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REDEFINING DIAPHRAGMATIC ASPIRATION TECHNIQUE TO ALLEVIATE DYNAMIC HYPERINFLATION IN CHRONIC OBSTRUCTIVE PULMONARY DISEASES: A PILOT STUDY

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ABSTRACT

Chronic obstructive pulmonary disease, bronchial asthma, bronchiectasis constitutes the obstructive lung disease group which classically exhibits expiratory airflow restriction and dynamic hyperinflation, leading to symptoms including dyspnoea, reduced exercise capacity, endurance and restrains in quality of life. Traditional expiratory muscle training methods have had variable efficacies in resolving air trapping leading to hyperinflation. This research sought to identify the feasibility and efficacy of diaphragmatic aspiration technique in diaphragmatic functioning by mitigating dynamic hyperinflation and enhancing respiratory outcomes in patients with Chronic obstructive lung disorders (COPD). This single blinded pilot investigation constituted of a single-group pre-post intervention design and was executed over a duration of 8 weeks. 20 subjects with moderate to severe obstructive lung disease were recruited using purposive sampling. The included subjects underwent an 8-week intervention using the diaphragmatic aspiration technique, including guided diaphragmatic breathing, postural modifications, and abdominal contraction. Feasibility outcomes encompassed recruitment rates, adherence, and patient satisfaction, whereas secondary outcomes, including inspiratory capacity (IC), dynamic hyperinflation (measured by inspiratory reserve volume), exercise tolerance (6-minute walk test, 6MWT), and quality of life (St. George's Respiratory Questionnaire), were evaluated both pre- and post-intervention. Data were analysed using descriptive statistics and paired t-tests or Wilcoxon signed-rank tests, with effect sizes computed for clinical outcomes. The research effectively enrolled 20 individuals, achieving a 90% adherence rate and favourable comments about the technique's acceptability. Notable improvements were seen in clinical outcomes. Inspiratory capacity augmented by 14.8% ($p < 0.01$), whereas dynamic hyperinflation, assessed by inspiratory reserve volume, decreased by 11.5% ($p < 0.05$). Exercise tolerance, evaluated by the 6MWT, increased by 20.4% ($p < 0.01$), and quality of life metrics, assessed using the SGRQ, showed substantial improvement ($p < 0.001$). No adverse occurrences were documented. This pilot investigation revealed that enhancing the diaphragmatic aspiration method significantly increased Inspiratory Capacity (IC) and Expiratory Reserve Volume (ERV) in COPD patients ($p < 0.0001$). The results showed its potential beneficial supplement in pulmonary rehabilitation, enhancing respiratory mechanics and ascending of the diaphragmatic contour, therefore reducing dynamic hyperinflation.

Key words: Dynamic Hyperinflation, Diaphragm, Aspiration Technique, COPD, Air trapping, Inspiratory Capacity

INTRODUCTION

Obstructive lung disorder (OLD) like asthma, chronic obstructive pulmonary disease (COPD), and bronchiectasis, represent a prominent health problem within the world on multiple levels. These disorders are described by sustained airflow limitation achieved by inflammation of the airways, hyper secretion of mucus, and remodeling of the lung parenchyma **[1, 2]**. Dynamic hyperinflation is one of the complications of COPD that makes dyspnoea, exercise intolerance, and quality of life exceedingly worse **[3, 4]**. Dynamic hyperinflation occurs when the augmentation of lung capacity exceeds the resting tidal volume and a stroke volume is added for extra ventilation due to lung flushing during expiration. Pathomechanical changes aside from Hyperinflation in COPD may appear as a diminished Zone of Apposition (ZOA) and a lesser radius of curvature causing diaphragm distension. This occurs when air is trapped in the lungs due to resistance to airflow such that an increase end-expiratory lung volume (EELV) is attained with each breath taken **[6, 7]**. This process restricts inspiratory capacity and exerts a significant mechanical burden on the respiratory muscles, especially the diaphragm, worsening respiratory inefficiency **[8]**.

