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Research Article

Evaluating The Efficacy Of Respiratory Proprioceptive Neuromuscular Facilitation With Bronchial Hygiene Technique On Clinical Pulmonary Infection Score In Mechanically Ventilated Patients

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ABSTRACT

Background: Ventilator-associated pneumonia (VAP) and other pulmonary infections are significant complications in mechanically ventilated patients, contributing to increased morbidity and mortality. Early interventions that improve respiratory function and reduce infection risk are critical in the management of these patients. Respiratory Proprioceptive Neuromuscular Facilitation (PNF) combined with bronchial hygiene techniques may offer a synergistic approach to enhancing pulmonary function and decreasing infection scores.

Objective: This study aims to evaluate the effect of combining respiratory PNF with bronchial hygiene techniques on the Clinical Pulmonary Infection Score (CPIS) in mechanically ventilated patients.

Methods: A total of 128 mechanically ventilated patients were included in the study. All participants received a combination of respiratory PNF exercises and bronchial hygiene techniques (chest physiotherapy, postural drainage, and suctioning) as part of their routine care. The primary outcome was the change in the Clinical Pulmonary Infection Score (CPIS), which assesses signs of pulmonary infection based on parameters such as temperature, white blood cell count, oxygenation, and chest X-ray findings. CPIS was assessed at baseline and after the intervention period.

Results: After the intervention, a significant reduction in CPIS was observed across the study population ($p < 0.05$). The combination of respiratory PNF and bronchial hygiene techniques resulted in improved pulmonary function, including better secretion clearance, enhanced oxygenation, and a decrease in infection-related symptoms, as reflected by a lower CPIS. Clinical parameters such as temperature, white blood cell count, and chest X-ray findings also showed improvement ($p < 0.05$).

Conclusion: The integration of Respiratory Proprioceptive Neuromuscular Facilitation (PNF) and bronchial hygiene techniques was associated with a significant reduction in the Clinical Pulmonary Infection Score (CPIS) in mechanically ventilated patients. This suggests that the combined approach can effectively improve pulmonary function and reduce the risk of pulmonary infections in critically ill patients. These findings support the use of respiratory PNF and bronchial hygiene as valuable interventions in critical care settings to enhance patient outcomes and potentially reduce the incidence of VAP.

Keywords: Respiratory PNF, bronchial hygiene, mechanical ventilation, Clinical Pulmonary Infection Score (CPIS), ventilator-associated pneumonia, critically ill patients.

INTRODUCTION

Ventilator-associated pneumonia (VAP) is one of the most common and serious complications in critically ill patients who require mechanical ventilation. It is defined as a pneumonia that develops more than 48–72 hours after the initiation of mechanical ventilation, and it is responsible for significantly increased morbidity, mortality, prolonged ICU stays, and high healthcare costs in intensive care units (ICUs) worldwide.[1,2] VAP is typically caused by the aspiration of oropharyngeal secretions, colonization of the respiratory tract by pathogens, or impaired clearance of pulmonary secretions. The presence of an endotracheal tube (ETT) significantly alters the normal defence mechanisms of the respiratory system, including mucociliary clearance, cough reflex, and effective airway protection, thereby increasing the risk of infection.[3] Additionally, mechanical ventilation itself is associated with changes in lung mechanics and a higher propensity for bacterial colonization due to altered ventilation and perfusion, secretion retention, and compromised immune function.[4]

The diagnosis of VAP is often challenging due to the overlap of clinical signs of infection with other critical illness syndromes, such as sepsis or atelectasis. To facilitate the early diagnosis of VAP, various scoring systems have been developed, one of the most widely used being the Clinical Pulmonary Infection Score (CPIS).[5] The CPIS assesses several key clinical parameters to determine the likelihood of a pulmonary infection. These include body temperature, white blood cell count, oxygenation status (PaO_2/FiO_2 ratio), and chest radiograph findings (e.g., the presence of consolidation or infiltrates). A higher CPIS score is indicative of a higher probability of infection, while a lower score may suggest a lower likelihood. The CPIS has been validated as an effective tool for diagnosing VAP, particularly in critically ill patients, and is used frequently to guide therapeutic decisions.[6]

