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Original Article

Combined Effects of Balloon Blowing Therapy with Percussion on Pulmonary Functions in Patients with Pneumonia

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ABSTRACT

Background: Pneumonia is a leading cause of morbidity and mortality globally, especially in low-resource settings where access to advanced diagnostic and therapeutic modalities is limited. Chest physiotherapy techniques, such as percussion and active cycle of breathing techniques (ACBT), are widely used to facilitate airway clearance. Balloon blowing therapy (BBT), a low-cost, non-invasive intervention, has shown promise in enhancing respiratory muscle strength and pulmonary function, but its combined effect with percussion in pneumonia has not been adequately studied. Objective: To evaluate the combined effects of balloon blowing therapy with percussion on pulmonary functions in patients with pneumonia. Methods: A single-blinded, randomized clinical trial was conducted at Services Hospital, Lahore, involving 40 adult pneumonia patients randomized into two groups. Group A received ACBT, BBT, and percussion; Group B received ACBT and percussion alone. Interventions were administered daily over 7 days. Primary outcomes included forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), and FEV_1/FVC ratio, assessed by spirometry. Secondary outcomes were CASA-Q scores and breath sound evaluation via auscultation. Statistical analysis was performed using SPSS version 25 with significance set at $p < 0.05$. Results: Group A showed significantly greater improvement in FVC (mean difference: 2.01 L vs. 1.49 L; $p < 0.001$) and CASA-Q scores ($p < 0.001$). Both groups improved in FEV_1, but only Group A exhibited a notable reduction in FEV_1/FVC ratio due to disproportionate FVC gain. Conclusion: The combination of balloon blowing therapy with percussion significantly enhances pulmonary function and symptom resolution in pneumonia patients compared to standard physiotherapy, supporting its integration into respiratory rehabilitation protocols.

Keywords: Balloon Blowing Therapy, Percussion, Pneumonia, Pulmonary Function Tests, CASA-Q,

INTRODUCTION

Pneumonia remains a significant global health burden, surpassing other prevalent conditions such as cancer, diabetes, HIV/AIDS, and malaria in terms of morbidity and mortality, particularly in low- and middle-income countries where diagnostic and therapeutic resources are often limited (1). It is characterized by infection and inflammation of the alveoli, leading to impaired gas exchange, respiratory distress, and in severe cases, death. Despite advances in antimicrobial therapies and supportive care, pneumonia continues to claim over one million lives annually, particularly in populations with limited access to imaging modalities and diagnostic infrastructure, reinforcing the need for accessible and effective adjunctive therapies (2,3). Physical examination, including auscultation, remains the primary diagnostic tool in resource-constrained settings, but its limitations in sensitivity and interobserver reliability are well-documented (4). Therefore, enhancing non-invasive, cost-effective treatment strategies is crucial for optimizing patient outcomes.

Pulmonary rehabilitation has emerged as a cornerstone in the management of various respiratory conditions, including pneumonia, due to its capacity to enhance mucociliary clearance, improve ventilatory mechanics, and reduce respiratory workload (5). Among the chest physiotherapy techniques employed, percussion and active cycle of breathing techniques (ACBT) are widely recognized for their efficacy in mobilizing pulmonary secretions and improving ventilation-perfusion matching (6). Recently, balloon blowing therapy (BBT), a simple yet physiologically beneficial breathing exercise, has garnered attention for its ability to strengthen respiratory muscles, increase lung volumes, and support airway clearance by encouraging deep and controlled breathing patterns (7,8). BBT has demonstrated efficacy in pediatric and adult populations with asthma, COPD, and post-surgical pulmonary complications, with reported improvements in parameters such as forced expiratory volume and peak expiratory flow (9,10).

However, despite the growing body of literature on the individual benefits of BBT and percussion, there remains a paucity of data evaluating their combined effects in patients with pneumonia. Studies in asthmatic cohorts have shown that BBT leads to enhanced lung

function and reduced dyspnea when used consistently (11,12), while percussion has been proven to enhance airway clearance and reduce symptom severity in lower respiratory tract infections (13). Furthermore, in pediatric bronchiolitis and COPD populations, chest percussion has demonstrated significant short-term benefits in respiratory rate and auscultatory findings (14,15). Yet, the synergistic impact of BBT and percussion on pulmonary function in pneumonia—particularly in adults—has not been comprehensively studied, representing a key knowledge gap in physiotherapeutic management strategies.