Dynamic hyperinflation is caused by expiratory flow limitation, airway obstruction, and reduced elastic recoil of the lung. These factors trap air in the lungs and result in an increase in the end-expiratory lung volume (EELV). The consequence is diaphragm displacement towards its most passive position and reduced mechanical advantage **[6]**. In such a situation, the recruitment of accessory respiratory muscles is needed, thereby increasing the work of breathing and worsening shortness of breath and intolerance to physical activity **[9, 10]**. The hyperinflation consequences at systemic levels – heightened cardiovascular burden and greater inflammatory responses – considerably worsen the severity of the disease **[11]**. Managing dynamic hyperinflation by treating the patient with underlying obstructive lung disease requires targeting respiratory mechanics and diaphragm function to improve patient outcomes. Hyperinflation related problems can be managed by altering breathing patterns with the use of specific exercises such as core stabilisation, as they are supposed to improve respiratory functions. Changing efferent diaphragmatic motion and intrathoracic pressure during expiration using the method of diaphragmatic aspiration (DA) is one of effectively applicable methods for different populations. Studies showed that DA-based therapy would improve pelvic floor muscle activity and alter intravaginal pressure profiles in women with stress urinary incontinence **[12]**. The results suggest that DA-based therapies can be beneficial in improving diaphragm function and reducing air trapping in patients suffering from COPD.

All these improvements notwithstanding, there is still a gap in the available literature regarding the use of DA-based expiratory training or similar approaches for the treatment of dynamic hyperinflation. Standard diaphragmatic or abdominal breathing exercises tend to be very difficult to carry out as they often lack the degree of definition and regulation that is necessary for therapeutic success **[14, 15]**. This study aimed to determine the effectiveness and practicality of the so-called combined method, which rests on the DA principle but incorporates active movement, change of position, and even verbal feedback. The primary target of the intervention was to reduce air trapping, enhance diaphragmatic mechanics by reducing the vertical dimension of the lung, and increasing the radius of curvature of the diaphragm in order to support moderate to severely obstructive lung disease patients' inspiratory flow. To our knowledge, these are the first steps that seek to fill the evidence gap in the effectiveness of physiotherapy for respiratory diseases through the prescription and systematic application of the DA method in pulmonary rehabilitation.

MATERIALS & METHODS

The research was scoped in order to assess the practical applicability and effectiveness of a refined diaphragmatic breathing technique on dynamic hyperinflation in people with Chronic Obstructive Pulmonary disease (COPD). It was conducted through a single blinded single group pre-post intervention pilot design at the Advanced Cardiovascular and Pulmonary Rehabilitation Unit Facility of the Faculty of Physiotherapy, over an 8-week period. The study received Institutional Review Board (IRB) approval from the Faculty of Physiotherapy ethics committee with the approval Reference Number [CRP/0022/IRB/PHYSIO/2024], which also ensures compliance with ethical conditions of the Declaration of Helsinki, 1975, updated 2013 **[16]**. All patients gave written informed consent before enrollment into the study. The consent process was informing the patients about the objectives of the study, the nature of the intervention, the risks involved, and the fact that participation was voluntary. Participants were informed that they had the right to withdraw from the study at any point without consequences.

SELECTION OF SUBJECTS

A total of 20 subjects diagnosed with moderate COPD according to the GOLD Standard were selected on purposive sampling, including diseases such as emphysema and chronic bronchitis. The inclusion criteria consist of subjects of both sexes aged 40 to 60 years on a stable pharmaceutical therapy for a minimum duration of 4 weeks and were capable and cooperative in performing the intervention. The exclusion criteria included individuals with active TB, any recent respiratory infections, acute exacerbation episodes during the last four weeks, and cognitive impairments that might hinder participation in the intervention.

INTERVENTION PROTOCOL

The intervention consisted of the redefined diaphragmatic aspiration technique, which aimed to enhance diaphragmatic efficiency and reduce dynamic hyperinflation. The technique involved:

1. Guided diaphragmatic breathing to optimize diaphragmatic descent.
2. Guided abdominal contraction to optimize diaphragmatic ascend
3. Postural adjustments to facilitate lung recoil and minimize accessory muscle recruitment.
4. Feedback-based correction using palpation and verbal cues.

   Sessions were held 4 days a week with one session per day, lasting 15 minutes each, for 8 weeks.

DESCRIPTION OF THE PROCEDURE:

1. **Starting Position**:
   - **Body position**: The individual starts lying on their back with their **hip and knee bent to 90°**.

- **Arms**: The arms should be placed on the ground beside the torso initially.

