, resulting in an I^2 value of 0%, indicating homogeneity among the studies. Consequently, we opted for a fixed-effects model for analysis. Utilizing this model, we observed that breathing exercises led to an improvement in postoperative FVC% among lung cancer patients, with an effect size of 0.36 and a 95% CI of 0.05–0.67 (*Figure 4A*). The funnel plot reveals a minor publication bias in the studies included (*Figure 4B*). The one-by-one elimination method was used for sensitivity analysis, revealing no change in the MD value (P=0.02). This finding indicates the reliability of the meta-analysis results (*Figure 4C*).

The meta-analysis for FEV1% revealed heterogeneity among the studies, as indicated by an I^2 value of 94%. The random-effects model analysis also found that the differences in effect sizes were not (Figure S1A). Given the potential impact of varying breathing exercise methods on the outcomes, we performed subgroup and sensitivity analyses (P=0.05). The results indicate a difference in the impact of RMT and comprehensive training methods

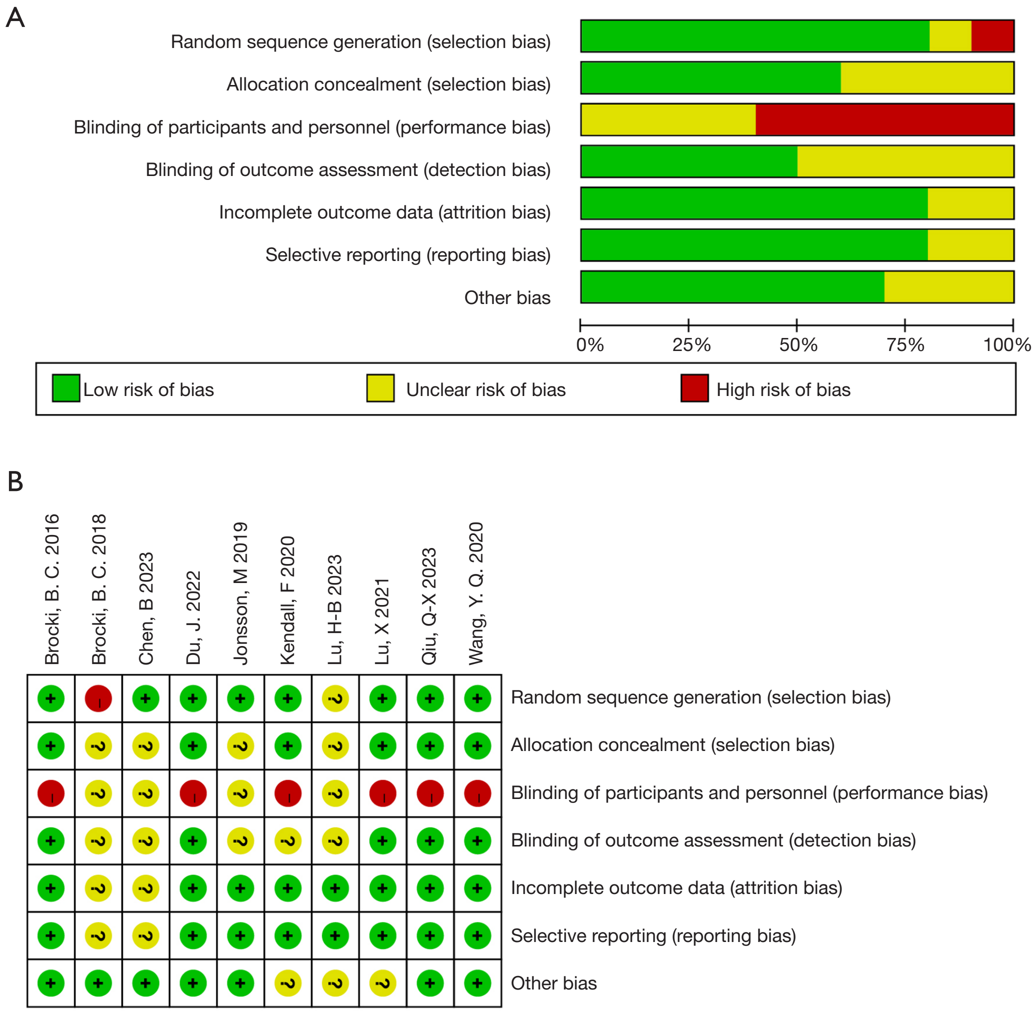

Figure 3 Literature risk assessment. (A) Bias risk graph, depicting the authors' judgment on each bias risk item, represented as a percentage of all included studies; (B) summary graph of bias risk in the literature, presenting the authors' judgment on each bias risk item for each included study.

