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# EFFECTIVENESS OF COMBINED DIAPHRAGMATIC BREATHING AND OSCILLATING POSITIVE EXPIRATORY PRESSURE THERAPY IN BRICK KILN WORKERS WITH CHRONIC BRONCHITIS: A RANDOMIZED CONTROLLED TRIAL

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## ABSTRACT

**Background:** Chronic bronchitis, a primary manifestation of chronic obstructive pulmonary disease (COPD) in occupational settings, is highly prevalent among brick kiln workers. This population faces continuous exposure to biomass fuel smoke, coal dust, and respirable crystalline silica, which induce persistent airway inflammation, mucus hypersecretion, and impaired mucociliary clearance. Non-pharmacological interventions, including breathing exercises and airway clearance techniques, are essential adjuncts to standard care.

**Objective:** This study evaluated the effectiveness of combined diaphragmatic breathing exercises (DBE) and oscillating positive expiratory pressure (OPEP) therapy using a Flutter device in improving respiratory function, dyspnea, and subjective discomfort in brick kiln workers with chronic bronchitis.

**Methods:** A randomized controlled trial was conducted with 150 brick kiln workers (75 intervention, 75 control) over 8 weeks. The intervention group practiced DBE (twice daily) and Flutter therapy (once daily).

Outcome measures included Peak Expiratory Flow Rate (PEFR), Modified Borg Dyspnoea Scale (MBS), and Visual Analogue Scale (VAS).

**Results:** Post-intervention, the experimental group showed highly significant improvements in PEFR ($t=28.16$, $p < 0.001$, Cohen's $d=2.30$), MBS ($t=-20.82$, $p < 0.001$), and VAS ($t=-20.21$, $p < 0.001$). Sub-group analysis indicated that females ($p=0.006$) and non-smokers ($p < 0.001$) achieved greater physiological gains. Correlation analysis revealed a disconnect between objective lung function and subjective symptom relief.

**Conclusion:** The combined intervention of DBE and Flutter therapy is an effective, non-invasive, and cost-efficient strategy for pulmonary rehabilitation in occupational chronic bronchitis.

**Keywords: Chronic Bronchitis; Brick Kiln Workers; Diaphragmatic Breathing Exercises; Oscillating Positive Expiratory Pressure; Flutter Device; Pulmonary Rehabilitation**

## INTRODUCTION

Chronic bronchitis is a major subtype of chronic obstructive pulmonary disease (COPD), characterized by chronic cough and sputum production for at least three months in two consecutive years **[1]**. It remains a significant public health issue, particularly among occupational groups exposed to long-term inhalation of dust, smoke, and industrial pollutants. Brick kiln workers represent one such vulnerable population, especially in developing countries, due to prolonged exposure to biomass fuel smoke, silica dust, particulate matter, and toxic gases released during brick manufacturing processes **[2, 3]**.

Brick kiln industries often operate with minimal occupational health safeguards. Workers are continuously exposed to high concentrations of airborne pollutants, including carbon monoxide, sulfur dioxide, nitrogen oxides, and respirable particulate matter. These pollutants induce airway inflammation, mucous hyper secretion, impaired mucociliary clearance, and progressive airflow limitation, predisposing workers to chronic bronchitis and other respiratory disorders **[4]**. Epidemiological studies have consistently reported a higher prevalence of chronic respiratory symptoms, reduced lung function, and increased absenteeism among brick kiln workers compared to the general population **[5]**.

Physiotherapy interventions play a crucial role in the non-pharmacological management of chronic bronchitis. Pulmonary rehabilitation programs aim to improve ventilation, reduce dyspnea, enhance airway clearance, and improve overall quality of life **[6]**. Among the various techniques employed, diaphragmatic breathing exercises and airway clearance devices such as the flutter device have gained increasing clinical attention.

Diaphragmatic breathing exercise focuses on promoting efficient breathing patterns by enhancing diaphragmatic excursion and reducing accessory muscle overuse. This technique improves alveolar ventilation, decreases the work of breathing, and enhances oxygenation in patients with chronic respiratory diseases **[7]**. Regular practice of diaphragmatic breathing has been shown to reduce dyspnea severity, improve lung volumes, and enhance exercise tolerance in individuals with COPD and chronic bronchitis **[8]**.

