

Efficacy of Stacked Breathing Technique on Respiratory Muscle Performance and Breath-Holding Capacity in Young Female Folk Vocalists

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Abstract:

➤ *Background:*

Breathing plays an essential role in singing by regulating airflow and subglottic pressure required for effective phonation. Female folk singers require adequate respiratory muscle strength, breath control, and lung expansion to sustain vocal performance. Breath Stacking (BS) may enhance lung volume and respiratory function by allowing successive inspiratory efforts without expiration.

➤ *Objective:*

To evaluate and compare the effects of Breath Stacking and Pursed Lip Breathing on respiratory muscle strength and breath hold time in female folk vocalists.

➤ *Design:*

Randomized Controlled Trial.

➤ *Setting:*

Department of Music, Khalsa College, Amritsar.

➤ *Methods:*

An experimental randomized controlled trial was conducted among 48 female folk singers aged 18–25 years at the Department of Music, Khalsa College, Amritsar. Participants were randomly allocated into two groups, with 24 participants in each group. Intervention Group (Group A) received Breath Stacking, while control group (Group B) received Pursed Lip Breathing. Both interventions were administered four days per week for four weeks. Respiratory muscle strength was assessed using Maximum Inspiratory Pressure (MIP) and Maximum Expiratory Pressure (MEP), while Breath Hold Time (BHT) was assessed using a static breath-holding test. Pre- and post-intervention measurements were compared using paired and unpaired t-tests.

➤ *Results:*

Both groups showed significant improvements in MIP, MEP, and BHT after four weeks ($p < 0.005$), with greater improvements observed in the Breath Stacking group compared with the Pursed Lip Breathing group.

➤ *Conclusion:*

Both Breath Stacking and Pursed Lip Breathing improved respiratory muscle strength and breath-holding capacity in female folk singers. However, Breath Stacking demonstrated greater effectiveness and may be a useful respiratory training technique for improving respiratory efficiency and supporting vocal performance.

Keywords: *Breath Stacking, Pursed Lip Breathing, Respiratory Muscle Strength, Breath Hold Time.*

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I. INTRODUCTION

In addition to facilitating gaseous exchange during singing, breathing also produces the subglottic pressure-the airway pressure beneath the larynx's closed vocal folds that is necessary to cause them to vibrate. The respiratory muscles must constantly modify subglottic pressure when singing order to preserve a steady vocal quality between notes with different loudness or pitch. Singers exhibit brief periods of muscle activation during phonation, which likely indicate that these muscles help control and lower subglottic pressure when lung volumes are high by counteracting the natural elastic recoil of the lungs. All of these adjustments allow singers to control their tone, pitch and loudness.

Adjusting the inspiratory and expiratory muscle activity leads to maintenance of optimum subglottic pressure. ^[1]

A lot of voice actors regret their incapacity to maintain a sound for an extended period of time during a performance. As a result, people see the performers as being unskilled and their performances as being poor. This may be caused by allergies, poor alveolar recruitment during breathing, lack of muscular power and endurance, poor respiratory function brought on by certain obstructive disorders, some of which may be asymptomatic or altered diaphragmatic function. Because the diaphragm and ribs are elastic, they can never expand for very long duration before returning to their resting posture. As a result, when singing, there is a rush of air released at once, which ends in a matter of seconds. Singers do not wish for this to occur. ^[2]

Breathing exercises have shown to be improving lung volumes, improving breath functions and reduce muscle tension. ^[2,3]

BS technique enhances inspiratory capacity and duration of the BS manoeuvre itself; while sustaining maximal volume in subjects who have reduced ability to sustain deep inspiration after surgery, trauma, or critical illness. When it comes to producing and maintaining the maximum inspiratory volume in patients during the post-operative phase after thoracic and abdominal surgery, BS has outperformed deep breathing exercises and incentive spirometry. After coronary artery bypass, BS has also been shown to be successful in lowering pulmonary shunt in intubated patients. ^[4,5]

