Original Article

# Effect of Balloon Inflation Exercise on Lung Function, Functional Capacity, and Symptom Scores in Patients with Stable Chronic Obstructive Pulmonary Disease

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## Abstract

**Background:** Chronic obstructive pulmonary disease (COPD) is a progressive condition marked by airflow limitation, leading to reduced lung function, increased symptom burden, and decreased resilience. Patients often experience persistent dyspnea and limited exercise tolerance, impacting daily activities. Pulmonary rehabilitation is essential for controlling symptoms and optimizing functional capacity. Balloon inflation exercise, involving coordinated inspiratory and expiratory muscle training, may enhance lung expansion, improve oxygenation, reduce air trapping, and strengthen respiratory muscles, thereby improving lung function and reducing symptoms.

**Method:** Experimental study with pre-test and post-test groups design. The number of study participants was 30 stable COPD outpatients in groups B and E of the Pulmonary Clinic of the UNS Hospital during the period of February 2023, by targeted sampling. The control group (n = 15) received standard care and the treatment group (n=15) received standard care plus additional balloon-inflation exercises for 6 weeks. Comparisons between pre-test and post-test groups were made on the %$VEP_1$ score, breathlessness symptoms, the CAT questionnaire, exercise capacity, and EID.

**Result:** Increased values of %$VEP_1$ ($P$=0.001), decreased Borg scale ($P$=0.001), decreased CAT score ($P$≤0.001), and physical activity performance ($P$=0.001) versus his EID ($P$≤0.001) increase.

**Conclusion:** Inflating the balloon affects %$VEP_1$, Borg scale, CAT score, training capacity increase, and EID values. Balloon blowing exercise increases the %$VEP_1$ value, lowers the Borg scale, lowers the CAT score, increases exercise capacity, and EID.

**Keywords:** %$VEP_1$, Borg scale, CAT, EID, training capacity

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## INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a non-communicable disease that often occurs in middle-aged or older adults.[1] COPD is characterized by persistent and progressive airflow limitation.[2] According World Health Organization (WHO) showed that COPD contributes to the third-highest mortality rate, estimating around 3.23 million deaths.[3]

Eighty to ninety percent of COPD is caused by smoking cigarettes.[4] Furthermore, eighty percent of COPD deaths occur in middle- or low- income countries, where prevention and control strategies are not working well.[3] COPD has a life expectancy that depends on the severity of COPD.[4]

Inflammation and luminal exudates in COPD are associated with a decrease in forced expiratory volume in 1 second ($FEV_1$) and the ratio of forced expiratory volume in one second to forced vital capacity ($FEV_1$/FVC). Decreased $FEV_1$ post bronchodilator is a hallmark of COPD, which is related to the degree of obstruction. Furthermore, obstruction of the airway causes hyperinflation that might increase functional residual capacity.[2,5]

Inspiration occurs due to the contraction of the diaphragm muscle, increasing the volume of the thoracic cavity.[6] Inspiratory muscle function in the maximum state is closely related to the inspiratory pressure.[5] The expiratory process is due to the elasticity of the lung tissue, which is a passive process. Exhalation becomes active during exercise and during hyperventilation. Expiratory muscles are required during maximal expiration.[6]

Impaired respiratory muscle function is caused by multiple mechanisms, namely chronic inflammation and oxidative stress, leading to decreased ventilation capacity in COPD.[5] Paralysis of accessory inspiratory muscles has minimal impact, as the diaphragm remains the dominant muscle responsible for respiration.[6] Imbalance of load and capacity of the respiratory system is the cause of diaphragmatic fatigue.[7] The diaphragm adapts by reducing the length of the sarcomere and increasing the concentration of mitochondria.[8]

Pulmonary rehabilitation in individuals with COPD is a means of controlling and reducing symptoms and optimizing functional capacity.[9] The definition of pulmonary rehabilitation according to the American Thoracic Society (ATS) 2006 is an evidence-based, multidisciplinary, and comprehensive intervention for symptomatic COPD and decreased activity in daily life.[10] Pulmonary rehabilitation in COPD groups B and E, which have a variety of symptoms and a high risk of exacerbations, provides optimum benefits when carried out for 6 to 8 weeks.[2,9]