The flutter device is a handheld oscillatory positive expiratory pressure (OPEP) device that combines airway vibrations with expiratory resistance. During exhalation, the oscillations generated by the steel ball inside the device help loosen bronchial secretions, reduce mucus viscosity, and enhance expectoration **[9]**. OPEP devices have been demonstrated to improve sputum clearance, reduce airway obstruction, and improve pulmonary function parameters in patients with chronic productive cough **[10]**.

Despite the proven benefits of diaphragmatic breathing and flutter devices individually, limited studies have explored their combined effectiveness in occupational populations such as brick kiln workers. Given the high burden of chronic bronchitis in this group and the low-cost, non-invasive nature of these interventions, evaluating their effectiveness is both clinically and socially relevant.

Therefore, this study aims to evaluate the effectiveness of diaphragmatic breathing exercise combined with the flutter device in improving respiratory outcomes among brick kiln workers diagnosed with chronic bronchitis.

## MATERIALS AND METHODS:

### Study Design and Population

This randomized controlled trial was conducted over an 8-week period to investigate the effectiveness of a structured pulmonary rehabilitation program incorporating diaphragmatic breathing exercises (DBE) and oscillating positive expiratory pressure (OPEP) therapy using the Flutter device among brick kiln workers with chronic bronchitis. The study was undertaken among workers employed in brick manufacturing units located in the Thovalai and Kalkulam Taluk regions of Kanyakumari District, Tamil Nadu, India. These areas are characterized by extensive brick manufacturing activities, where workers are routinely exposed to airborne particulate matter, including mineral dust, silica-containing particles, smoke, and other combustion-related pollutants.

The target population comprised adult brick kiln workers with a clinical diagnosis of chronic bronchitis. A total of 150 participants were recruited for the study. Participants were eligible if they were between 25 and 60 years of age, had a minimum occupational exposure of 5 years in a brick kiln environment, and had a clinical diagnosis consistent with chronic bronchitis. The requirement for prolonged occupational exposure was established to ensure that the study population had experienced sustained exposure to the occupational respiratory hazards associated with brick manufacturing.

Participants were excluded if they had an acute respiratory tract infection at the time of recruitment, active pulmonary tuberculosis, severe cardiovascular disease, or any other condition that could substantially interfere with participation in pulmonary rehabilitation. Individuals who were already enrolled in a formal pulmonary rehabilitation program were also excluded to avoid potential confounding from previous structured respiratory rehabilitation.

Before recruitment, eligible workers were informed about the purpose, procedures, potential benefits, and possible risks associated with the study. Participation was entirely voluntary, and written informed consent was obtained from all participants before baseline assessment. Ethical approval was obtained from the appropriate institutional ethics committee prior to commencement of the study. Confidentiality of participant information was maintained throughout the investigation, and participants were free to withdraw from the study at any stage without penalty.

The randomized controlled design was selected to allow comparison between participants receiving the structured combined pulmonary rehabilitation intervention and those receiving conventional breathing exercises and postural advice. Baseline and post-intervention measurements were obtained using standardized outcome measures to determine changes associated with the 8-week intervention.

**Randomization and Interventions**

Following completion of the baseline assessment, the 150 eligible participants were randomly allocated into two equal groups using a computer-generated randomization sequence. Random allocation was undertaken to minimize selection bias and to provide comparable groups for evaluating the effectiveness of the intervention.

**Intervention Group (Group A; n = 75)**

Participants assigned to Group A received an 8-week structured pulmonary rehabilitation program consisting primarily of diaphragmatic breathing exercises and Flutter-based OPEP therapy. Nutritional education was also incorporated into the intervention program.

**Diaphragmatic Breathing Exercises**

Diaphragmatic breathing exercises were prescribed twice daily throughout the 8-week intervention period. Each session consisted of three sets of approximately 10–15 controlled breathing repetitions. Participants were instructed to perform the exercise in a comfortable position with emphasis on diaphragmatic rather than excessive upper-chest movement.

During inspiration, participants were instructed to inhale slowly through the nose while allowing the abdomen to expand. This was followed by controlled expiration through pursed lips. The breathing pattern was designed to promote more efficient diaphragmatic recruitment, improve ventilation distribution, reduce unnecessary accessory muscle activity, and facilitate controlled expiration.

Participants were educated regarding the importance of maintaining a slow and relaxed respiratory rhythm rather than performing rapid or forceful breathing. Particular attention was given to avoiding excessive respiratory effort and maintaining a comfortable breathing pattern. Diaphragmatic breathing has been used as a component of pulmonary rehabilitation because it may improve ventilatory efficiency, respiratory muscle coordination, and perceived control over breathing **[11-14]**.

