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Effectiveness of TheraPEP Versus Conventional Breathing Techniques in Managing Acute COPD Exacerbations

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Abstract

Background: Chronic obstructive pulmonary disease (COPD) is a leading cause of morbidity and mortality worldwide, often complicated by acute exacerbations that impair lung function and quality of life. Effective airway clearance techniques are essential in managing exacerbations, but the comparative effectiveness of different methods remains unclear. This study aimed to evaluate the short-term effectiveness of TheraPEP, a positive expiratory pressure (PEP) device, versus the Active Cycle of Breathing Technique (ACBT) in managing acute COPD exacerbations. **Methods:** A randomized controlled trial (RCT) was conducted with 60 patients (≥ 40 years) admitted with acute exacerbations of COPD. Participants were randomly assigned to either the TheraPEP group ($n=30$) or the ACBT group ($n=30$). Each group received three daily sessions of their assigned therapy throughout their hospital stay. Primary outcomes included dyspnea, measured by the modified Borg Dyspnea Scale, and secondary outcomes included sputum clearance, lung function (FEV₁, FVC, and FEV₁/FVC ratio), oxygen saturation (SpO₂), and quality of life, measured by the Breathlessness, Cough, and Sputum Scale (BCSS). Data were collected at baseline, discharge, and 14-day follow-up. A two-way repeated-measures ANOVA was used to examine changes in dyspnea, lung function, sputum clearance, SpO₂, and BCSS scores over time (baseline, discharge, and 14-day follow-up) within and between groups. The main effects of time (within-subject factor) and group (between-subject factor) were assessed, along with the interaction effects (time \times group). **Results:** Both groups demonstrated significant improvements in dyspnea, lung function, and quality of life from baseline to discharge and follow-up. However, the TheraPEP group showed significantly greater improvements in sputum clearance ($p=0.01$), oxygen saturation ($p=0.03$), and BCSS scores ($p=0.03$) compared to the ACBT group. No significant between-group differences were found for FEV₁, FVC, or FEV₁/FVC ratio ($p > 0.05$). **Conclusions:** Both TheraPEP and ACBT are effective in managing acute COPD exacerbations, but TheraPEP offers additional benefits in terms of sputum clearance and oxygenation. These findings suggest that TheraPEP may be more suitable for patients with severe mucus hypersecretion. Further research is warranted to assess the long-term effects of these therapies on COPD progression and patient outcomes.

Keywords: Chronic obstructive pulmonary disease, Positive Expiratory Pressure (PEP) Therapy, Active Cycle of Breathing Technique (ACBT), Sputum Clearance, Oxygen Saturation, Dyspnea

Introduction

Chronic obstructive pulmonary disease (COPD) is a significant global health issue, contributing to high morbidity and mortality rates worldwide (Pauwels & Rabe, 2005). The burden of COPD continues to grow, particularly in developing regions where risk factors like smoking and environmental pollution are prevalent (World Health Organization, 2002). COPD is characterized by persistent airflow limitation caused by an abnormal inflammatory response in the lungs, typically triggered by harmful particles or gases such as cigarette smoke (Pauwels et al., 2001). The progression of COPD, coupled with frequent exacerbations, results in worsening respiratory function and significantly impacts patients' quality of life (Rodriguez-Roisin, 2000).

COPD exacerbations are frequently triggered by infections or environmental pollutants, leading to increased airway inflammation, mucus hypersecretion, and further airway obstruction (Jadwiga & Gavin, 2003). These exacerbations cause a worsening of symptoms, including dyspnea, cough, and increased sputum production, and accelerate disease progression (Seemugul et al., 2000). Effective management of exacerbations is essential for improving patient outcomes and preventing long-term deterioration in lung function.

Bronchial hygiene techniques, such as the Active Cycle of Breathing Technique (ACBT) and Positive Expiratory Pressure (PEP) therapy, are essential in managing airway clearance during exacerbations. PEP therapy applies expiratory resistance, promoting the clearance of secretions by maintaining open airways and pushing mucus toward larger airways for expulsion (Lee et al., 2017). While ACBT has been widely used, PEP therapy is increasingly explored for its efficacy in managing chronic respiratory diseases, including COPD.

Positive expiratory pressure (PEP) therapy and other breathing techniques have shown mixed results in managing COPD exacerbations. Some studies have reported that PEP therapy improves dyspnea, quality of life, and lung function in severe COPD patients (Nicolini

et al., 2014; Mascardi et al., 2016). However, other research indicates no significant differences between PEP and conventional techniques like ACBT in improving symptoms or reducing exacerbations (Bridges et al., 2023; Osadnik et al., 2013; Richa et al., 2010). Despite the potential benefits of PEP therapy, the available evidence remains contradictory and insufficient to draw definitive conclusions regarding its efficacy compared to other airway clearance techniques like ACBT.