Research by Zarneshan shows that respiratory muscle exercises can improve FVC, $FEV_1$, and maximal oxygen consumption ($VO_2$max), while other studies have shown significant increases in PImax (maximum inspiratory pressure) and PEmax (maximum expiratory pressure) in COPD patients, aiming to improve chronic respiratory failure conditions.[11,12] Garcia-Talavera et al found that 20% of COPD patients experience exercise-induced oxygen desaturation (EID), defined as a ≥4% drop in oxygen saturation from baseline or a fall to ≤88% during activity.[13]

Exercise-induced oxygen desaturation in COPD is caused by an increase in the ratio of ventilation and perfusion.[14] A study by Waatevik et al in Norway stated that desaturation in COPD patients at 6MWT determines the prognosis of the disease. A low %$FEV_1$ predictive value in COPD affects the occurrence of EID.[15]

The six-minute walk test (6MWT) is a commonly used test to assess functional capacity, therapy response, and chronic cardiopulmonary status, with desaturation during the test associated with higher mortality rates.[16] Six-minute walking is a better predictor of mortality than the $FEV_1$ value. The six-minute walking test is a simple and inexpensive test for evaluating functional disability in COPD.[17]

Besides that, patients with COPD, as recommended by GOLD 2023, undergo a 6-week pulmonary rehabilitation program to achieve optimal improvement in respiratory muscle function. The balloon inflation exercise is relatively easy, does not require any special skills, and can be done at any time in an upright position at any time.

Balloon blowing exercises are also effective in helping to expand the lungs, thereby improving oxygen supply and removing carbon dioxide trapped in the lungs of COPD sufferers.[18] Basso-Vanelli et al reported that aerobic breathing exercise can effectively increase the respiratory muscle strength in COPD patients. Combining effective techniques can increase the inspiratory-expiratory ratio and reduce the respiratory rate.[19]

A study by Kosayriyah et al concluded that respiratory exercise combined with balloon inflation in elderly COPD patients with a smoking history of at least four weeks resulted in significant increases in $FEV_1$ and oxygen saturation ($SpO_2$).[20] A study by Suharno in Surabaya also found that $FEV_1$ in COPD after inflating balloons for 4 weeks of balloon inflation was 1.248 liters in the treatment group. An increase in $FEV_1$ is indicated by an increase in her $FEV_1$ score on a pulmonary function test using spirometry.[21]

Researchers developed the concept of home-based pulmonary rehabilitation (HBPR) as an alternative model of pulmonary rehabilitation, one of the balloon blowing. The HBPR concept aims to improve exercise adherence and has therefore been shown to improve patient quality of life. Therefore, this study was conducted to evaluate the effect of balloon inflation exercise on lung function, functional capacity, and symptom scores in patients with stable COPD.

## METHOD

This study was an experimental study of pre- and post-test group designs in stable COPD groups B and E, comparing %$FEV_1$, breathlessness symptoms, exercise capacity, COPD Assessment Test (CAT) questionnaire and EID. This study was conducted at Pulmonary Clinic, UNS Hospital in February and March 2023 until the sample size was fulfilled. The sample consisted of 30 stable COPD patients who were divided into two groups: a control group (n=15) who received only standard care only and a treatment group (n=15) who received standard care and received additional balloon inflation exercises each day was carried out for six weeks.

