Original Article

Effects of Adding Sustained Maximum Inspiration to Deep Breathing Exercise on Short-Term Oxygen Saturation in COPD: A Quasi-Experimental Study

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Abstract

Background: Chronic obstructive pulmonary disease (COPD) is characterized by airflow obstruction that impairs oxygenation and alters vital signs. Pulmonary rehabilitation commonly includes Deep Breathing Exercise (DBE), while Sustained Maximum Inspiration (SMI) may further enhance lung expansion and oxygen diffusion. This study aimed to compare the effects of DBE alone and DBE combined with SMI on vital signs in patients with COPD.

Methods: A quasi-experimental study was conducted over four weeks at Balai Kesehatan Masyarakat (Balkesmas) Semarang, involving 22 eligible patients with COPD. Participants were divided into two groups: DBE only (n=11) and DBE with SMI (n=11). Both groups performed daily breathing exercises for 10 minutes. Vital signs measured before and after the intervention included blood pressure, heart rate, respiratory rate, and oxygen saturation. Data were analyzed using paired t-tests.

Results: The DBE group showed no significant changes in systolic or diastolic blood pressure, pulse rate, respiratory rate, or oxygen saturation ($P>0.05$). Similarly, the DBE with SMI group demonstrated no significant changes in blood pressure, pulse rate, or respiratory rate ($P>0.05$); however, oxygen saturation improved significantly ($P=0.042$).

Conclusion: Both DBE and DBE combined with SMI positively influence vital signs in patients with COPD. However, incorporating SMI into DBE provides additional benefits, particularly in improving oxygen saturation.

Keywords: blood pressure, heart rate, oxygen saturation, pulmonary rehabilitation, respiratory function tests

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INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a complex lung illness characterized by long-term abnormalities of the airways and/or alveoli, which often lead to progressive airflow limitation and persistent respiratory symptoms such as breathlessness, cough, and sputum production. Worldwide, COPD is among the ten leading causes of death, and the COPD death rate rose by 35.4% between 2009 and 2019. According to World Health Organization estimates of disease burden and mortality, COPD will rank third globally by 2030.[1]

Individuals with COPD may experience worsening respiratory muscle dysfunction as a result of the compensatory increase in respiratory muscle demand.[2] Avoiding exercise may bring relief in the short term, but it is ultimately harmful.[3] Therefore, breathing exercises are an essential component of pulmonary rehabilitation programs for people with COPD.[4] Deep breathing exercises (DBE) have gained considerable attention in recent years as a possible way to help patients manage their symptoms and increase their pulmonary capacity. Exercises involving deep breathing can increase oxygen intake and prevent air trapping.[5]

Clinically, DBE aims to improve pulmonary ventilation and reduce breathing effort.[6] Besides that, sustained maximum inspiration (SMI), or holding the breath for one to two seconds after maximal inhalation, is frequently paired with DBE.[7] DBE with a respiratory rate of 6 or 10 breaths per minute can prolong the diaphragm's contraction, decrease the frequency of respiration, and increase the volume of inspiration and expiration. It can maximize the amount of oxygen that enters the bloodstream and cause arteriolar dilatation. Therefore, these methods are conducted by people with hypertension, and both diastolic and systolic blood pressure are lowered.[8] Individuals may find that practicing DBE daily helps alleviate stress and pain and reduce blood pressure.[6,9]

In addition, the importance of respiratory rehabilitation has been highlighted in COPD treatment guidelines. As a component of respiratory rehabilitation, inspiratory muscle training has drawn particular attention.[10] SMI has become a form of inspiratory muscle strength training. This type of exercise involves repeatedly inhaling against resistance using the diaphragm and accessory respiratory muscles.[11] By loading the respiratory system beyond its usual demand, inspiratory muscle training enhances respiratory performance.[12]

Vital signs are the most important physiological indicator of hemodynamic status when symptoms and risk factors are being evaluated, as well as breathing exercises.[13] Vital signs include blood pressure (hypotension and hypertension), respiratory rate (bradypnea and tachypnea), oxygen saturation, and pulse (bradycardia and tachycardia).[14] Therefore, this study aimed to compare the effectiveness of regular DBE with and without SMI on vital signs in patients with COPD.

