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OUTCOME OF PER-PROTOCOL CHEST PHYSIOTHERAPY VERSUS ADD-ON PATIENT-DIRECTED SELF-PRONING IN CRITICALLY ILL RESPIRATORY PATIENTS: A QUASI-EXPERIMENTAL STUDY

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ABSTRACT

Background: Acute respiratory failure due to diverse underlying clinical conditions is a common cause of hospitalization and intensive care admission, often requiring supplemental oxygen and supportive respiratory interventions. Chest physiotherapy and awake prone positioning have independently demonstrated benefits in improving oxygenation and pulmonary mechanics. However, evidence regarding their effectiveness when combined in a mixed population of critically ill respiratory patients remains limited.

Objective: To compare the clinical outcomes of chest physiotherapy alone versus chest physiotherapy combined with patient-directed self-proning in critically ill respiratory patients requiring supplemental oxygen.

Methods: This prospective quasi-experimental study was conducted at a Tertiary Care Military Hospital (PEMH). A total of 106 adult patients with acute or acute-on-chronic respiratory illness requiring more than 2 L/min of supplemental oxygen were allocated to either chest physiotherapy alone (Group A) or chest physiotherapy plus patient-directed self-proning (Group B). Primary outcomes included reduction in oxygen requirement, improvement in respiratory distress score, and improvement in WHO functional class. Secondary outcomes included the need for escalation to high-flow nasal oxygen (HFNO), non-invasive ventilation (NIV), shifting to Medical ITC, endotracheal intubation, and length of hospital stay. Statistical analysis was performed using SPSS, with a p-value <0.05 considered statistically significant.

Results: Patients receiving chest physiotherapy combined with self-proning demonstrated greater improvement in oxygenation, respiratory distress scores, and WHO functional class compared with those receiving chest physiotherapy alone. The self-proning group also exhibited lower rates of escalation to HFNO/NIV, reduced intubation requirements, and shorter hospital stays. The intervention was well tolerated and associated with favorable clinical outcomes.

Conclusion: The addition of patient-directed self-proning to standard chest physiotherapy significantly improves oxygenation, functional recovery, and respiratory outcomes in critically ill respiratory patients. This low-cost and easily implementable intervention may reduce the need for advanced respiratory support and should be considered as an adjunctive strategy in the management of hypoxemic respiratory failure in addition to standard care as per guidelines.

KEYWORDS: Awake prone positioning, self-proning, chest physiotherapy, acute respiratory failure, oxygen therapy, hypoxemia, respiratory support, critical care.

INTRODUCTION

Acute respiratory failure is a major cause of hospitalization, intensive care unit admission, and mortality worldwide. It occurs when the respiratory system fails to maintain adequate gas exchange, resulting in hypoxemia, hypercapnia, or both. Patients with pneumonia, acute respiratory distress syndrome (ARDS), chronic obstructive pulmonary disease (COPD) exacerbations, asthma, and other inflammatory respiratory disorders frequently require supplemental oxygen and supportive respiratory interventions to improve oxygenation and reduce the risk of clinical deterioration. Despite advances in respiratory care, optimizing non-invasive supportive strategies remains an important clinical objective, particularly in resource-limited healthcare settings.

