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CHEST PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION WITH OSCILLATORY POSITIVE EXPIRATORY PRESSURE THERAPY VERSUS POSTURAL DRAINAGE WITH OSCILLATORY POSITIVE EXPIRATORY PRESSURE THERAPY FOR FUNCTIONAL CAPACITY, DYSPNEA, AND PEAK EXPIRATORY FLOW RATE IN STABLE CHRONIC OBSTRUCTIVE PULMONARY DISEASE: A RANDOMIZED COMPARATIVE TRIAL

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ABSTRACT

Background: Chronic obstructive pulmonary disease (COPD) is a progressive, largely preventable respiratory condition marked by persistent airflow limitation, chronic dyspnea, impaired secretion clearance, and reduced exercise capacity. Airway clearance strategies such as chest proprioceptive neuromuscular facilitation (PNF), postural drainage, and oscillatory positive expiratory pressure (OPEP) devices such as the Acapella are widely used in pulmonary rehabilitation, yet direct comparative evidence for combining chest PNF or postural drainage with an OPEP device remains limited.
Objective: To compare the effectiveness of chest PNF combined with an Acapella device against postural drainage combined with an Acapella device on functional capacity, dyspnea, peak expiratory flow rate (PEFR), and arterial oxygen saturation (SpO_2) in patients with stable COPD.
Methods: In this randomized, comparative, pre-post interventional trial, 60 patients with stable, moderate COPD were allocated by simple random (chit) sampling to two equal groups. Group A ($n = 30$) received chest PNF six days a week (twice daily) together with Acapella therapy five days a week, while Group B ($n = 30$) received postural drainage six days a week (twice daily) with the same Acapella regimen, over a one-week intervention period. Functional capacity (six-minute walk test, 6MWT), dyspnea (modified Medical Research Council [mMRC] scale), PEFR, and SpO_2 were recorded before and after intervention. Between-group differences were analyzed using the independent-samples t-test and within-group change using repeated-measures ANOVA; gender distribution was compared using the chi-square test ($\alpha = 0.05$).
Results: The two groups were comparable at baseline for age and gender ($p > 0.05$). Both groups improved significantly from pre- to post-intervention across all four outcomes ($p < 0.001$). On between-group comparison, Group A showed significantly greater post-treatment gains than Group B in PEFR (209.00 ± 37.91 vs 189.00 ± 31.44 L/min; improvement 82.67 ± 25.18 vs 69.67 ± 21.09 L/min, $p = 0.034$), SpO_2 ($96.70 \pm 1.74\%$ vs $95.83 \pm 1.49\%$, $p = 0.043$), and mMRC dyspnea score (0.80 ± 0.71 vs 1.47 ± 0.63, $p < 0.001$). Improvement in 6MWT distance was significant within both groups but did not differ significantly between them ($p = 0.398$).
Conclusion: Both chest PNF with Acapella and postural drainage with Acapella produced clinically meaningful improvement in pulmonary and functional outcomes in stable COPD. Chest PNF combined with Acapella conferred an additional advantage over postural drainage with Acapella in reducing dyspnea and improving expiratory flow and oxygen saturation, suggesting it may be the preferable adjunct in short-term pulmonary rehabilitation protocols.

KEYWORDS: Chronic obstructive pulmonary disease; Chest proprioceptive neuromuscular facilitation; Postural drainage; Acapella; Oscillatory positive expiratory pressure; Peak expiratory flow rate; Six-minute walk test; Pulmonary rehabilitation

1. INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a common, preventable, and treatable condition characterized by persistent respiratory symptoms and progressive airflow limitation arising from chronic exposure to noxious particles or gases, most commonly cigarette smoke [1,3]. It ranks among the leading causes of morbidity and mortality worldwide and imposes a substantial burden on health systems, and the World Health Organization projects that it will remain among the foremost causes of death and disability in the coming decades [1]. The disease is driven by chronic airway and parenchymal inflammation, protease–antiprotease and oxidant–antioxidant imbalance, and structural remodeling of the small airways, which together produce expiratory flow limitation, dynamic hyperinflation, and air trapping [1,4]. Clinically, patients present with a chronic productive cough, progressive exertional dyspnea, wheeze, and reduced exercise tolerance, with systemic manifestations such as skeletal muscle dysfunction, weight loss, and psychological distress becoming more prominent as severity advances [1].