The exercises were performed consistently throughout the intervention period, with participants encouraged to maintain the prescribed frequency at home. Where applicable, participants were monitored by the investigators or trained personnel to ensure appropriate technique and adherence to the breathing protocol.

**Flutter/OPEP Therapy**

In addition to DBE, participants received oscillating positive expiratory pressure therapy using a Flutter device. OPEP therapy was administered once daily for approximately 10–15 minutes.

Participants were instructed to sit comfortably, place the mouthpiece securely between the lips, inhale slowly, and then perform an active but controlled expiration through the Flutter device. The expiratory maneuver was performed against the resistance generated by the device. The resulting positive expiratory pressure was intended to help maintain airway patency, while the oscillatory vibrations generated during expiration were expected to facilitate loosening and mobilization of retained bronchial secretions **[15, 16, 17]**.

Participants were taught to maintain the device at the appropriate angle because the position of the Flutter device influences the oscillatory characteristics and resistance encountered during expiration. They were instructed to generate a sufficiently active expiratory flow without excessive coughing or fatigue. When secretions were mobilized, participants were encouraged to use controlled coughing or huffing techniques to facilitate clearance of mucus from the central airways.

The combined use of DBE and OPEP was intended to address two complementary components of respiratory dysfunction. DBE was directed primarily toward improving breathing mechanics and respiratory efficiency, whereas OPEP therapy was intended to facilitate airway clearance and reduce the effects of retained respiratory secretions.

**Nutritional Education**

Participants in the intervention group additionally received nutritional education during the study period. The educational component focused on the importance of adequate nutritional intake, balanced meals, sufficient protein, hydration, and maintenance of an appropriate body weight. Nutritional counseling was included because occupational respiratory disease may coexist with inadequate nutritional status, and nutritional support combined with respiratory rehabilitation may contribute to improved functional respiratory outcomes.

Previous research involving workers exposed to silica and other occupational respiratory hazards has suggested that combined nutritional and breathing interventions may positively influence pulmonary parameters and overall respiratory function **[18, 19]**. Therefore, nutritional education was incorporated as a supportive component of the pulmonary rehabilitation program.

**Control Group (Group B; n = 75)**

Participants assigned to Group B received conventional breathing exercises and general postural advice during the 8-week study period. The conventional program consisted of relaxed thoracic expansion exercises and general instructions regarding appropriate posture during rest and daily activities.

Participants were instructed to perform controlled breathing without the structured diaphragmatic breathing protocol used in Group A. They did not receive Flutter-based OPEP therapy or any specialized airway-clearance device. This distinction allowed the study to evaluate whether the addition of structured DBE and OPEP therapy provided benefits beyond conventional breathing and postural advice.

The control intervention was designed to provide an active comparison rather than completely withholding respiratory care. This approach helped maintain participant engagement while allowing differences in respiratory outcomes between the two rehabilitation strategies to be evaluated.

**Outcome Measures**

Outcome assessments were conducted at two predefined time points: **baseline (Pre-test)** and immediately following completion of the **8-week intervention (Post-test)**. The same assessment procedures were used at both time points to minimize measurement variability.

Three primary outcome measures were selected to evaluate objective pulmonary function, subjective dyspnoea, and perceived respiratory discomfort.

**Peak Expiratory Flow Rate**

Peak expiratory flow rate (PEFR) was used as an objective indicator of expiratory airflow and large-airway function. PEFR represents the maximum expiratory flow achieved during a forceful expiration following maximal inspiration. It provides an accessible and practical measure of airway obstruction and expiratory performance, particularly in field-based occupational respiratory studies.

PEFR was measured using a standard peak flow meter. Participants were instructed regarding the correct procedure before testing. They were asked to inhale maximally and then exhale as forcefully and rapidly as possible through the mouthpiece. Measurements were repeated as appropriate, and the best technically acceptable value was recorded.

PEFR was selected because occupational exposure to dust and particulate matter may result in airway narrowing, increased airway resistance, and impaired expiratory flow. Improvement in PEFR following pulmonary rehabilitation would therefore suggest improved expiratory airway function and/or respiratory muscle performance **[20]**.