Chest volume is increased by successive inspiratory efforts while inhibiting expiration via BS, which encourages the redistribution of air in regions with varying time constants. Maintaining maximal inspiration raises transpulmonary pressure, which attracts collapsed alveoli and aids in lung expansion and PaO₂. ^[6]

Folk singing is the hallmark of high pitch and loud singing. ^[7] hence exhibiting great demand on respiratory system. BS enhances lung volume and capacity by stacking multiple breaths thereby reaching lung insufflation capacity (LIC). Hence, improving chest wall compliance and expansion. ^[8]

II. MATERIALS AND METHODS

➤ Study Design

Experimental Research Design- Randomised Controlled Trial.

➤ Study Setting

The study was carried out at the Department of Music, Khalsa College, Amritsar.

➤ Ethical Consideration

Ethical approval was sought and obtained from the Institutional Ethics Committee, Khalsa College, Amritsar with reference number IEC/KCA/PT/2025/19. An information form and consent form was given to the target folk singers. This was given to them to decide if they are willing to participate. The advanced group of singers were informed about the purpose of the study. They were allowed to ask questions regarding the study. The privacy and confidentiality of the subject was maintained throughout the study.

➤ Inclusion Criteria

The study enrolled college-aged folk singers (18–25 years) who had been performing for a minimum of one year. Eligible participants needed intact lung function and had to be capable of comprehending and complying with the study procedures.

➤ Exclusion Criteria

Individuals were excluded if they had suffered an upper respiratory infection in the past month, smoked or had a smoking history, or were trained in any other vocal discipline professionally. Those with a documented history of respiratory, cardiac, or neuromuscular conditions — such as asthma, tuberculosis, congenital cardiac anomalies, or vocal fold pathology — were not considered eligible. The study also excluded students who were already enrolled in formal voice therapy or pulmonary rehabilitation programs.

➤ Sample Size

The sample size for the study was calculated using G*Power version 3.1.9.7. An a priori power analysis was performed using an independent-samples t-test. The calculation was based on an anticipated effect size (Cohen's d) of 0.75, a significance level (α) of 0.05, and a statistical power of 0.81 (81%), with an allocation ratio of 1:1 between the two groups. The analysis indicated a required sample size

of 48 participants, with 24 participants allocated to the intervention group and 24 participants to the control group. The calculated actual power for the proposed sample size was 0.8198 (approximately 82%). Thus, a total of 48 female folk singers were included in the study.

➤ Outcome Measures

The intervention was administered over a period of four weeks. The outcome variables assessed were Respiratory Muscle Strength and Breath Hold Time, which were measured using respiratory pressure meter and a stopwatch, respectively. Measurements were recorded at two time points: the baseline assessment was conducted before the initiation of the intervention in both groups, and the post-intervention assessment was performed after four weeks, following completion of the intervention period.

➤ Respiratory Muscles Strength

It was measured while the subject was in standing position. In order to measure maximum inspiratory pressure (MIP), subject was instructed to exhale as slowly as possible and then inhale as strongly as possible through a mouthpiece attached to pressure meter. For measuring maximum expiratory pressure (MEP), subject was instructed to inhale as much as they can, nearly to their maximum lung capacity and then exhale as forcefully as they could through mouthpiece attached to pressure meter. At every measurement, the highest pressure that lasted for a minimum of one second was noted.^[9]

➤ Breath Hold Time

Breath-hold time was measured using a static breath-holding test (SBHT), performed in a seated position: the participant took a normal breath in and out through the nose, then pinched the nose and started a timer at the onset of breath-holding. Timing continued until the first definite urge to breathe appeared—signaled by sensations such as the need to swallow, diaphragmatic contractions, or airway constriction—at which point the nose was released and the timer stopped, followed by a calm inhalation. To improve accuracy, participants rested quietly for about 10 minutes beforehand to reach a calm state and focused attention on their breathing to enhance interoceptive awareness, since correctly identifying the first urge to breathe (rather than pushing to a maximal, involuntary breakpoint) was essential for a valid result.