on FEV1% in patients, which is the main source of heterogeneity (Figure S1B,S1C).

The results of the meta-analysis using the fixed effects model indicated that breathing exercises enhanced postoperative maximal voluntary ventilation (MVV) in patients with lung cancer. The effect size was calculated as 0.40, with a 95% CI ranging from 0.04 to 0.75 (*Figure 4D*). The funnel plot illustrates a minor publication bias among the included studies (*Figure 4E*). We conducted a sensitivity analysis using the one-at-a-time method. The MD value did not change (P=0.03), suggesting the result is relatively stable (*Figure 4F*).

The meta-analysis conducted using a fixed-effects model demonstrated that breathing exercises improved postoperative MIP in patients with lung cancer. The effect size was found to be 0.48, with a 95% CI ranging from 0.16 to 0.79 (*Figure 5A*). The funnel plot represents the inclusion of studies without publication bias (*Figure 5B*). The one-at-a-time elimination method was employed for sensitivity analysis. The MD values exhibited no changes (P<0.01), which suggests the stability of the results (*Figure 5C*).

Furthermore, during the meta-analysis of patient breathlessness ratings, the heterogeneity test yielded an I^2 value of 42%, suggesting moderate heterogeneity across the studies. An analysis using a fixed effects model revealed that breathing exercises reduced postoperative breathing