2. **Inward Drawing of the Abdomen**:
   - First the patient is asked to take a deep inspiration feeling the abdominal raise, now the patient is instructed to slowly breath out through mouth feeling the abdomen lowering.
   - As the technique begins, the patient was instructed to contract the abdominal muscles actively to draw the abdomen inward.
   - There should be a visible **inward drawing of the abdomen**, clearly showcased by the abdominals **contraction**
3. **Overhead Lifting of the Hand**:
   - As the abdomen is drawn inside, the person raises their arms upwards, gradually extending towards the floor above while sustaining the abdominal contraction.
   - The shoulder must be completely flexed at this juncture, with the hands either touching or extending towards the ears.
   - This posture is maintained for 3 seconds before the subsequent inspiration cycle begins.
4. **Final Position:**
   - In the concluding phase, the hands should extend maximally, nearly contacting the ground, while the individual achieves maximum stretch, with the abdomen retracted and the diaphragm elevated, resulting in a vertical compression of the lungs that expels trapped air, aiding in the deflation of the hyperinflated lung.
   - This entire technique was executed for 10 cycles of inspiration, followed by the diaphragmatic aspiration technique during expiration **[Figure 1]**.

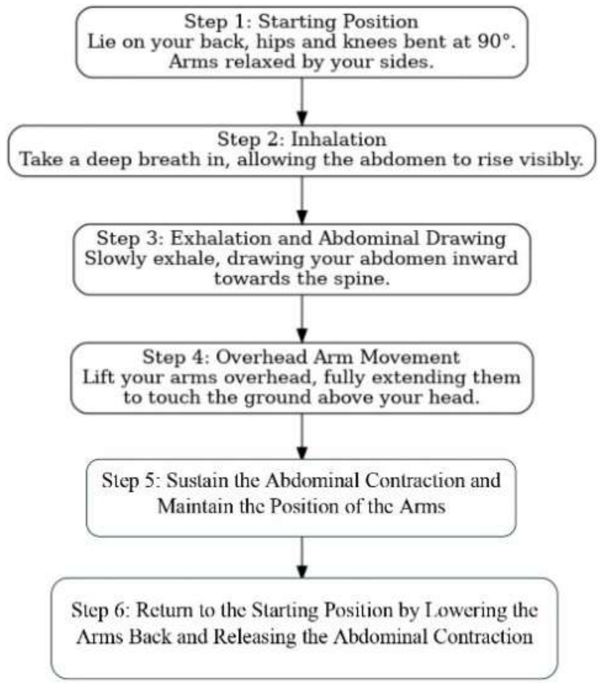


Figure 1: Flowchart depiction of the Diaphragmatic Aspiration Technique Procedure

MECHANISM OF ACTION OF DIAPHRAGMATIC ASPIRATION TECHNIQUE:

The Diaphragmatic Aspiration Technique aims to address these issues, specifically targeting the abdominal and diaphragm mechanics to enhance the deflation of the lungs:

1. **Inward Drawing of the Abdomen (Abdominal Contraction):**

During this phase, the abdominal contraction increases intrathoracic pressure, pushing upward on the diaphragm. This action encourages the diaphragm to move upwards, which is critical in helping to deflate the lungs. This upward movement of the diaphragm reduces the vertical diameter of the thoracic cavity, increasing intra-abdominal pressure and facilitating the compression of the lungs. It counters the flattened diaphragm typical of COPD patients. The increased intra-abdominal pressure supports the diaphragm, allowing it to regain some of its effectiveness during exhalation.

2. **Overhead Lifting of the Arms:**

The elevation of the arms amplifies the diaphragm's stretching, leading to a more significant drop of the diaphragm when abdominal pressure elevates it.

Shoulder flexion and arm elevation facilitate the expansion of the chest cavity, while the contraction of the abdominal muscles propels air upward into the thoracic cavity. This posture can improve the recruitment of the lower rib cage, enhancing ventilation in the lower lung zones, which is especially advantageous for individuals with COPD, as air trapping often transpires in the lower lung regions.

3. **Lung Deflation and Diaphragmatic Ascension:**

   The upward movement of the diaphragm exerts a compressive force on the lungs, particularly in the lower lobes, facilitating the expulsion of retained air. The diaphragm aids in compressing the lungs by decreasing the vertical width of the thoracic cavity, so generating a pressure gradient that facilitates the expulsion of air. The decrease in the diaphragm's radius of curvature (transitioning from a flatter to a more domed configuration) amplifies its compressive impact, facilitating more efficient lung deflation. This results in the expulsion of entrapped air and a decrease in lung hyperinflation, aiding in the restoration of normal pulmonary mechanics.