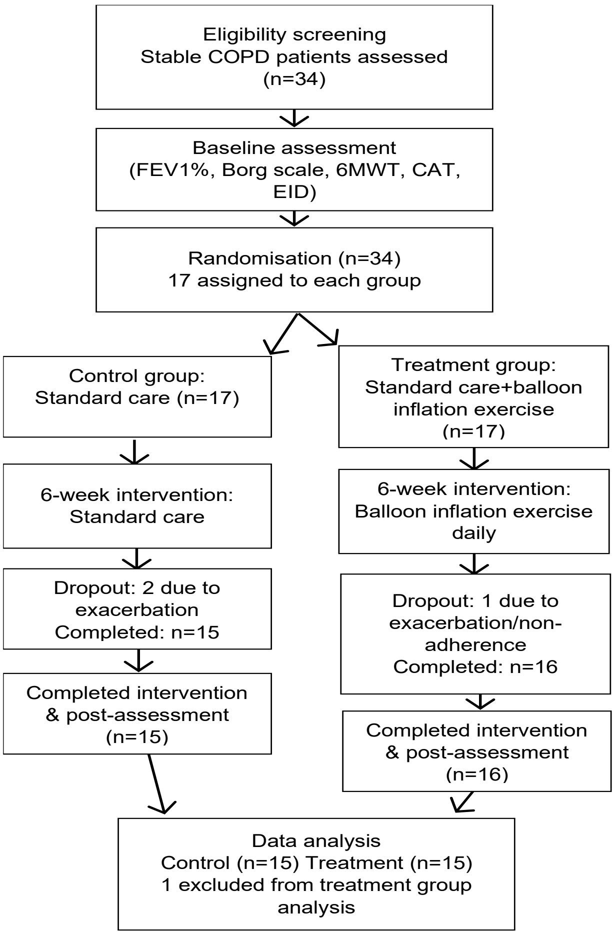


Figure 1. Flow–diagram of the Study Procedures

Inclusion criteria for this study were stable COPD patients willing to participate with written consent, age >40 years, able to answer and complete a questionnaire, and having balloon inflation results recorded. The study protocol included support facilities such as video calls and balloon inflation exercises. Exclusion criteria were patients with acute lung disease, physical and sensory disturbances, cardiac disease, malignancies within or outside the lung, as well as tuberculosis, pneumothorax, pleural effusion, interstitial lung disease (ILD), pneumonic bullae, or lung abscess. Dropout criteria were patients who experienced acute exacerbation requiring hospitalization, became incomprehensible during follow-up, resigned, or showed low compliance and motivation.

Data for all variables were analyzed using SPSS 21 for Windows. As the data were not normally distributed, comparisons were performed using the Wilcoxon signed-rank test for paired data and the Mann–Whitney test for independent data.

## RESULT

Baseline characteristics of the research subjects consisted of gender, age, occupation, body mass index, COPD group, and Brinkman index. The homogeneity results test for the characteristics of the control and treatment group variables were normally distributed, as indicated by the Shapiro-Wilk test $P>0.05$. Table 1 shows the basic characteristics of the research themes.

Table 1. Basic Characteristics of Research Subjects

| Basic Characteristics | Group | | *P* |
|---|---|---|---|
| | **Blowing balloon** | **Control** | |
| Gender | | | |
| Man | 14 (93.3%) | 10 (66.7%) | 0.169[a] |
| Woman | 1 (6.7%) | 5 (33.3%) | |
| Age | 64.67±9.44 | 65.40±8.85 | 0.828[b] |
| Occupational | | | |
| Laborer | 7 (46.7%) | 7 (46.7%) | 0.477[a] |
| Not working | 0 (0.0%) | 1 (6.7%) | |
| Pension | 2 (13.3%) | 1 (6.7%) | |
| Farmer | 2 (13.3%) | 3 (20.0%) | |
| Government employees | 2 (13.3%) | 0 (0.0%) | |
| Privat employees | 1 (6.7%) | 0 (0.0%) | |
| Self employed | 1 (6.7%) | 3 (20.0%) | |
| Body Mass index | | | |
| Underweight | 0 (0.0%) | 2 (13.3%) | 0.091[c] |
| Normoweight | 11 (73.3%) | 9 (60.0%) | |
| Overweight | 2 (13.3%) | 2 (13.3%) | |
| Obese | 2 (13.3%) | 2 (13.3%) | |
| Group | | | |
| B | 0 (0.0%) | 1 (6.7%) | 1.000[a] |
| E | 15 (100.0%) | 14 (93.3%) | |
| Brigman Index | | | |
| Passive | 1 (6.7%) | 6 (40.0%) | 0.585[c] |
| Mild | 3 (20.0%) | 0 (0.0%) | |
| Moderate | 4 (26.7%) | 6 (40.0%) | |
| Severe | 7 (46.7%) | 3 (20.0%) | |