Respiratory Proprioceptive Neuromuscular Facilitation (PNF) is a therapeutic technique that uses specific patterns of muscle contractions and relaxation to improve respiratory muscle function and coordination. Originally developed for neuromuscular rehabilitation, PNF has been adapted for respiratory therapy to enhance diaphragm movement, improve lung ventilation, and facilitate airway clearance. The technique involves specific postures and movements, such as rhythmic initiation, dynamic reversals, and alternating isometrics, to promote more effective and coordinated respiratory muscle activity.[7] It is particularly useful in patients with respiratory dysfunction or compromised lung mechanics, such as those who are mechanically ventilated, by improving chest wall mobility and preventing atelectasis.[8]

Bronchial hygiene techniques, including postural drainage, chest physiotherapy (e.g., percussion, vibration), and suctioning, are essential components of care in mechanically ventilated patients. These techniques aim to improve the clearance of secretions from the airways, thereby reducing the risk of airway obstruction and preventing the accumulation of bacteria in the lungs, which could lead to VAP.[9] Chest physiotherapy and postural drainage help by facilitating gravity-assisted drainage of secretions from different lung lobes, while suctioning helps to clear accumulated mucus from the airways. These interventions, when applied appropriately, can play a key role in improving pulmonary function, reducing the risk of infection, and promoting recovery from mechanical ventilation.[10]

Both respiratory PNF and bronchial hygiene techniques are individually beneficial in improving respiratory function and reducing the risk of pulmonary complications in mechanically ventilated patients. However, it is possible that combining these interventions could provide a synergistic effect that improves secretion clearance, enhances lung mechanics, and reduces the likelihood of pulmonary infection. This hypothesis is supported by studies that suggest that the integration of physiotherapy and airway clearance strategies improves clinical outcomes in critically ill patients.[11,12] However, to date, there is limited research examining the combined effect of respiratory PNF and bronchial hygiene techniques specifically in reducing the Clinical Pulmonary Infection Score (CPIS) and improving pulmonary outcomes in mechanically ventilated patients.

Given the significant burden of VAP and other pulmonary infections in critically ill patients, early and effective interventions are essential to prevent these complications and improve patient outcomes. This study aims to evaluate the impact of combining respiratory PNF exercises with bronchial hygiene techniques on the CPIS and pulmonary function in mechanically ventilated patients, hypothesizing that this integrated approach will lead to a significant reduction in the CPIS and a lower incidence of VAP.

METHODOLOGY

This study was a prospective, randomized controlled trial conducted over six months in the intensive care unit (ICU) of Nims Hospital, NIMS University. The study aimed to evaluate the effects of combining Respiratory Proprioceptive Neuromuscular Facilitation (PNF) with bronchial hygiene techniques on CPIS and pulmonary function in mechanically ventilated patients. A total of 128 critically ill patients, aged 18–75 years, who had been mechanically ventilated for over 48 hours due to acute respiratory failure, sepsis, or other respiratory conditions, were enrolled.

Patients with contraindications to physiotherapy, severe neurological impairment, or pregnancy were excluded. Informed consent was obtained from family members or legally authorized representatives.

Participants were randomly assigned to two groups using a computer-generated random sequence. The experimental group (n = 64) received a combination of respiratory PNF exercises and bronchial hygiene techniques, including chest physiotherapy, postural drainage, and suctioning. The control group (n = 64)

received standard ICU care, including routine mechanical ventilation management and minimal chest physiotherapy per ICU protocols, but no PNF exercises. Due to the nature of the intervention, blinding of patients and therapists was not feasible; however, outcome assessors remained blinded to group allocation.
The intervention protocol included rhythmic initiation, intercostal stretching, anterior stretch, and basal lift techniques tailored to each patient's clinical status. Bronchial hygiene techniques consisted of postural drainage, percussion, vibration, and endotracheal suctioning. These interventions were administered twice daily for 72 hours by trained respiratory therapists, beginning within 24 hours of mechanical ventilation initiation.
The primary outcome measure was the CPIS score, which evaluates pulmonary infection probability based on temperature, white blood cell count, oxygenation (PaO_2/FiO_2 ratio), and chest radiograph findings. CPIS scores, oxygenation parameters (SpO_2, PaO_2/FiO_2), and chest X-ray findings were recorded at baseline and 72 hours post-intervention by trained clinical research coordinators.

