The Research of Medical Science Review
ISSN: 3007-1208 & 3007-1216 Volume 3, Issue 2, 2025

DIAPHRAGMATIC BREATHING VS. INCENTIVE SPIROMETRY IN PULMONARY REHABILITATION: A CROSS-SECTIONAL STUDY.

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DOI: https://doi.org/10.5281/zenodo.14862811

Keywords
Diaphragmatic, Dyspneal, Pulmonary Rehabilitation, Chronic Respiratory, Incentive Spirometry, Diaphragmatic Breathing.

Article History
Received on 05 January 2025
Accepted on 05 February 2025
Published on 13 February 2025

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Abstract

Background: *Pulmonary rehabilitation plays a vital role in managing chronic respiratory conditions and post-operative recovery. Breathing exercises such as diaphragmatic breathing (DB) and incentive spirometry (IS) are widely used to improve lung function and reduce symptoms. However, comparative evidence on their effectiveness remains limited.*

Objectives: *This study aimed to compare the effectiveness of diaphragmatic breathing and incentive spirometry in improving lung function, reducing dyspnea, and enhancing patient adherence and satisfaction.*

Methods: *A cross-sectional study was conducted at a pulmonary rehabilitation center, including 200 participants (100 in the DB group and 100 in the IS group). Lung function parameters (FEV1, FVC, tidal volume), dyspnea severity (mMRC scale), adherence rates, and patient satisfaction were assessed pre- and post-intervention. Data were analyzed using descriptive statistics, paired and independent t-tests, and chi-square tests.*

Results: *Both interventions significantly improved lung function and reduced dyspnea. The DB group showed greater improvements in FEV1 (0.40 L vs. 0.26 L) and FVC (0.45 L vs. 0.28 L) compared to the IS group ($p < 0.05$). Dyspnea scores decreased in both groups, with a slightly* *greater reduction in the DB group. Adherence (92% vs. 85%) and patient satisfaction (4.5 vs. 4.2, p = 0.02) were significantly higher in the DB group.*

***Conclusion**: Diaphragmatic breathing is a cost-effective, non-device-based intervention that offers comparable or superior outcomes to incentive spirometry, particularly for chronic conditions like COPD and asthma. Its simplicity and high adherence make it a valuable addition to pulmonary rehabilitation programs.*

INTRODUCTION

Pulmonary rehabilitation is a cornerstone of managing chronic respiratory conditions and improving lung function after surgery or acute illness. Two widely used techniques, diaphragmatic breathing (DB) and incentive spirometry (IS), are designed to enhance respiratory efficiency and prevent complications such as atelectasis, pneumonia, and respiratory muscle weakness (Al Chikhanie et al., 2021). Diaphragmatic breathing emphasizes deep breathing to strengthen the diaphragm and improve oxygen exchange, while incentive spirometry provides visual feedback to encourage patients to achieve maximal lung inflation(Dixit et al., 2021). Both techniques are commonly employed in clinical practice, but their comparative efficacy remains underexplored, especially in the context of routine pulmonary rehabilitation programs.

In recent years, increasing attention has been given to personalized and evidence-based rehabilitation approaches. However, limited data exist on the differential impact of DB and IS on lung function parameters, such as forced expiratory volume (FEV1), forced vital capacity (FVC), and tidal volume, particularly across various patient populations (Michaelchuk et al., 2022). This study aims to address this gap by evaluating the effectiveness of diaphragmatic breathing versus incentive spirometry in improving respiratory outcomes, providing valuable insights for clinicians to optimize rehabilitation protocols (Polgar et al., 2022).

Respiratory illnesses, such as chronic obstructive pulmonary disease (COPD), asthma, and post-surgical respiratory complications, impose significant morbidity and mortality worldwide. Pulmonary rehabilitation plays a vital role in alleviating symptoms, improving lung function, and enhancing the quality of life in patients with respiratory disorders (Holland et al., 2022). Diaphragmatic breathing and incentive spirometry are two primary interventions used in rehabilitation programs to promote effective breathing patterns, increase lung capacity, and prevent respiratory complications (Ahmed et al., 2022).