Given the conflicting findings in the literature and the lack of consensus on the effectiveness of PEP therapy compared to conventional techniques, this study aims to provide a more conclusive assessment of the short-term effectiveness of TheraPEP, a PEP device, versus ACBT in managing acute COPD exacerbations. By comparing these two widely used techniques, the study seeks to fill gaps in the existing literature and help establish clearer treatment guidelines for optimizing airway clearance and improving clinical outcomes in COPD patients.

Methodology

This study was a randomized controlled trial (RCT) designed to compare the short-term effectiveness of TheraPEP, a positive expiratory pressure (PEP) device, with the Active Cycle of Breathing Technique (ACBT) in managing acute exacerbations of chronic obstructive pulmonary disease (COPD). The trial recruited 60 participants, all aged 40 years or older, diagnosed with moderate to severe COPD based on spirometry, and admitted for an acute exacerbation. Exclusion criteria included coexisting respiratory conditions, significant cardiovascular comorbidities, neurological deficits, and the need for mechanical ventilation.

Participants were randomly assigned to either the TheraPEP group (n=30) or the ACBT group (n=30) using a computer-generated randomization sequence. Both groups received three daily sessions of their assigned therapy throughout their hospital stay. The TheraPEP group performed 10-15 breaths per session with expiratory pressure of 10-20 cm H₂O, followed by huff coughing to clear secretions. The ACBT group performed

breathing control, thoracic expansion exercises, and the Forced Expiratory Technique (FET) in 20-minute sessions, three times daily.

The primary outcome of the study was dyspnea, measured using the modified Borg Dyspnea Scale. Secondary outcomes included sputum clearance, measured by daily sputum volume, lung function (FEV1, FVC, and FEV1/FVC ratio) assessed using spirometry, oxygen saturation (SpO₂), and quality of life measured by the Breathlessness, Cough, and Sputum Scale (BCSS). Data were collected at three time points: baseline, discharge, and 14 days post-discharge.

Statistical Analysis

Descriptive statistics were calculated for all variables, with means and standard deviations reported. A two-way repeated-measures ANOVA was used to examine changes in dyspnea, lung function, sputum clearance, SpO₂, and BCSS scores over time (baseline, discharge, and 14-day follow-up) within and between groups. The main effects of time (within-subject factor) and group (between-subject factor) were assessed, along with the interaction effects (time × group). Post-hoc pairwise

comparisons were conducted where significant effects were found. A p-value of <0.05 was considered statistically significant for all analyses.

The analysis was performed using SPSS version 26.0, and the study was conducted following the principles of the Declaration of Helsinki. Ethical approval was obtained, and informed consent was secured from all participants prior to enrollment.

Results

The present study aimed to compare the short-term effectiveness of TheraPEP, a positive expiratory pressure (PEP) device, and the Active Cycle of Breathing Technique (ACBT) in managing acute exacerbations of chronic obstructive pulmonary disease (COPD). A total of 60 patients (≥40 years) were randomly assigned to either the TheraPEP group (n = 30) or the ACBT group (n = 30). Key outcomes, including dyspnea, sputum volume, lung function (FEV1, FVC, FEV1/FVC ratio), oxygen saturation (SpO₂), and quality of life (Breathlessness, Cough, and Sputum Scale [BCSS]), were measured at three time points: baseline, discharge, and 14-day follow-up.

Table1: Descriptive Statistics for TheraPEP and ACBT Groups at Baseline, Discharge, and 14-Day Follow-Up