Breath-hold time signifies an individual's chemosensitivity—specifically, their tolerance to rising CO₂ and falling O₂ levels, which are the primary physiological stimuli driving the urge to breathe. Longer breath-hold times generally indicate lower chemosensitivity and better tolerance to hypercapnia, often associated with more functional breathing patterns, whereas an inability to hold the breath for at least 20 seconds is commonly used as an indicator of a possible breathing disorder.^[10]

➤ Intervention Group- Breath Stacking

Prior to the intervention, the participants were informed about the study procedure and its potential benefits. Written informed consent was obtained from all participants before

commencement of the intervention, followed by collection of baseline data. The Breath Stacking technique was initially demonstrated by the therapist to ensure proper understanding of the procedure. The participant was then seated upright on a chair with the back supported and both feet flat on the floor. A warm-up session consisting of 3–4 gentle breaths was performed before initiating the technique. The participant was instructed to inhale slowly and deeply according to her comfort level, followed by three quick additional inhalations without exhaling. The participant then held her breath for 10 seconds or up to her maximum comfortable capacity, after which she was instructed to exhale slowly. A rest period of 30 seconds was provided between each repetition. The manoeuvre was repeated five times per set, with three sets performed per session and a two-minute rest period between sets. The intervention was administered four days per week for a duration of four weeks.^[6]

➤ Control Group-Pursed Lip Breathing

The participant was seated comfortably in an upright position with the back supported and feet flat on the floor. The participant was instructed to inhale gently through the nose, avoiding forceful inspiration. Following inhalation, the participant was instructed to purse her lips as if whistling or blowing out a candle and then exhale slowly through the pursed lips for approximately 4–6 seconds. The exhalation was performed gradually without forceful expiration. Ten breaths were performed in each set, with three sets completed per session and a rest interval of 1–2 minutes between sets. The intervention was administered four days per week for four weeks. Following completion of the four-week intervention period, post-intervention assessments were conducted for participants in both groups.

➤ Statistical Analysis

The data were analysed using Statistical Package for the Social Science (SPSS) version 24. Statistical analysis was performed using paired and unpaired t-test. Paired t-test was used for within-group comparisons, while unpaired t-test was used for between-group comparisons.

III. RESULTS

Paired t-test was used to analyse the pre- and post-intervention changes within each group, while independent t-test was used for between-group comparison to compare the effectiveness of Group A and Group B following intervention. The findings obtained from statistical analysis demonstrated improvement in respiratory muscle strength and breath hold time, with greater improvement observed in Breath Stacking group.

For respiratory muscle strength, the Maximum Inspiratory Pressure (MIP) in Group A increased from a mean value of 68.91 cmH₂O to 85.16 cmH₂O, demonstrating a statistically significant improvement ($p < 0.005$). Similarly, Group B showed an increase in mean MIP from 68.62 cmH₂O to 72.16 cmH₂O, which was also statistically significant ($p < 0.005$). Regarding Maximum Expiratory Pressure (MEP), Group A demonstrated an increase from 81.50 cmH₂O to 99.41 cmH₂O, with a statistically significant improvement (p

< 0.005), while Group B showed an increase from 80.33 cmH₂O to 84.16 cmH₂O, which was also statistically significant ($p < 0.005$). On between-group comparison, Group A demonstrated greater improvement in both MIP and MEP compared with Group B, indicating a significantly greater effect on respiratory muscle strength.

Breath Hold Time (BHT) also demonstrated a statistically significant improvement in both groups

following the intervention ($p < 0.005$). In Group A (Breath Stacking), the mean BHT increased from 49.50 seconds at baseline to 61.45 seconds after 4 weeks, while in Group B (Pursed Lip Breathing), the mean BHT increased from 51.41 seconds to 54.12 seconds. Between-group comparison demonstrated a greater improvement in BHT in Group A compared with Group B, suggesting that Breath Stacking was more effective than Pursed Lip Breathing in improving Breath Hold Time.