4. **Diaphragm Movement and Airway Patency**

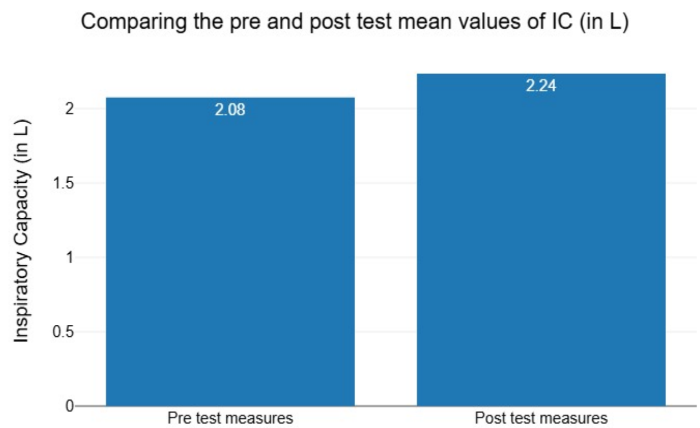
   The diaphragm's upward migration in this approach mitigates mechanical blockage from excessive lung expansion, hence enhancing airway patency and diminishing dynamic airway collapse. In COPD, the diminished elastic recoil leads to airway collapse during forceful exhale. Diaphragmatic contraction, particularly when supported by abdominal pressure, mitigates airway collapse by facilitating the expulsion of trapped air.

RESULT:

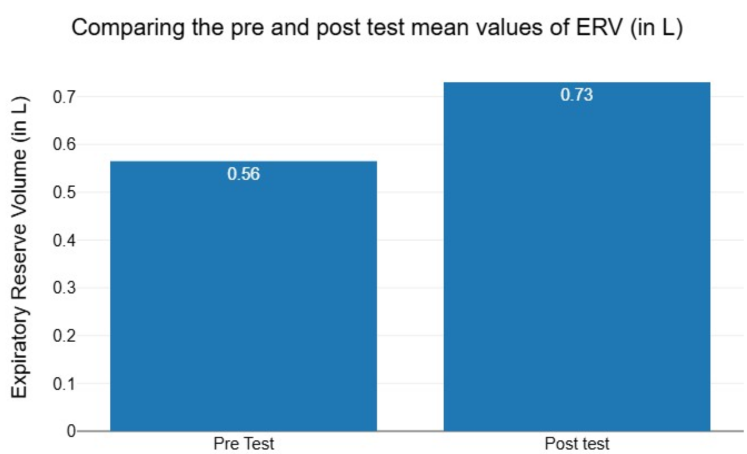
The pilot investigation gauging the effectiveness of the diaphragmatic aspiration method in addressing dynamic hyperinflation in COPD patients revealed significant enhancements in inspiratory capacity (IC) and expiratory reserve volume (ERV) post-intervention. Twenty individuals completed pre-test and post-test evaluations. The average IC rose from 2.08 ± 0.17 L to 2.24 ± 0.15 L **[Graph 1]**, demonstrating a statistically significant change ($t = -11.96$, $p < 0.001$, Cohen's $d = 2.67$), indicating a considerable effect size. The mean ERV increased from 0.56 ± 0.1 L to 0.73 ± 0.09 L **[Graph 2]**, demonstrating a statistically significant difference ($t = -15.08$, $p < 0.001$, Cohen's $d = 3.37$), indicating a substantial clinical effect **[Table 1]**. The confidence intervals corroborated these results, indicating a persistent improvement in pulmonary function metrics. The findings indicated that the diaphragmatic aspiration approach effectively mitigated dynamic hyperinflation and improved lung function in COPD patients, necessitating future exploration in bigger clinical trials.

Table 1: Pre-test and Post test values of Inspiratory Capacity (IC) and Expiratory Reserve Volume (ERV) Measured Using PFT

Respiratory Parameter	Pretest	Post test	p value
	Mean±SD	Mean+SD	
Inspiratory Capacity (IC) (L)	2.08 ± 0.17	2.24 ± 0.15	<.001
Expiratory Reserve Volume (ERV) (L)	0.56 ± 0.1	0.73 ± 0.09	<.001



Graph 1: Pre-test and Post test mean values of Inspiratory Capacity (IC) in litres



Graph 2: Pre-test and Post test mean values of Expiratory Reserve Volume (ERV) in litres