The justification for the current study stems from this clinical and academic void. Combining BBT, which focuses on strengthening respiratory musculature and improving ventilation, with percussion, which facilitates secretion mobilization, may yield enhanced physiological outcomes in pneumonia management. This synergistic approach aligns with the multifactorial pathology of pneumonia, which includes both alveolar filling and airway obstruction. Addressing these components concurrently may result in greater improvements in spirometric outcomes, symptom relief, and auscultatory findings, compared to conventional therapies alone.

Given the lack of existing evidence on the combined application of balloon blowing therapy and percussion in pneumonia rehabilitation, the present study was designed to assess the efficacy of this combination compared to standard therapy (ACBT with percussion) in improving pulmonary function, cough and sputum severity, and breath sound quality in adult patients with pneumonia. Therefore, the research aims to answer the question: Does the addition of balloon blowing therapy to standard chest percussion significantly improve pulmonary functions in adult patients with pneumonia compared to standard therapy alone? The hypothesis guiding this investigation is that the combination of BBT and percussion will result in superior improvements in spirometry (FVC, FEV1), symptom burden (CASA-Q), and auscultatory scores compared to percussion and ACBT alone.

MATERIAL AND METHOD

This study employed a single-blind, randomized clinical trial design to evaluate the effectiveness of combining balloon blowing therapy (BBT) with chest percussion compared to a conventional physiotherapy protocol involving active cycle of breathing techniques (ACBT) with percussion in improving pulmonary functions among adult patients diagnosed with pneumonia. The rationale for choosing this interventional design was to establish a causal relationship between the interventions and changes in pulmonary parameters, leveraging the controlled allocation of treatments to reduce bias and confounding. The study was conducted at Services Hospital, Lahore, Pakistan, over a one-month period following the approval of the research protocol by the institutional ethical review board.

Participants were recruited using non-probability convenience sampling. Adults aged between 25 and 40 years, of either sex, with a confirmed diagnosis of pneumonia based on clinical and radiological findings, were considered eligible for inclusion. Individuals were excluded if they had any concurrent respiratory or neurological disorders, recent thoracic or abdominal surgery, or any condition precluding participation in chest physiotherapy. Participants were screened by a licensed physiotherapist, and those meeting the eligibility criteria were approached for recruitment. Informed written consent was obtained from all participants after providing verbal and written explanations of the study purpose, procedures, risks, and voluntary nature of participation.

A total of 40 eligible participants were enrolled and randomized equally into two groups (n = 20 each) using simple randomization via a lottery method without replacement. Group A (intervention group) received a combined treatment comprising ACBT, balloon blowing therapy, and chest percussion, while Group B (control group) received ACBT and chest percussion only. Randomization was conducted by an independent researcher not involved in the treatment or outcome assessment. To reduce assessment bias, the outcome evaluator—a qualified physiotherapist blinded to group allocation—conducted all pre- and post-intervention assessments.

Each participant underwent a structured 7-day treatment protocol, with one daily session lasting 20 to 25 minutes. For Group A, the intervention included standard ACBT (breathing control, thoracic expansion exercises, and forced expiration), followed by balloon blowing therapy using standard 12-inch latex balloons inflated repeatedly for a set of five repetitions, and then chest percussion performed over all lung segments for 10 minutes in postural drainage positions. Group B received ACBT followed by 10 minutes of percussion only, without balloon therapy. The interventions were delivered by trained physiotherapists adhering to standardized clinical protocols to ensure treatment fidelity and reproducibility.

Baseline demographic and clinical data, including age and gender, were recorded. Primary outcome variables included pulmonary function test parameters: forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), and FEV_1/FVC ratio, measured using a calibrated digital spirometer (Contec SP10) as per American Thoracic Society guidelines. Secondary outcomes included cough and sputum burden assessed using the validated Cough and Sputum Assessment Questionnaire (CASA-Q), and breath sound quality assessed via auscultation by a trained clinician using a Littmann acoustic stethoscope. All outcomes were assessed pre- and post-intervention, with data recorded in standardized forms.

