



RESEARCH ARTICLE

# The Efficacy of Pursed Lips Breathing on Enhancing Thoracic Expansion in Active Smokers: A Quasi-Experimental Study in Salimpaung District, Indonesia

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## Abstract

Smoking impairs lung function as hemoglobin binds more easily to carbon dioxide than oxygen, weakening respiratory muscles and reducing thoracic expansion. This condition increases the risk of shortness of breath and respiratory complications. Pursed Lips Breathing (PLB) is a breathing technique that improves alveolar ventilation and strengthens respiratory muscles, ultimately enhancing thoracic expansion. This quasi-experimental study aimed to determine the effect of PLB on thoracic expansion in active smokers. The study was conducted from March 13 to March 26, 2023, involving 15 active male smokers aged 30–40 years in Salimpaung District, Tanah Datar Regency. Thoracic expansion was measured at three anatomical points: axilla, costa 4, and xyphoid process using the midline technique. The findings showed significant increases in thoracic expansion at all measurement points. The mean expansion at the axilla improved from 1.07 cm to 2.73 cm ( $p = 0.000$ ), at costa 4 from 2.20 cm to 5.33 cm ( $p = 0.001$ ), and at the xyphoid process from 4.73 cm to 7.27 cm ( $p = 0.001$ ). These results confirm the positive effect of PLB on thoracic expansion in active smokers. In conclusion, PLB is an effective intervention for enhancing thoracic expansion and improving respiratory function in active smokers. It can be a practical and accessible method for respiratory rehabilitation, particularly for populations with limited access to medical facilities. The adoption of PLB may help reduce respiratory complications and improve overall lung capacity in smokers.

Keywords: Pursed Lips Breathing, Thoracic Expansion, Respiratory Rehabilitation, Active Smokers, Breathing Exercises, Quasi-Experimental Study

## INTRODUCTION

Smoking is one of the most critical global health problems, causing significant morbidity and mortality worldwide. Cigarettes, as defined by the Indonesian Minister of Health Regulation No. 28 of 2013, are tobacco products that can be burned, smoked, or inhaled, including clove cigarettes, white cigarettes, cigars, and other forms made from *Nicotiana tabacum*, *Nicotiana rustica*, or synthetic substitutes. These products contain harmful substances such as nicotine and tar, which adversely affect the respiratory system (Wulandari et al., 2019). Smoking

behavior is characterized by inhaling cigarette smoke, exposing not only the smoker but also bystanders to harmful toxins. Active smokers inhale these substances directly, while passive smokers are indirectly affected by secondhand smoke (Parwati, 2018).

Smoking adversely affects multiple physiological systems, particularly the respiratory system. Prolonged exposure to cigarette smoke introduces carbon monoxide into the bloodstream, which binds to hemoglobin more readily than oxygen, reducing the oxygen-carrying capacity of the blood. This impairs gas exchange, weakens the respiratory muscles, and decreases thoracic expansion, which are crucial for efficient breathing (Rahmah, 2015). According to Saminan (2016), continuous smoking accelerates the decline in thoracic expansion, leading to reduced lung function and higher risks of respiratory complications.

Smoking prevalence in Indonesia is among the highest globally, posing a significant public health challenge. Riskesdas (2018) reports that 26.9% of the population in West Sumatra are smokers, ranking it seventh among Indonesian provinces. West Sumatra also has the highest proportion of people exposed to secondhand smoke in

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closed spaces, including homes, workplaces, and public transportation (Mardhotilla, 2020). Specifically, in Salimpaung District, it was estimated that there were 1,537 active male smokers in 2019 (Bps Tanah Datar, 2013). The widespread prevalence of smoking, combined with limited awareness of its health risks, exacerbates the burden of smoking-related diseases in this region.

Globally, the World Health Organization (WHO) estimates that smoking is responsible for approximately 6 million deaths annually, with active smokers facing a significantly higher risk of mortality compared to passive smokers (World Health Organization, 2016). Smoking is a major risk factor for chronic respiratory diseases, including chronic obstructive pulmonary disease (COPD), lung cancer, and cardiovascular diseases. In Indonesia, smoking-related deaths account for a substantial portion of the national disease burden, underscoring the urgent need for targeted interventions to mitigate its impact (Ismail & Wibisono, 2021).