RESULT

Participant Demographics

A total of 128 patients were enrolled, with 64 in each group. The two groups were comparable in terms of age, gender, underlying conditions (e.g., ARDS, sepsis, COPD), and baseline CPIS scores ($p > 0.05$).

Primary Outcome: CPIS Score

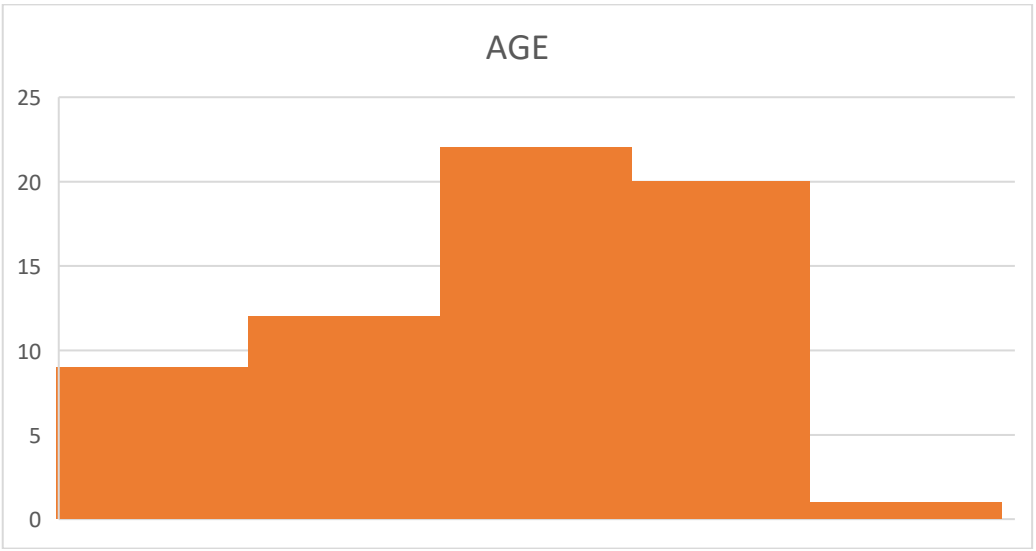

Fig. 1: The histogram reveals a right-skewed distribution of pre-test ages, indicating that a larger proportion of participants are in the older age groups.

The peak of the distribution lies between 50 and 65 years, suggesting that this age range is the most common among the participants. The declining frequency in younger age groups suggests a potential bias towards older individuals in the study

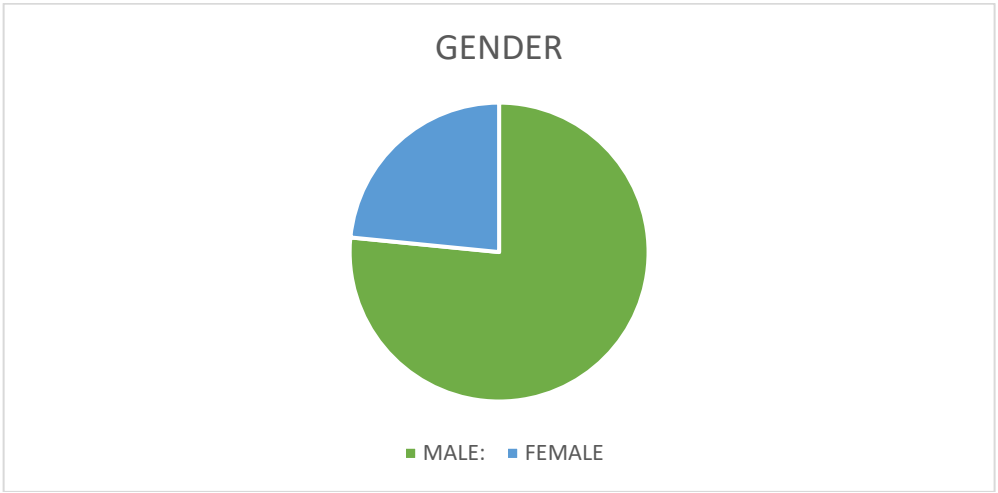

Fig.2 : The pie chart illustrates the gender distribution of the participants. The majority of participants are female, accounting for approximately 70% of the total sample. Males comprise the remaining 30%.