**Modified Borg Dyspnoea Scale**

Subjective breathlessness was assessed using the Modified Borg Dyspnoea Scale (MBS). The Borg scale is a commonly used clinical measure for quantifying the individual's perceived intensity of dyspnoea. Participants were asked to rate their respiratory difficulty according to the standardized scale, with lower scores indicating less perceived breathlessness.

The MBS was selected because subjective respiratory symptoms may not always correspond directly with objective lung-function measurements. A participant may demonstrate relatively modest changes in pulmonary function while experiencing a clinically meaningful improvement in breathlessness. Therefore, assessment of perceived dyspnoea complemented the objective PEFR measurement.

The scale has been widely used in respiratory rehabilitation and has demonstrated clinical utility for evaluating changes in perceived respiratory effort and dyspnoea **[21, 22, 23]**.

**Visual Analogue Scale**

A 10-cm Visual Analogue Scale (VAS) was used to quantify participants' perceived respiratory discomfort. Participants were instructed to indicate the point on the scale corresponding to their overall level of respiratory discomfort, with one end representing minimal or no discomfort and the opposite end representing the greatest perceived discomfort.

The VAS provided an additional subjective measure of the participant's respiratory experience and complemented the MBS. Whereas the MBS primarily focused on perceived breathlessness, the VAS allowed participants to express their broader perception of respiratory discomfort and well-being.

The combination of objective and subjective outcome measures enabled the study to evaluate whether pulmonary rehabilitation produced measurable physiological improvements as well as improvements in symptoms experienced during daily life.

**RESULTS:**

**General Treatment Efficacy**

A total of 150 participants were included in the randomized controlled trial, with 75 participants allocated to the intervention group and 75 participants allocated to the control group. The intervention group participated in the structured 8-week pulmonary rehabilitation program comprising diaphragmatic breathing exercises, Flutter-based OPEP therapy, and nutritional education, whereas the control group received conventional breathing exercises and postural advice.

Following completion of the 8-week intervention, the combined pulmonary rehabilitation group demonstrated substantial improvements in all three primary outcome measures. The magnitude and statistical significance of the changes suggest that the structured intervention was associated with clinically meaningful improvements in objective expiratory airflow, perceived dyspnoea, and respiratory discomfort.

The reported effect sizes were also large, indicating that the observed improvements were not merely statistically significant but represented substantial changes relative to baseline variability.

**Peak Expiratory Flow Rate**

PEFR demonstrated a marked improvement following the 8-week intervention in Group A. The within-group analysis showed a highly statistically significant increase in PEFR, with a **t-statistic of 28.16 and p < 0.001**.

The magnitude of the improvement was further supported by a **Cohen's d effect size of 2.30**, which represents a very large effect. Such an effect suggests that the intervention was associated with a substantial improvement in expiratory flow performance.

The observed improvement in PEFR may be explained by the complementary physiological effects of the intervention. Diaphragmatic breathing may improve breathing coordination and respiratory muscle recruitment, while controlled expiration through the Flutter device provides positive expiratory pressure and oscillatory airflow. These mechanisms may contribute to improved airway patency and more effective mobilization of bronchial secretions.

**Table 1: Paired Pre- vs. Post-Intervention Analysis**

| Measure | t-statistic | p-value | Cohen's d | Interpretation |
|---|---|---|---|---|
| PEFR | 28.16 | < 0.001 | 2.30 | Very large increase in lung function |
| MBS | –20.82 | < 0.001 | –1.70 | Large reduction in breathlessness |
| VAS | –20.21 | < 0.001 | –1.65 | Large reduction in discomfort |

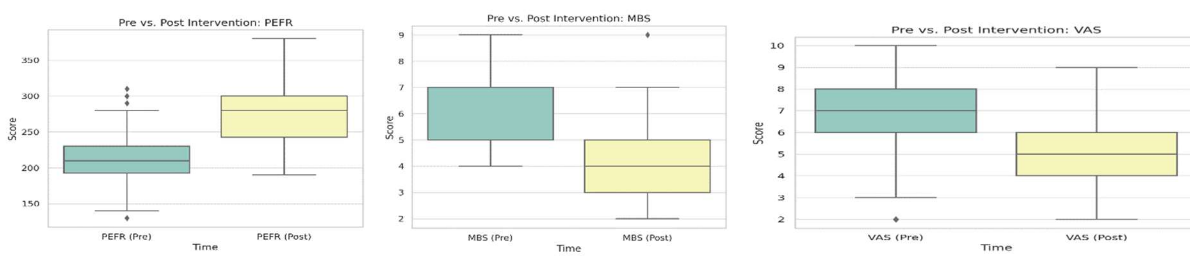


**Figure 1: Pre- and Post-Intervention Comparison of PEFR in the Intervention and Control Groups**

**Modified Borg Dyspnea Scale**

The intervention also produced a substantial reduction in perceived breathlessness. Following the 8-week program, the Modified Borg Dyspnea Scale score decreased significantly in the intervention group.

