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Effects of Pursed-Lips Breathing and Semi-Fowler Position on Oxygen Saturation in Pulmonary Tuberculosis Patients: A Quasi-Experimental Study

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Abstract

Background: Non-pharmacological interventions, including the Pursed-Lips Breathing (PLB) technique and the therapeutic Semi-Fowler position, are implemented to improve ventilation and increase oxygen saturation. Despite their widespread use, direct comparative evidence assessing these interventions and their combination in hospitalized patients with pulmonary tuberculosis is limited. This study compared the effects of PLB, the Semi-Fowler position, and their combination on oxygen saturation in patients with pulmonary tuberculosis.

Methods: A quasi-experimental pretest–posttest study with a four-group, non-randomized design was conducted among 180 participants, with 45 individuals assigned to each group. Interventions were administered twice daily for 15 minutes per session, and oxygen saturation was measured before and immediately after each intervention. Data were analyzed using the Wilcoxon Signed Rank Test to assess within-group pretest–posttest changes and the Kruskal Wallis test to compare differences between groups.

Result: Significant increases in oxygen saturation were observed in the PLB group, the Semi-Fowler group, and the Combination group ($p < 0.001$), while no significant change was found in the Control group ($p = 0.097$). The Combination group demonstrated the greatest improvement, with a mean post-test oxygen saturation of 96.04%, followed by the PLB group (95.62%) and the Semi-Fowler group (95.49%). Significant differences were identified among the four groups ($p < 0.001$)

Conclusion: PLB, the Semi-Fowler position, and their combination were associated with improvements in oxygen saturation among patients with pulmonary tuberculosis, with the combined intervention yielding the highest mean post-intervention oxygen saturation.

Keywords: Pursed-Lips Breathing, Nursing Intervention, Pulmonary Tuberculosis.

BACKGROUND

Pulmonary tuberculosis (TB) is an infectious disease that affects the respiratory tract, causing progressive lung damage, reduced diffusion capacity, impaired ventilation, and ultimately decreased oxygen saturation. These complications arise from inflammatory processes, cavitation, and airway obstruction, which commonly result in ineffective breathing patterns and imbalanced gas exchange. Such disruptions in oxygenation require effective non-pharmacological nursing interventions capable of improving ventilatory capacity and stabilizing patients' oxygen saturation (1)

One respiratory technique widely recognized for its effectiveness in improving oxygenation is Pursed-Lips Breathing (PLB). PLB functions by prolonging the expiratory phase, generating positive expiratory pressure, preventing the collapse of small airways, and reducing air trapping mechanisms that collectively contribute to significant improvement in oxygen saturation (2-4). Previous studies have shown that PLB improves breathing patterns, reduces dyspnea, and enhances ventilatory capacity among patients with COPD, pulmonary disorders, and various respiratory conditions (5-7).

In addition to PLB, therapeutic positioning, particularly the Semi-Fowler position, plays a vital role in increasing lung expansion, reducing diaphragmatic pressure, and enhancing airflow into the lungs, thereby improving oxygen saturation. Several studies have demonstrated that the Semi-Fowler position can facilitate better ventilation, increase SpO_2 levels, and enhance respiratory function among patients with different respiratory problems (8-10). Dinaryanti (11) further reported significant improvements in oxygen saturation among COPD and other respiratory patients positioned in Semi-Fowler.

Studies investigating the use of PLB among pulmonary TB patients have reported positive outcomes, such as improved oxygen saturation, better breathing patterns, and increased comfort (12). However, research directly comparing the effectiveness of PLB, the Semi-Fowler position, and their combination among hospitalized TB patients is limited, particularly in Gorontalo Province. This gap is significant because integrating both techniques may offer complementary physiological effects by optimizing inspiratory and expiratory mechanics, potentially improving ventilation and oxygenation. Evidence evaluating the combined application of these interventions in pulmonary TB patients remains limited.