Thoracic expansion, defined as the difference in chest circumference between maximum inspiration and expiration, is a key indicator of respiratory function (Puspitasari et al., 2017). Smoking accelerates the decline in thoracic expansion by causing structural and functional damage to the lungs and weakening the respiratory muscles involved in inspiration and expiration (Lima & Machado, 2019). These changes include the loss of alveolar elasticity, increased airway resistance, and reduced diaphragmatic strength, which collectively impair lung ventilation and gas exchange (Rahmah, 2015). Over time, reduced thoracic expansion can lead to chronic hypoxia, reduced physical endurance, and increased susceptibility to respiratory complications (Saminan, 2016).

Thoracic expansion can be assessed using the midline measurement technique at three anatomical points: the axilla, costa 4, and xyphoid process. These measurements provide an objective evaluation of lung capacity and respiratory muscle function, particularly in individuals with compromised respiratory systems (Puspitasari et al., 2017). Research has shown that smokers exhibit significantly lower thoracic expansion compared to non-smokers, highlighting the adverse impact of smoking on respiratory health (Sundari et al., 2015).

Pursed Lips Breathing (PLB) is a simple yet effective breathing technique widely used in respiratory rehabilitation. PLB involves slow, deep inspiration through the nose followed by prolonged expiration through pursed lips, which creates positive pressure in the airways. This technique reduces airway resistance, improves alveolar ventilation, and enhances respiratory muscle function (Qamila et al., 2019). By slowing down the respiratory rate and increasing expiratory time, PLB prevents airway collapse, reduces hyperinflation, and promotes better gas exchange in the lungs (Lima & Machado, 2019).

PLB has been extensively studied in patients with chronic respiratory diseases such as COPD, where it has been shown to improve dyspnea, thoracic expansion, and overall respiratory efficiency (Lima & Machado, 2019; Qamila et al., 2019). However, there is limited research on the application of PLB in active smokers without pre-existing respiratory diseases. Smokers represent a unique population with early signs of respiratory dysfunction, making them ideal candidates for preventive interventions such as PLB (Ismail & Wibisono, 2021).

Despite the documented benefits of PLB in respiratory rehabilitation, studies on its effectiveness in improving thoracic expansion in active smokers, particularly in Indonesia, remain scarce. Most existing studies focus on clinical populations with advanced respiratory diseases,

leaving a gap in the literature regarding preventive interventions for healthy smokers. This study aims to address this gap by evaluating the impact of PLB on thoracic expansion in active smokers in Salimpaung District, Tanah Datar Regency. The high prevalence of smoking in this region, coupled with limited access to respiratory rehabilitation programs, underscores the importance of developing locally relevant interventions.

The theoretical framework underlying PLB is rooted in respiratory physiology. By increasing alveolar ventilation, PLB enhances oxygen delivery and carbon dioxide removal, reducing the work of breathing and improving respiratory efficiency (Lima & Machado, 2019). The positive pressure created during prolonged expiration through pursed lips prevents airway collapse, maintaining airway patency and reducing hyperinflation (Qamila et al., 2019). Additionally, PLB strengthens the diaphragm and intercostal muscles, improving thoracic expansion and respiratory muscle elasticity (Rahmah, 2015). These mechanisms make PLB an effective tool for addressing the respiratory challenges faced by smokers.

This study aims to evaluate the effect of Pursed Lips Breathing on thoracic expansion in active smokers in Salimpaung District, Tanah Datar Regency. By addressing the research gap in preventive respiratory interventions for smokers, this study seeks to contribute to the development of evidence-based strategies for improving respiratory health in high-risk populations. The findings are expected to provide valuable insights for the implementation of community-based respiratory rehabilitation programs tailored to the needs of smokers in Indonesia.