Prone positioning has emerged as an effective intervention for improving oxygenation in patients with respiratory failure. The physiological benefits of prone positioning include improved ventilation-perfusion matching, enhanced alveolar recruitment, reduction of dorsal lung compression, and more homogeneous distribution of transpulmonary pressure across the lungs. These mechanisms collectively contribute to improved gas exchange and reduced ventilator-induced lung injury. The landmark PROSEVA trial by Guérin et al. demonstrated a significant reduction in mortality among patients with severe ARDS managed with prolonged prone positioning, establishing prone ventilation as a standard therapeutic strategy in critically ill mechanically ventilated patients [1]. During the coronavirus disease 2019 (COVID-19) pandemic, interest in awake prone positioning increased substantially. Several studies evaluated the effectiveness of self-proning among non-intubated self-ventilating patients with hypoxemic respiratory failure. Coppo et al. reported significant improvement in oxygenation following awake prone positioning in hospitalized COVID-19 patients, suggesting that the intervention may delay respiratory deterioration and reduce the need for invasive ventilation [2]. Similarly, Elharrar et al. observed improvements in oxygen saturation among spontaneously breathing patients, although the degree of benefit varied among individuals [3]. More recently, the multinational meta-trial conducted by Ding et al. demonstrated that awake prone positioning reduced the risk of treatment failure and the need for intubation among patients receiving advanced oxygen therapy, further supporting its clinical utility [4]. The beneficial effects of prone positioning are not limited to viral pneumonia. Sodhi and Chanchalani. demonstrated that early awake prone positioning combined with high-flow nasal oxygen or non-invasive ventilation significantly improved oxygenation and clinical outcomes in patients with moderate to severe respiratory failure [5]. Additional physiological and observational studies have also shown favorable effects on lung mechanics, respiratory effort, and gas exchange in diverse respiratory conditions [6,7]. Chest physiotherapy is another important component of respiratory management and is routinely employed to facilitate airway clearance, mobilize secretions, improve lung expansion, and enhance respiratory muscle function. Techniques such as postural drainage, chest percussion, vibration, assisted coughing and breathing exercises have been widely used in patients with respiratory diseases to improve pulmonary function and reduce complications associated with prolonged immobility and secretion retention. When combined with optimal patient positioning, chest physiotherapy may provide synergistic benefits that enhance respiratory recovery [8]. Although both chest physiotherapy and awake prone positioning have demonstrated individual benefits, evidence regarding their combined use in a heterogeneous population of critically ill respiratory patients remains limited. Most available studies have focused primarily on patients with COVID-19 or ARDS, while data regarding their effectiveness in patients with acute respiratory presentation with mixed etiologies as is the case in real world scenario are scarce. Furthermore, few investigators have evaluated the impact of combined therapy on functional recovery and escalation to advanced respiratory support. Therefore, the present study aimed to compare the outcomes of chest physiotherapy alone with chest physiotherapy combined with patient-directed self-proning in critically ill respiratory patients requiring supplemental oxygen while receiving standard care for their primary conditions as per guidelines. We hypothesized that the addition of self-proning would result in greater improvement in oxygenation, respiratory distress, functional status, and overall clinical outcomes compared with chest physiotherapy alone.

MATERIALS AND METHODS

Study Design and Setting

This prospective quasi-experimental study was conducted at Pak Emirates Military Hospital, Rawalpindi, Pakistan, from Oct 2025 to May 2026. The study was carried out in the Acute Medical Unit (AMU), Pulmonology High Dependency Unit (HDU), and Medical Intensive Therapy Care (ITC) units. The objective was to evaluate the effectiveness of chest physiotherapy alone compared with chest physiotherapy combined with patient-directed self-proning in critically ill respiratory patients requiring supplemental oxygen more than 2L/min.

Ethical Approval

Ethical approval was obtained from the Ethical Committee of Pakistan Emirates Military Hospital, Rawalpindi, Pakistan (Ref. No. A/28/ERC-149/2025; CCM-2024-124-211 Dated:3-12-2025). Written informed consent was obtained from all participants prior to enrollment in the study.

Study Population

Adult patients admitted with acute or acute-on-chronic respiratory illness requiring supplemental oxygen therapy were screened for eligibility. Terminally ill patients, or those with palliative intent of care and severe comorbidities were excluded from the study. Patients received standard care as per consultants and guidelines recommendations for their primary conditions.

Inclusion Criteria

Patients fulfilling all of the following criteria were included:

- Age 18-70 years.
- Acute respiratory illness or acute exacerbation of chronic respiratory disease.
- Requirement of supplemental oxygen greater than 2 L/min to maintain oxygen saturation ≥92%.
- Hemodynamic stability without vasopressor support.
- Ability to cooperate with physiotherapy and prone positioning instructions.
- Patients with predicted admission duration at least more than two days.