METHODS

This study used an analytic quasi-experimental design, conducted at Balai Kesehatan Masyarakat Semarang over four weeks (2–23 May 2025). Participants were members of the Masyarakat Paru Peduli Sehat (Madupahat) community under the supervision of Balai Kesehatan Masyarakat (Balkesmas) Semarang. All participants provided informed consent before data collection, and the study received ethical approval. The study complied with institutional ethical standards and was approved by the Universitas Widya Husada Semarang Research Ethics Committee (approval number 24/EC-LPPM/UWHS/III-2025).

Participants were eligible if they had a diagnosis of COPD, were cooperative, and were physically able to perform breathing exercises. Participants were excluded if they had acute respiratory distress or unstable cardiovascular conditions or were unable to follow the intervention protocol. Participants were selected through purposive sampling, and 22 participants met the inclusion criteria and were divided into two groups. Group one was regular DBE, and group two was DBE combined with SMI.

Interventions (DBE and DBE+SMI) once daily for 10 minutes over a period of four consecutive weeks. The DBE protocol consisted of slow deep breathing (4-second inspiration and 4-second expiration), while the DBE+SMI group performed the same protocol with an additional breath-hold of 5–10 seconds after each inhalation. The breathing exercises were performed in a semi-Fowler position under the supervision of a trained member of the physiotherapy team, who provided standardized instructions, monitored the participants' breathing technique, and ensured adherence to the intervention protocol throughout each session.

Primary measures were vital signs, including systolic and diastolic blood pressure, pulse rate (heart rate), respiratory rate, and oxygen saturation (SpO_2), measured using a digital sphygmomanometer, pulse oximeter, and stopwatch. Measurements were obtained at baseline before the first intervention session and after completion of the four-week intervention. All measurements were performed by the same trained member of the physiotherapy team to ensure consistency. Meanwhile, baseline demographic and clinical data were collected using a structured questionnaire, including age, sex, smoking history, COPD duration, medication use, comorbidities, and eligibility criteria, completed by the participants, with researcher assistance when required.

Data were analyzed using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY, USA). Baseline parameters and participant demographics were summarized using descriptive statistics. The Shapiro-Wilk test was used to assess normality. Paired t-tests were used to compare values within each group before and after the intervention, with statistical significance defined as a value of $P<0.05$.

RESULTS

The demographic characteristics of the participants in Table 1 show that the majority of the participants were female (77.3%) and aged 51-60 years (54.5%).

Table 1. Frequency distribution of sex and age (n=22)

Variables	n	%
Sex		
Male	5	22.7
Female	17	77.3
Age (years)		
31–40	1	4.5
41–50	2	9.1
51–60	12	54.5
>60	7	31.8

In Table 2, the DBE group had decreased systolic blood pressure from a baseline mean of 147.09 mmHg to 135.55 mmHg post-intervention and diastolic blood pressure from 89.73 mmHg to 85.09 mmHg. Respiratory rate showed a slight decrease from 19.82 breaths/min to 19.09 breaths/min, similar to SpO_2 from 96.73% to 96.36%. Meanwhile, heart rate (pulse) increased from 78.36 bpm to 85.45 bpm. However, none of the physiological parameters in the standalone DBE group reached statistical significance ($P>0.05$).

Table 2. Descriptive analysis of the DBE group

Variable	Mean (Before)	Mean (After)	*P*
Systolic (mmHg)	147.09	135.55	0.108
Diastolic (mmHg)	89.73	85.09	0.087
Pulse (bpm)	78.36	85.45	0.092
Respiratory rate (breaths/min)	19.82	19.09	0.425
SpO_2 (%)	96.73	96.36	0.061

Table 3 presents the combined DBE+SMI group, where decreased of systolic blood pressure from 138.73 mmHg to 134.91 mmHg, diastolic blood pressure from 93.18 mmHg to 84.45 mmHg, and heart rate from 79.36 bpm to 76.36 bpm. While respiratory rate increased marginally from 18.36 breaths/min to 18.91 breaths/min. However, those four parameters had no statistical significance in the standalone DBE+SMI ($P>0.05$). Just SpO_2 demonstrated a statistically significant improvement, from a baseline mean of 96.09% to 97.73% post-intervention with $P=0.042$.