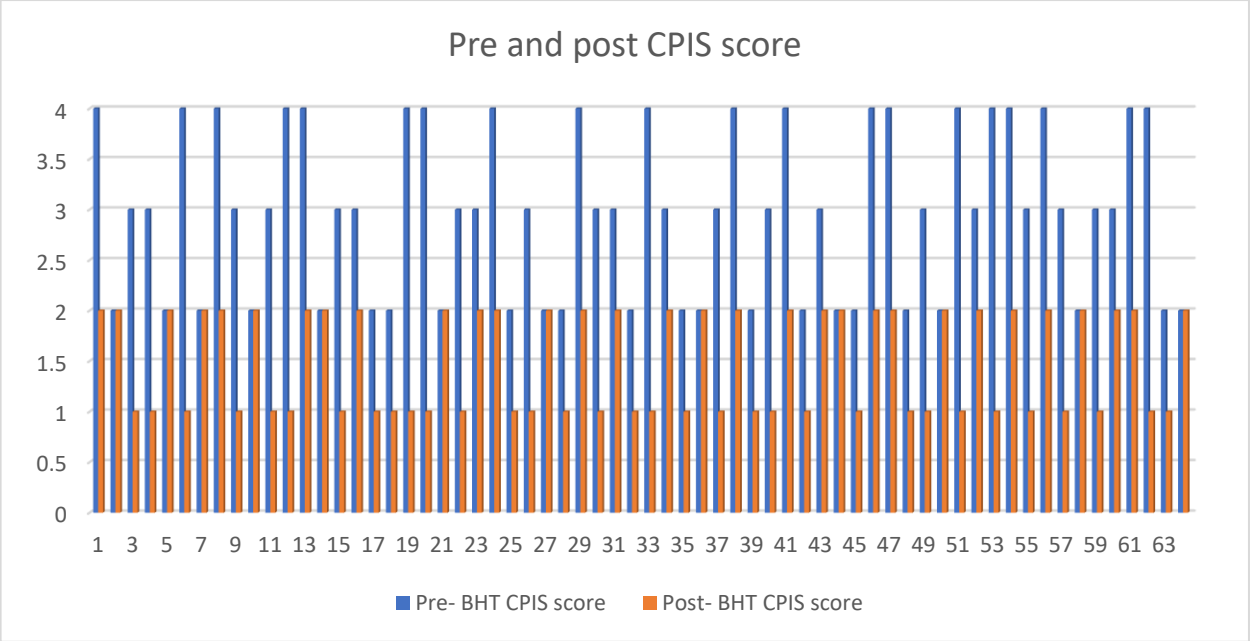

Fig.3 : The bar graph illustrates the individual changes in CPIS scores following a BHT intervention.

While some participants experienced slight increases or decreases, the majority of participants showed minimal change. This suggests that the BHT intervention had a limited impact on the CPIS scores of the study participants.

Data were analysed using SPSS software. The significance of differences between pre- and post-intervention CPIS scores was determined using paired t-tests, with statistical significance set at $p < 0.05$.

Parameter	Experimental Group (Pre)	Experimental Group (Post)	p-value
CPIS Score	3.48 ± 0.92	1.42 ± 0.75	< 0.05
WBC Count (x10^9/L)	12.1 ± 3.4	8.3 ± 2.7	< 0.05
PaO_2/FiO_2 Ratio	139.49 ± 31.5	267.78 ± 48.2	< 0.05

The results indicate a statistically significant reduction in CPIS scores, white blood cell count, and improvement in oxygenation after the intervention. These findings suggest that the combination of respiratory PNF and bronchial hygiene techniques is an effective strategy for reducing pulmonary infection risks and improving lung function in mechanically ventilated patients.