Note: [a]Chi-square test; [b]Independent t-test; [c]Mann–Whitney test

Table 2 shows the difference between before and after %$FEV_1$ between the balloon inflation exercise treatment group and the control group. The treatment group experienced a mean increase in %$FEV_1$ of 9.23±4.67 after the balloon inflation exercise, which was statistically significant (*P*=0.001), whereas the control group experienced a decrease in %$FEV_1$, with a mean of 1.00±1.83 (*P*=0.054). Comparing the differences in %$FEV_1$ changes, one value showed a statistically significant difference (*P*≤0.001). Performing balloon inflation exercise therapy had a significant effect on increasing %$FEV_1$ compared with the control group.

Table 2.%$FEV_1$ difference test between the blowing balloon and control groups

| Group | %$FEV_1$ | | *P* | Difference %$FEV_1$ |
|---|---|---|---|---|
| | Pre | Post | | |
| Blowing balloon | 55.62±13.03 | 64.86±11.13 | 0.001[b]* | 9.23±4.67 |
| Control | 50.11±11.87 | 49.11±11.08 | 0.054[c]* | -1.00±1.83 |
| *P* | 0.178[a] | 0.001[a] | --- | <0.001[a]* |

Note: [a]Mann–Whitney test; [b]Wilcoxon signed-rank test; [c]Paired t-test; *statistically significant (*P*<0.05)

The Borg scale measurement results after balloon inflation exercise were statistically significantly decreased by -2.00±0.93 in the treatment group (*P*=0.001) and by -0.40±0.51 in the control group (*P*=0.014). The Borg scale measurements before and after treatment and the difference between the pre- and post- treatment and control groups are shown in Table 3.

Table 3.Measurement of Borg scale before, after, and the difference between the post-pre blowing ballon and the control group

| Group | Borg scale | | *P* | Difference Borg scale |
|---|---|---|---|---|
| | Pre | Post | | |
| Blowing ballon | 4.80±1.08 | 2.80±0.56 | 0.001[b]* | -2.00±0.93 |
| Control | 5.20±0.77 | 4.80±0.86 | 0.014[b]* | -0.40±0.51 |
| *P* | 0.326[a] | <0.001[a]* | --- | <0.001[a]* |

Note: [a]Mann–Whitney test; [b]Wilcoxon signed-rank test; *statistically significant (*P*<0.05)

The treatment group had a statistically significant 6MWT increase in score after receiving balloon inflation exercise therapy with a mean of 69.73±7.00 (*P*=0.001). In the control group, he had a 6MWT decrease with a mean value of -2.53±5.37, which was not statistically significant (*P*=0.138). Table 4 shows the measured 6MWT values before and after, as well as the differences between the balloon inflation exercise treatment group and the control group before and after treatment.

Table 4.Measurement of 6MWT before, after, and the difference between the post-pre blowing balloon and the control group

| Group | 6MWT | | *P* | Differenc e 6MWT |
|---|---|---|---|---|
| | Pre | Post | | |
| Blowing balloon | 264.13±66.69 | 333.87±61.45 | 0.001[b]* | 69.73±7.00 |
| Control | 236.53±37.88 | 234.00±38.44 | 0.138[b] | -2.53±5.37 |
| *P* | 0.010[a]* | <0.001[a]* | --- | <0.001[a]* |

Note: [a]Mann–Whitney test; [b]Wilcoxon signed-rank test; *statistically significant (*P*<0.05)

Examination the CAT score in the treatment group after balloon inflation exercise resulted in a statistically significant decrease of -5.07±1.62 (*P*≤0.001), and a mean decrease of -0.13±1.06 in the control group (*P*=0.643). The pre- and post- CAT score measurements and differences between the balloon bladder-treated group and the control group are shown in Table 5.