DISCUSSION

Chronic obstructive pulmonary disease (COPD) is a progressive respiratory disorder marked by airflow restriction, hyperinflation, and respiratory muscle impairment, which considerably diminishes ventilatory efficiency and exercise capacity. Mitigating dynamic hyperinflation (DH) using specific respiratory therapies is essential for enhancing pulmonary function and overall quality of life in patients with COPD. The findings of this pilot research indicate that the Diaphragmatic Aspiration (DA) approach significantly enhances inspiratory capacity (IC) and expiratory reserve volume (ERV) in patients with COPD, indicating its potential as an efficacious strategy for treating dyspnoea. The DA technique, comprises of active contraction of the abdominal musculature leading to upward ascend of the diaphragm augmenting the relaxation and flushing of the lung in end expiratory phase which has shown improvement in diaphragmatic efficiency and respiratory mechanics optimisation. The function of the diaphragm is essential for respiratory efficiency, especially in COPD, when patients often have diaphragm flattening, hyperinflation, and diminished inspiratory efficacy. The research conducted by Yollande Sénan *et al*. (2021) shown that an abdominal workout integrating diaphragmatic aspiration (DA) and curl-ups significantly influenced inter-recti distance, indicating that DA not only efficiently activates the diaphragm but also improves its mechanical advantage **[17]**. This corresponds with our research results, whereby IC markedly increased after the intervention, corroborating the concept that DA enhances diaphragmatic recruitment and facilitates better inspiratory performance in COPD patients. In a comparable research, Reman T *et al*. (2022) examined intravaginal pressure profiles during two DA tasks in women with stress urine incontinence and found that DA induced negative intrathoracic pressure, which favourably affected core stability and diaphragmatic relaxation **[18]**. The negative pressure mechanism may elucidate the enhancements seen in ERV in our investigation, as DA likely augments expiratory muscle activation and mitigates air trapping, hence counteracting DH in COPD patients. Diaphragmatic relaxation is a crucial element of respiratory rehabilitation. A research on diaphragm muscle relaxation indicated that enhancing diaphragmatic flexibility and relaxation reduces the effort required for breathing and improves lung compliance **[19]**. This further corroborates our results, since post-intervention elevations in IC and ERV indicate enhanced lung mechanics and decreased dynamic hyperinflation in COPD patients. These results underscore the curative potential of DA in COPD care, emphasising its role in improving diaphragmatic function, decreasing DH, and promoting respiratory efficiency.

CONCLUSION:

Cardiorespiratory function is essential in the management of COPD, since dynamic hyperinflation considerably affects respiratory efficiency. This research found that enhancing the diaphragmatic aspiration method significantly improved lung function, especially in Inspiratory Capacity (IC) and Expiratory Reserve Volume

(ERV). The post-intervention study indicated a statistically significant improvement in both parameters ($p < 0.0001$), with Group A exhibiting better results than Group B. The substantial effect sizes (Cohen's d = 2.67 for IC and 3.37 for ERV) underscored the therapeutic significance of this method. The data suggest that integrating diaphragmatic aspiration into pulmonary rehabilitation regimens may improve respiratory mechanics and functional ability in COPD patients. This strategy may effectively mitigate dynamic hyperinflation and enhance overall respiratory efficiency and could act as a beneficial adjunct in pulmonary rehabilitation for COPD patients, possibly improving respiratory mechanics and functional ability.

STUDY CONSTRAINTS

The limited sample size of this research constrains the generalisability of its results. The brief intervention period hindered the evaluation of long-term benefits, and the absence of follow-up made it ambiguous if the gains were maintained. Moreover, the research omitted functional and quality-of-life metrics, which are essential for comprehending real-world advantages. Outcomes may have been affected by selection bias resulting from purposeful sampling. Furthermore, the research failed to compare diaphragmatic aspiration with other pulmonary rehabilitation methods, complicating the assessment of its relative efficacy against recognised respiratory therapy.

FUTURE SCOPE OF THE STUDY:

Subsequent study needs to use bigger sample numbers to enhance statistical validity. Extended follow-up durations are essential to evaluate enduring advantages. Incorporating functional and quality-of-life measurements would provide a more thorough review of patient outcomes. Comparative research with conventional pulmonary rehabilitation methods might determine the technique's clinical superiority or its complementary function. Examining its impact on cardiopulmonary fitness, particularly VO_2 max, might provide more insights. Finally, investigating the fundamental physiological principles may enhance the approach and improve its implementation in pulmonary rehabilitation for COPD patients.

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