Diaphragmatic breathing is a controlled breathing technique designed to engage the diaphragm during inspiration, reducing accessory muscle usage and increasing lung ventilation (Chen et al., 2022). It has been shown to improve diaphragmatic motion, reduce dyspnea, and enhance oxygen exchange. On the other hand, incentive spirometry involves the use of a handheld device to encourage patients to take slow, deep breaths, facilitating lung expansion and preventing alveolar collapse. It is particularly beneficial in post-operative settings to prevent atelectasis and enhance pulmonary function (Zhang et al., 2022). Despite the widespread use of these techniques, little is known about their relative effectiveness in improving specific lung function parameters or patient-reported outcomes. Furthermore, patient adherence and preferences may influence the success of these interventions, making it essential to investigate their practical implications in real-world settings (Hayden et al., 2021).

While both diaphragmatic breathing and incentive spirometry are integral to pulmonary rehabilitation, there is a lack of comparative studies evaluating their efficacy. Clinicians often choose between these techniques based on anecdotal evidence or individual patient characteristics without robust data to guide their decisions (Uzzaman et al., 2022). The problem is further compounded by variability in patient adherence, differences in underlying conditions, and inconsistent implementation of these techniques across rehabilitation programs. This lack of clarity creates challenges in optimizing treatment protocols and delivering personalized care. A direct comparison of diaphragmatic breathing and incentive spirometry could provide critical insights into their respective benefits, enabling evidence-based recommendations for clinicians and therapists.

Objectives

The primary objective of this study is to compare the effectiveness of diaphragmatic breathing and incentive spirometry in improving lung function and patient outcomes during pulmonary rehabilitation. The specific objectives are:

1. To evaluate changes in lung function parameters (FEV1, FVC, and tidal volume) among patients using diaphragmatic breathing and incentive spirometry.
2. To assess the impact of these interventions on patient-reported outcomes, including dyspnea and quality of life.
3. To examine adherence rates and patient satisfaction with diaphragmatic breathing and incentive spirometry.
4. To identify demographic or clinical factors that may influence the relative efficacy of the two techniques.

Significance of the Study

This study has significant implications for clinical practice and patient care in pulmonary rehabilitation. By directly comparing diaphragmatic breathing and incentive spirometry, it seeks to provide evidence-based recommendations on their relative efficacy, enabling healthcare providers to make informed decisions tailored to individual patient needs.

Moreover, understanding the factors influencing adherence and patient satisfaction with these techniques could help improve the design and implementation of rehabilitation programs, enhancing long-term outcomes for patients with respiratory disorders. This research also addresses a critical gap in the literature, paving the way for future studies and innovations in pulmonary rehabilitation.

Ultimately, the findings could contribute to reducing the burden of respiratory complications, improving quality of life, and promoting cost-effective healthcare delivery.

Literature Review

Pulmonary rehabilitation is an essential component of managing chronic respiratory diseases, improving lung function, and enhancing the quality of life for patients with compromised respiratory health. Among the many techniques employed in pulmonary rehabilitation, diaphragmatic breathing (DB) and incentive spirometry (IS) are two of the most widely used interventions. Both techniques aim to improve ventilation, reduce complications such as atelectasis, and promote efficient respiratory mechanics (Tonga & Oliver, 2023). However, there is limited comparative evidence to guide clinicians in determining which technique is more effective under specific clinical circumstances. This literature review synthesizes existing research on diaphragmatic breathing and incentive spirometry, focusing on their mechanisms, efficacy, and application in pulmonary rehabilitation (Soril et al., 2022).

Diaphragmatic breathing is a controlled breathing technique that involves engaging the diaphragm during inspiration to optimize lung expansion and reduce reliance on accessory respiratory muscles. This technique is widely used to improve ventilation efficiency, alleviate dyspnea, and enhance oxygen exchange in patients with respiratory disorders (Al Chikhanie et al., 2021).

The core principle of diaphragmatic breathing lies in the activation of the diaphragm, which increases lung volume and promotes deep, effective breaths. By shifting breathing patterns from thoracic (chest-based) to diaphragmatic (abdomen-based), the technique reduces the work of breathing and prevents respiratory muscle fatigue(Spielmanns et al., 2021). Furthermore, diaphragmatic breathing improves ventilation-perfusion matching, facilitating better oxygenation and carbon dioxide removal (Hartman et al., 2023).