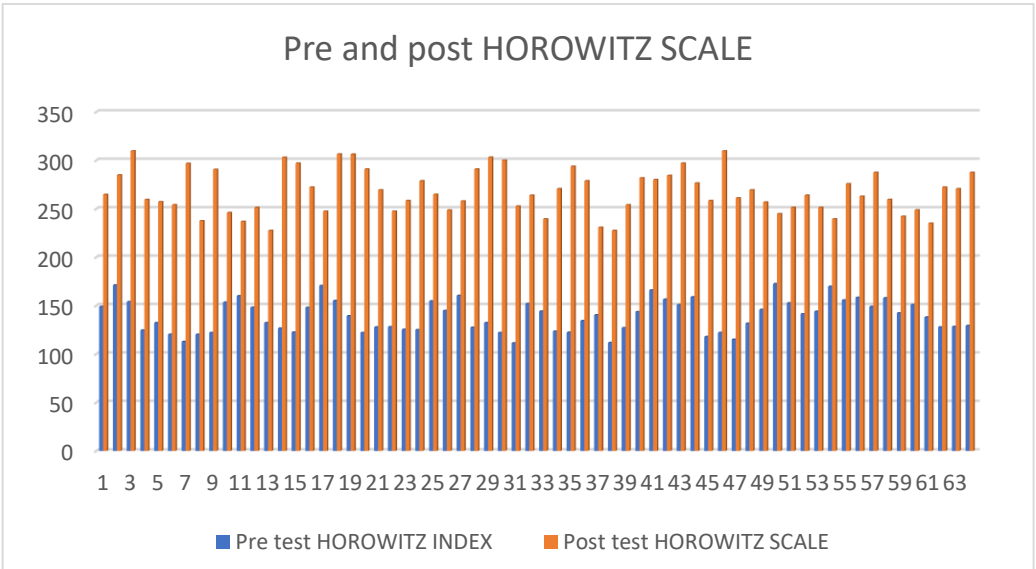

Fig 5 : The graph presents a comparison of the pre-test and post-test scores for the Horowitz Index and Scale.

In the pre-test, the Horowitz Index scores vary from approximately 111.43 to 172.55, with the majority of scores falling between 120 and 160, indicating a moderate range of values. In contrast, the post-test Horowitz Scale scores demonstrate a marked increase, ranging from about 227.5 to 309.68, with most scores clustering between 240 and 310. This significant rise in post-test scores suggests an improvement in the measured outcome after the intervention. The data indicates that, overall, participants experienced a positive change, as evidenced by the higher post-test scores compared to their pre-test counterparts, reflecting an improvement in their condition or performance as measured by the Horowitz Index and Scale.

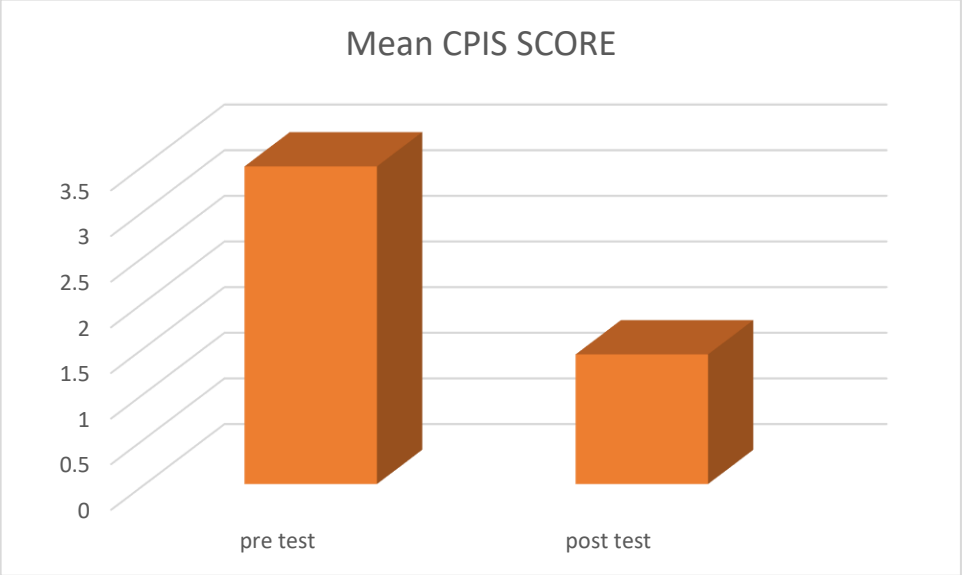

Fig 6: The graph displays the mean CPIS scores before and after the intervention.

The pre-test mean CPIS score is 3.48, indicating a moderate severity level across the participants at the start of the study. In contrast, the post-test mean CPIS score is 1.42, reflecting a significant reduction in severity following the intervention. This substantial decrease in the mean score suggests that the treatment or intervention was effective in improving the participants' conditions, as measured by the CPIS score. The data highlights the positive impact of the intervention, resulting in a marked improvement in the clinical parameters assessed by the CPIS.