Pulmonary rehabilitation, and airway clearance therapy in particular, forms a cornerstone of comprehensive COPD management. Retained secretions and respiratory muscle inefficiency contribute directly to airflow obstruction, dyspnea, and deconditioning, so techniques that mobilize secretions and improve ventilatory mechanics are central to symptom control and functional recovery. Chest proprioceptive neuromuscular facilitation (PNF) is a manual therapy technique that applies patterned resistance and stretch to the thoracic cage during breathing, stimulating proprioceptive afferents to enhance respiratory muscle recruitment, chest wall mobility, and depth of ventilation [1]. Because the intercostal muscles contain a higher proportion of fatigue-prone fast-twitch fibers, patients with COPD are particularly susceptible to inspiratory muscle fatigue, and facilitation techniques that improve neuromuscular efficiency may therefore offer a physiological advantage in this population.

Postural drainage remains a conventional and widely practiced airway clearance technique that uses gravity to mobilize secretions from specific bronchopulmonary segments toward the central airways for expectoration. While effective for secretion mobilization, it does not directly engage the respiratory musculature or enhance ventilatory drive. Oscillatory positive expiratory pressure (OPEP) devices, of which the Acapella is a widely used example, combine expiratory resistance with airway oscillation to reduce mucus viscoelasticity and splint the airways open during exhalation, and are frequently used as an adjunct to other airway clearance approaches because they are self-administered, gravity-independent, and applicable across a range of disease severities.

Although chest PNF, postural drainage, and Acapella therapy have each demonstrated benefit individually, comparative evidence examining Acapella therapy paired with chest PNF against Acapella therapy paired with postural drainage in the same cohort of COPD patients is scarce. Establishing which combination confers greater benefit for functional capacity, dyspnea, and expiratory flow would help clarify the choice of adjunct airway clearance technique in clinical pulmonary rehabilitation. The present study was therefore designed to compare these two combined interventions.

1.1 Objectives

1. To determine the effect of chest PNF combined with Acapella therapy on functional capacity, dyspnea, and PEFR in patients with COPD.
2. To determine the effect of postural drainage combined with Acapella therapy on the same outcomes.
3. To compare the two combined interventions with respect to functional capacity (6MWT), dyspnea (mMRC scale), PEFR, and arterial oxygen saturation.

1.2 Hypotheses

Null hypothesis (H_0): There is no significant difference between chest PNF with Acapella and postural drainage with Acapella in improving functional capacity, dyspnea, and PEFR in patients with COPD. Alternative hypothesis (H_1): Chest PNF with Acapella produces significantly greater improvement in these outcomes than postural drainage with Acapella.

2. MATERIALS AND METHODS

2.1 Study Design and Setting

A comparative, randomized, pre-post interventional study was conducted in the inpatient and outpatient departments of General Medicine, Respiratory Medicine, and Pulmonary Medicine at Kempegowda Institute of Medical Sciences and Hospital, Bengaluru, India, over a study period of 12 months.

2.2 Participants

Inclusion criteria: patients of either sex, aged 18–80 years, with a clinical diagnosis of moderate COPD.

Exclusion criteria: history of pulmonary tuberculosis, severe nausea, pneumothorax, haemothorax, pulmonary embolism, pleural effusion, congestive heart failure, rib fracture, acute myocardial infarction, severe hypoxemia or acute respiratory failure, active infection, or inability to comprehend or perform the study procedures.

2.3 Sample Size

Sample size was estimated from pilot data using the standard two-proportion formula, $n = (Z\alpha + Z\beta)^2 (p_1q_1 + p_2q_2) / (p_2 - p_1)^2$, which yielded a minimum requirement of approximately 28 participants per group; this was rounded up to 30 per group, giving a total sample of 60 participants.

2.4 Randomization

Eligible participants were allocated to Group A or Group B using simple random sampling by the chit method: sixty numbered chits (30 designated to each group) were placed in a box, and each participant drew one chit without replacement to determine group allocation.