Studies have demonstrated the benefits of diaphragmatic breathing in various populations, including patients with chronic obstructive pulmonary disease (COPD), asthma, and post-operative conditions. For example, a study by Melendez-Oliva et al. (2023) found that diaphragmatic breathing significantly improved tidal volume and reduced dyspnea in COPD patients. Similarly, researchers have highlighted the role of diaphragmatic breathing in reducing anxiety and promoting relaxation, which are critical factors in managing chronic respiratory diseases (Rutkowski et al., 2021).

However, the efficacy of diaphragmatic breathing is influenced by patient adherence, proper technique, and individual respiratory mechanics. Despite its benefits, some studies report limited improvements in lung function parameters such as FEV1 and FVC, suggesting that its impact may vary based on the severity of the underlying condition and patient-specific factors (Sami et al., 2021).

Incentive spirometry is a device-based breathing technique that encourages patients to take deep, sustained breaths. The device provides visual feedback, motivating patients to achieve maximal lung inflation and preventing complications such as atelectasis, particularly after surgery. The primary mechanism of incentive spirometry involves creating a sustained trans-pulmonary pressure gradient, which facilitates alveolar recruitment and prevents alveolar collapse. By promoting slow and deep inspiration, incentive spirometry helps improve lung compliance, enhance ventilation, and reduce the risk of post-operative pulmonary complications (Yohannes et al., 2021).

Numerous studies have investigated the efficacy of incentive spirometry in various clinical settings, with mixed results. For instance, a systematic review by Li et al. (2022) found that incentive spirometry was effective in preventing pulmonary complications in patients undergoing abdominal or thoracic surgery. Another study by Rochester et al. (2023) reported significant improvements in FEV1 and FVC in patients using incentive spirometry during pulmonary rehabilitation.

Despite these positive findings, some studies question the standalone efficacy of incentive spirometry. For example, research by Nolan et al. (2022) suggested that incentive spirometry may be no more effective than standard deep-breathing exercises in improving lung function post-surgery. This highlights the need for further research to clarify its role in different clinical contexts.

While diaphragmatic breathing and incentive spirometry share the common goal of improving respiratory function, their mechanisms and applications differ. Diaphragmatic breathing emphasizes intrinsic control of respiratory patterns, focusing on strengthening the diaphragm and reducing reliance on accessory muscles. In contrast, incentive spirometry provides extrinsic motivation through visual feedback, encouraging sustained maximal inspiration (Zampogna et al., 2021).

Several studies have attempted to compare the efficacy of diaphragmatic breathing and incentive spirometry in pulmonary rehabilitation, albeit with limited scope. A randomized controlled trial by Reinert et al. (2022) compared these two techniques in post-operative patients and found no significant difference in lung function improvement, suggesting that both techniques may be equally effective when appropriately implemented.

However, patient-specific factors such as adherence, ease of use, and underlying conditions may influence the choice between the two techniques. For example, diaphragmatic breathing may be more suitable for patients with chronic respiratory diseases such as COPD, where strengthening the diaphragm is critical. In contrast, incentive spirometry may be more effective in post-operative settings, where visual feedback helps ensure patient compliance (Hodgkin et al., 2023).

Patient adherence is a critical factor in the success of both techniques. Studies suggest that the simplicity and non-invasiveness of diaphragmatic breathing may make it more appealing to some patients, particularly those who struggle with device-based interventions. Conversely, the visual feedback provided by incentive spirometry may enhance motivation and engagement, particularly in post-surgical patients (Dixit et al., 2021).

Despite extensive research on diaphragmatic breathing and incentive spirometry, there are several gaps in the literature:

1. **Lack of Direct Comparisons:** Few studies have directly compared the efficacy of these two techniques in improving specific lung function parameters, such as FEV1, FVC, and tidal volume.
2. **Diverse Patient Populations:** Most studies focus on specific populations, such as COPD or post-operative patients, without exploring their effectiveness across a broader range of respiratory conditions.
3. **Long-Term Outcomes:** Limited research has assessed the long-term impact of these

techniques on respiratory health and quality of life.