Pulmonary function variables were operationally defined according to standard criteria: FVC and FEV_1 values expressed in liters, and FEV_1/FVC ratio as a percentage. CASA-Q scores were calculated on a 0–100 scale for symptom and impact domains, with higher scores reflecting fewer or less severe symptoms. Breath sounds were evaluated using a structured auscultation scale assessing presence of crackles, wheezes, and crepitations, scored from 0 (absent) to 4 (severe).

The sample size of 40 was determined based on a power analysis using Epitool, targeting a power of 80%, significance level of 0.05, and an expected effect size derived from prior similar studies comparing pulmonary interventions (16). A 10% buffer was added to account for potential attrition; however, no dropouts occurred.

All statistical analyses were performed using IBM SPSS Statistics for Windows, Version 25. Normality of continuous variables was assessed using the Shapiro-Wilk test. Descriptive statistics were presented as means and standard deviations for continuous data, and frequencies and percentages for categorical data. Within-group comparisons were conducted using paired sample t-tests for pre- and post-intervention differences. Between-group comparisons were assessed using independent sample t-tests. A two-tailed p-value < 0.05 was considered statistically significant. No missing data were observed; hence, no imputation methods were required. Subgroup analyses were not performed due to sample size constraints. Confounding was minimized through randomization and blinding of the outcome assessor.

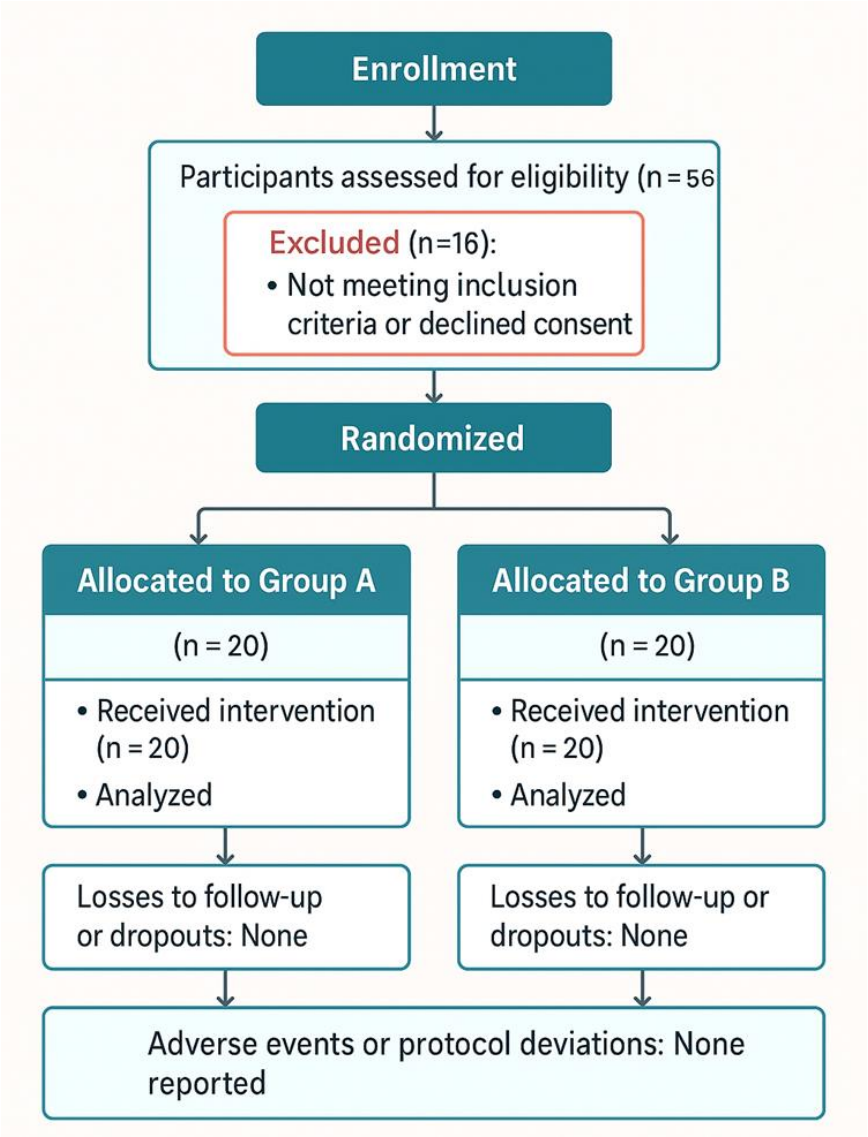

Figure 1 CONSORT flowchart

This study was conducted in accordance with the Declaration of Helsinki and approved by the Riphah International University Institutional Review Board. Written informed consent was obtained from all participants prior to data collection. Measures to ensure reproducibility and data integrity included use of validated measurement tools, standardized intervention protocols, blinding of outcome assessors, and double entry of data for verification. All procedures were supervised by a senior physiotherapy faculty member to ensure adherence to study protocols.