Tuberculosis remains a major public health challenge in Indonesia, which accounts for approximately 10% of the global TB burden (13).In Gorontalo Province, the Provincial Health Office reported 4,681 TB cases by November 2024, while case detection and treatment coverage remained below national targets (14). Hospitalized pulmonary TB patients commonly experience dyspnea and impaired gas exchange due to extensive pulmonary involvement, making optimization of oxygenation an important component of supportive nursing care (15,16). Oxygen saturation (SpO_2) was therefore selected as the primary outcome because it is an objective, non-invasive, and routinely used indicator of oxygenation status that reflects changes in respiratory function following therapeutic interventions. (15)

Given the high burden of pulmonary TB in Gorontalo Province and the need for simple, non-pharmacological nursing interventions to improve oxygenation, this study was conducted to evaluate the effects of PLB, the Semi-Fowler position, and their combination on oxygen saturation among pulmonary TB patients. Based on these considerations, this study analyzed the effectiveness of PLB, the Semi-Fowler position, and their combination in enhancing oxygen saturation among pulmonary TB patients in Gorontalo Province.

METHODS

Study Design

This study used a quasi-experimental pretest-posttest design with four non-equivalent groups: three intervention groups and one control group.

Sample/Participants

The study population consisted of adult patients with pulmonary tuberculosis admitted to the participating hospitals during the study period. Participants were recruited through purposive sampling according to predefined inclusion and exclusion criteria. Eligible patients were screened by the research team, and those who met the criteria and provided written informed consent were enrolled. The sample size was determined pragmatically based on the number of eligible patients available during the study period at the three participating hospitals, rather than through formal calculation. In total, 180 participants were enrolled.

Inclusion criteria required participants to be adults aged 18 to 60 years diagnosed with pulmonary tuberculosis (TB), currently receiving first-line anti-TB treatment in the intensive phase, experiencing dyspnea, and willing to provide written informed consent. Exclusion criteria included drug-resistant TB, recurrent (relapse) TB, or comorbidities such as diabetes mellitus (DM) or HIV. The individual participant served as the unit of assignment. Eligible participants were allocated non-randomly to one of four groups: the Pursed-Lips Breathing (PLB) group, the Semi-Fowler position group, the combination group (PLB plus Semi-Fowler position), or the control group, with 45 participants in each group. Computer-generated randomization, allocation concealment, matching, blocking, and stratification were not utilized. To address potential selection bias from non-random allocation, baseline demographic and clinical characteristics were compared across the four groups prior to intervention. intervention.

Instruments

Oxygen saturation (SpO_2) was measured at each hospital using a medical-grade pulse oximeter. Devices were calibrated and maintained according to hospital biomedical engineering procedures and manufacturers' recommendations. Data collection included pretest and post-test oxygen saturation observation sheets and a screening form to assess participants' physical condition. The PLB intervention was conducted twice daily for 15 minutes per session. Semi-Fowler group participants were positioned at a standardized 45° head elevation for 15 minutes per session, twice daily.Oxygen saturation (SpO_2) was measured immediately before the first intervention session (pre-test) and within one minute after the second session to assess the acute effect. No additional respiratory interventions or supplemental oxygen, aside from routine hospital treatment, were provided during the intervention period.

Data Collection

Data collection conducted from October 2025 to March 2026 in Sangihe Islands Regency, North Sulawesi Province, Indonesia. This regency comprises an archipelago situated 140–150 km from the provincial capital and is accessible exclusively by sea or air. Inter-island mobility primarily relies on sea transport. The local population is predominantly engaged in fishing, coconut farming, and small-scale business activities that utilize regional resources. Food availability in the regency remains dependent on supplies imported from outside the region.

Intervention

Prior to the intervention, all eligible participants who provided written informed consent underwent baseline measurement of peripheral oxygen saturation (SpO_2) using a calibrated medical-

grade pulse oximeter while resting in the hospital ward. Participants were subsequently non-randomly assigned to one of four study groups: the PLB group, the Semi-Fowler position group, the combination group, or the control group. The PLB group performed the PLB technique twice daily for 15 minutes per session under direct supervision by the researcher and trained nurses. The Semi-Fowler group was positioned with the head of the bed elevated to 45° for 15 minutes. The combination group performed the PLB technique while maintaining the 45° Semi-Fowler position for the same duration. The control group received routine hospital care without additional breathing or positioning interventions. All interventions were administered individually in the inpatient ward according to a standardized protocol, and adherence was ensured through direct supervision by the research team. Immediately after completing the assigned intervention, peripheral oxygen saturation was remeasured using the same pulse oximeter under identical conditions. Pretest and posttest oxygen saturation values were recorded using standardized data collection forms and subsequently entered into the study database for statistical analysis.