The statistical analysis demonstrated a **t-statistic of −20.82 with p < 0.001**, indicating a highly significant reduction in perceived dyspnea. The corresponding **Cohen's d effect size was −1.70**, representing a very large treatment effect.

The negative direction of the effect reflects the reduction in dyspnea scores following treatment. From a clinical perspective, the finding suggests that participants experienced less breathlessness after completing the rehabilitation program.

**Visual Analogue Scale**

Respiratory discomfort measured using the VAS also improved substantially following the intervention. Participants in the intervention group demonstrated a significant reduction in VAS scores after completion of the 8-week pulmonary rehabilitation program. The statistical analysis produced a **t-statistic of −20.21 with p < 0.001**, demonstrating a highly significant reduction in respiratory discomfort. The corresponding **Cohen's d effect size of −1.65** indicates a very large effect.

**Table 2: Correlation between Objective and Subjective**

| Comparison | Pearson r | p-value | Interpretation |
|---|---|---|---|
| ΔPEFR vs. ΔMBS | 0.027 | 0.75 | No significant correlation |
| ΔPEFR vs. ΔVAS | 0.126 | 0.12 | Weak, non-significant correlation |

**Figure 2: Participants Performing Breathing Exercise during the Intervention**

**Influence of Demographic and Lifestyle Factors**

In addition to evaluating the overall effectiveness of the intervention, subgroup analyses were performed to determine whether demographic and lifestyle characteristics influenced the magnitude of treatment response.

The subgroup analysis focused particularly on **gender** and **smoking status**, as both factors may influence respiratory physiology, occupational exposure patterns, airway responsiveness, and recovery following pulmonary rehabilitation.

**Gender Differences**

Gender-based analysis revealed a significant difference in the magnitude of PEFR improvement between male and female participants in the intervention group.

Female participants demonstrated a significantly greater median improvement in PEFR compared with male participants. The statistical analysis yielded a **t-statistic of −2.78 with p = 0.006**, indicating that the difference between the groups was statistically significant.

Although both male and female participants demonstrated improvement following the pulmonary rehabilitation program, the greater PEFR response observed among women suggests that sex-related physiological or occupational factors may influence the magnitude of objective respiratory recovery.

**Table 3: Gender-Based Group Comparison**

| Δ Metric | t-statistic | p-value | Interpretation |
|---|---|---|---|
| ΔPEFR | –2.78 | 0.006 | ***Female workers improved significantly more in PEFR than males*** |
| ΔMBS | 1.15 | 0.25 | **No significant gender difference in breathlessness reduction** |
| ΔVAS | –0.56 | 0.58 | **No significant gender difference in discomfort reduction** |

**Smoking Status**

Smoking status was another important factor associated with the magnitude of physiological response to pulmonary rehabilitation.

Non-smoking participants in the intervention group demonstrated substantially greater improvement in PEFR compared with participants who were smokers. The statistical analysis showed a **t-statistic of −4.99 with p < 0.001**, indicating a highly significant difference between smokers and non-smokers. Interestingly, the effect of smoking status was not similarly observed for perceived breathlessness. The reduction in Modified Borg Dyspnoea Scale scores did not differ significantly between smokers and non-smokers, with **p > 0.5**. This suggests that both groups experienced comparable subjective relief from dyspnoea despite the greater objective improvement in PEFR among non-smokers.