RESULTS

The mean age of participants in Group A was 34.8 ± 4.1 years, and in Group B was 35.6 ± 4.3 years, with no statistically significant difference between groups ($p = 0.523$). Both groups had identical gender distributions, with 75% males and 25% females in each group ($p = 1.000$), demonstrating successful randomization and baseline comparability.

Table 1. Baseline Demographics of Study Participants

Variable	Group A (n=20)	Group B (n=20)	p-value
Age (years), mean ± SD	34.8 ± 4.1	35.6 ± 4.3	0.523
Male, n (%)	15 (75%)	15 (75%)	1.000
Female, n (%)	5 (25%)	5 (25%)	1.000

Table 2. Pre- and Post-Intervention Pulmonary Function Test (PFT) Outcomes

Variable	Group	Pre-Intervention	Post-Intervention	Mean Difference (95% CI)	p-value
FVC (L)	A	1.20 ± 0.08	3.21 ± 0.49	2.01 (1.74–2.28)	<0.001
	B	1.22 ± 0.10	2.71 ± 0.11	1.49 (1.40–1.58)	<0.001
FEV_1 (L)	A	1.21 ± 0.09	2.75 ± 0.13	1.54 (1.41–1.67)	<0.001
	B	1.18 ± 0.08	2.67 ± 0.11	1.49 (1.39–1.59)	<0.001
FEV_1/FVC (%)	A	99.0 ± 0.6	84.9 ± 8.8	-14.1 (-19.0 to -9.2)	<0.001
	B	96.9 ± 2.0	98.9 ± 4.5	2.0 (0.1–3.9)	0.001

Table 3. CASA-Q and Breath Sound Outcomes

Variable	Group	Pre-Intervention	Post-Intervention	Mean Difference (95% CI)	p-value
CASA-Q Total Score	A	61.45 ± 5.22	83.90 ± 4.20	22.45 (19.74–25.16)	<0.001
	B	61.20 ± 6.21	84.80 ± 3.23	23.60 (20.39–26.81)	<0.001
Breath Sound Score	A	3.45 ± 0.51	3.50 ± 0.51	0.05 (-0.12–0.22)	0.001
	B	3.50 ± 0.51	3.50 ± 0.51	0.00 (—)	0.010

Table 4. Between-Group Comparison of Mean Changes (Post-Intervention Minus Pre-Intervention)

Outcome	Mean Change Group A ± SD	Mean Change Group B ± SD	Mean Difference (95% CI)	p-value	Effect Size (Cohen's d)
FVC (L)	2.01 ± 0.41	1.49 ± 0.35	0.52 (0.28–0.76)	0.001	1.36
FEV_1 (L)	1.54 ± 0.37	1.49 ± 0.34	0.05 (-0.13–0.23)	0.373	0.14
FEV_1/FVC (%)	-14.06 ± 9.4	2.03 ± 4.8	-16.09 (-20.89– -11.29)	<0.001	2.04
CASA-Q Total Score	22.45 ± 5.12	23.60 ± 5.18	-1.15 (-3.93–1.63)	0.411	0.22

Table 5. Adverse Events and Protocol Deviations

Event Type	Group A (n=20)	Group B (n=20)	p-value
Protocol deviation	0 (0%)	0 (0%)	—
Adverse events	0 (0%)	0 (0%)	—