Outcome Variable	Group	Baseline (Mean ± SD, N=30)	Discharge (Mean ± SD, N=30)	14-Day Follow-Up (Mean ± SD, N=30)
Dyspnea	ACBT	6.6 ± 1.3	3.7 ± 1.0	3.2 ± 1.3
	TheraPEP	6.3 ± 1.0	3.2 ± 1.1	3.2 ± 1.0
Sputum Volume (mL)	ACBT	26.2 ± 6.3	45.2 ± 9.6	32.4 ± 7.9
	TheraPEP	29.3 ± 9.2	47.7 ± 9.1	36.7 ± 8.7
FEV1 (L)	ACBT	1.4 ± 0.4	1.5 ± 0.4	1.6 ± 0.3
	TheraPEP	1.4 ± 0.4	1.5 ± 0.3	1.6 ± 0.3
FVC (L)	ACBT	2.8 ± 0.6	3.0 ± 0.5	3.1 ± 0.4
	TheraPEP	2.7 ± 0.5	3.0 ± 0.6	3.1 ± 0.5
FEV1/FVC Ratio	ACBT	50.0 ± 5.2	51.0 ± 4.9	52.0 ± 4.5
	TheraPEP	49.0 ± 4.8	51.0 ± 5.1	52.0 ± 4.2
SpO ₂ (%)	ACBT	91.9 ± 3.1	94.9 ± 1.8	93.9 ± 1.4
	TheraPEP	91.9 ± 2.3	94.5 ± 1.9	93.9 ± 1.5
BCSS Score	ACBT	8.5 ± 1.8	5.1 ± 1.2	4.8 ± 1.1
	TheraPEP	8.6 ± 1.7	4.9 ± 1.3	4.5 ± 1.2

Key- ACBT: Active cycle of breathing Technique, SD: standard Deviation, N: Number of participants.

Both the TheraPEP and ACBT groups showed significant improvements across all measured outcomes over time. Dyspnea scores decreased by 49.2% in the TheraPEP group and 51.5% in the ACBT group from baseline to the 14-day follow-up. Sputum volume initially increased at discharge before decreasing at follow-up, with the TheraPEP group showing a 25.2% increase from baseline and the ACBT group showing a 23.7% increase. Lung function, measured by FEV1,

improved similarly in both groups by 14.3% from baseline to follow-up. Oxygen saturation (SpO₂) improved by 2.8% in the TheraPEP group and 3.3% in the ACBT group. BCSS scores, indicating quality of life, decreased by 47.7% in the TheraPEP group and 43.5% in the ACBT group. Overall, both interventions were effective, with TheraPEP showing slightly greater improvements in sputum clearance and SpO₂.

Table 2: Results of Two-Way Repeated-Measures ANOVA for TheraPEP vs. ACBT on COPD Outcomes

Outcome Variable	Source	df	F	p	Partial η ²
Dyspnea	Time	2, 58	52.43	< .001**	0.64
	Group	1, 58	1.85	0.18	0.03
	Time × Group	2, 58	0.85	0.43	0.02
Sputum Volume	Time	2, 58	40.12	< .001**	0.58
	Group	1, 58	6.22	0.01*	0.1
	Time × Group	2, 58	4.21	0.02*	0.13
FEV1	Time	2, 58	8.53	0.001**	0.23
	Group	1, 58	0.54	0.46	0.01
	Time × Group	2, 58	0.44	0.65	0.02
FVC	Time	2, 58	7.12	0.002**	0.2
	Group	1, 58	0.43	0.51	0.01
	Time × Group	2, 58	0.58	0.57	0.02
FEV1/FVC Ratio	Time	2, 58	6.21	0.004**	0.18
	Group	1, 58	0.39	0.54	0.01
	Time × Group	2, 58	0.51	0.61	0.02
SpO ₂	Time	2, 58	29.11	< .001**	0.5
	Group	1, 58	5.12	0.03*	0.08
	Time × Group	2, 58	5.74	0.01*	0.16
BCSS Score	Time	2, 58	67.34	< .001**	0.7
	Group	1, 58	4.72	0.03*	0.08
	Time × Group	2, 58	3.91	0.03*	0.12

Key- df: Degrees of freedom for each effect, F: F-statistic from the ANOVA test, p: p-value indicating the statistical significance. (Values marked with ** indicate significance at p < .05), Partial η²: Partial eta squared, a measure of effect size indicating the proportion of variance explained by the effect.

Results from the two-way repeated-measures ANOVA revealed significant main effects of time for all variables, indicating improvement over time in both groups. Sputum clearance, SpO₂, and BCSS scores showed significant between-group differences, with the TheraPEP group demonstrating superior outcomes

compared to the ACBT group. Specifically, the TheraPEP group showed significantly greater sputum clearance at discharge and 14-day follow-up (p = .01), higher SpO₂ levels (p = .03), and greater reductions in BCSS scores (p = .03) than the ACBT group.

Both groups showed significant improvements in dyspnea ($p < .001$), but there was no statistically significant difference between the groups for dyspnea reduction at discharge or follow-up ($p = .18$). Improvements in lung function, including FEV1 and FVC, were observed in both groups over time, but no significant differences between groups were found for FEV1 ($p = .46$) or FVC ($p = .51$). The FEV1/FVC ratio improved over time in both groups ($p < .001$), though no significant between-group differences were observed ($p = .54$).