4. **Adherence and Feasibility:** Few studies have explored factors influencing patient adherence and satisfaction, which are critical for the success of pulmonary rehabilitation programs.

Diaphragmatic breathing and incentive spirometry are two widely used techniques in pulmonary rehabilitation, each with distinct mechanisms and benefits. While diaphragmatic breathing emphasizes intrinsic control and diaphragmatic strength, incentive spirometry relies on visual feedback to promote sustained maximal inspiration. Both techniques have demonstrated efficacy in improving respiratory function and reducing complications, though their comparative effectiveness remains unclear (Fekete et al., 2021).

This review highlights the need for further research to address gaps in the literature, particularly in comparing the long-term outcomes, adherence rates, and patient satisfaction associated with these techniques. By providing a comprehensive understanding of their relative efficacy, future studies can guide clinicians in selecting the most appropriate intervention for individual patients, ultimately enhancing the effectiveness of pulmonary rehabilitation programs (Hartman et al., 2023).

Methodology

Study Setting

The study was conducted in a pulmonary rehabilitation center affiliated with a tertiary care hospital. Patients attending the rehabilitation program for chronic respiratory diseases or post-operative recovery were recruited. The center provided access to equipment, trained staff, and a controlled environment to standardize the interventions and measurements.

Study Design

This research employed a cross-sectional comparative study design to evaluate the effectiveness of diaphragmatic breathing and incentive spirometry in improving lung function and patient-reported outcomes. Participants were divided into two groups based on the technique used during their rehabilitation program: Group A (diaphragmatic breathing) and Group B (incentive spirometry).

Sampling Technique

A convenience sampling technique was used to recruit participants. Eligible patients attending the rehabilitation center during the study period were invited to participate. Inclusion criteria ensured that participants had stable respiratory conditions, were capable of performing the required techniques, and provided informed consent. Patients with severe cognitive impairment, uncontrolled co-morbidities, or contraindications to physical therapy were excluded.

Population and Sample Size

The study population comprised patients aged 18 years and older with a history of chronic respiratory diseases (e.g., COPD, asthma) or those undergoing rehabilitation after thoracic or abdominal surgery. A sample size of 200 participants was calculated using power analysis, with 100 participants in each group to ensure adequate statistical power for detecting differences between interventions.

Measurement Tools

1. **Spirometry:** A portable spirometer was used to measure lung function parameters, including forced expiratory volume in one second (FEV1), forced vital capacity (FVC), and tidal volume. Baseline measurements were taken before starting the interventions, and follow-up measurements were recorded after four weeks of rehabilitation.
2. **Dyspnea Assessment:** The Modified Medical Research Council (mMRC) Dyspnea Scale was used to evaluate the severity of breathlessness before and after the intervention.
3. **Patient Satisfaction:** A 5-point Likert scale questionnaire assessed patient satisfaction with the assigned technique, focusing on ease of use, perceived benefits, and overall comfort.

Data Analysis

Data were analyzed using SPSS software (version 25). Descriptive statistics, such as means and standard deviations, were used to summarize demographic and clinical characteristics. Paired t-tests were conducted to compare pre- and post-intervention lung function parameters within each group, while independent t-tests assessed differences between groups. Chi-square tests were used to analyze categorical variables such as patient satisfaction levels. A p-value of <0.05 was considered statistically significant.

Ethical Considerations

Ethical approval was obtained from the institutional review board (IRB) of the hospital. Written informed consent was obtained from all participants before enrollment in the study. Participants were assured of the confidentiality of their data, and their right to withdraw from the study at any time was respected. The study adhered to the principles of the Declaration of Helsinki.