**DISCUSSION:**

The present study showed that an 8-week pulmonary rehabilitation program combining diaphragmatic breathing exercises (DBE) and Flutter therapy was effective in improving respiratory function and reducing respiratory symptoms among brick kiln workers with chronic bronchitis. The intervention group demonstrated a significant improvement in Peak Expiratory Flow Rate (PEFR), along with significant reductions in Modified Borg Dyspnea Scale (MBS) and Visual Analogue

Scale (VAS) scores. The large effect size observed for PEFR (Cohen's d = 2.30) indicates a substantial improvement in expiratory airflow following the intervention. Brick kiln workers are regularly exposed to dust, smoke, and other airborne particles during their occupational activities. Continuous exposure to these respiratory irritants can cause airway inflammation, increased mucus production, cough, breathlessness, and gradual reduction in lung function **[25, 26]**. Long-term exposure to respirable dust and silica-containing particles may further increase the risk of chronic respiratory problems among workers **[27, 28]**. Therefore, pulmonary rehabilitation may be an important supportive approach for improving respiratory function in this occupational population.

The improvement in PEFR observed in the intervention group may be related to the combined effects of diaphragmatic breathing and Flutter therapy. Diaphragmatic breathing encourages the effective use of the diaphragm and promotes a slower and more controlled breathing pattern. It may improve breathing efficiency and reduce unnecessary use of the accessory respiratory muscles **[29, 30]**. Regular diaphragmatic breathing may also improve respiratory muscle coordination and help participants develop better control over inspiration and expiration **[31]**. Pursed-lip expiration, which was included in the breathing technique, may provide greater control during expiration and help reduce premature airway closure **[32, 33]**. These effects may explain, at least in part, the improvement in PEFR and reduction in breathlessness observed in the present study.

Flutter therapy provides oscillating positive expiratory pressure during expiration. The oscillations produced by the device can help loosen and mobilize thick respiratory secretions and facilitate their movement toward the central airways **[34, 35]**. The positive expiratory pressure generated during treatment may also help maintain airway patency during expiration and improve airflow through the airways **[36]**. Improved mucus mobilization may make coughing and expectoration more effective and reduce the amount of retained secretion. This may contribute to improved airway clearance and better expiratory airflow. Previous studies have reported beneficial effects of oscillating positive expiratory pressure therapy on mucus clearance and respiratory symptoms in individuals with chronic respiratory disorders **[37, 38]**. Therefore, the combination of DBE and Flutter therapy may provide complementary benefits by improving breathing mechanics while simultaneously supporting airway clearance.

The significant improvement in PEFR is an important finding because PEFR provides a simple measure of expiratory airflow and can be useful for monitoring changes in airway function **[39]**. The very large effect size of 2.30 observed in this study suggests that the improvement was not only statistically significant but also clinically important. Breathing exercises may improve respiratory muscle coordination and expiratory control, while Flutter therapy may improve airflow by reducing the effect of retained secretions. Similar improvements in pulmonary function have been reported in studies involving individuals with chronic respiratory disease who participated in structured breathing exercise programs **[40, 41]**. Studies among occupational groups exposed to dust have also shown that long-term exposure can adversely affect pulmonary function **[42, 43]**. The improvement observed in the present study suggests that pulmonary rehabilitation may provide a useful method for improving respiratory function in workers with chronic occupational exposure.

A significant reduction in Modified Borg Dyspnea Scale scores was also observed in the intervention group. The effect size of −1.70 indicates a large reduction in perceived breathlessness. Diaphragmatic breathing may help participants develop a slower and more controlled respiratory pattern and may reduce unnecessary respiratory effort **[29, 31]**. Flutter therapy may further reduce breathing difficulty by improving clearance of retained respiratory secretions **[34, 35]**. Reduced dyspnea is an important clinical benefit because chronic breathlessness can interfere with work, physical activity, and activities of daily living. Pulmonary rehabilitation has previously been shown to improve respiratory symptoms and functional ability in individuals with chronic respiratory conditions **[44, 45]**. The findings of the present study therefore suggest that the combined intervention may have provided meaningful symptomatic relief in addition to improving objective respiratory function.

The significant reduction in VAS scores provides further evidence of improvement in respiratory comfort following the intervention. The large effect size of −1.65 indicates a substantial reduction in perceived respiratory discomfort. The improvement in VAS may be related to better breathing control, improved airway clearance, and reduced breathlessness. Previous studies have reported improvements in respiratory symptoms and quality of life following pulmonary rehabilitation and breathing exercises **[46, 47]**. Improvement in respiratory comfort may also encourage workers to participate more actively in daily activities and may reduce the limitation caused by chronic respiratory symptoms.