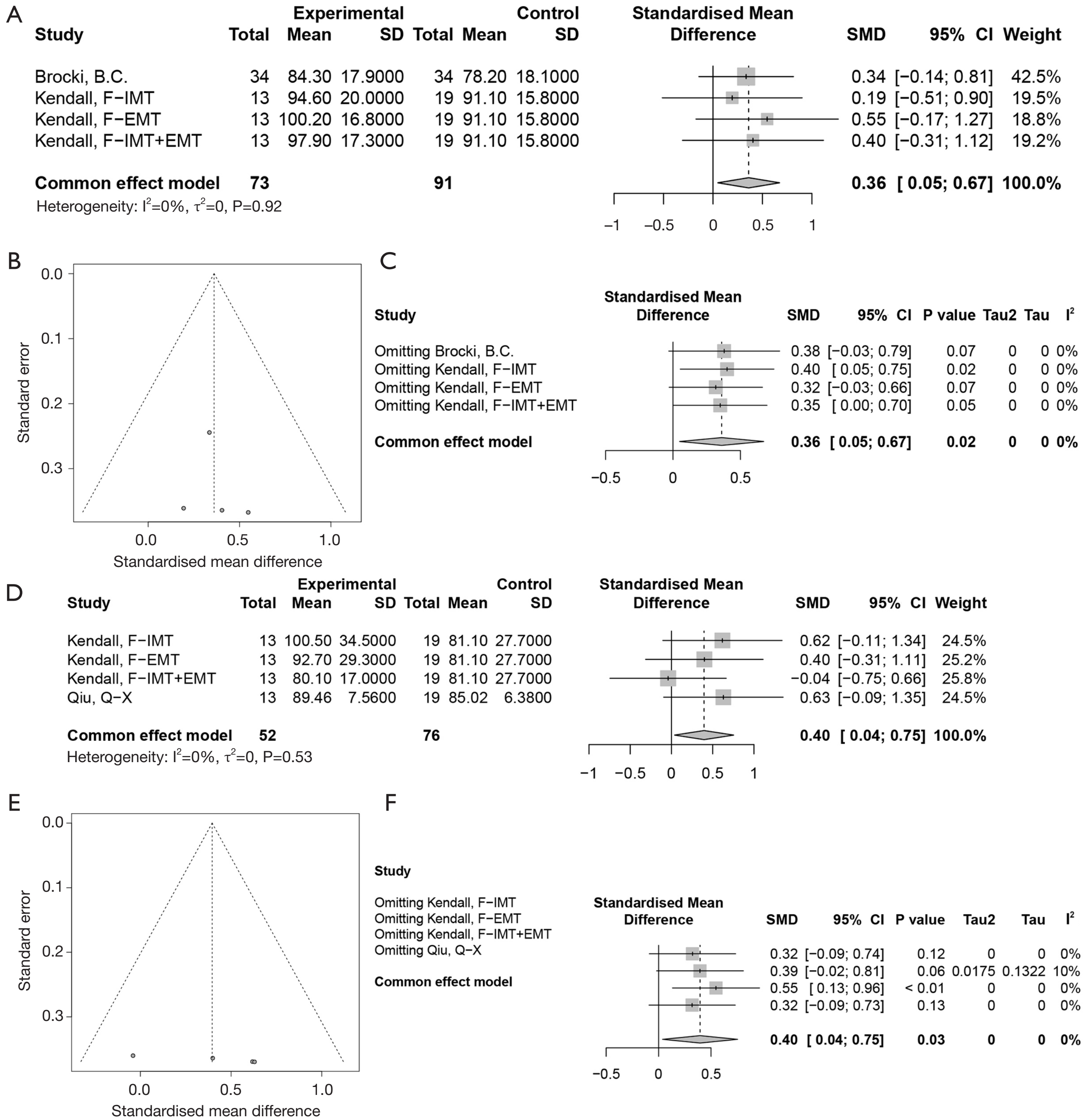

Figure 4 Meta-analysis of pulmonary function related indicators. (A) Forest plot of FVC% variation. The vertical line in the middle of the graph represents the null line, meaning SMD =0, indicating no statistical association between the studied factor and the outcome. Each horizontal line represents the 95% CI of a study, and the small square in the middle of the line represents the point estimate of the MD value, with the square's size reflecting the study's weight. If the horizontal line of a study's 95% CI does not cross the null line (i.e., 95% CI does not include 0), it suggests a statistical association between the studied factor and the outcome. (B) Funnel plot of publication bias for FVC% analysis data. (C) Sensitivity analysis results using the one-study-removed method. (D) Forest plot of MVV variation. (E) Funnel plot of publication bias for MVV analysis data. (F) Sensitivity analysis results using the one-study-removed method. FVC%, forced vital capacity percentage; MVV, maximal voluntary ventilation; CI, confidence interval; SD, standard deviation; IMT, inspiratory muscle training; EMT, expiratory muscle training; SMD, standardised mean difference.