Exclusion Criteria

Patients were excluded if they met any of the following criteria:

- Immediate requirement for endotracheal intubation on presentation

- Hemodynamic instability requiring vasopressor support.
- Terminally ill patients with expected survival in months, treatment with palliative intent or those patient with severe comorbidities.
- Pregnancy in the third trimester.
- Recent thoracic, abdominal, spinal, or pelvic surgery contraindicating prone positioning.
- Inability or refusal to perform self-proning.
- Altered mental status preventing compliance with study procedures.

Sample Size Calculation

The sample size was calculated using the World Health Organization (WHO) formula for estimation of proportions:

$n = Z^2 \times p(1 - p) / d^2$

Where:

- Z = 1.96 at a 95% confidence level
- p = 0.50
- d = 0.10

The calculated sample size was 96 participants. After adding 10% for possible attrition and incomplete follow-up, the final sample size was increased to 106 patients. Participants were equally allocated into two groups, with 53 patients in each group.

Allocation of Participants

A quasi-experimental alternate allocation method was used. Eligible patients were sequentially assigned to one of two intervention groups:

- Group A: Chest physiotherapy alone.
- Group B: Chest physiotherapy plus patient-directed self-proning.

Because alternate allocation rather than true randomization was employed, the study was classified as quasi-experimental.

Intervention Protocol

Group A: Chest Physiotherapy

Patients assigned to Group A received standard chest physiotherapy twice daily by trained physiotherapists. The protocol included:

- Postural drainage.
- Chest percussion.
- Chest vibration techniques.
- Deep breathing exercises.
- Assisted coughing maneuvers.
- Incentive spirometry when clinically indicated.
- Early mobilization as tolerated.

Group B: Chest Physiotherapy Plus Self-Proning

Patients assigned to Group B received the same chest physiotherapy protocol as Group A in addition to awake self-proning.

Patients were instructed and assisted to maintain the prone position for a target duration of 8–16 hours per day, divided into multiple sessions according to tolerance. Nursing staff were trained for patient assistance, monitoring and timely entry of observations and documentation of findings in provided Performa. Patients were encouraged to change positions other than prone in intervening according to their comfort to prevent pressure sores.

Data Collection

Baseline demographic and clinical data were recorded at enrollment, including age, sex, primary diagnosis, comorbidities, oxygen requirements, respiratory rate, heart rate, blood pressure, and oxygen saturation. Respiratory Distress Score is an objective assessment scale based on several physical findings with a total score of 3 or more indicating increasing respiratory difficulty. WHO functional class assessment is an assessment tool for respiratory distress and mobility limitation with four grades from 1 to 4, severity in garde increases with severity of illness.

Daily assessments included:

- Oxygen requirement (L/min).
- Peripheral oxygen saturation (SpO_2).
- Respiratory rate.
- Respiratory distress score.
- WHO Functional Class.
- Need for Medical ITC transfer.
- Need for escalation to high-flow nasal oxygen (HFNO).
- Requirement for non-invasive ventilation (NIV).
- Requirement for invasive mechanical ventilation.
- Length of hospital stay.

Data was collected using a structured case-report form by trained investigators.

- Outcome Measures
- Primary Outcomes

The primary outcomes were:

- Reduction in oxygen requirements.
- Improvement in respiratory distress score.
- Improvement in WHO Functional Class from baseline to discharge.

Secondary Outcomes

The secondary outcomes included:

- Requirement for HFNO.
- Requirement for NIV.
- Requirement for endotracheal intubation.
- Transfer to intensive care.
- Length of hospital stay.
- In-hospital mortality.

Follow-Up

Participants were followed daily until hospital discharge, follow up in Medical ITC, initiation of invasive mechanical ventilation, withdrawal from the study, or death, whichever occurred first.