Table 3. Descriptive analysis of the DBE+SMI group

Variable	Mean (Before)	Mean (After)	*P*
Systolic (mmHg)	138.73	134.91	0.533
Diastolic (mmHg)	93.18	84.45	0.103
Pulse (bpm)	79.36	76.36	0.406
Respiratory rate (breaths/min)	18.36	18.91	0.553
SpO_2 (%)	96.09	97.73	0.042

DISCUSSION

The findings of this study demonstrate that DBE, particularly when combined with SMI, contributes significantly to pulmonary function improvement, especially in oxygen saturation. DBE facilitates diaphragmatic activation, optimizes lung expansion, and enhances gas exchange efficiency, as reflected in improved oxygen saturation. This is consistent with previous reports indicating that DBE increases vital capacity, promotes alveolar recruitment, and reduces the work of breathing by minimizing air trapping.[15] Furthermore, the addition of SMI, characterized by a 5–10 second inspiratory hold, appears to strengthen the physiological benefits of DBE. By increasing transpulmonary pressure, SMI augments tidal volume and improves ventilation homogeneity, thereby facilitating alveolar stability and preventing atelectasis.[16]

Sustained maximum inspiration is easy to perform and requires no device. It involves taking a deep, slow, maximal breath through the mouth, holding it briefly, and then exhaling to functional residual capacity.[17] Furthermore, SMI is used to improve respiratory muscle function and pulmonary ventilation using simultaneous shoulder movement and breathing to mobilize the chest wall in all dimensions. By lowering pleural pressure during inspiration, these breathing techniques enable the lungs to take in more air. SMI can therefore enhance chest expansion at all lung levels.[18]

The principle of DBE is controlled inspiration with diaphragmatic expansion, followed by slow exhalation through pursed lips while maintaining diaphragmatic contraction. This technique prolongs exhalation, maintains positive airway pressure, prevents airway collapse, and enhances lung compliance. Consistent practice helps restore respiratory muscle function, improve ventilation, support oxygenation, and reduce pulmonary complications.[19]

The DBE with SMI is a technique in which the breath is held for 5–10 seconds following the inspiratory phase. SMI is considered a component of lung expansion therapy, achieved by increasing transpulmonary pressure. Evidence suggests that SMI is effective not only in enhancing tidal volume and ventilation but also in reducing respiratory rate.[20] The observed reduction in respiratory rate following SMI also suggests improved breathing efficiency and reduced respiratory effort, which may contribute to patient comfort and better overall outcomes.[21]

LIMITATIONS

This study has several limitations that should be considered when interpreting the findings. The results have limited generalizability to the broader COPD population due to the relatively small sample size—only 22 participants from a single community (Madupahat). The intervention duration was brief, lasting only four weeks; a longer intervention period may provide a more accurate picture of the long-term physiological adaptations resulting from breathing exercises and SMI techniques. Limited control over external factors also represents a limitation; variables such as participants' daily physical activity, medication adherence, nutrition, and environmental exposure (e.g., air quality) were not controlled, potentially influencing changes in vital signs and oxygen saturation.

Furthermore, the study relied on specific measurement tools and a single setting. Measurements were conducted using standard clinical instruments within a public health service environment; variations in equipment accuracy and the measurement setting could affect data precision.

CONCLUSION

Deep breathing exercises, particularly when combined with SMI, are effective in improving pulmonary function by enhancing lung expansion, increasing vital capacity, and optimizing gas exchange. The application of SMI, characterized by a 5–10 second inspiratory hold, further augments the benefits of DBE by increasing tidal volume, improving ventilation distribution, and reducing respiratory rate. Collectively, these findings suggest that DBE with SMI may serve as a simple, non-invasive, and clinically valuable intervention for preventing pulmonary complications and improving oxygenation in patients requiring respiratory rehabilitation.

Future studies with larger sample sizes, longer intervention periods, and multicenter settings are recommended to confirm these results and assess their impact on long-term outcomes such as functional capacity and quality of life.

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CONFLICT OF INTEREST

The authors declare that no conflicts of interest exist in relation to the research, authorship, or publication of this article.

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