## RESEARCH METHODS

### Study Design

This study employed a quasi-experimental design with a one-group pretest-posttest approach to evaluate the effect of Pursed Lips Breathing (PLB) on thoracic expansion in active smokers. This design allows for the measurement of thoracic expansion before and after the intervention, enabling the assessment of changes attributable to PLB. Although the absence of a control group limits the generalizability of the findings, this design is suitable for preliminary studies in community settings (Harris et al., 2020).

### Study Location and Duration

The study was conducted in Salimpaung District, Tanah Datar Regency, from March 13 to March 26, 2023, over a period of two weeks. Each participant underwent 14 sessions of PLB, with a frequency of 7 sessions per week. The two-week intervention duration was selected based on previous studies indicating that short-term respiratory interventions can lead to measurable improvements in thoracic expansion within this timeframe (Lima & Machado, 2019).

### Sample Selection and Power Analysis

The sample consisted of 15 active male smokers aged 30–40 years. This sample size was determined based on practical feasibility and the limited availability of eligible respondents in the study area. Although relatively small, the sample size is consistent with similar exploratory studies in respiratory rehabilitation (Ismail & Wibisono,

2021). A post-hoc power analysis indicated that the sample size provides sufficient power to detect significant changes in thoracic expansion, assuming a large effect size (Cohen, 1988).

### Inclusion and Exclusion Criteria

Participants in this study were selected based on specific inclusion and exclusion criteria to ensure the homogeneity and reliability of the sample. The inclusion criteria required participants to be male, aged between 30 and 40 years, and willing to participate by providing informed consent. Additionally, eligible participants had to be active smokers who consumed at least one pack of cigarettes per day for a minimum of 10 years and had no physical disability that could affect respiratory function. Conversely, participants were excluded if they had a chronic or serious illness during the study period or if they were diagnosed with comorbid lung diseases such as chronic obstructive pulmonary disease (COPD) or asthma. These criteria were carefully established to minimize confounding variables and ensure that the study focused on the primary population of interest—active smokers without severe underlying health conditions.

### Intervention Protocol

The Pursed Lips Breathing (PLB) intervention was conducted following a standardized protocol to ensure consistency and accuracy across all sessions. Each session lasted approximately 15–20 minutes and was supervised by a trained physiotherapist. Participants were instructed to sit comfortably with their backs straight and shoulders relaxed, then inhale deeply through the nose for about 2–3 seconds. They were guided to exhale slowly through pursed lips for 4–6 seconds, ensuring a prolonged expiratory phase. This breathing cycle was repeated 15 times per session. The technique was demonstrated and practiced under supervision during the initial sessions to ensure proper execution and avoid errors. Participants were reminded to avoid forced expiration, as it could cause unnecessary strain on the respiratory muscles, potentially leading to discomfort or reduced effectiveness of the intervention (Qamila et al., 2019). This structured approach was designed to maximize the benefits of PLB and promote respiratory muscle strengthening while minimizing the risk of complications.

### Measurement of Thoracic Expansion

Thoracic expansion was measured at three anatomical landmarks—axilla, costa 4, and xyphoid process—using a midline technique and a non-elastic measuring tape. Measurements were taken at maximum inspiration and maximum expiration, with the difference in chest circumference recorded in centimeters (Puspitasari et al., 2017).

To ensure accuracy and consistency, all measurements were performed by the same trained examiner. Prior to the study, the examiner underwent calibration exercises to minimize inter-observer variability and improve measurement reliability. The measuring tape was placed horizontally and aligned to avoid measurement errors caused by uneven positioning (Harris et al., 2020).

### Quality Control Procedures

Several quality control measures were implemented to ensure the reliability and accuracy of data collection

throughout the study. All measurements were conducted following a standardized protocol to maintain consistency and reduce measurement bias. The examiner received specialized training and calibration exercises to ensure uniformity in applying the measurement procedures. Additionally, each measurement was taken three times, and the average value was recorded to minimize random errors and improve the precision of the results. These measures were essential to enhance the validity and reliability of the data, ensuring that the findings accurately reflected the true effects of the intervention.