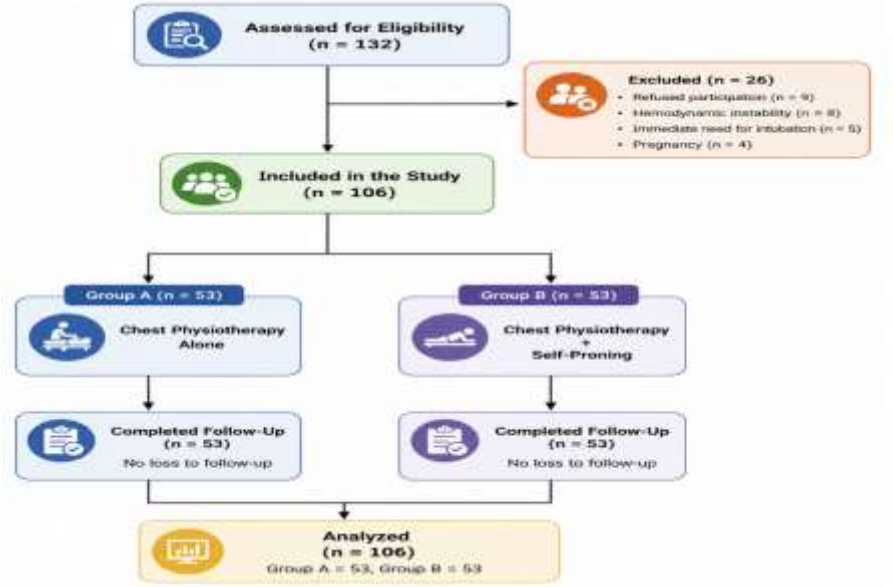
Statistical Analysis

Data was analyzed using Statistical Package for Social Sciences (SPSS) version 27.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. Comparisons between groups were performed using the independent-samples t-test for continuous variables and the chi-square test or Fisher's exact test for categorical variables, as appropriate. Multivariable logistic regression analysis was performed to adjust for potential confounding variables. A two-tailed p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 132 patients were screened for eligibility during the study period. Twenty-six patients were excluded due to refusal to participate (n=9), hemodynamic instability (n=8), immediate need for intubation (n=5), and pregnancy (n=4). The remaining 106 patients were enrolled and allocated equally to Group A (chest physiotherapy alone; n=53) and Group B (chest physiotherapy plus self-proning; n=53). All enrolled participants completed follow-up and were included in the final analysis (Figure 1). The baseline demographic and clinical characteristics of the study participants are presented in Table 1. The mean age of patients in Group A was 55.4 ± 14.2 years compared with 56.8 ± 13.7 years in Group B (p=0.63). Males constituted 60.4% of Group A and 58.5% of Group B (p=0.84). The distribution of underlying respiratory diagnoses, including pneumonia, COPD exacerbation, asthma, and other respiratory diseases, was comparable between the two groups. Baseline oxygen requirements were also similar (6.1 ± 2.2 L/min vs. 6.3 ± 2.0 L/min; p=0.68), indicating good comparability of the study groups at enrollment (Table 1).Patients receiving chest physiotherapy combined with self-proning demonstrated significantly greater clinical improvement than those receiving chest physiotherapy alone (Table 2).The mean reduction in oxygen requirement was significantly higher in Group B compared to Group A L2.8± 1.3 L/min vs. 2.2 ± 1.2 L/min; p<0.04). Similarly, improvement in respiratory distress scores was significantly greater among patients undergoing self-proning (5.40 ± 1.35 vs. 4.77 ± 1.60; p<0.03). Improvement in WHO Functional Class was also more pronounced in Group B than Group A (2.6 ± 0.8 vs. 2.1 ± 0.9; p<0.03). Serial assessment of oxygen requirements throughout hospitalization demonstrated a more rapid decline among patients receiving self-proning. By Day 7, mean oxygen requirements had decreased to 2.8 L/min in Group B compared with 3.8 L/min in Group A. Secondary clinical outcomes are summarized in Table 3. Patients in the self-proning group required significantly less escalation to advanced respiratory support. The requirement for HFNO or NIV was observed in 15.1% of patients in Group B compared with 30.2% in Group A (p=0.041). Although intubation rates were numerically lower in the self-proning group (5.7% vs. 15.1%), the difference did not reach statistical significance (p=0.11). Similarly, ICU transfer occurred less frequently in Group B than in Group A (7.5% vs. 18.9%; p=0.08) which was not statistically significant. In-hospital mortality was lower in the self-proning group (3.8% vs. 7.5%), although this difference was not statistically significant (p=0.40). Patients receiving chest physiotherapy plus self-proning experienced a shorter duration of hospitalization than those receiving chest physiotherapy alone. The mean hospital stay was 8.5 ± 4.0 days in Group B compared with 10.5 ± 4.5 days in Group A (p=0.05), representing a reduction of approximately two days in average hospital stay (Table 4). Multivariable logistic regression analysis was performed to evaluate factors independently associated with the need for escalation to advanced respiratory support. After adjustment for age, sex, baseline oxygen requirement, and primary respiratory diagnosis, self-proning remained independently associated with a reduced likelihood of requiring HFNO, NIV, or intubation (adjusted odds ratio [aOR]: 0.42; 95% confidence interval [CI]: 0.20–0.88; p=0.021).Overall, patients managed with chest physiotherapy combined with patient-directed self-proning demonstrated significantly greater improvements in oxygenation, respiratory distress, and functional status compared with patients receiving chest physiotherapy alone. Furthermore, self-proning was associated with reduced escalation to advanced respiratory support and shorter hospital stays, supporting its role as an effective adjunctive intervention in critically ill respiratory patients.