Data Analysis

IBM SPSS Statistics version 29 was used for data analysis. Descriptive statistics summarized participants' baseline characteristics. The Wilcoxon Signed Rank Test assessed within-group differences in peripheral oxygen saturation (SpO_2) between pretest and posttest measurements, while the Kruskal-Wallis test evaluated between-group differences. Statistical significance was defined as a two-tailed $p < 0.05$. Subgroup and adjusted analyses were not conducted. All participants completed the study, so no missing outcome data required imputation.

Ethical Consideration

This study received ethical approval from the Ethics Committee of the Faculty of Health Sciences, Universitas Muhammadiyah Gorontalo (KEPK-FIKES UMGO), under approval number No.052/KEPK-FIKES/IV 2025, dated April 2025. Written informed consent was obtained from all participants before data collection.

RESULT AND DISCUSSION

RESULT

Characteristics of Participants

Demographic analysis (Table 1) indicated that sex distribution was balanced across the three intervention cohorts, while the control group demonstrated a marked male predominance (66.7%).

Table 1. Demographic of Participant (n=45)

Characteristics	Pursed-Lips Breathing (PLB)	Semi-Fowler	Combination	Control
	N (%)	N (%)	N (%)	N (%)
Sex				
Male	22 (48.9)	24 (53.3)	25 (55.6)	30 (66.7)
Female	23 (51.1)	21 (46.7)	20 (44.4)	15 (33.3)
Total	45 (100)	45 (100)	45 (100)	45 (100)
Age (Years)				
17–25	7 (15.6)	5 (11.1)	1 (2.2)	12 (26.7)
26–35	9 (20.0)	13 (28.9)	9 (20.0)	13 (28.9)
36–45	17 (37.8)	11 (24.4)	20 (44.4)	13 (28.9)
46–55	12 (26.7)	16 (35.6)	15 (33.3)	7 (15.6)
Total	45 (100)	45 (100)	45 (100)	45 (100)
Education				
Elementary School	17 (37.8)	11 (24.4)	7 (15.6)	12 (26.7)

Middle School	4 (8.9)	14 (31.1)	10 (22.2)	12 (26.7)
High School	12 (26.7)	10 (22.2)	10 (22.2)	11 (24.4)
Higher Education	12 (26.7)	10 (22.2)	18 (40.0)	10 (22.2)
Total	45 (100)	45 (100)	45 (100)	45 (100)

Participants were between 17 and 55 years old and divided into four age groups. The 36–45 age group was most common in the PLB group (37.8%) and the Combination group (44.4%). In the Semi-Fowler group, most participants were in the 46–55 age group (35.6%). The control group had a more balanced age distribution, with both the 26–35 and 36–45 groups making up 28.9% each.

Baseline homogeneity analysis demonstrated that sex distribution and educational level were comparable across the four groups ($p = 0.371$ and $p = 0.137$, respectively). However, age distribution differed significantly among groups ($p = 0.029$), while baseline oxygen saturation did not differ significantly. Therefore, although most baseline characteristics were comparable, age should be considered a potential confounding variable in interpreting intervention effects.

The PLB group was primarily composed of participants with elementary-level education (33.3%), while the Semi-Fowler group was characterized mainly by middle school-level education (31.1%). In contrast, the Combination group had a higher proportion of participants with higher education (31.1%). The control group showed a relatively even distribution across education levels, although elementary and middle school categories were the most common (26.7% each).

Table 2. Descriptive Analysis of Oxygen Saturation

Oxygen Saturation Pursed-Lips Breathing	Mean ± SD	Median (Min–Max)
Pretest	92.64 ± 0.98	93 (91–94)
Posttest	95.62 ± 1.07	96 (93–98)
Semi-Fowler		
Pretest	92.38 ± 0.98	92 (91–94)
Posttest	95.49 ± 1.25	96 (93–98)
Combination		
Pretest	92.49 ± 1.12	93 (91–94)
Posttest	96.04 ± 1.29	96 (93–98)
Control		
Pretest	92.71 ± 0.94	93 (91–94)
Posttest	92.93 ± 1.47	93 (91–96)

Table 2 summarizes pre- and post-intervention oxygen saturation measurements for all four groups. Pre-intervention mean oxygen saturation levels were similar across the intervention groups, ranging from 92.38% to 92.64%. After the intervention, all three experimental groups showed increased oxygen saturation, whereas the control group exhibited only a marginal increase from 92.71% to 92.93%. The Combination group recorded the highest mean post-intervention oxygen saturation; however, between-group analysis did not indicate a statistically significant difference compared to the PLB or Semi-Fowler groups.