Table 1 Unpaired T-Test for Comparison at Pre and Post Score Measurements of Respiratory Muscle Strength (MIP) Between Group A and Group B

Unpaired T-Test	Comparison			
	Respiratory Muscle Strength (MIP) (Cmh2o)			
	Pre Score		Post Score	
	Group-A	Group-B	Group-A	Group-B
Mean	68.917	98.625	85.167	72.167
S.D.	3.844	2.683	5.164	4.565
N	24	24	24	24
M.D.	0.292		13.000	
Df	46		46	
Unpaired T-Test	0.305		9.240	
P Value	2.013		2.013	
Result	Non-Significant		Significant	

Table 2 Unpaired T-Test for Comparison at Pre and Post Score Measurements of Respiratory Muscle Strength (MEP) Between Group A and Group B

Unpaired T-Test	Comparison			
	Respiratory Muscle Strength (MIP) (Cmh2o)			
	Pre Score		Post Score	
	Group-A	Group-B	Group-A	Group-B
Mean	81.500	80.333	99.417	84.167
S.D.	3.502	3.397	6.128	5.088
N	24	24	24	24
M.D.	1.167		15.250	
Df	46		46	
Unpaired T-Test	1.172		9.380	
Tab. Value at 0.05	2.013		2.013	
P Value	0.247		<0.001*	
Result	Non-Significant		Significant	

Table 3 Unpaired T-Test for Comparison at Pre and Post Score Measurements of Breath Hold Time Between Group A and Group B

Unpaired T-Test	Comparison			
	Respiratory Muscle Strength (MIP) (Cmh2o)			
	Pre Score		Post Score	
	Group-A	Group-B	Group-A	Group-B
Mean	49.500	51.417	61.458	54.125
S.D.	6.359	7.655	5.579	7.531
N	24	24	24	24
M.D.	1.917		7.333	
Df	46		46	
Unpaired T-Test	0.944		3.833	
Tab. Value at 0.05	2.013		2.013	
P Value	0.350		<0.001*	
Result	Non-Significant		Significant	

IV. DISCUSSION

Breathing constitutes the physiological foundation of voice production and is particularly critical in trained vocalists, where precise control of airflow directly determines vocal efficiency, endurance, and quality. Singing is a highly coordinated neuromuscular activity involving the integration of the respiratory system, laryngeal mechanism, and resonating structures. Among these, the respiratory system plays a dominant role by generating and regulating subglottic pressure, which is essential for initiating and sustaining vocal fold vibration.^[1] Adequate breath support enables singers to maintain pitch stability, vocal intensity, and prolonged phonation, all of which are crucial for optimal performance.

Therefore, the present study was designed to evaluate and compare the effects of Breath Stacking and Pursed Lip Breathing on respiratory muscle strength and phonatory outcomes, including Maximum Phonation Time, Breath Hold Time, chest expansion, and MIP/MEP in female folk singers. Understanding the differential effects of these techniques may provide valuable insights for optimizing respiratory training protocols in vocalists and enhancing their overall performance.

The findings of the present study revealed a significant improvement in Maximum Inspiratory Pressure (MIP) and Maximum Expiratory Pressure (MEP) in both groups, with greater improvement in the Breath Stacking group.

Respiratory muscle strength is crucial for generating adequate subglottic pressure and airflow during phonation, especially in singers who require sustained and controlled expiration.

Breath stacking enhances respiratory muscle strength through several mechanisms like increasing lung volume to near total lung capacity, improving length-tension relationship of respiratory muscles and enhancing neuromuscular activation.

These findings are supported by Sang-Kyun et.al.^[11] who demonstrated significant improvements in MIP and MEP following breath stacking training in patients with spinal. Similarly, Christin Ray et al. reported that respiratory muscle training significantly improves inspiratory and expiratory pressures in trained singers. Rasha et.al.^[12] also emphasized that respiratory muscle training enhances ventilatory function and endurance in singers.