Smoking status was found to influence the improvement in PEFR. Non-smokers in the intervention group showed significantly greater improvement in PEFR compared with smokers, with a $t$ value of −4.99 and $p < 0.001$. Smoking is associated with persistent airway irritation, inflammation, increased mucus production, and progressive impairment of lung function **[48]**. Continued tobacco exposure may therefore reduce the physiological response to pulmonary rehabilitation. The greater improvement observed among non-smokers suggests that avoidance of tobacco exposure may enhance the benefits of respiratory rehabilitation. However, the reduction in MBS scores did not differ significantly between smokers and non-smokers. This finding suggests that both groups may experience symptomatic improvement even when the objective improvement in expiratory airflow differs. Therefore, smoking cessation should be encouraged as an important component of respiratory rehabilitation programs for occupational workers.

The study also showed a significant difference in PEFR improvement according to gender. Female participants demonstrated greater improvement in PEFR than male participants, with a $t$ value of −2.78 and $p = 0.006$. This difference may be related to variations in baseline lung function, respiratory muscle performance, occupational activities, exposure levels, or adherence to the rehabilitation program. However, the exact reason for the greater improvement among female participants cannot be established from the present study. Importantly, no significant gender difference was observed in the improvement of MBS and VAS scores. This indicates that both male and female participants experienced similar improvements in perceived breathlessness and respiratory discomfort despite the difference in objective PEFR response.

The findings of the present study are generally consistent with previous studies reporting beneficial effects of breathing exercises in individuals with chronic respiratory disorders **[40, 41, 44]**. Studies among farmers, stone-cutting workers, and other occupational groups exposed to dust have demonstrated that prolonged exposure to airborne particles can negatively affect pulmonary function and respiratory health **[42, 43]**. Such findings emphasize the importance of early identification of respiratory impairment and implementation of appropriate rehabilitation strategies in occupational populations. The present study further suggests that the addition of Flutter therapy may provide an additional benefit in workers who have increased mucus production or difficulty clearing respiratory secretions **[34-36]**.

The occupational relevance of these findings is considerable because brick kiln workers may experience repeated exposure to dust and smoke during different stages of brick production. Long-term exposure can contribute to chronic respiratory symptoms and deterioration in lung function **[25, 26, 42]**. Pulmonary rehabilitation may provide a simple supportive intervention for workers who have already developed respiratory problems. Diaphragmatic breathing exercises require minimal equipment and can be performed at home or in the workplace after appropriate instruction. Flutter therapy is also relatively simple and can be incorporated into an individualized airway-clearance program. However, pulmonary rehabilitation should not be considered a replacement for occupational safety measures. Reduction of workplace dust, adequate ventilation, appropriate respiratory protective equipment, and regular health screening remain important for preventing further respiratory damage **[27, 43, 49]**.

The results of this study have important clinical implications. An 8-week program combining DBE and Flutter therapy may be a useful non-pharmacological intervention for brick kiln workers with chronic bronchitis. The improvement in PEFR indicates better expiratory airflow, while the reductions in MBS and VAS indicate decreased breathlessness and respiratory discomfort. The combination of breathing retraining and airway-clearance therapy may therefore address both respiratory muscle efficiency and secretion retention. The program is relatively simple and may be suitable for implementation through occupational health services or community-based pulmonary rehabilitation programs. Workers may also benefit from education regarding correct breathing techniques, airway clearance, smoking cessation, and reduction of occupational exposure.

Overall, the findings demonstrate that combined diaphragmatic breathing exercises and Flutter therapy can significantly improve respiratory outcomes among brick kiln workers with chronic bronchitis. The improvement in PEFR suggests better expiratory airflow, while the reduction in MBS and VAS scores indicates improvement in subjective respiratory symptoms. The findings suggest that DBE may improve breathing efficiency and respiratory control, whereas Flutter therapy may assist in mobilizing airway secretions and maintaining airway patency **[25-49]**. The greater PEFR improvement among non-smokers further emphasizes the importance of smoking cessation, while the gender-related findings suggest that individual characteristics may influence physiological response to rehabilitation. Although the results are encouraging, longer-term studies with larger samples and additional pulmonary-function measurements such as FEV1, FVC, and FEV1/FVC are recommended to confirm the sustained effectiveness of this intervention. In conclusion, an 8-week DBE and Flutter-based pulmonary rehabilitation program appears to be a simple, practical, and effective non-pharmacological approach for improving respiratory function and reducing respiratory symptoms among brick kiln workers with chronic bronchitis **[49]**.