Table 5.Measurement of CAT before, after, and the difference between the post-pre blowing balloon and the control group

| Group | CAT | | *P* | Difference CAT |
|---|---|---|---|---|
| | Pre | Post | | |
| Blowing balloon | 23.33±2.29 | 18.27±1.49 | <0.001[b]* | -5.07±1.62 |
| Control | 23.47±1.19 | 23.33±1.05 | 0.643[b] | -0.13±1.06 |
| *P* | 0.843[a] | <0.001[a]* | --- | --- |

Note: [a]Mann–Whitney test; [b]Wilcoxon signed-rank test; *statistically significant (*P*<0.05)

Fewer patients in the treatment group experienced EID after balloon inflation exercise than in the control group. Three patients in the treatment group had less EID than the control group after balloon inflation exercise or post-treatment, compared to 13 patients in the control group. An unpaired difference test comparing her EID in the treatment and control groups showed a significant difference (*P*≤0.001). A measure of the pre- and post- treatment EID differences between the balloon inflation treatment group and the control group is shown in Table 6.

Table 6.Measurement of EID before, after, and the difference between the post-pre blowing balloon and the control group

| EID | Group | | *P* |
|---|---|---|---|
| | Blowing ballon | Control | |
| Pre-test | | | |
| Yes | 11 (73.3%) | 12 (80.0%) | 1.000 |
| No | 4 (26.7%) | 3 (20.0%) | |
| Post-test | | | |
| Yes | 3 (20.0%) | 13 (86.7%) | <0.001* |
| No | 12 (80.0%) | 2 (13.3%) | |

## DISCUSSION

Baseline data from 30 subjects showed that most participants were male (93.3% in the treatment group and 66.7% in the control group), consistent with previous pulmonary rehabilitation studies and the higher smoking prevalence among men.[22,23] The mean age was 64.67±9.44 years in the treatment group and 65.40±8.85 years in the control group, aligning with the typical onset of COPD in middle-aged and older adults with long-term exposure to tobacco smoke or toxic gases.

Most patients had severe (46.7%) or moderate (40.0%) Brinkman index, reflecting the dose–response relationship between smoking and COPD risk.[1] Nutritional status was generally normal in both groups, with BMI not significantly different ($P$=0.091). Stable COPD patients were receiving inhaled therapy, which may have contributed to maintaining muscle strength and reducing airway inflammation.[24–26]

All study participants in the treatment and control groups were in COPD group E, namely 15 patients (100%). These results are consistent with previous studies conducted by Raharjo and by Mentariningrum at UNS Hospital, Surakarta, where most COPD patients belonged to group E. As usual, many healthcare professionals do not understand the steps to diagnosing COPD, and many primary care services still lack spirometry tools. Lack of knowledge about COPD affected the majority of treatment-seeking patients with group E COPD.[22,23]

One of the treatments that can be done is inflatable balloon exercise, a respiratory muscle exercise to increase muscle strength and endurance, reduce tension, and improve quality of life. The benefits of pulmonary rehabilitation with balloon inflation are increased ventilation, maintenance of gas exchange, reduction of $CO_2$ accumulation, and relief of dyspnea in COPD.[21]

The study by Suharno et al showed that 4 weeks of balloon inflation and respiratory muscle exercise could increase %$FEV_1$ to 41.7±13.54, with an initial balloon inflation exercise of 40.95±15.37.[21] A study by Jun et al also showed that balloon inflation exercise over 6 weeks increased $FEV_1$ values of 1% from a starting value of 2.76±0.54 liters to 4.130±0.77 liters in smokers.[27]

A strong and prolonged expiratory breath exercise during balloon inflation exercise is accompanied by intra-abdominal muscle strength increase upward movement of the diaphragm and an increase in intrathoracic pressure.[18] It prevents air from becoming trapped in the bleb.[28] The balloon inflation motion causes airway obstruction due to airway back pressure.[29] When the balloon inflation motion opens the airway, the end tidal volume increases, thereby releasing more $CO_2$.[22,29] Respiratory muscle training by providing expiratory pressure improves inspiratory capacity and vital capacity by reducing dynamic hyperinflation.[30]

If seen from the results of the Borg scale was reduced by 2.80±0.56 in the treatment group, which was statistically significant ($P$=0.001) compared to the control group, with the Borg scale was reduced by 0.40±0.5. The results of this study are consistent with those of Mohammad et al and Kosayriyah et al showed that COPD patients who underwent respiratory muscle exercise had reduced symptoms of shortness of breath on parameters of the Borg scale.[20,31] The standard treatment with respiratory muscle exercise can reduce symptoms of shortness of breath, indicating that statistically significant compared to controls ($P$=0.01). This proves that balloon inflation exercises can stabilize and reduce symptoms of shortness of breath on the Borg scale in COPD patients.