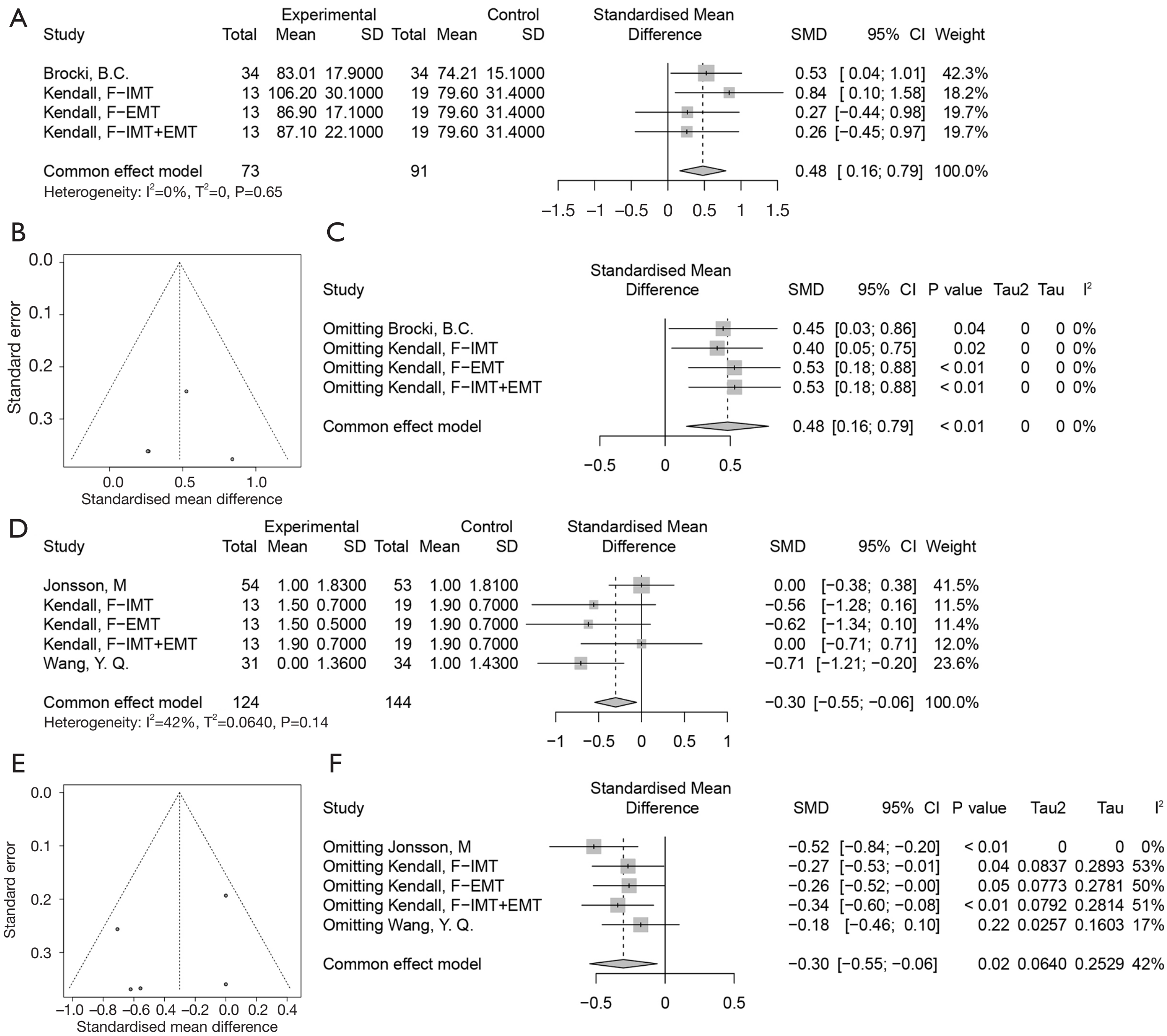

Figure 5 Meta-analysis of pulmonary function related indicators. (A) Forest plot of MIP variation. The vertical line in the middle of the graph represents the null line, meaning SMD =0, indicating no statistical association between the studied factor and the outcome. Each horizontal line represents the 95% CI of a study, and the small square in the middle of the line represents the point estimate of the MD value, with the square's size reflecting the study's weight. If the horizontal line of a study's 95% CI does not cross the null line (i.e., 95% CI does not include 0), it suggests a statistical association between the studied factor and the outcome. (B) Funnel plot of publication bias for MIP analysis data. (C) Sensitivity analysis results using the one-study-removed method. (D) Forest plot of respiratory difficulty score variation. (E) Funnel plot of publication bias for respiratory difficulty analysis data. (F) Sensitivity analysis results using one-study-removed method. SMD, standardised mean difference; SD, standard deviation; CI, confidence interval; MIP, maximal inspiratory pressure; IMT, inspiratory muscle training; EMT, expiratory muscle training.

difficulty scores and alleviated respiratory difficulties in lung cancer patients. The effect size is −0.30, with a 95% CI of −0.55 to −0.06 (*Figure 5D*). The funnel plot demonstrates that incorporating studies led to minimal publication bias (*Figure 5E*). By employing a one-by-one exclusion method for sensitivity analysis, it was discovered that a single study with a considerable sample size influenced the outcomes, whereas the other MD values exhibited no alterations (P=0.02). Moreover, all values intersected the null line, demonstrating the stability of the findings (*Figure 5F*).