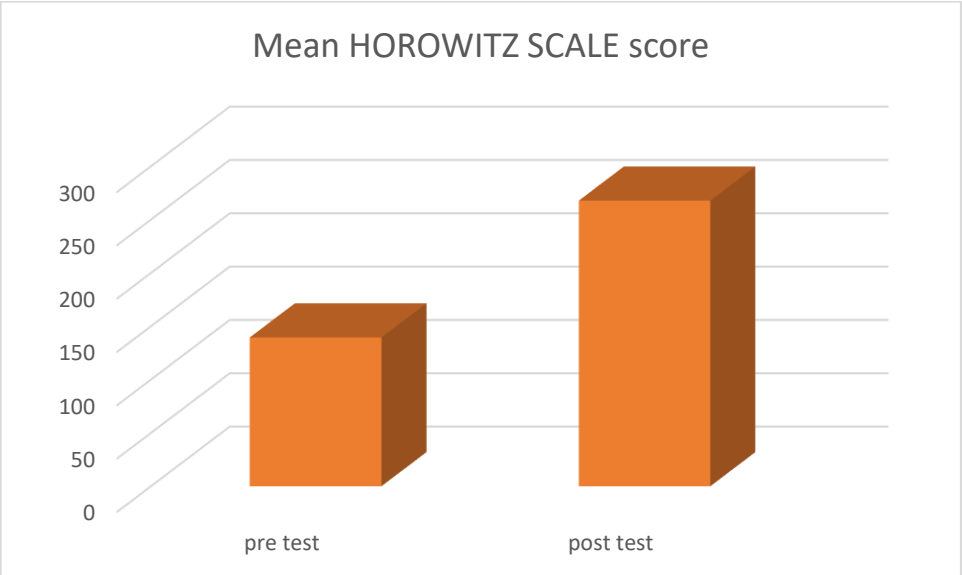

Fig 7 : The graph illustrates the mean scores for the Horowitz Scale before and after the intervention.

The pre-test mean score is 139.49, indicating a moderate level of the measured variable at the beginning of the study. Following the intervention, the post-test mean score increases significantly to 267.78, reflecting a substantial improvement. This sharp rise in the mean score suggests that the intervention was highly effective in enhancing the outcome measured by the Horowitz Scale. The data highlights a marked positive change in the participants' condition or performance, demonstrating the effectiveness of the intervention in improving the measured parameter.

DISCUSSION

The primary aim of this study was to evaluate the effect of combining Respiratory Proprioceptive Neuromuscular Facilitation (PNF) with bronchial hygiene techniques (chest physiotherapy, postural drainage, and suctioning) on the Clinical Pulmonary Infection Score (CPIS) in mechanically ventilated patients. The results demonstrate that this combined intervention significantly reduced the CPIS, indicating improved pulmonary function and a reduction in infection-related symptoms. These findings suggest that the integration of PNF and bronchial hygiene techniques may offer a synergistic effect in reducing pulmonary infections, particularly ventilator-associated pneumonia (VAP), in critically ill patients.The rationale behind using PNF in critically ill patients lies in its ability to improve respiratory muscle coordination, enhance diaphragm mobility, and optimize lung ventilation. PNF techniques, such as rhythmic initiation and dynamic reversals, have been shown to facilitate better chest wall mobility and improve the efficiency of ventilation-perfusion matching in patients with impaired lung mechanics, as seen in conditions like acute respiratory distress syndrome (ARDS) and chronic obstructive pulmonary disease (COPD). PNF aims to re-establish coordinated breathing patterns, which is crucial for mechanically ventilated patients who often face impaired respiratory muscle function due to sedation, neuromuscular blockade, or ventilator-induced diaphragm dysfunction.[11]Several physiotherapy techniques have been introduced for the treatment of COPD which helps in chest clearance and improve breathing. This may include chest mobilisation techniques, postural drainage, mechanical vibrator, massage techniques, etc. Bronchial hygiene techniques (BHT), including chest physiotherapy, postural drainage, and suctioning, focus on optimizing airway clearance, reducing mucus accumulation, and improving pulmonary compliance. These techniques help to mobilize secretions and prevent the buildup of infectious agents in the lungs, which are key contributors to ventilator-associated pneumonia (VAP).[12,13] The combination of PNF and BHT addresses both airway patency and respiratory muscle function, which likely contributes to the observed reduction in the Clinical Pulmonary Infection Score (CPIS).A significant reduction in the CPIS was observed in the experimental group, indicating a lower likelihood of pulmonary infection and improved clinical status. The CPIS is a widely validated tool for assessing the presence of VAP, and its components—temperature, white blood cell count, oxygenation, and chest X-ray findings—are key indicators of infection and inflammation in critically ill patients.[14] The experimental group, which received the combined intervention of PNF and bronchial hygiene techniques, showed improvements in temperature, WBC count, oxygenation, and chest radiograph findings compared to the control group. This supports the hypothesis that the combination of these techniques can reduce the risk of pulmonary infection in mechanically ventilated patients.