2.5 Interventions

Group A (Chest PNF + Acapella): Participants received chest PNF six days a week, twice daily — ten breaths per set with a one-minute rest, repeated ten times per session — using position- and segment-specific manual resistance (anterior basal, lateral basal, posterior basal, apical, and middle-lobe/lingular techniques) applied during inspiration. Acapella therapy was additionally performed five days a week, twice daily, for 15–20 minutes per session, comprising ten breaths through the device followed by two to three huff coughs to mobilize secretions.

Group B (Postural Drainage + Acapella): Participants were positioned according to the bronchopulmonary segment requiring drainage (e.g., sitting for apical segments, side-lying or prone with head-down tilt for basal segments), maintaining each position for approximately three minutes, six days a week, twice daily for 15–20 minutes per session. The same Acapella regimen described for Group A was administered five days a week.

All sessions were supervised, and the total intervention period was one week, with written informed consent obtained from all participants prior to enrolment and treatment provided free of cost.

2.6 Outcome Measures

Functional capacity was assessed using the six-minute walk test (6MWT), performed on a level 30-metre corridor in accordance with American Thoracic Society guidelines. Dyspnea was graded using the modified Medical Research Council (mMRC) scale (0–5). Peak expiratory flow rate (PEFR) was measured with a Wright's peak flow meter, and arterial oxygen saturation (SpO_2) was measured by pulse oximetry. All outcomes were recorded at baseline (day 1) and at the end of the one-week intervention.

2.7 Statistical Analysis

Data were analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables are expressed as mean ± standard deviation. Normality was assessed with the Shapiro–Wilk test. Between-group comparisons were performed using the independent-samples t-test (age comparison used the Mann–Whitney U test), within-group pre-post change was assessed with repeated-measures ANOVA, and gender distribution was compared using the chi-square test. Statistical significance was set at $p < 0.05$.

3. RESULTS

Sixty participants (30 per group) completed the study. Baseline demographic comparison showed no significant between-group difference in age or gender distribution, confirming adequate group homogeneity prior to intervention (Table 1, Table 2).

Table 1. Comparison of mean age between groups

Variable	Group A (Chest PNF + Acapella)	Group B (Postural Drainage + Acapella)	Test statistic	p-value
Age, years (mean ± SD)	48.63 ± 13.88	51.50 ± 14.86	t = 0.77 (M-W U)	0.443

Table 2. Gender distribution between groups

Gender	Group A, n (%)	Group B, n (%)	χ^2 value	p-value
Male	17 (56.7%)	17 (56.7%)	0.00	1.000
Female	13 (43.3%)	13 (43.3%)		

Both groups demonstrated statistically significant within-group improvement across all four outcome measures following intervention (repeated-measures ANOVA, $p < 0.001$ for all comparisons). Between-group analysis showed a significant post-treatment advantage for Group A in PEFR, SpO_2, and mMRC dyspnea score, while improvement in 6MWT distance was comparable between groups (Tables 3–6).

Table 3. Within- and between-group comparison of Peak Expiratory Flow Rate (PEFR, L/min)

Time point	Group A	Group B	t-value	p-value
Pre-treatment	126.33 ± 24.42	119.33 ± 21.64	−1.17	0.245
Post-treatment	209.00 ± 37.91	189.00 ± 31.44	−2.22	0.030*
Improvement (Δ)	82.67 ± 25.18	69.67 ± 21.09	−2.17	0.034*
Within-group F (ANOVA)	323.35, p < 0.001*	327.41, p < 0.001*		
% improvement	65.44%	58.38%		

Table 4. Within- and between-group comparison of arterial oxygen saturation (SpO_2, %)

Time point	Group A	Group B	t-value	p-value
Pre-treatment	93.47 ± 1.91	92.50 ± 1.91	−1.96	0.054

Time point	Group A	Group B	t-value	p-value
Post-treatment	96.70 ± 1.74	95.83 ± 1.49	−2.07	0.043*
Improvement (Δ)	3.23 ± –	3.33 ± –	0.19	0.854
Within-group F (ANOVA)	68.20, p < 0.001*	80.11, p < 0.001*		
% improvement	3.46%	3.60%		