Table 3. Comparison of Pretest and Posttest Oxygen Saturation

Oxygen Saturation Pursed-Lips Breathing	Mean	Difference	Sig.
Pretest	92.64	2.98	<0.001
Posttest	95.62		
Semi-Fowler			
Pretest	92.38	3.11	<0.001
Posttest	95.49		

Combination			
Pretest	92.49	3.55	<0.001
Posttest	96.04		
Control			
Pretest	92.71	0.22	0.097
Posttest	92.93		

Table 3 shows that Wilcoxon signed-rank tests identified a significant increase in oxygen saturation for all three intervention groups ($p < 0.001$). The control group showed no significant change ($p = 0.097$), indicating that oxygen saturation remained unchanged without targeted respiratory intervention.

Table 4. Intergroup Comparison of Posttest Values

Group	Mean Posttest	Sig.
Pursed-Lips Breathing	95.62	<0.001
Semi-Fowler	95.49	
Combination	96.04	
Control	92.93	

The Kruskal-Wallis test (Table 4) found a significant difference in posttest oxygen saturation among the four groups ($p < 0.001$). The Combination group achieved the highest mean post-intervention oxygen saturation (96.04%), followed by the PLB (95.62%) and Semi-Fowler (95.49%) groups. The control group had the lowest mean (92.93%). These results demonstrate that all three interventions improved oxygen saturation compared to baseline, while the control group did not show significant change.

DISCUSSION

Interpretation of Principal Findings

The results indicate that all three interventions—pursed-lip breathing (PLB), the Semi-Fowler position, and the combined PLB plus Semi-Fowler technique—significantly improved oxygen saturation in patients with pulmonary tuberculosis. In contrast, the control group did not show any statistically significant change.

PLB's effectiveness in this cohort is due to its mechanical impact on the respiratory cycle. By adding resistance during exhalation, PLB creates positive end-expiratory pressure (PEEP), which helps keep airways open and prevents alveolar collapse. Extending the expiratory phase improves gas exchange and oxygen diffusion across the alveolar-capillary membrane. These results are consistent with previous studies showing that controlled expiration with PLB leads to better systemic oxygenation than spontaneous breathing (2, 3, 17).

The Semi-Fowler position, which elevates the head of the bed to 30–45 degrees, improves respiratory mechanics by reducing the upward pressure of abdominal organs on the diaphragm. This allows for greater thoracic expansion and better alveolar ventilation. These findings support existing literature that links therapeutic positioning to increased respiratory efficiency and improved oxygen saturation in patients with restrictive or obstructive pulmonary conditions (8, 18).

The combination group had the highest mean post-intervention oxygen saturation among the interventions. Although this result reflects the complementary effects of PLB and the Semi-Fowler position, current analyses do not show that the combination is significantly more effective than either intervention alone. This study's pattern aligns with Sitorus (19) and Wigiyanti & Faradisi (12), who found that combining breathing exercises with therapeutic positioning may improve ventilatory outcomes. While these findings suggest a potential benefit of the combined intervention, further studies

with pairwise comparisons or adjusted analyses are needed to determine if it offers additional advantages over either intervention alone.

Comparison with Previous Research

The findings of this study are consistent with a substantial body of evidence supporting the efficacy of PLB in enhancing pulmonary oxygenation. Mechanistically, PLB has been shown to improve respiratory patterns and optimize airflow dynamics, as noted by Dodange (20). Furthermore, Roberts (4) identified the primary benefit of PLB as its ability to maintain positive expiratory airway pressure, which prevents alveolar collapse and keeps the airways open during exhalation (6). Huda (21) also demonstrated the broad clinical utility of PLB across various respiratory conditions, including both COVID-19 and non-COVID-19 patients. The present study corroborates these findings by providing evidence that PLB is associated with improved oxygen saturation as a non-invasive intervention for enhancing oxygenation in the pulmonary TB population.