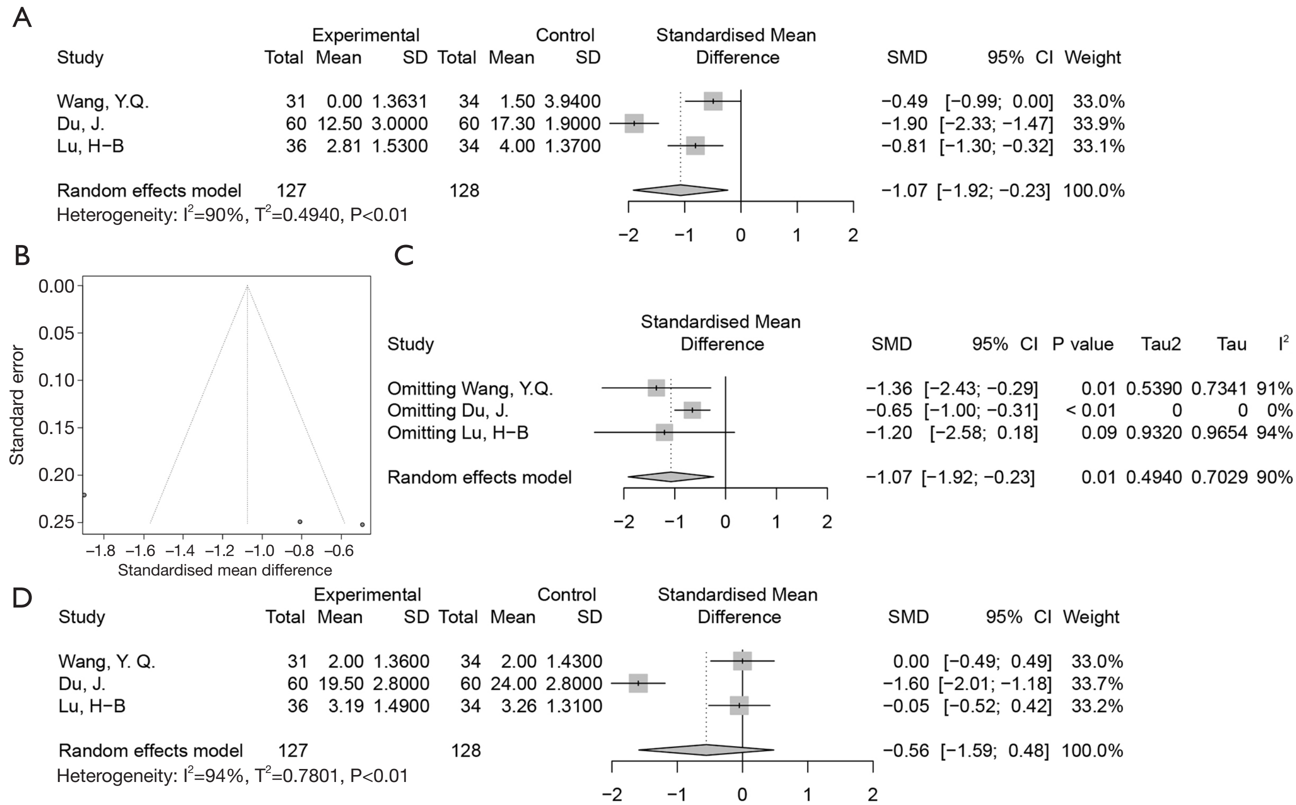

Figure 6 Meta-analysis of postoperative anxiety scores in lung cancer patients. (A) Forest plot of anxiety score variation. The vertical line in the middle of the graph represents the null line, meaning SMD =0, indicating no statistical association between the studied factor and the outcome. Each horizontal line represents the 95% CI of a study, and the small square in the middle of the line represents the point estimate of the MD value, with the square's size reflecting the study's weight. If the horizontal line of a study's 95% CI does not cross the null line (i.e., 95% CI does not include 0), it suggests a statistical association between the studied factor and the outcome. (B) Funnel plot of publication bias for anxiety score. (C) Sensitivity analysis results using the one-study-removed method. (D) Forest plot of depression score variation. SMD, standardised mean difference; CI, confidence interval; SD, standard deviation.