### Data Analysis

The collected data were analyzed using SPSS version 26.0. Descriptive statistics were used to summarize baseline characteristics of the participants. Changes in thoracic expansion at the three anatomical landmarks were analyzed using the Wilcoxon signed-rank test, as the sample size and data distribution did not meet the assumptions for parametric testing (Pallant, 2020). Statistical significance was set at  $p < 0.05$  for all analyses.

### Research Ethics

This study was conducted following the principles outlined in the Declaration of Helsinki for ethical research involving human subjects. Ethical approval was obtained from the Ethics Committee of the Faculty of Health Sciences at Universitas Fort De Kock. All participants provided written informed consent prior to participation. They were informed about the study objectives, procedures, potential risks, and benefits. Participants had the right to withdraw from the study at any time without consequences. Confidentiality and anonymity were maintained throughout the study.

## RESULTS

This study aimed to evaluate the effect of Pursed Lips Breathing (PLB) on thoracic expansion in active smokers in Salimpaung District. The results are presented below, including pre-intervention and post-intervention measurements, along with their clinical implications. Measurements were taken at three anatomical points—axilla, costa 4, and xyphoid process—to assess thoracic expansion and determine whether PLB significantly improves respiratory capacity.

Table 1 displays the baseline measurements of thoracic expansion before the PLB intervention. The average thoracic expansion at the axilla was 1.07 cm (SD = 0.258), with a range between 1 and 2 cm. At costa 4, the mean thoracic expansion was 2.20 cm (SD = 0.676), ranging from 1 to 3 cm. Meanwhile, at the xyphoid process, the average expansion was 4.73 cm (SD = 0.799), with values ranging from 4 to 6 cm. These baseline values indicate limited thoracic expansion among the participants, reflecting weakened respiratory muscles due to prolonged smoking. The relatively small standard deviations suggest that the measurements were consistent across participants at each anatomical point, indicating that most participants had similar baseline thoracic expansion values before the intervention. These findings highlight the need for interventions to improve thoracic mobility and respiratory function in this population.

**Table 1**  
**Average Before Pursed Lips Breathing Implementation In Sal Districtimpaug**

Variables	N	Mean	SD	Minimum	Maximum
Axilla Before Treatment	15	1.07	0.258	1	2
Costa4 Before Treatment	15	2.20	0.676	1	3
Xyphoid Before Treatment	15	4.73	0.799	4	6

After 14 sessions of PLB, thoracic expansion increased significantly across all measurement points (Table 2). At the axilla, the average thoracic expansion rose to 2.73 cm (SD = 0.458), with a minimum of 2 cm and a maximum of 3 cm. At costa 4, the mean increased to 5.33 cm (SD = 0.488), ranging from 5 to 6 cm. The xyphoid process showed the highest average expansion, increasing to 7.27 cm (SD = 1.280), with values ranging from 3 to 8 cm. The increase in

thoracic expansion demonstrates the effectiveness of PLB in enhancing respiratory muscle function and lung capacity. The post-intervention variability at the xyphoid process (SD = 1.280) suggests that individual responses to the intervention were more variable at this measurement point. This may be attributed to differences in compliance, effort during the intervention, or variations in baseline lung capacity.

**Table 2**  
**Average After Pursed Lips Breathing Implementation In Salimpaung District.**

Variables	N	Mean	SD	Minimum	Maximum
Axilla After Treatment	15	2.73	0.458	2	3
Costa4 After Treatment	15	5.33	0.488	5	6
Xyphoid After Treatment	15	7.27	1,280	3	8

Table 3 presents the statistical analysis of thoracic expansion differences before and after the intervention using the Wilcoxon signed-rank test. This test was chosen due to the small sample size and the non-parametric nature of the measurements. The analysis reveals statistically significant improvements in thoracic expansion across all measurement points.

At the axilla, the mean difference in thoracic expansion was 1.66 cm, with a p-value of 0.000 ( $< 0.05$ ), indicating a significant improvement. This increase suggests enhanced upper thoracic mobility, which plays a critical role in reducing breathing effort and improving oxygen exchange during daily activities. At costa 4, the mean difference was 3.13 cm, with a p-value of 0.001 ( $< 0.05$ ), confirming a significant enhancement. The increased expansion at this mid-thoracic level reflects improved diaphragmatic function and better respiratory muscle coordination,

essential for sustained physical activity and reduced dyspnea.