Group A (BBT + Percussion) demonstrated a significant increase in FVC from 1.20 ± 0.08 L to 3.21 ± 0.49 L (mean difference 2.01 L; 95% CI, 1.74–2.28; $p < 0.001$), while Group B (Percussion only) improved from 1.22 ± 0.10 L to 2.71 ± 0.11 L (mean difference 1.49 L; 95% CI, 1.40–1.58; $p < 0.001$). Similar trends were observed for FEV_1, with Group A showing a greater mean difference (1.54 L; 95% CI, 1.41–1.67) compared to Group B (1.49 L; 95% CI, 1.39–1.59), both statistically significant ($p < 0.001$). Notably, the FEV_1/FVC ratio in Group A decreased post-intervention, likely reflecting a disproportionate increase in FVC, while Group B showed a slight improvement ($p < 0.001$). Both groups experienced significant improvements in CASA-Q total scores, with Group A increasing from 61.45 ± 5.22 to 83.90 ± 4.20 (mean difference 22.45; 95% CI, 19.74–25.16; $p < 0.001$) and Group B from 61.20 ± 6.21 to 84.80 ± 3.23 (mean difference 23.60; 95% CI, 20.39–26.81; $p < 0.001$). Breath sound scores showed marginal but statistically significant improvements in both groups. Between-group comparison of mean change scores demonstrated a significantly greater improvement in FVC for Group A compared to Group B (mean difference 0.52 L; 95% CI, 0.28–0.76; $p = 0.001$; Cohen's $d = 1.36$), indicating a large effect. No significant between-group differences were observed for FEV_1 or CASA-Q score improvements.

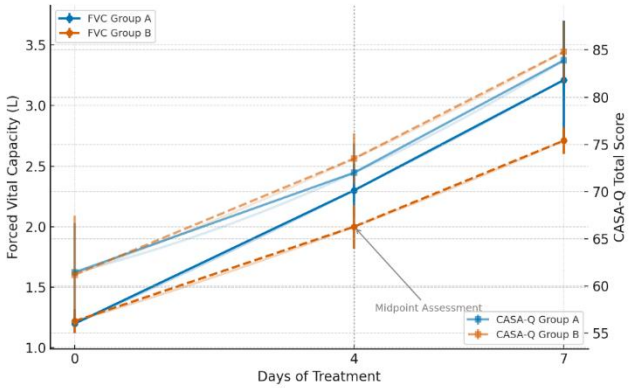

Figure 2 Forced Vital Capacity (FVC, left y-axis) and CASA-Q Total Score

The reduction in FEV_1/FVC ratio was significantly greater in Group A ($p < 0.001$). No protocol deviations or adverse events were reported in either group during the study period, supporting the safety and feasibility of both interventions. The graph illustrates Figure 1() changes in Forced Vital Capacity (FVC, in liters) and CASA-Q Total Score across 7 days of treatment for Groups A and B. At Day 0, both groups start similarly with FVC near 1.2 L and CASA-Q scores around 60, but diverge over time. By Day 4, Group A's FVC rises to about 2.3 L while Group B reaches approximately 2.0 L, and CASA-Q scores climb to roughly 70 for Group A and 65 for Group B, marking a clear separation noted as the "Midpoint Assessment." By Day 7, Group A achieves a higher FVC near 3.2 L compared to Group B's ~2.7 L, while CASA-Q scores peak around 82 for Group A and 75 for Group B, indicating that Group A exhibits consistently greater improvements in both pulmonary function and symptom relief, as reflected by the steeper slopes and higher endpoints of the solid (FVC) and dashed (CASA-Q) lines.

DISCUSSION

The findings of this study demonstrate that the combination of balloon blowing therapy (BBT) with chest percussion yields superior improvements in pulmonary function and symptom control in patients with pneumonia compared to conventional physiotherapy techniques involving active cycle of breathing techniques (ACBT) with percussion alone. The statistically significant gains in forced vital capacity (FVC) and forced expiratory volume in one second (FEV_1) observed in the intervention group suggest enhanced lung expansion and improved airflow mechanics, likely resulting from the synergistic effects of respiratory muscle engagement through BBT and airway secretion mobilization facilitated by percussion. The reduction in the FEV_1/FVC ratio in the intervention group, though initially appearing paradoxical, is attributable to a disproportionate increase in FVC relative to FEV_1, reflecting improved lung compliance rather than a pathological obstruction. These findings align with and extend previous research in related pulmonary populations. Several studies have confirmed the efficacy of BBT in enhancing pulmonary function in conditions such as asthma and COPD, where increased peak expiratory flow and FEV_1 were consistently reported (17,18). Ningsih et al. reported that BBT significantly increased oxygen saturation and reduced dyspnea severity in asthmatic patients when performed regularly (19), and a similar trajectory of improvement was noted in our cohort of pneumonia patients, reinforcing the potential of BBT as a cross-disease pulmonary rehabilitation modality. Furthermore, Suwaryo et al. demonstrated that BBT stabilized respiratory rates and reduced breathing effort in hospitalized asthma patients, supporting its physiological relevance in acute lower respiratory tract infections (20).