BHT reflects CO₂ tolerance, respiratory control, and efficiency of gas exchange.^[10] An increase in BHT indicates improved ability of the respiratory system to tolerate higher levels of carbon dioxide and maintain breath control.

Breath stacking enhances lung volume and improves alveolar recruitment, leading to increased oxygen reserves and delayed accumulation of carbon dioxide. This physiological mechanism allows individuals to hold their breath for longer durations.

The present study demonstrated a significant improvement in breath-hold time (BHT), indicating enhanced respiratory efficiency and ventilatory control following the intervention. Breath-holding is a complex physiological phenomenon influenced by the interplay between respiratory muscle strength, central respiratory drive, metabolic demand, and tolerance to hypercapnia and hypoxia.^[13]

During breath-holding, there is continuous suppression of the central respiratory rhythm, which requires adequate respiratory muscle strength and neuromuscular control.

Prolonged breath-hold duration reflects a balance between oxygen consumption and carbon dioxide accumulation, Suggesting improved physiological efficiency.^[1]

Furthermore, factors such as increased metabolic demand or underlying respiratory compromise can significantly shorten breath-hold duration, highlighting its sensitivity as a functional indicator of respiratory status.^[13]

The observed improvement in BHT in the present study can be attributed to enhanced respiratory muscle performance and improved tolerance to elevated CO₂ levels. Evidence from inspiratory muscle training (IMT) studies suggests that strengthening respiratory muscles improves ventilatory endurance and breath control, which directly contributes to increased breath-holding capacity.^[14]

Patel et.al stated that pranayama training improves lung and thorax compliance, respiratory muscle strength and tolerance of respiratory control against higher pCO₂. As a result there is notable increase in BHT.^[15]

This finding is supported by Larissa et.al^[4], who reported that breath stacking achieves significantly higher inspiratory volumes compared to conventional breathing techniques.

Additionally, Sheers et.al^[8], highlighted that lung volume recruitment techniques improve ventilation and prevent alveolar collapse, thereby enhancing respiratory efficiency.

V. LIMITATIONS OF THE STUDY

The study had certain limitations that should be considered while interpreting the findings. The sample size was relatively small, comprising 48 participants, and the study was conducted at a single centre, which may limit the generalizability of the results. The intervention period was limited to four weeks, and no long-term follow-up was conducted to determine whether the observed benefits were maintained over time. Additionally, the study included only female folk singers between 18 and 25 years of age, thereby limiting the applicability of the findings to male singers, other age groups, and singers from different vocal backgrounds, such as classical or professional singers. The assessment primarily focused on physiological parameters and did not include detailed acoustic analysis or subjective evaluation of

voice quality. Furthermore, the single-blinded design may have introduced a degree of bias.

VI. FUTURE SCOPE

Future studies should consider conducting multi-centre research involving larger and more diverse populations to improve the generalizability of findings. Longer intervention periods and follow-up assessments should be incorporated to evaluate the sustainability and long-term retention of the effects of Breath Stacking. Further research may also investigate the combined effects of Breath Stacking with diaphragmatic breathing techniques and respiratory muscle training devices. Incorporating specific vocal training exercises may provide additional benefits for singers. Future investigations should include advanced outcome measures such as acoustic voice analysis, Voice Handicap Index (VHI), and quality-of-life assessments. Comparative studies examining Breath Stacking against other advanced respiratory training techniques may further establish its effectiveness and clinical applicability in singers.

VII. CONCLUSION

Based on the findings of the present study, both Breath Stacking and Pursed Lip Breathing techniques demonstrated significant improvements in respiratory muscle strength and phonatory outcomes among female folk singers. However, Breath Stacking demonstrated greater effectiveness in improving maximum phonation time, chest expansion, breath hold time, and respiratory muscle strength compared with Pursed Lip Breathing. Therefore, Breath Stacking may be considered a more effective breathing technique for enhancing respiratory efficiency and supporting improved vocal performance among female folk singers.