Results

Demographics

Characteristics	Total (n = 200)	DB Group (n = 100)	IS Group (n = 100)
Age (Mean ± SD)	55.4 ± 12.7	54.8 ± 12.9	55.9 ± 12.5
Gender			
Male (%)	58% (116)	60% (60)	56% (56)
Female (%)	42% (84)	40% (40)	44% (44)
Primary Diagnosis			
COPD (%)	62% (124)	63% (63)	61% (61)
Post-Operative (%)	28% (56)	27% (27)	29% (29)
- Asthma (%)	10% (20)	10% (10)	10% (10)
Smoking Status			
Current Smokers (%)	25% (50)	27% (27)	23% (23)
Former Smokers (%)	35% (70)	34% (34)	36% (36)
Non-Smokers (%)	40% (80)	39% (39)	41% (41)
Body Mass Index (BMI)			
- Mean ± SD	26.5 ± 3.8	26.7 ± 3.7	26.3 ± 3.9
Baseline FEV1 (L)	1.41 ± 0.33	1.40 ± 0.35	1.42 ± 0.32
Baseline FVC (L)	2.11 ± 0.47	2.10 ± 0.45	2.12 ± 0.48
Baseline Tidal Volume (mL)	455 ± 78	450 ± 75	460 ± 80

The demographic and clinical characteristics of the study participants reveal that the average age was comparable across both groups, with a mean of 55.4 ± 12.7 years (54.8 ± 12.9 years in the diaphragmatic breathing group and 55.9 ± 12.5 years in the incentive spirometry group). Gender distribution was similar, with 58% males and 42% females overall. The primary diagnosis predominantly comprised COPD (62%), followed by post-operative conditions (28%) and asthma (10%), with no significant differences between groups. Smoking status showed a balanced distribution, with 25% current smokers, 35% former smokers, and 40% non-smokers. The mean body mass index (BMI) was slightly higher in the diaphragmatic breathing group (26.7 ± 3.7) compared to the incentive spirometry group (26.3 ± 3.9). Baseline lung function parameters, including FEV1 (1.41 ± 0.33 L), FVC (2.11 ± 0.47 L), and tidal volume (455 ± 78 mL), were nearly identical between groups. These comparable baseline characteristics ensured the validity of subsequent interventional analyses and highlighted the homogeneous distribution of key variables between the two intervention groups.

Parameter	DB Group (Mean ± SD)	IS Group (Mean ± SD)	p-value
FEV1 (L)	Pre: 1.40 ± 0.35	Pre: 1.42 ± 0.32	0.72
	Post: 1.80 ± 0.38	Post: 1.68 ± 0.35	0.04*
FVC (L)	Pre: 2.10 ± 0.45	Pre: 2.12 ± 0.48	0.88
	Post: 2.55 ± 0.50	Post: 2.40 ± 0.47	0.03*

Tidal Volume (mL)	Pre: 450 ± 75 Post: 550 ± 80	Pre: 460 ± 80 Post: 530 ± 85	0.56 0.12

The comparison of post-intervention lung function parameters between the diaphragmatic breathing (DB) group and the incentive spirometry (IS) group revealed significant improvements in both groups, with the DB group showing slightly superior outcomes. Baseline measurements of FEV1 (1.40 ± 0.35 L for DB, 1.42 ± 0.32 L for IS) and FVC (2.10 ± 0.45 L for DB, 2.12 ± 0.48 L for IS) were similar between the groups, with non-significant p-values (0.72 and 0.88, respectively). Post-intervention, the DB group exhibited a greater increase in FEV1 (1.80 ± 0.38 L vs. 1.68 ± 0.35 L, $p = 0.04$) and FVC (2.55 ± 0.50 L vs. 2.40 ± 0.47 L, $p = 0.03$). Tidal volume also improved in both groups, but the difference between DB (550 ± 80 mL) and IS (530 ± 85 mL) was not statistically significant ($p = 0.12$). These findings suggest that diaphragmatic breathing was slightly more effective than incentive spirometry in improving key pulmonary function parameters, particularly FEV1 and FVC, while both techniques provided meaningful benefits in lung volume expansion.

Group	Pre-Intervention (Mean ± SD)	Post-Intervention (Mean ± SD)	p-value
DB Group	3.2 ± 0.8	1.8 ± 0.6	<0.001*
IS Group	3.3 ± 0.7	2.1 ± 0.7	<0.001*

The analysis of dyspnea severity, measured using the mMRC scale, revealed significant reductions in both the diaphragmatic breathing (DB) and incentive spirometry (IS) groups following the interventions. Pre-intervention scores were comparable between the groups, with a mean of 3.2 ± 0.8 in the DB group and 3.3 ± 0.7 in the IS group. Post-intervention, the DB group showed a greater reduction in dyspnea severity (1.8 ± 0.6) compared to the IS group (2.1 ± 0.7), with both reductions being statistically significant ($p < 0.001$). These results indicate that both techniques effectively reduced dyspnea, though diaphragmatic breathing demonstrated slightly greater efficacy in alleviating breathing difficulties.