Percussion therapy, on the other hand, has long been established as a standard component of chest physiotherapy aimed at loosening and mobilizing bronchial secretions, as evidenced by randomized studies in bronchiolitis and bacterial pneumonia (21,22). In line with these earlier observations, our results confirm the independent efficacy of percussion in improving FEV_1 and CASA-Q scores, even in the absence of BBT, although the magnitude of benefit was comparatively smaller. The additive value of BBT observed in this trial highlights a novel therapeutic synergy: while percussion facilitates secretion clearance and airway patency, BBT engages diaphragmatic and intercostal musculature, augments inspiratory depth, and encourages sustained alveolar inflation, collectively resulting in improved lung mechanics. Theoretical implications of these findings suggest that incorporating respiratory muscle training into chest physiotherapy may accelerate recovery by addressing both secretory and ventilatory limitations in pneumonia. Mechanistically, balloon inflation induces increased trans-diaphragmatic pressure, improving thoracic mobility and promoting collateral ventilation, which may aid in reopening collapsed alveoli and enhancing gas exchange efficiency. Clinically, this approach is particularly valuable in resource-constrained settings where reliance on non-invasive, low-cost interventions is imperative.

Although the study offers valuable insights, several limitations merit consideration. The sample size was relatively small (n=40), potentially limiting the generalizability of the findings to broader pneumonia populations, including those with comorbidities or severe disease presentations. The single-center design may introduce contextual biases related to physiotherapy delivery or patient demographics. Moreover, the short intervention duration (7 days) restricts the understanding of long-term outcomes, such as relapse rates, sustained symptom control, or pulmonary function recovery over time. The absence of objective radiologic or biomarker-based endpoints further narrows the interpretation of physiological improvements to spirometry and symptom-based assessments alone. Despite these limitations, the study's methodological strengths—including randomized allocation, blinded outcome assessment, standardized treatment protocols, and validated outcome instruments—enhance its internal validity. The reproducibility of the interventions and their feasibility in outpatient or low-resource environments bolster the study's clinical applicability. Importantly, the absence of adverse events or dropouts attests to the safety and acceptability of BBT in acutely ill patients.

Based on the observed outcomes, future research should focus on multi-center trials with larger, more diverse patient populations to validate these findings and assess their generalizability. Incorporating longer follow-up periods would allow evaluation of sustained pulmonary improvements and the potential for BBT to reduce readmission or progression to chronic respiratory impairment. Investigating the effects of BBT across different pneumonia etiologies, including viral or aspiration pneumonia, and its integration with other rehabilitation strategies such as incentive spirometry or positioning techniques, would further refine its clinical utility. Additionally, future studies should explore biomarker correlations and imaging-based outcomes to elucidate the physiological mechanisms underpinning the observed improvements. In conclusion, this study contributes meaningful evidence supporting the integration of balloon blowing therapy into pneumonia rehabilitation protocols. By addressing both ventilatory mechanics and secretion clearance simultaneously, this combined approach offers a promising, low-cost intervention capable of improving pulmonary outcomes in patients with acute lower respiratory tract infections. Further research is warranted to optimize its application and confirm its long-term benefits in diverse clinical settings.

CONCLUSION

This study demonstrates that the combined use of balloon blowing therapy with percussion significantly enhances pulmonary functions in patients with pneumonia compared to conventional physiotherapy alone, as evidenced by greater improvements in forced vital capacity, symptom relief, and breath sound clarity. These findings support the clinical utility of integrating simple, cost-effective respiratory muscle engagement techniques like balloon blowing with traditional airway clearance methods to optimize lung function recovery in pneumonia. The results align with the study’s objective and title, emphasizing the additive benefits of combining modalities. Clinically, this approach offers a non-invasive, accessible intervention for improving respiratory outcomes in both hospital and community settings. From a research perspective, the findings highlight the need for further multicenter, long-term studies to validate and expand upon the therapeutic potential of such combined physiotherapy strategies in respiratory care.

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