Figure 1. Study Flow Diagram of Participant Enrollment, Allocation, Follow-Up, and Analysis



A total of 132 patients were assessed for eligibility, of whom 26 were excluded due to refusal to participate (n=9), hemodynamic instability (n=8), immediate requirement for endotracheal intubation (n=5), or pregnancy (n=4). The remaining 106 eligible patients were enrolled and allocated equally to Group A (chest physiotherapy alone; n=53) and Group B (chest physiotherapy plus patient-directed self-proning; n=53). All participants completed follow-up without loss to follow-up and were included in the final analysis.

Table 1. Baseline Demographic and Clinical Characteristics of the Study Participants

Variable	Group A (Chest Physiotherapy) n=53	Group B (Chest Physiotherapy + Self-Proning) n=53	p-value
Age (years), Mean ± SD	55.4 ± 14.2	56.8 ± 13.7	0.63
Male Gender, n (%)	32 (60.4)	31 (58.5)	0.84
Pneumonia, n (%)	24 (45.3)	25 (47.2)	0.85
COPD Exacerbation, n (%)	15 (28.3)	14 (26.4)	0.82
Asthma, n (%)	8 (15.1)	7 (13.2)	0.78
Other Respiratory Disorders, n (%)	6 (11.3)	7 (13.2)	0.76
Baseline Oxygen Requirement (L/min), Mean ± SD	6.1 ± 2.2	6.3 ± 2.0	0.68
Respiratory Distress Score, Mean ± SD	6.4 ± 1.5	6.6 ± 1.4	0.57
WHO Functional Class, Mean ± SD	3.2 ± 0.7	3.1 ± 0.8	0.49

Table 1 demonstrates the baseline demographic and clinical characteristics of patients enrolled in the study. No statistically significant differences were observed between the two groups regarding age, gender distribution, underlying respiratory diagnoses, baseline oxygen requirements, respiratory distress scores, or WHO functional class, indicating comparability of the study groups before intervention.

Table 2. Comparison of Primary Clinical Outcomes Between Study Groups

Outcome	Group A (n=53)	Group B (n=53)	p-value
Reduction in Oxygen Requirement (L/min), Mean ± SD	2.2 ± 1.2	2.8 ± 1.3	<0.04
Improvement in Respiratory Distress Score, Mean ± SD	4.7 ± 1.60	5.4± 1.35	<0.03
Improvement in WHO Functional Class, Mean ± SD	2.1 ± 0.9	2.6 ± 1.0	<0.03

Table 2 compares the primary outcomes between patients receiving chest physiotherapy alone and those receiving chest physiotherapy combined with self-proning. Patients in the self-proning group demonstrated greater reductions in oxygen requirements, greater improvement in respiratory distress scores, and superior functional recovery as measured by WHO functional class.