Variable	DB Group (%)	IS Group (%)	p-value
Adherence Rate	92%	85%	0.03*
Satisfaction Score	4.5 ± 0.6	4.2 ± 0.7	0.02*

The comparison of adherence rates and patient satisfaction between the diaphragmatic breathing (DB) group and the incentive spirometry (IS) group revealed significant differences in favor of the DB group. Adherence to the intervention was higher in the DB group (92%) compared to the IS group (85%), with a statistically significant difference ($p = 0.03$). Additionally, patient satisfaction scores were notably higher in the DB group (4.5 ± 0.6) compared to the IS group (4.2 ± 0.7), also reaching statistical significance ($p = 0.02$). These findings suggest that diaphragmatic breathing not only promotes better compliance but also results in greater patient satisfaction, likely due to its simplicity and ease of implementation compared to device-based techniques.

Subgroup	Intervention	FEV1 Improvement (L)	FVC Improvement (L)	Adherence Rate (%)	p-value
COPD Patients (n=124)	Diaphragmatic Breathing	0.50 ± 0.15	0.60 ± 0.20	90%	0.03*
	Incentive Spirometry	0.42 ± 0.12	0.52 ± 0.18	85%	
Post-Operative Patients (n=56)	Diaphragmatic Breathing	0.40 ± 0.12	0.50 ± 0.15	93%	0.25
	Incentive Spirometry	0.38 ± 0.10	0.48 ± 0.12	89%	
Asthma Patients (n=20)	Diaphragmatic Breathing	0.60 ± 0.18	0.65 ± 0.22	95%	0.04*
	Incentive	0.55 ± 0.16	0.60 ± 0.20	90%	

	Spirometry				
Age < 60 Years (n=110)	Diaphragmatic Breathing	0.48 ± 0.14	0.58 ± 0.18	93%	0.09
	Incentive Spirometry	0.45 ± 0.12	0.55 ± 0.15	88%	
Age ≥ 60 Years (n=90)	Diaphragmatic Breathing	0.42 ± 0.10	0.50 ± 0.12	90%	0.07
	Incentive Spirometry	0.40 ± 0.08	0.48 ± 0.10	80%	

The subgroup analysis demonstrated that diaphragmatic breathing (DB) consistently outperformed incentive spirometry (IS) in improving lung function and adherence across different patient categories, although the degree of significance varied. Among COPD patients, DB achieved significantly greater improvements in FEV1 (0.50 ± 0.15 L vs. 0.42 ± 0.12 L, $p = 0.03$) and FVC (0.60 ± 0.20 L vs. 0.52 ± 0.18 L) with higher adherence (90% vs. 85%). In post-operative patients, both interventions yielded comparable improvements in FEV1 and FVC, and adherence was slightly higher in the DB group (93% vs. 89%), though not statistically significant ($p = 0.25$). For asthma patients, DB showed significantly greater improvements in FEV1 (0.60 ± 0.18 L vs. 0.55 ± 0.16 L, $p = 0.04$) and FVC (0.65 ± 0.22 L vs. 0.60 ± 0.20 L), with the highest adherence rate (95%). Younger participants (<60 years) experienced slightly better outcomes with DB compared to IS in FEV1 (0.48 ± 0.14 L vs. 0.45 ± 0.12 L) and FVC (0.58 ± 0.18 L vs. 0.55 ± 0.15 L), with higher adherence (93% vs. 88%, $p = 0.09$). Older participants (≥60 years) also benefited more from DB (FEV1: 0.42 ± 0.10 L vs. 0.40 ± 0.08 L; adherence: 90% vs. 80%), though differences were not statistically significant ($p = 0.07$). These findings suggest that diaphragmatic breathing offers more consistent benefits across diverse subgroups, particularly in chronic conditions like COPD and asthma.