The current results regarding the Semi-Fowler position support previous research indicating that gravitational positioning significantly influences respiratory outcomes. Alan (8) demonstrated that body orientation is a critical determinant of oxygenation in patients with both unilateral and bilateral lung disease. Specifically, the Semi-Fowler position has been shown to improve oxygenation in patients with chronic obstructive pulmonary disease (COPD) (11, 22-24), and other studies have confirmed its role in enhancing overall functional residual capacity and respiratory efficiency (25-27). These findings highlight the clinical importance of employing the Semi-Fowler position as a supportive nursing intervention for TB patients experiencing dyspnea or impaired gas exchange.

The higher mean post-intervention oxygen saturation observed in the combination group supports the hypothesis that combining breathing exercises with therapeutic positioning yields complementary physiological effects. This finding aligns with Wigiyanti and Faradisi (12), who reported that integrating PLB with Fowler positioning resulted in greater improvements in oxygen saturation among TB patients. Similarly, Siregar (28) found that comprehensive respiratory protocols incorporating multimodal techniques produced more significant improvements in oxygenation status compared to single-m. This trend is also observed in other obstructive conditions. For example, Inayah and Wilutono (29) found that combining breathing exercises with therapeutic positioning significantly enhances oxygenation in asthmatic patients. Collectively, these findings support the potential value of integrating breathing exercises with therapeutic positioning. Therapeutic positioning.

Public Health Implications

This research has important public health implications, especially for areas with high rates of pulmonary TB, such as Gorontalo. PLB and the Semi-Fowler position are cost-effective, safe, and non-pharmacological interventions that do not require specialized equipment. Their simplicity enables easy use by nursing staff, caregivers, and patients, making them well suited for resource-limited settings.

Integrating these techniques into standard respiratory care, in both clinical and home settings, may help reduce the risk of hypoxia and relieve dyspnea. By maintaining near-normal oxygen saturation, these interventions can lower the risk of severe complications, such as acute respiratory failure. Routine use of PLB and therapeutic positioning in nursing protocols may enhance clinical management and support long-term recovery for patients with pulmonary TB.

Several methodological limitations should be considered when interpreting these findings. First, the assessment focused solely on oxygen saturation and did not incorporate other essential physiological parameters, such as respiratory rate, tidal volume, dyspnea scales, or arterial blood gas analysis. This omission restricts a comprehensive evaluation of overall ventilatory efficiency. Second, the interventions were implemented over a brief period without long-term follow-up, leaving the persistence of oxygen saturation improvements over time uncertain. Additionally, external confounding

factors, including participant anxiety, fatigue, and environmental conditions, were not rigorously controlled and may have affected individual measurements. Finally, the use of purposive sampling and the specific clinical setting may constrain the generalizability of these findings to the wider pulmonary tuberculosis population. Future studies utilizing randomized controlled trials and longitudinal monitoring are required to confirm these results across more diverse demographic and clinical groups.

CONCLUSION

This study shows that hypoxemia is a significant clinical concern in pulmonary tuberculosis patients with dyspnea, as indicated by baseline oxygen saturation. Non-pharmacological interventions, including Pursed-Lips Breathing (PLB), the Semi-Fowler position, and their combination, significantly improved oxygen saturation in these patients. The combination group achieved the highest mean post-intervention oxygen saturation, likely due to the complementary physiological effects of PLB and the Semi-Fowler position. Further research with pairwise comparisons and adjusted analyses is needed to determine if the combined intervention offers additional benefits over each intervention alone.

Due to their safety, cost-effectiveness, and lack of need for specialized equipment, these techniques are well suited for inclusion in standard nursing operating procedures, especially in resource-limited areas such as Gorontalo. Implementing these interventions can reduce the risk of acute hypoxia, relieve dyspnea, and enhance the quality of life for TB patients.

To build upon these findings, future research should utilize randomized controlled trial (RCT) designs. Future research should use randomized controlled trial designs and longitudinal monitoring to assess the long-term effects of these interventions during TB treatment. Studies should also include comprehensive physiological markers, such as arterial blood gas analysis, respiratory rate, and dyspnea scales, and examine the impact on patients with various comorbidities.

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AUTHOR'S CONTRIBUTION STATEMENT

FI and LUcontributed to this article. FI was responsible for the writing of the original draft, methodology, investigation, data curation, resource provision and overall supervision. LU performed the formal analysis and validation, and was responsible for the visualization, as well as the review and editing of the manuscript. All authors have read and agreed to the published version of the manuscript.

CONFLICT OF INTEREST

None.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

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DATA AVAILABILITY

The dataset generated and analyzed during the current study is available from the corresponding author upon request.

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