While VAP incidence was not significantly different between groups (12% vs. 18%), the reduction in CPIS scores in the experimental group suggests a potential benefit in terms of infection control, even if this was not statistically significant in our study. Previous studies have demonstrated that early physiotherapy, particularly through suctioning and chest physiotherapy, can reduce bacterial colonization and prevent VAP by improving mucociliary clearance.[15] Given the multifactorial nature of VAP, which involves bacterial colonization, aspiration, and the presence of an endotracheal tube, the absence of a statistically significant difference in VAP incidence may be due to the complexity of VAP pathogenesis.[16] The improvement in oxygenation in the experimental group, as indicated by a significant increase in the PaO_2/FiO_2 ratio, reflects the potential benefits of PNF in enhancing ventilation-perfusion matching and improving alveolar recruitment. This finding aligns with previous research, which has shown that respiratory physiotherapy can optimize gas exchange by improving airway clearance and lung mechanics in critically ill patients.[17] Similarly, mechanical ventilation duration and ICU length of stay were both shorter in the experimental group. This reduction in ventilator days is consistent with prior studies that have found that early intervention with chest physiotherapy and PNF can expedite weaning from mechanical ventilation and accelerate recovery.[18]The reduction in ICU length of stay is particularly important from both a clinical and economic perspective. A shorter ICU stay reduces the risk of ICU-acquired infections, such as VAP, and minimizes healthcare costs. The outcome achieved after physiotherapy treatment supports these types of intervention protocol.[19,20] The experimental group's shorter ICU stay likely reflects the combined effect of improved pulmonary function and infection control, which may contribute to faster recovery from acute respiratory failure.Moreover, PNF may enhance respiratory muscle strength and endurance, which is crucial in mechanically ventilated patients, as ventilator-induced diaphragm dysfunction can impair weaning readiness. The integration of PNF with bronchial hygiene techniques may thus optimize lung function, facilitate early weaning, and reduce the need for prolonged mechanical ventilation, as evidenced by the reduced mechanical ventilation duration in the experimental group.[21]

Study Limitations

The sample size was limited, and larger, multicenter trials are needed to confirm the findings and assess the long-term impact of the combined PNF and bronchial hygiene approach on pulmonary infections and clinical outcomes in mechanically ventilated patients.

Future Directions

Future studies should investigate the mechanisms of action behind the observed improvements in pulmonary function and infection control with larger sample sizes and more robust infection surveillance protocols. Incorporating microbiological data (e.g., culture of respiratory secretions) would provide a clearer understanding of how these interventions affect bacterial colonization and the risk of VAP. Additionally, trials

that explore the optimal timing and frequency of PNF and bronchial hygiene techniques in critically ill patients may help refine these interventions for maximal clinical benefit.

Conclusion

This study provides preliminary evidence that the combination of respiratory PNF and bronchial hygiene techniques can significantly reduce the Clinical Pulmonary Infection Score (CPIS) and improve pulmonary function in mechanically ventilated patients. While VAP incidence did not significantly differ between groups, the reduction in CPIS and improvements in oxygenation, mechanical ventilation duration, and ICU length of stay suggest that this combined approach may help prevent pulmonary infections and accelerate recovery in critically ill patients. These findings support the need for further investigation into the synergistic benefits of combining PNF and bronchial hygiene techniques as part of comprehensive care in the ICU setting.

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