Table 3. Comparison of Secondary Outcomes and Escalation of Respiratory Support

Outcome	Group A (n=53)	Group B (n=53)	p-value
HFNO/NIV Requirement, n (%)	16 (30.2)	8 (15.1)	0.041
Intubation Requirement, n (%)	8 (15.1)	3 (5.7)	0.11
ICU Transfer, n (%)	10 (18.9)	4 (7.5)	0.08
In-Hospital Mortality, n (%)	4 (7.5)	2 (3.8)	0.40

Table 3 summarizes secondary clinical outcomes. Patients managed with add-on self-proning exhibited lower requirements for escalation to advanced respiratory support, including HFNO, NIV, and invasive mechanical ventilation. Although reductions in ICU transfer and mortality were observed in the intervention group, these differences did not reach statistical significance.

Table 4. Length of Hospital Stay Among Study Participants

Variable	Group A (n=53)	Group B (n=53)	p-value
Length of Hospital Stay (days), Mean ± SD	10.5 ± 4.5	8.5± 4.0	0.05

Table 4 presents the duration of hospitalization in both study groups. Patients receiving chest physiotherapy combined with patient-directed self-proning had a significantly shorter hospital stay compared with those receiving chest physiotherapy alone, suggesting faster clinical recovery and reduced healthcare resource utilization.

DISCUSSION

The present prospective quasi-experimental study evaluated the effectiveness of patient-directed self-proning as an adjunct to standard chest physiotherapy in critically ill respiratory patients requiring supplemental oxygen. The findings demonstrated that patients receiving self-proning in addition to chest physiotherapy experienced significantly greater improvements in oxygen requirements, Respiratory Distress Scores and WHO functional class compared with those receiving chest physiotherapy alone. In addition, the self-proning group showed reduced escalation to advanced respiratory support and shorter hospital stays providing evidence for this low-cost intervention. Respiratory failure remains a significant contributor to morbidity and mortality in hospitalized patients, particularly in low- and middle-income countries where access to advanced respiratory support may be limited. Regional studies from Pakistan have highlighted the burden of severe respiratory illnesses and the challenges associated with managing hypoxemic patients requiring critical care support [9–11]. However, limited local evidence exists regarding non-pharmacological interventions such as awake patient proning and chest physiotherapy. Our study therefore provides valuable data supporting the incorporation of self-proning into routine respiratory care protocols. These beneficial effects are biologically plausible and consistent with established physiological principles. Prone positioning improves ventilation-perfusion matching, redistributes transpulmonary pressures more evenly across lung regions and promotes recruitment of dependent alveoli, resulting in enhanced oxygenation and reduced shunt fraction [12]. This particularly applies to patients with acute pulmonary conditions represented within our study population. In addition to prone positioning, chest physiotherapy remains an important supportive therapy aimed at enhancing airway clearance and improving pulmonary mechanics. Previous studies conducted in both local and international settings have demonstrated that chest physiotherapy facilitates secretion mobilization, improves respiratory muscle performance, and contributes to overall pulmonary recovery [13,14]. Nevertheless, evidence regarding its impact on major clinical outcomes remains variable. In the present study both treatment groups demonstrated improvement, indicating the therapeutic value of chest physiotherapy with superior outcomes in proning groups suggesting its synergistic effect. Recent investigators have increasingly focused on awake prone positioning in non-intubated patients. Sethi et al. reported favorable oxygenation in patients managed with awake proning, emphasizing its feasibility in routine clinical practice [15]. Similarly, Ferrando et al. demonstrated that prone positioning improved oxygenation parameters in patients with acute respiratory failure, although the magnitude of benefit varied according to disease severity and patient adherence [16]. Rosén et al. evaluated awake prone positioning in hospitalized patients with respiratory distress and reported significant short-term improvements in oxygenation and respiratory parameters [17]. Likewise, Kharat et al. found that awake proning was associated with better oxygen saturation and reduced progression to invasive mechanical ventilation among selected patients with hypoxemic respiratory failure [18]. The lower rates of HFNO, NIV, and intubation observed in our study are consistent with these findings and support the role of proning as an effective adjunctive intervention. Additional studies have demonstrated that the benefits of awake proning extend beyond immediate oxygenation improvements. Fazzini et al. reported enhanced respiratory mechanics and reduced work of breathing among patients managed with prone positioning [19]. Li et al. further demonstrated improved clinical recovery and reduced need for escalation of respiratory support among patients receiving prolonged awake proning [20]. These findings correspond with improvement in respiratory distress scores and WHO functional class in the intervention group in our study.More recent evidence has reinforced the growing role of awake proning in respiratory care. Weatherald et al. reported that prone positioning contributes to improved gas exchange and may reduce treatment failure when implemented early in the disease course [21]. These observations were addressed by inclusion of patients with O2 requirement of 2L/min or more. Rampon et al. similarly observed favorable outcomes among hospitalized patients receiving structured proning protocols, particularly when combined with standard supportive care [22]. Nayan et al. demonstrated improved patient-centered outcomes, including reduced hospitalization duration and faster recovery among patients managed with awake proning strategies [23]. Our study similarly demonstrated a significantly shorter hospital stay among patients receiving self-proning.The strengths of the present study include its prospective design, inclusion of a heterogeneous respiratory population, assessment of both physiological and functional outcomes, and evaluation of clinically relevant endpoints such as escalation to advanced respiratory support.Many previous investigators focused exclusively on viral pneumonia or ARDS, the current study included patients with pneumonia, COPD exacerbations, asthma, and other respiratory disorders, thereby enhancing the generalizability of the findings. Furthermore, the incorporation of WHO functional class assessment provided additional insight