The results above indicate that postoperative breathing exercises in patients with lung cancer could effectively improve FVC%, FEV1%, MVV, and MIP values, alleviate breathing difficulties, and promote recovery of lung function.

Evaluating the impact of breathing exercises on postoperative quality of life, psychological well-being, and physical activity in lung cancer patients: a comprehensive meta-analysis

The extent to which anxiety and depression manifest in a patient directly impacts their postoperative functional recovery and psychological well-being (33). We measured improved postoperative QoL in lung cancer patients who underwent breathing exercises using the mean difference as an effect size. It was determined through a thorough assessment. The heterogeneity test results in the meta-analysis of anxiety scores indicate a high degree of heterogeneity among the studies, as evidenced by an I^2 value of 90%. Consequently, we adopted a random-effects model for the analysis. According to this model, it was discovered that breathing exercises resulted in a reduction in postoperative anxiety scores among lung cancer patients, with an effect size of −1.07 and a 95% CI of −1.92 to −0.23 (*Figure 6A*). The funnel plot suggests the presence of publication bias in the included studies (*Figure 6B*). A study of considerable size was excluded by employing the one-by-one elimination method for sensitivity analysis. Consequently, there were alterations in the MD value (P=0.01), suggesting that this study influenced the outcomes

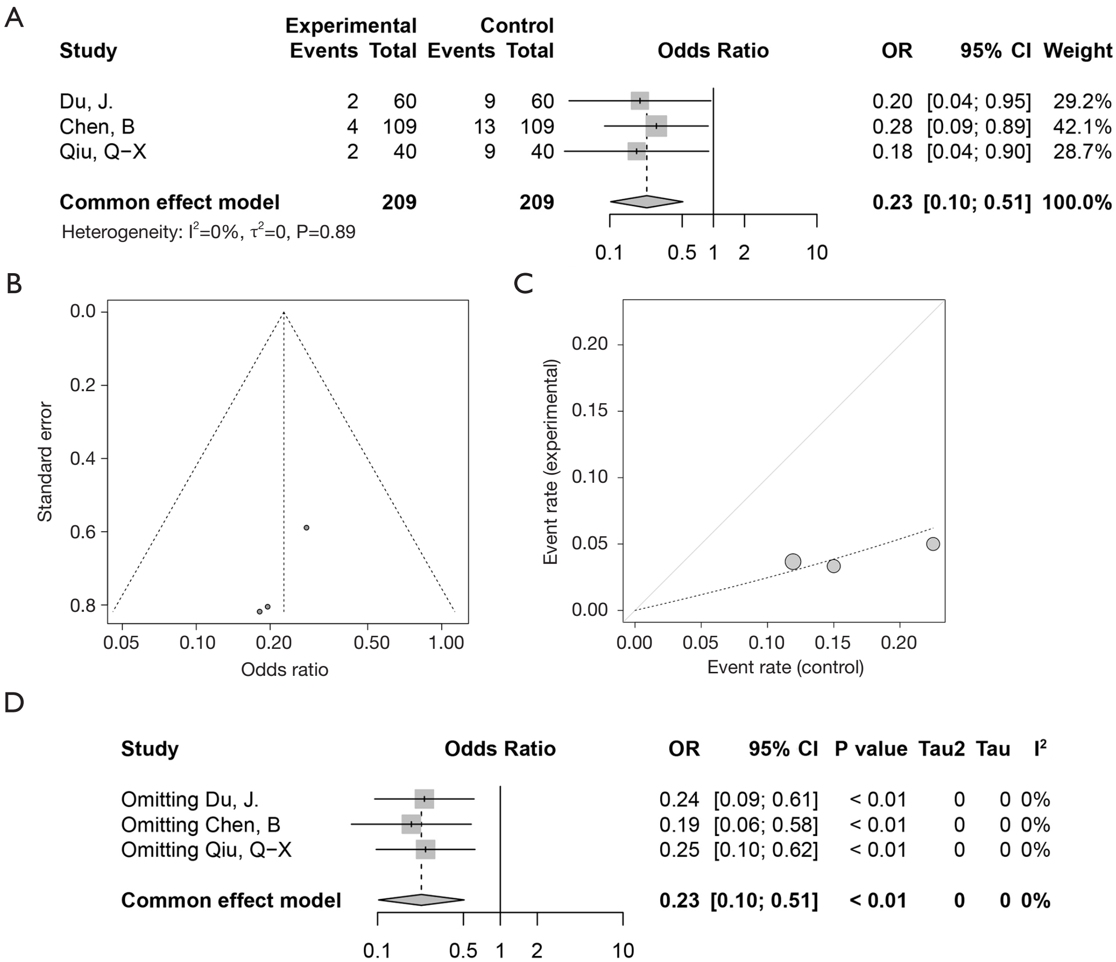

Figure 7 Meta-analysis of postoperative complication statistics in lung cancer patients. (A) Forest plot of postoperative complication statistics. The vertical line in the middle of the graph represents the null line, meaning SMD =1, indicating no statistical association between the studied factor and the outcome. Each horizontal line represents the 95% CI of a study, and the small square in the middle of the line represents the point estimate of the OR value, with the square's size reflecting the study's weight. If the horizontal line of a study's 95% CI does not cross the null line (i.e., 95% CI does not include 1), it suggests a statistical association between the studied factor and the outcome. (B) Funnel plot of publication bias for postoperative complication statistics. (C) L'Abbe plot of the relationship between the incidence of postoperative complications in the control group and intervention group. (D) Sensitivity analysis results using one-study-removed method. SMD, standardised mean difference; CI, confidence interval; OR, odd ratio.

(*Figure 6C*). The results of the meta-analysis on depression scores using a random effects model indicated that breathing exercises did not affect postoperative depression in patients with lung cancer (*Figure 6D*).