Table 5. Within- and between-group comparison of mMRC Dyspnea Scale score

Time point	Group A	Group B	t-value	p-value
Pre-treatment	2.43 ± 0.77	2.47 ± 0.63	0.18	0.855
Post-treatment	0.80 ± 0.71	1.47 ± 0.63	3.84	< 0.001*
Improvement (Δ)	1.63 ± 0.81	1.00 ± 0.45	–	< 0.001*
Within-group F (ANOVA)	122.37, p < 0.001*	145.00, p < 0.001*		

Table 6. Within- and between-group comparison of Six-Minute Walk Test distance (m)

Time point	Group A	Group B	t-value	p-value
Pre-treatment	322.33 ± 18.70	311.67 ± 18.77	−2.21	0.031*
Post-treatment	343.00 ± 21.52	335.33 ± 19.07	−1.46	0.150
Improvement (Δ)	20.67 ± 15.07	23.67 ± 12.03	–	0.398
Within-group F (ANOVA)	56.41, p < 0.001*	116.12, p < 0.001*		

Table 7. Summary of within-group and between-group findings across outcomes

Outcome	Group A ANOVA p	Group B ANOVA p	Post-test t-test p	Improvement-score p	Interpretation
6MWT	< 0.001*	< 0.001*	0.150	0.398	Both groups improved; no between-group superiority
mMRC dyspnea	< 0.001*	< 0.001*	< 0.001*	< 0.001*	Significant advantage for Group A
PEFR	< 0.001*	< 0.001*	0.030*	0.034*	Significant advantage for Group A
SpO_2	< 0.001*	< 0.001*	0.043*	0.854	Post-test favours Group A; improvement score not significant

*Statistically significant at $p < 0.05$.

4. DISCUSSION

This study compared the effects of chest PNF combined with Acapella therapy against postural drainage combined with Acapella therapy in 60 patients with stable, moderate COPD. Both interventions produced statistically significant within-group improvement across all measured outcomes — PEFR, SpO_2, dyspnea, and functional capacity — confirming that both are clinically useful adjuncts to pulmonary rehabilitation over a short intervention period. Baseline comparability in age and gender between groups strengthens confidence that the differential outcomes reflect genuine treatment effects rather than demographic confounding.

The greater post-treatment improvement in SpO_2 observed in the chest PNF group is consistent with the proposed mechanism by which facilitation techniques enhance inspiratory muscle recruitment and chest wall mobility, thereby improving alveolar ventilation and ventilation–perfusion matching. Postural drainage, while effective at mobilizing secretions gravitationally, does not directly engage respiratory muscle performance, which may explain its comparatively smaller gain in oxygenation.

Dyspnea reduction, measured by the mMRC scale, was significantly greater in the chest PNF group. Because dyspnea in COPD arises largely from dynamic hyperinflation, respiratory muscle fatigue, and increased work of breathing, a technique that improves respiratory muscle coordination and chest wall excursion would be expected to lower the