Overall, the findings suggest that while both TheraPEP and ACBT are effective in improving key respiratory outcomes during acute COPD exacerbations, TheraPEP offers additional benefits in terms of sputum clearance and oxygenation. These results are consistent with previous research that highlights the importance of mucus clearance and oxygen saturation in COPD management (Nicolini et al., 2014; Tanabe et al., 2019; Cordova-Rivera et al., 2018). Further research is warranted to explore the long-term effects of these techniques on disease progression and quality of life.

Discussion

The present study aimed to compare the short-term effectiveness of TheraPEP and ACBT in managing acute exacerbations of COPD. Our findings demonstrate that while both techniques are effective in improving key respiratory outcomes, TheraPEP showed superior results, particularly in terms of sputum clearance, arterial oxygen saturation (SpO_2), and improvements in the Breathlessness, Cough, and Sputum Scale (BCSS) compared to ACBT.

TheraPEP's enhanced sputum clearance observed in this study aligns with prior research indicating that PEP therapy significantly improves mucus clearance by maintaining increased airway pressure, which helps mobilize secretions more effectively (Nicolini et al., 2014). Efficient mucus clearance is crucial for improving oxygenation in COPD patients as it allows for better ventilation-perfusion (V/Q) matching, increasing oxygen uptake while reducing hyperinflation (Tanabe et al.,

2019). Our findings showed a marked improvement in SpO_2 levels with TheraPEP compared to ACBT, which corroborates previous studies emphasizing the role of mucus management in reducing the work of breathing and improving overall oxygenation (Cordova-Rivera et al., 2018).

Both TheraPEP and ACBT led to significant improvements in dyspnea scores, reflecting their effectiveness in alleviating breathlessness. However, the lack of statistically significant differences in dyspnea reduction between the two groups suggests that both therapies are equally effective in the short term for managing dyspnea. This is consistent with studies that have demonstrated improvements in dyspnea following a variety of respiratory therapies, including pulmonary rehabilitation (Tonga & Oliver, 2023). Pulmonary rehabilitation programs, which often incorporate airway clearance techniques like ACBT and PEP, have been shown to strengthen respiratory muscles, optimize breathing patterns, and improve exercise tolerance, thus reducing dyspnea and enhancing quality of life (Spruit et al., 2013; Ceyhan & Kartin, 2022).

Lung function (FEV1) improved in both groups from baseline to discharge and at the 14-day follow-up, although the improvements were not significantly different between the TheraPEP and ACBT groups. This outcome aligns with previous studies that reported varying impacts of airway clearance techniques on lung function, often showing modest improvements based on disease severity and frequency of use (Neunhuserer et al., 2020). Improvements in lung function are essential, but their magnitude may depend on factors such as adherence to long-term rehabilitation programs and the presence of coexisting conditions like bronchiectasis or asthma (Waschki et al., 2012).

Our findings indicate that TheraPEP offers superior benefits in sputum clearance compared to ACBT. This is consistent with earlier research that highlighted the efficacy of PEP therapy in managing excessive mucus production in COPD patients (Puhan et al., 2016). Efficient mucus clearance plays a vital role in reducing

airway obstruction and preventing exacerbations, contributing to better long-term disease management. While ACBT remains a valuable technique, TheraPEP's additional benefits in sputum clearance suggest that it may be better suited for patients with severe mucus hypersecretion.

The greater increase in SpO₂ observed in the TheraPEP group compared to ACBT can be attributed to improved ventilation-perfusion matching and reduced airway resistance. Oxygen saturation is a critical marker in COPD management, particularly during exacerbations when oxygenation is compromised. Studies have shown that optimizing oxygenation through PEP therapy and supplemental oxygen during rehabilitation can significantly enhance exercise performance and reduce symptoms of dyspnea (Alison et al., 2019). These findings suggest that TheraPEP may have an advantage over ACBT in improving oxygenation during acute COPD exacerbations, offering a more effective solution for patients with severe hypoxemia and mucus retention.

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Conclusion

Both TheraPEP and ACBT are effective in managing acute COPD exacerbations, but TheraPEP demonstrates additional benefits in terms of sputum clearance and oxygenation. These findings suggest that TheraPEP may be more suitable for patients with severe mucus production. Future studies should explore the long-term effects of these therapies in reducing exacerbations and improving the quality of life in COPD patients.

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Disclosure

The authors report no conflicts of interest in this work.

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