into patient-centered recovery outcomes. Despite these strengths, several limitations should be acknowledged. The quasi-experimental design introduces the possibility of selection bias and residual confounding. The study was conducted at a single center, which may limit its external validity. Adherence to self-proning varied among participants and was dependent upon patient tolerance. Additionally, long-term outcomes after hospital discharge were not assessed. Future multicenter randomized controlled trials are needed to confirm these findings and establish optimal proning duration and patient selection criteria. Overall, the present study supports the integration of patient-directed self-proning as an adjunct to standard chest physiotherapy in critically ill respiratory patients. The intervention is inexpensive, readily implementable and associated with meaningful improvements in oxygenation, respiratory function and healthcare utilization, making it particularly attractive for resource-constrained healthcare settings like Pakistan.

Authors' Contributions (ICMJE Criteria)

All authors fulfilled the International Committee of Medical Journal Editors (ICMJE) criteria for authorship.

Dr. Shabir Hussain: Conceptualization of the study, study design, supervision, interpretation of data, and critical revision and correspondence of the manuscript.

Dr. Abdul Rasheed: Data collection, patient recruitment, acquisition of clinical data, and manuscript drafting.

Dr. Muhammad Haroon Shahid: Data analysis, statistical interpretation, preparation of tables and figures, and manuscript writing.

Dr. Nabeel Tahir Butt: Literature review, methodology development, data verification, and manuscript editing.

Dr. Bilal Ahmad: Clinical oversight, patient management, interpretation of findings, and critical review of the manuscript.

Dr. Sumbal Rana: Final manuscript review, intellectual content revision, administrative support, and approval of the final version for publication.

Authors' Statement

All authors have made substantial contributions to the conception and design of the study, acquisition of data, analysis and interpretation of results, drafting and critical revision of the manuscript, and approval of the final version to be published. All authors agree to be accountable for all aspects of the work and affirm that questions related to the accuracy or integrity of any part of the study have been appropriately investigated and resolved. The authors declare that this manuscript is original, has not been published previously, and is not under consideration for publication elsewhere.

Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this study.

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