If seen from an assessment of 6MWT, the balloon-inflation exercise study showed an increase in exercise with an increase in the 6MWT post-test scores of 69.73±7.00 in the treatment group and statistically significant ($P$=0.001) compared to the control group, which experienced a decrease in 6MWT of 2.53±5.37 m. This result is in line with research by Mulyadi et al showed that pulmonary rehabilitation might increase the exercise capacity of COPD patients, as seen in changes in the 6MWT value from 361.1±45.55 m to 408±47.09 m.[32] Research by Mentariningrum also mentions there was an increase in 6MWT of 231.33±54.28 m, and

Yekefallah's study mentions that there was an increase in 6MWT of 21.6±10.0 m.[22,31]

Minimum value clinically important difference (MCID) according to ERS for the 6MWT test is 30 m, so that the increase in 6MWT exercise capacity of 69.73±7.00 m in this study is said to be clinically significant. This proves that balloon-inflating exercise for 6 weeks has an effect on exercise capacity by increasing the 6MWT value in stable COPD patients.

Inspiratory muscle exercises target the respiratory muscles and can improve exercise tolerance. Respiratory muscle exercises also enhance respiratory function, including reducing tension, decreasing respiratory and musculoskeletal fatigue, and improving overall exercise performance.[33] Inflatable balloon exercise, including strengthening the neuromuscular and respiratory muscles, is also beneficial for improving respiratory rate.[28,29] Lastly, respiratory muscle exercise improves the exercise capacity in COPD patients, as dynamic hyperinflation may strengthen the respiratory muscles.[28]

Seen from the reduction in the CAT score in this study, with a score of 18.27±1.49 in the treatment group from the post-test, assess statistically significant ($P$<0.001) compared to the control group experienced a CAT score reduction of 0.13±1.06. This indicates that standard therapy with respiratory muscle exercise can reduce the CAT score, which shows improvement of symptoms. The results of this study are consistent with those of Mentariningrum et al showed that COPD patients who underwent respiratory muscle exercise had lower CAT scores.[22]

Respiratory muscle exercise in COPD patients increases respiratory muscle strength, increases exercise capacity, and improves stability. It can reduce symptoms of shortness of breath in COPD patients, thus improving health status, as assessed by a reduction in CAT score.[34] This suggests that balloon inflation exercise improves health outcomes in stable COPD patients.

The results of this study showed that the EID post-test was statistically significant in the treatment group compared with the control group. The results of this study were obtained after the treatment group, who experienced fewer EID, i.e., 3 patients and were statistically significant compared to the control group, which had 13 patients with EID ($P$≤0.01). This finding is consistent with a study by Suharno et al, which reported that balloon inflation exercises stabilized $SpO_2$ in COPD patients, increasing a pre-test value of 96.8±0.89 to a post-test value of 97.35±1.14.[21]

Respiratory muscle exercise improves ventilation and increases the work of the abdominal and pectoral muscles.[28] Respiratory muscle exercise reduces dynamic hyperinflation by providing expiratory pressure, thereby increasing inspiratory capacity and improving lung capacity. By improving inspiratory capacity and lung capacity, oxygen saturation can be increased.[30]

## LIMITATION

This study implemented home-based pulmonary rehabilitation, which required support and active involvement of family members to monitor exercise adherence. Blood eosinophil levels were not assessed; therefore, the therapy provided to COPD patients was not fully aligned with the 2023 GOLD guidelines.

## CONCLUSION

Balloon inflation exercise significantly improved $\%FEV_1$, Borg scale scores, 6MWT distance, CAT scores, and EID in patients with stable COPD.

## CONFLICT OF INTEREST

None.

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None.

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