Similarly, the xyphoid process showed a mean difference of 2.54 cm, with a p-value of 0.001 ( $< 0.05$ ), indicating a substantial improvement in lower thoracic expansion. The lower thoracic region is crucial for deep breathing and maximal inspiratory efforts. The observed improvement suggests that participants gained greater control over their breathing patterns, which is vital for maintaining respiratory efficiency. These findings are clinically significant, demonstrating that PLB not only enhances thoracic expansion but also contributes to better respiratory capacity. The intervention holds the potential to reduce the risk of respiratory complications in active smokers, making it a valuable and accessible strategy for respiratory rehabilitation.

**Table 3**  
**Research Results on the Effect of Pursed Lips Breathing of Active Smokers (N=15).**

Measurements	Variables	N	Mean	SD	Mean Difference	P-Value																
Axilla	Pre-test	15	1.07	0.258	1.16	0,000																
	Post test		2.73	0.458			Costa 4	Pre-test	15	2.20	0.676	3.13	0.001	Post test	5.33	0.488	Axilla	Pre-test	15	4.73	0.799	2.54
Costa 4	Pre-test	15	2.20	0.676	3.13	0.001																
	Post test		5.33	0.488			Axilla	Pre-test	15	4.73	0.799	2.54	0.001	Post test	7.27	1,280						
Axilla	Pre-test	15	4.73	0.799	2.54	0.001																
	Post test		7.27	1,280																		

The increase in thoracic expansion at all measurement points indicates that PLB is an effective intervention for improving respiratory function in active smokers. Improved thoracic mobility can enhance lung ventilation, reduce respiratory effort, and increase oxygen saturation, ultimately improving participants' quality of life (Lima & Machado, 2019). The greater variability observed at the xyphoid process suggests that individual factors, such as baseline lung capacity, adherence to the intervention

protocol, and physical fitness, may influence the magnitude of improvement.

Individual responses to PLB varied, with some participants showing marked improvements while others experienced more modest changes. This variability highlights the importance of personalized interventions and close supervision during respiratory rehabilitation programs to maximize the benefits of PLB. Further research is needed to explore the factors influencing individual

responses and to develop tailored strategies for optimizing outcomes.

In summary, the results of this study show that PLB significantly enhances thoracic expansion in active smokers at all three measurement points—axilla, costa 4, and xyphoid process. These findings confirm the potential of PLB as a simple, cost-effective intervention for improving respiratory function in high-risk populations. The observed improvements in thoracic expansion can lead to better respiratory efficiency, reduced symptoms of breathlessness, and improved overall respiratory health.

## DISCUSSION

### Average Thoracic Expansion Before Pursed Lips Breathing in Active Smokers

The findings of this study reveal that thoracic expansion in active smokers was significantly reduced before the Pursed Lips Breathing (PLB) intervention. At the axilla, the mean thoracic expansion was 1.07 cm, with a minimum of 1 cm and a maximum of 2 cm. This limited expansion reflects poor upper thoracic mobility, which compromises lung ventilation. Similarly, at costa 4, the average thoracic expansion was 2.20 cm (range: 1–3 cm), indicating mid-thoracic restriction, while at the xyphoid process, the mean thoracic expansion was 4.73 cm (range: 4–6 cm), suggesting reduced lower thoracic capacity. These pre-intervention values highlight the impact of prolonged smoking on thoracic expansion and respiratory function.

Smoking is a major risk factor for respiratory decline, as it weakens respiratory muscles and reduces lung elasticity due to chronic exposure to harmful substances such as carbon monoxide and tar (Rahmah, 2015). Carbon monoxide competes with oxygen in binding to hemoglobin, forming carboxyhemoglobin, which reduces oxygen transport capacity. This chronic oxygen deprivation leads to weakening of the respiratory muscles and ligaments, limiting thoracic mobility (Saminan, 2016). Reduced thoracic expansion, in turn, leads to shortness of breath, decreased oxygen saturation, and increased risk of respiratory conditions such as chronic obstructive pulmonary disease (COPD) (Ismail & Wibisono, 2021).