Postoperative complications in lung cancer patients impact various aspects, including physical symptoms, mental health, and daily functioning (34). A meta-analysis using fixed-effects models demonstrated that breathing exercises reduce the occurrence of postoperative complications in patients (*Figure 7A*). The funnel plot indicates the absence of evident publication bias in the included studies (*Figure 7B*). The Labette chart demonstrates that the study results exhibit a linear distribution and a high degree of homogeneity, as depicted in *Figure 7C*. The results of the sensitivity analysis indicate that the findings of the meta-analysis are highly robust (P<0.01) (*Figure 7D*).

Utilizing an accelerometer for quantifying the physical activity of postoperative lung cancer patients proves to be a more objective and reliable approach. This method aids in comprehensively evaluating the rehabilitation process and

QoL (35). The assessment is subdivided into three aspects: SEDPA, LIGPA, and MVPA. Despite the improved average scores of SEDPA and LIGPA, the meta-analysis results indicate little to no heterogeneity in the included literature and reveal that breathing exercises do not impact them (Figure S2A-S2C).

Despite the widespread use of the 6-minute walk test (6MWT) for assessing physical recovery in postoperative lung cancer patients (36), our meta-analysis indicates that the studies included did not show a statistically significant improvement in 6MWT scores as a result of breathing exercises (Figure S2D). This finding suggests that while breathing exercises may be beneficial for respiratory function and cardiopulmonary health, their impact on overall physical recovery measured by the 6MWT may not be as direct or significant as that of aerobic training.

The results above indicate that breathing exercises has a positive effect on alleviating postoperative anxiety in patients with lung cancer and reducing the occurrence of postoperative complications. It contributes to improving the QoL for patients.

Discussion

Lung cancer's pervasive impact necessitates interventions that extend beyond surgical procedures, with postoperative care being crucial for recovery and long-term well-being. The incorporation of breathing exercises into postoperative rehabilitation has garnered attention due to its potential to enhance pulmonary functions and improve life quality (1-3,37,38). Through this process, breathing exercises are believed to potentially enhance patients' lung function and QoL (13-15). In order to gain a deeper understanding of the role of breathing exercises in the postoperative recovery of lung cancer patients, the research team conducted a systematic comprehensive assessment and meta-analysis, searching across multiple medical databases and screening 10 relevant studies. The strategies of RMT in the included studies were diverse, encompassing both IMT and expiratory muscle training (EMT). Among these, IMT stood out as one of the most common forms, aimed at enhancing patients' respiratory muscle strength and endurance by increasing inspiratory resistance.