Discussion

This study evaluated the comparative effectiveness of diaphragmatic breathing (DB) and incentive spirometry (IS) in improving lung function, reducing dyspnea, and enhancing adherence and satisfaction among patients with chronic respiratory conditions or post-operative status (Mehmood et al., 2024). The findings demonstrated that both interventions significantly improved lung function parameters (FEV1, FVC, and tidal volume), with the DB group showing slightly greater improvements in FEV1 and FVC. Additionally, diaphragmatic breathing was associated with higher adherence and patient satisfaction compared to incentive spirometry.

The observed improvements in lung function parameters align with previous studies that have emphasized the benefits of breathing exercises in pulmonary rehabilitation (Tonga & Oliver, 2023). For instance, Soril et al. (2022) reported significant improvements in FEV1 and FVC following a 4-week diaphragmatic breathing program in patients with COPD. Our results showed a similar trend, with a 0.40 L increase in FEV1 and a 0.45 L increase in FVC in the DB group. In contrast, the IS group demonstrated smaller but significant improvements, consistent with findings by Zhang et al. (2022) who reported moderate gains in lung volumes with incentive spirometry among post-operative patients.

In terms of dyspnea reduction, both techniques significantly decreased mMRC scores, indicating improved breathing comfort. The DB group experienced a more pronounced reduction (1.4 points) compared to the IS group (1.2 points). Similar results were reported by Yohannes et al. (2021) where diaphragmatic breathing significantly reduced dyspnea scores in COPD patients. However, studies like Paul et al. (2018) noted comparable dyspnea improvements between IS and DB, suggesting that the setting and patient-specific factors might influence outcomes.

The higher adherence rates observed in the DB group (92%) compared to the IS group (85%) can be attributed to the simplicity and accessibility of diaphragmatic breathing. Previous research by Zampogna et al. (2021) highlighted that patient compliance is often higher with non-device-based techniques, as they require minimal external tools and can be performed anytime. In contrast, incentive spirometry, despite being effective, demands consistent device availability, which may contribute to slightly lower adherence.

Patient satisfaction was also higher in the DB group, which resonates with findings by Sella et al. (2020), who noted that patients often prefer techniques that are easy to integrate into their daily routines. The subjective perception of benefit and ease of learning likely influenced these results. The subgroup analysis revealed that diaphragmatic breathing was particularly effective in patients with chronic obstructive pulmonary disease (COPD) and asthma, whereas both interventions were equally effective for post-operative patients. This observation is consistent with studies by Bianchi et al. (2021) and Ahmed et al. (2018), which emphasized the role of breathing exercises in reducing hyperinflation and enhancing lung mechanics in chronic respiratory conditions.

In older adults (≥60 years), adherence was slightly lower for incentive spirometry (80%) compared to diaphragmatic breathing (90%). This aligns with past findings suggesting that device-based techniques might be less appealing to elderly patients due to the perceived complexity or physical limitations.

Strengths and Limitations

One of the strengths of this study is the large sample size and inclusion of a diverse patient population, allowing for subgroup analyses. The standardized protocol for both interventions ensured consistency, and the use of validated measurement tools enhanced the reliability of the results.

However, the study has some limitations. The use of convenience sampling may introduce selection bias, and the short duration of follow-up (4 weeks) limits the assessment of long-term outcomes. Additionally, self-reported adherence might overestimate compliance rates. Future studies with randomized controlled designs and longer follow-up periods are recommended to validate these findings.

Conclusion

This study demonstrated that both diaphragmatic breathing and incentive spirometry significantly improve lung function, reduce dyspnea, and enhance the quality of life in patients with chronic respiratory conditions and post-operative status. Diaphragmatic breathing was slightly more effective in improving FEV1 and FVC and had higher adherence and patient satisfaction rates compared to incentive spirometry. Subgroup analyses suggest that diaphragmatic breathing may be particularly beneficial for patients with COPD and asthma, while both techniques are equally effective for post-operative recovery.

These findings highlight the importance of incorporating personalized breathing exercises into pulmonary rehabilitation programs. Diaphragmatic breathing, being a non-device-based and cost-effective intervention, offers a practical alternative, particularly for resource-limited settings. Further research is needed to explore the long-term benefits and broader applicability of these techniques across diverse patient populations.

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