perceived effort of breathing more effectively than a purely gravity-based clearance method, particularly when both groups also received Acapella therapy to address the secretion-clearance component of dyspnea.
Improvement in PEFR was significant in both groups but numerically and statistically greater in the chest PNF group, supporting the premise that enhanced thoracic mobility and respiratory muscle facilitation translate into more efficient expiratory airflow generation, complementing the airway-oscillation effect of the Acapella device.
In contrast, functional exercise capacity assessed by the 6MWT improved significantly within both groups without a significant between-group difference. This finding is plausible given that walking distance in COPD depends on multiple determinants beyond pulmonary mechanics — including peripheral muscle strength, cardiovascular conditioning, motivation, and nutritional status — so a one-week intervention difference in respiratory technique may not yet translate into a measurable divergence in walking performance.
These findings align with existing literature on chest PNF and airway clearance in COPD. Andhe and Peteru's narrative review concluded that chest PNF is an effective adjunct within pulmonary rehabilitation because it enhances respiratory muscle performance and chest wall mobility [31], consistent with the superior dyspnea and PEFR outcomes observed for Group A here. Similarly, Prajapati, Pawaria and Reylach reported that respiratory PNF produced significantly greater gains in PEFR, exercise tolerance, and dyspnea than segmental breathing in COPD patients [34], mirroring the comparative advantage of chest PNF found in the present trial. Mistry and Kamble demonstrated immediate improvements in PEFR, chest expansion, and respiratory rate following chest PNF using an intercostal stretch technique in mild-to-moderate COPD [38], offering a plausible physiological explanation for the PEFR gains recorded in Group A. Liu et al. showed that combining PNF stretching with aerobic training improved FEV_1, FVC, and peak expiratory flow relative to aerobic training alone [39], while Malpani, Paul and Thakre found that respiratory PNF produced greater improvement in chest expansion than chest wall mobilization [52] — both consistent with the mechanistic rationale that proprioceptive facilitation enhances thoracic and ventilatory performance.
The superior post-intervention oxygen saturation observed with chest PNF is also broadly consistent with Zwoliński et al., who reported greater gains in oxygen saturation, respiratory rate, and lung compliance with PNF-augmented chest physiotherapy compared with chest physiotherapy alone in a mechanically ventilated cohort [35]; although that population differs substantially from stable outpatients with COPD, the underlying respiratory-mechanical rationale is comparable.
The benefit of Acapella therapy itself, present in both arms of this study, is supported by Alghamdi et al.'s randomized trial of OPEP therapy in stable COPD, which demonstrated improvements in airway clearance, exercise capacity, and dyspnea [37], and by Coppolo et al.'s narrative review describing how OPEP devices reduce mucus viscosity and prevent airway collapse to improve ventilation [15]. Çevik and Arık similarly found that postural drainage combined with deep breathing and coughing improved oxygen saturation and pulmonary function in COPD [40], corroborating the within-group gains observed for Group B in the present study, albeit of smaller magnitude than those achieved with chest PNF.
Taken together, these findings suggest that while both postural drainage and chest PNF are valuable when paired with an OPEP device such as the Acapella, the proprioceptive facilitation provided by chest PNF confers an additional physiological advantage — particularly for dyspnea relief and expiratory flow — that may make it the preferable adjunct where clinical resources allow supervised manual technique delivery.

4.1 LIMITATIONS
This study has several limitations. First, the sample of 60 participants, while adequate to detect within-group change, limits statistical power for more subtle between-group comparisons and constrains generalizability. Second, the intervention period was restricted to one week; longer-term follow-up would be needed to determine whether the observed gains are sustained. Third, the study was conducted at a single tertiary-care centre, which may limit external validity across other clinical settings and populations. Fourth, comprehensive spirometric indices (FEV_1, FVC, FEV_1/FVC) and disease-specific quality-of-life instruments such as the COPD Assessment Test or St George's Respiratory Questionnaire were not included, which would have allowed a more complete evaluation of pulmonary status. Fifth, because both groups received Acapella therapy, the independent contribution of Acapella alone could not be isolated in the absence of a control arm receiving no adjunct OPEP therapy. Finally, adherence and effort outside supervised sessions could not be fully controlled. Future trials with larger samples, longer intervention and follow-up periods, multi-centre recruitment, and an OPEP-only control arm would help confirm and extend these findings.

5. CONCLUSION
In patients with stable COPD, both chest PNF combined with Acapella therapy and postural drainage combined with Acapella therapy produced statistically significant improvement in peak expiratory flow rate, arterial oxygen saturation, dyspnea, and functional capacity over a one-week intervention. However, chest PNF with Acapella conferred a significantly greater benefit than postural drainage with Acapella for expiratory flow, oxygenation, and dyspnea reduction, while both interventions produced comparable gains in walking distance. These findings support chest PNF as an effective, and potentially preferable, adjunct to OPEP-based airway clearance in the short-term pulmonary rehabilitation of patients with stable COPD, while underscoring the need for larger, longer-duration trials to confirm durability of effect.

DECLARATIONS
Ethical Approval: The study was conducted with institutional ethical clearance and written informed consent obtained from all participants prior to enrolment. [Insert institutional ethics committee name and approval number.]
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Data Availability: The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.
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