REFERENCES

- [1]. Welch GF, Howard DM, Nix J, editors. The Oxford handbook of singing. Oxford University Press, USA; 2019.
- [2]. Chukwu SC, Egbumike CJ, Ojukwu CP, Uchenwoke C, Igwe ES, Ativie NR, Okemmuo AJ, Chukwu NP, Ezeugwu UA, Ikele CN, Uduonu EM. Effects of diaphragmatic breathing exercise on respiratory functions and vocal sustenance in apparently healthy vocalists. *Journal of Voice*. 2025 Mar 1;39(2):564-e37.
- [3]. Ahmadi N, Moein N, Tarameshlu M, Ghelichi L, Kamali M, Jenabi MS. The effect of breathing exercises combined with manual therapy on muscle tension dysphonia in traditional singers: a blinded randomized controlled trial. *European Archives of Oto-Rhino-Laryngology*. 2022 Jun;279(6):2989-96.
- [4]. de Sá Feitosa LA, Barbosa PA, Pessoa MF, Rodrigues-Machado MD, de Andrade AD. Clinimetric properties of breath-stacking technique for assessment of inspiratory capacity. *Physiotherapy Research International*. 2012 Mar;17(1):48-54.
- [5]. David J, Patil H. Immediate effect of Buteyko breathing technique versus stacked breathing technique in asthma patients. *International journal of health science and research*. 2022;12(6):158.
- [6]. Fernandes DD, Righi NC, Rubin LJ, Bellé JM, Pippi CM, Ribas CZ, Nichele LD, Signori LU, Silva AM. Effects of the breath stacking technique after upper abdominal surgery: a randomized clinical trial. *Jornal Brasileiro de Pneumologia*. 2022 Mar 14;48(01):e20210280.
- [7]. Lyu S, Chen S, Qi H. Research on the Application of Voice Acoustics for Speech Intelligence in Folk Songs. In *IEEE International Conference on Advanced Infocomm Technology 2022 Oct 28* (pp. 131-141). Singapore: Springer Nature Singapore.
- [8]. Sheers NL, O'Sullivan R, Howard ME, Berlowitz DJ. The role of lung volume recruitment therapy in neuromuscular disease: a narrative review. *Frontiers in Rehabilitation Sciences*. 2023 Jul 26;4:1164628.
- [9]. Dimitriadis Z, Kapreli E, Konstantinidou I, Oldham J, Strimpakos N. Test/retest reliability of maximum mouth pressure measurements with the MicroRPM in healthy volunteers. *Respiratory care*. 2011 Jun;56(6):776-82.
- [10]. Lőrinczi F, Lőrincziová D, Vanderka M. Reliability of breath-holding tests with potential for use in sports practice. *Journal of Kinesiology and Exercise Sciences*. 2023 Sep 26;33(103):27-34.
- [11]. An SK, Shin WS. Effect of air stacking training on pulmonary function, respiratory strength and peak cough flow in persons with cervical spinal cord injury. *Physical Therapy Rehabilitation Science*. 2018 Dec 28;7(4):147-53.
- [12]. Elmarakby RM, Rahmy AF, El Batanoni MM, Elnahas NG. Lung boost training effect on ventilatory functions in choral singers: a randomized controlled trial. *Fizjoter Pol*. 2021;21:144-9.
- [13]. Soroksky A, Balmor GR, Nugzar R, Goldstein AL, Tayem E, Galante O, Tocut M. Novel respiratory breath hold index: A predictor for successful Extubation in mechanically ventilated patients, a prospective cohort study. *Life*. 2025 Oct 1;15(10):1541.
- [14]. Li G, Zhao Y, Mo T, Zhang Z, Zhang X, Hou S. The effects of inspiratory muscle training on respiratory function and aerobic capacity in sedentary adolescents: A single-blind randomized controlled trial. *Scientific Reports*. 2026 Mar 22;16(1):14484.
- [15]. Patel SK, Srivastava S. Effect of pranayama on breath holding time of college students. *Integr. J. Res. Arts Human*. 2024;4(2):88-91.