The results are consistent with previous studies showing reduced thoracic expansion in smokers compared to non-smokers due to loss of alveolar elasticity and diminished respiratory muscle strength (Lima & Machado, 2019). Nursalam (2016) found that thoracic mobilization significantly improved respiratory frequency in COPD patients, emphasizing the importance of restoring thoracic expansion. Similarly, Christian (2016) reported increased oxygen saturation after active-assistive thoracic cage mobilization in COPD patients, reinforcing the link between thoracic mobility and respiratory function.

### Average Thoracic Expansion After Pursed Lips Breathing in Active Smokers

The post-intervention results showed significant improvements in thoracic expansion at all measurement points. The mean thoracic expansion at the axilla increased to 2.73 cm (range: 2–3 cm), indicating enhanced upper thoracic mobility. At costa 4, the mean expansion rose to 5.33 cm (range: 5–6 cm), reflecting better mid-thoracic function and improved diaphragmatic coordination. The most substantial improvement was observed at the xyphoid process, where the mean thoracic expansion

increased to 7.27 cm (range: 3–8 cm). This indicates that PLB is an effective intervention for restoring thoracic mobility and improving overall respiratory capacity.

PLB works by increasing expiratory time and creating positive pressure in the airways, which helps reduce airway resistance and prevents airway collapse (Qamila et al., 2019). This breathing technique promotes better alveolar ventilation and improves oxygen and carbon dioxide exchange, ultimately enhancing respiratory muscle elasticity and thoracic expansion (Lima & Machado, 2019). The current findings align with Cabral, et al (2022) study, which reported a significant increase in mid-thoracic expansion in active smokers after two weeks of PLB.

The improvement in thoracic expansion at the xyphoid process is particularly noteworthy because this region plays a crucial role in deep breathing and maximal inspiratory efforts. Enhanced lower thoracic mobility is associated with better lung capacity and reduced respiratory effort, which are vital for maintaining physical endurance and preventing respiratory complications (Ismail & Wibisono, 2021).

### Clinical Implications for Respiratory Rehabilitation

The observed improvements in thoracic expansion have significant clinical implications for respiratory rehabilitation. Increased thoracic mobility improves lung ventilation, reduces dyspnea, and increases oxygen saturation, which collectively enhance the quality of life for individuals with compromised respiratory function (Lima & Machado, 2019). PLB is a simple and accessible intervention that can be easily integrated into community-based respiratory rehabilitation programs, particularly in regions with limited healthcare resources.

Given the variability in post-intervention responses, it is essential to consider individual factors such as baseline lung capacity, adherence to the intervention, and physical fitness when implementing PLB in broader populations. Personalized approaches that combine PLB with other breathing techniques or physical therapy exercises may optimize outcomes and promote long-term respiratory health. Future research should focus on identifying predictors of response to PLB and developing tailored interventions for different populations.

This study extends the current body of knowledge on the benefits of PLB in improving thoracic expansion among active smokers. Previous research by McCormack and Grant (2021) demonstrated that PLB significantly improved ventilation efficiency in individuals with smoking-related respiratory issues. Sumedi et al. (2020) also reported increased thoracic mobility at costa 4 after PLB intervention, highlighting its role in reducing respiratory muscle fatigue and enhancing lung function. The findings are consistent with the results of Li, et al (2025), who found that deep breathing exercises improved thoracic and lung expansion in post-operative coronary artery bypass graft (CABG) patients. These studies, together with the current research, reinforce the value of PLB as a cost-effective and non-invasive intervention for improving respiratory function in both clinical and non-clinical settings.

The improvements observed in this study can be explained through the lens of respiratory physiology. PLB increases intrathoracic air pressure during expiration, which reduces airway resistance and prevents alveolar collapse. This process enhances oxygen delivery and carbon dioxide removal, improving overall respiratory efficiency (Rahmah, 2015). Moreover, the prolonged expiration associated with PLB strengthens the diaphragm and intercostal muscles, promoting greater thoracic

expansion and respiratory muscle elasticity (Lima & Machado, 2019). These physiological adaptations contribute to the observed improvements in thoracic mobility and support the use of PLB as a therapeutic tool for smokers.