**Table 4: Comparison of the Present Study with Recent Studies [25-49]**

| Study | Population / Sample | Intervention | Duration | Main Outcomes | Major Findings | Comparison with Present Study |
|---|---|---|---|---|---|---|
| **Ceyhan & Tekinsoy Kartin (2022)** | **67 patients with COPD** | **Pursed-lip breathing + inhaler training vs inhaler training alone** | **4 weeks** | **Dyspnea, CAT, SGRQ** | **Breathing exercise intervention improved respiratory symptoms and quality-of-life-related outcomes** | **Supports the present finding that breathing exercises can reduce perceived dyspnea.** |
| **Yu *et al*. (2022/2023)** | **110 patients with COPD** | **Diaphragmatic breathing training with/without discharge care bundle** | **Follow-up up to 3 months** | **CAT, SGRQ, psychological outcomes, readmission** | **Diaphragmatic breathing combined with supportive care improved patient outcomes** | **Similar to the present study in demonstrating the usefulness of DBE as part of respiratory rehabilitation.** |
| **Breathing control RCT (2023)** | **Patients with severe COPD** | **Group breathing-control exercises added to standard rehabilitation** | **6 weeks** | **SGRQ, COPD assessment, Modified Borg scale, physical function** | **Additional breathing-control training was evaluated as an adjunct to standard rehabilitation** | **Supports adding structured breathing exercises to conventional rehabilitation, similar to the DBE component of the present study.** |
| **Tai Chi pulmonary rehabilitation RCT (2023)** | **120 patients with stable COPD** | **Conventional exercise, Tai Chi, or combined rehabilitation** | **2-month supervised + 10-month follow-up** | **Quality of life, exercise capacity, pulmonary function, symptoms** | **Combined rehabilitation produced greater improvements in quality of life, exercise capacity, pulmonary function, and symptoms** | **Supports the concept that combining different rehabilitation components may provide greater benefits than a single intervention.** |
| **Dodange *et al*. (2024)** | **60 elderly patients with COPD** | **Diaphragmatic breathing and pursed-lip breathing** | **4 weeks each** | **Sleep quality and COPD-related outcomes** | **Both breathing techniques improved sleep-related outcomes;** | **Supports the use of controlled diaphragmatic and pursed-lip breathing** |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | **DB followed by PLB showed greater improvement in the study sequence** | **used in the present intervention.** |
| **Li *et al*. (2024)** | **65 patients with COPD** | **Active cycle of breathing techniques + supportive education vs routine care** | **Follow-up at 2, 4 and 8 weeks** | **Sputum clearance, exercise adherence, self-efficacy** | **Intervention improved cough and sputum evacuation ability and exercise adherence** | **Particularly relevant to the present Flutter component because both approaches emphasize airway secretion clearance.** |
| **Shiraishi *et al*. (2024)** | **33 patients with COPD completing the trial** | **Inspiratory muscle training after pulmonary rehabilitation** | **12-week PR + 12-week IMT** | **Diaphragm excursion and exercise tolerance** | **Additional respiratory muscle training was investigated for improving diaphragm function and exercise capacity** | **Supports the physiological rationale for targeting respiratory muscles in addition to conventional rehabilitation.** |
| **Zare *et al*. (2025)** | **32 patients with COPD** | **Routine breathing exercises vs breathing + stretching exercises** | **Short-term intervention** | **Respiratory indices, disease severity, exercise capacity** | **Combined breathing and stretching exercises produced additional rehabilitation benefits** | **Supports the present study's principle that combining rehabilitation techniques can improve respiratory outcomes.** |
| **Avci *et al*. (2025)** | **30 patients with COPD** | **Posture and breathing exercises through telerehabilitation** | **8 weeks** | **Respiratory function, exercise capacity, fatigue, psychosocial outcomes** | **An 8-week structured breathing/posture program was evaluated for multiple respiratory and functional outcomes** | **Similar 8-week duration and supports the feasibility of structured breathing rehabilitation.** |

## CONCLUSION:

This study demonstrates that the combined use of diaphragmatic breathing exercises (DBE) and Flutter device therapy significantly improves respiratory outcomes among brick kiln workers. Considering the high burden of respiratory morbidity in this occupational setting, these non-pharmacological interventions offer a practical, effective, and cost-efficient approach to pulmonary rehabilitation and respiratory health management.

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**Conflict of interest**

Authors do not have any conflict of interest during the elaboration of this paper.

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