The core findings of this study indicate that breathing exercises significantly improved lung function indicators in postoperative lung cancer patients, such as FVC%, MVV, and MIP. These exercises effectively alleviated postoperative breathing difficulties, reduced anxiety levels, and decreased the incidence of complications. These data suggest that recommending breathing exercises not only plays a positive role in lung function recovery but also greatly benefits the overall QoL of patients. It is noteworthy that differences in the follow-up duration between studies may have a certain impact on result interpretation; however, both short-term and long-term follow-ups demonstrate positive effects of breathing exercises. Although true breathing exercises are not widely implemented on a global scale, the results of this study support their application in postoperative lung rehabilitation, especially in cases where routine postoperative training faces obstacles or cannot be sustained. Furthermore, for patients showing aerobic or significant pulmonary function changes before surgery, breathing exercises may bring even greater benefits.

Compared to existing literature, our study findings align with the majority of current literature supporting the efficacy of breathing exercises in improving lung function and QoL in postoperative lung cancer patients (18). Despite some variances in study results, these differences may be attributed to variations in study design, patient demographics, and training protocols. This study stands out for its comprehensive literature search strategy and rigorous quality assessment, providing a robust analytical framework that enhances the stability of the conclusions. Moreover, by exploring various breathing exercise strategies, this study offers broader clinical insights. Future research should emphasize the long-term benefits of breathing exercises and their impact on QoL to deepen the understanding of their overall advantages. Additionally, this study examines the multifaceted mechanisms of breathing exercises, including enhancing respiratory muscles, improving thoracic flexibility, and lung ventilation function, thereby promoting rapid postoperative recovery and QoL enhancement in lung cancer patients (16,17). While this study did not observe significant impacts of breathing exercises on physical activity and the 6MWT, this does not diminish the potential value of breathing exercises in other domains. Future studies should delve deeper into the comprehensive effects of breathing exercises to provide more precise assessments.

The strengths of this study lie in the thorough literature search strategy and stringent quality assessment tools employed, ensuring the reliability of the research findings. Additionally, through a comprehensive analysis of various pulmonary function and QoL-related indicators, this study offers scientific and personalized respiratory exercise intervention strategies for clinical practice. Despite limitations in study design and sample size, our findings underscore the crucial role of breathing exercises in postoperative lung cancer rehabilitation. Particularly in cases where standard postoperative training faces obstacles or cannot be sustained, breathing exercises offer an effective rehabilitation approach. Furthermore, our analysis reveals that breathing exercises may yield greater benefits for patients with preoperative aerobic capacity or significant changes in lung function. Therefore, we recommend customizing the application of breathing exercises based on individual patient circumstances in post-lung cancer surgery rehabilitation programs.

Looking ahead, we look forward to more high-quality studies exploring different facets of breathing exercises, including their impact on the recovery process of various types of lung cancer patients and how to maximize their clinical utility. With further research, we believe that the role of breathing exercises in postoperative lung cancer rehabilitation will garner wider recognition and application.

Conclusions

This study has confirmed that breathing exercises significantly improve lung function and QoL in postoperative lung cancer patients. Key findings include the significant enhancement of crucial lung function indicators (FVC%, MVV, MIP) through breathing exercises. In addition to the improvement in lung function, breathing exercises also positively impact the patient's QoL by reducing anxiety scores and decreasing the occurrence of complications. These achievements provide new scientific evidence for the rehabilitation of postoperative lung cancer patients and underscore the importance of breathing exercises in the rehabilitation program. Future research should further explore its long-term benefits to optimize rehabilitation strategies.

Acknowledgments

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Footnote

Reporting Checklist: The authors have completed the PRISMA reporting checklist. Available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-1733/rc

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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