### Study Limitations and Future Directions

Despite the positive findings, this study has several limitations that should be acknowledged. First, the sample size was relatively small ( $n = 15$ ), which limits the generalizability of the results to larger populations. Future studies with larger sample sizes are needed to confirm the findings and explore potential variations in response across different demographic groups. Second, the study used a one-group pretest-posttest design without a control group, which limits the ability to attribute the observed improvements solely to the PLB intervention. A randomized controlled trial (RCT) design would provide stronger evidence of causality and reduce the risk of bias.

Third, the intervention duration was relatively short (two weeks), which may not capture the long-term effects of PLB on thoracic expansion and respiratory health. Longitudinal studies are necessary to evaluate the sustainability of the observed improvements and determine whether continued practice of PLB can prevent respiratory decline in high-risk populations. Finally, the study did not assess participants' adherence to the intervention protocol outside the supervised sessions. Variations in adherence could have influenced the results, and future research should include objective measures of adherence to ensure consistency and accuracy.

Based on the findings and limitations of this study, several areas for future research are suggested. First, larger-scale studies with more diverse populations are needed to validate the results and explore potential differences in response based on age, gender, and smoking history. Second, incorporating a control group and adopting an RCT design would strengthen the evidence base and enhance the validity of the findings.

Additionally, exploring the combination of PLB with other physical therapy techniques or aerobic exercises could yield greater improvements in thoracic expansion and overall respiratory health. Finally, long-term follow-up studies are essential to assess the durability of the observed benefits and determine the optimal duration and frequency of PLB for sustained respiratory function improvement.

In summary, this study provides strong evidence that PLB is an effective intervention for improving thoracic expansion in active smokers. The significant increases in thoracic mobility at all measurement points highlight the potential of PLB as a simple, accessible, and cost-effective tool for respiratory rehabilitation. While the study has some limitations, the findings contribute valuable insights into the role of PLB in promoting respiratory health and preventing respiratory decline. Future research should build on these findings to refine and expand the use of PLB in broader populations, ultimately improving the quality of life for individuals at risk of respiratory complications.

### CONCLUSION

This study highlights the significant effect of the Pursed Lips Breathing (PLB) technique on enhancing thoracic expansion in active smokers in Salimpaung District, Tanah Datar Regency. The intervention demonstrated notable

improvements across all measurement points. The average thoracic expansion in the axilla increased from 1.07 cm to 2.73 cm, while the costa 4 region improved from 2.20 cm to 5.33 cm. Similarly, the thoracic expansion at the xyphoid process rose from 4.73 cm to 7.27 cm. The Wilcoxon signed-rank test confirmed that these differences were statistically significant, with  $p$ -values well below the 0.05 threshold, indicating that PLB is a highly effective intervention for improving respiratory function.

These findings underscore the clinical importance of integrating PLB into respiratory rehabilitation programs for active smokers. The increase in thoracic expansion suggests enhanced respiratory muscle strength and improved lung capacity, which are essential for reducing breathlessness, increasing oxygen saturation, and preventing further respiratory decline. Such improvements have the potential to positively impact the daily lives of individuals, increasing physical endurance and overall well-being. In addition to its clinical implications, PLB is a simple, cost-effective, and accessible intervention that can be easily implemented in community-based settings. Given the high prevalence of smoking and limited access to advanced respiratory care in many rural areas, adopting PLB as a routine breathing exercise could offer a practical solution for improving respiratory health on a larger scale.

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### DECLARATION

#### Ethics approval and consent to participate:

Research approved by the Research Ethics Committee of the authors' institution (Certificate of Presentation of Ethical Review number: 34445720.8.0000.0023).

#### Consent for publication:

All participants were informed of the objectives and procedures of the study and subsequent publication of the results.

#### Availability of Data and Material (ADM):

Data not available because it compromises the anonymity of participants.

#### Competing interests:

Authors declare no conflict of interest

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#### Authors' contributions:

The authors confirm responsibility for the following - study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

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