INSIGHTS-JOURNAL OF
LIFE AND SOCIAL SCIENCES

INSIGHTS-JLSS
Insights-Journal of Life and Social Sciences

COMBINED EFFECTS OF ACBT AND BUTEYKO TECHNIQUES ON AIRWAY CLEARANCE IN POST STERNOTOMY PATIENTS

Original Article

Amina Saeed[1], Muhammad Ashir Rehman Malik[2]*, Subayyal Iftikhar[2], Neelum Mehmood[3], Anam Waris[4], Iqra Ghafor[5]
[1]University of Management Technology, Pakistan.
[2]Al-Zahra Rehabilitation Center, Gulab Devi Teaching Hospital, Lahore, Pakistan.
[3]Doctor of Physical Therapy, Riphah International University, Lahore, Pakistan.
[4]Riphah International University, Lahore, Pakistan.
[5]Riphah International University, Pakistan.
Corresponding Author: Muhammad Ashir Rehman Malik, Al-Zahra Rehabilitation Center, Gulab Devi Teaching Hospital, Lahore, Pakistan. ashrawan467@gmail.com

Conflict of Interest: None

Grant Support & Financial Support: None

ABSTRACT

Background: Sternotomy, a surgical incision through the sternum, is commonly performed in various cardiopulmonary procedures. Despite its significance in facilitating surgical access, sternotomy is associated with post-operative complications such as respiratory failure, atelectasis, pneumonia, and acute respiratory distress syndrome (ARDS). Effective respiratory rehabilitation is crucial to mitigate these risks. The Active Cycle of Breathing Technique (ACBT) and Buteyko breathing techniques have shown potential in improving lung function and clearing respiratory secretions, reducing the likelihood of post-surgical complications.

Objective: To evaluate the combined effects of ACBT and Buteyko breathing techniques on airway clearance in post-sternotomy patients.

Methods: This randomized clinical trial included 44 post-sternotomy patients selected through non-probability convenience sampling. Participants were randomly divided into two groups. Group A received a combination of ACBT and Buteyko techniques, while Group B was treated with Buteyko techniques and conventional therapy. Both male and female patients aged 40–60 years were included. Pulmonary function tests and the Breathlessness, Cough, and Sputum Scale (BCSS) were used as outcome measures. Data were analyzed using SPSS, applying parametric and non-parametric tests as appropriate.

Results: Group A consisted of 22 patients (15 males, 7 females; mean age 53.77±4.99), while Group B included 22 patients (13 males, 9 females; mean age 54.40±4.89). Significant improvements were observed in both groups. For FVC, Group A improved from 0.86±0.12 L pre-treatment to 1.08±0.12 L post-treatment ($p<0.0001$), while Group B increased from 0.81±0.92 L to 1.01±0.13 L ($p<0.0001$). BCSS scores decreased significantly in both groups, from 52.31±14.81 to 16.22±8.91 in Group A and from 48.81±11.47 to 12.86±7.12 in Group B ($p<0.0001$). Group A showed greater improvement in pulmonary outcomes compared to Group B.

Conclusion: Both ACBT and Buteyko breathing techniques were effective for post-sternotomy patients. However, the combination of ACBT with Buteyko techniques proved superior, demonstrating greater efficacy in improving lung function, enhancing airway clearance, and reducing pulmonary complications.

Keywords: ACBT, airway clearance, Buteyko techniques, lung function, pulmonary complications, sternotomy, thoracic surgery.

INTRODUCTION

A sternotomy is a surgical procedure involving an incision through the sternum, or breastbone, to gain access to the chest cavity. It is commonly performed in various thoracic surgeries, including cardiovascular procedures such as cardiac transplantation, coronary artery bypass grafting (CABG), lung surgeries like pneumonectomy and lobectomy, esophageal operations, and thymectomy, where the thymus gland is removed (1). This approach provides surgeons with direct access to critical structures, including the heart, lungs, and surrounding organs, enabling complex surgical interventions with improved mobility and accessibility (2). While the procedure is indispensable for managing severe thoracic and cardiac conditions, it is not without its risks and complications, which include infections, hemorrhage, respiratory complications, and even sleep disorders (3). Proper postoperative care, including pulmonary care, wound management, and pain control, is crucial to mitigate these complications and ensure optimal recovery (4). Sternotomy techniques vary based on the surgical requirement and the extent of access needed. These include median sternotomy, dual thoracosternotomy, hemi-sternotomy, T-shaped sternotomy, and J-shaped sternotomy, among others, each tailored to specific anatomical and procedural considerations (3, 4). In cardiovascular surgeries, sternotomy plays a pivotal role in procedures such as CABG, cardiac valve correction and replacement, myocardial infarction repair, and implantation of ventricular assist devices (5). Additionally, it is a key approach in lung-related surgeries, including lung volume reduction surgery for chronic obstructive pulmonary disease (COPD) and bronchoplasty for repairing bronchi affected by disease or malignancy (9). Despite its benefits, sternotomy remains associated with significant complications, including impaired lung function, pain, and an elevated risk of subsequent surgeries or cardiac events, which underscores the importance of effective postoperative rehabilitation strategies (6).

The burden of cardiovascular and pulmonary diseases remains high globally, with modifiable and non-modifiable risk factors contributing to their prevalence. Modifiable factors such as poor nutrition, sedentary lifestyles, smoking, and uncontrolled diabetes exacerbate the risk of conditions like coronary artery disease, hypertension, and COPD (12, 13). Early detection and management of these conditions are imperative to improve patient outcomes and reduce mortality. Respiratory disorders, in particular, are among the most prevalent complications following sternotomy, often leading to prolonged hospital stays and increased healthcare costs (8). Effective preoperative and postoperative interventions targeting respiratory function are therefore essential. Respiratory physiotherapy has emerged as a cornerstone in the management of postoperative complications. The Active Cycle of Breathing Technique (ACBT) and the Buteyko Breathing Technique (BBT) are two physiotherapeutic approaches that have demonstrated significant benefits in improving pulmonary function, airway clearance, and overall respiratory health. ACBT, which includes components such as thoracic expansion exercises, controlled breathing, and forced expiration, has been extensively used in managing conditions like pneumonia, cystic fibrosis, and COPD (12). Its simplicity and cost-effectiveness make it a valuable tool in postoperative care, particularly for sternotomy patients. By enhancing lung volume, reducing wheezing, and improving oxygenation, ACBT not only promotes faster recovery but also minimizes the risk of complications such as atelectasis and pneumonia (15, 16).

Similarly, BBT, developed by Konstantin Buteyko, focuses on controlled breathing to enhance carbon dioxide tolerance and reduce respiratory rate (20). This technique has been widely employed in managing respiratory conditions such as asthma and COPD and has shown promise in improving oxygen saturation, reducing symptoms, and enhancing overall respiratory function (21). The incorporation of BBT into routine care has been associated with improved quality of life, reduced reliance on medication, and better sleep quality (22). Despite the independent benefits of ACBT and BBT, there is limited research on their combined application in post-sternotomy patients. Combining these techniques offers a comprehensive approach to respiratory rehabilitation, addressing both lung expansion and carbon dioxide regulation. This synergistic approach has the potential to enhance airway clearance, improve gas exchange, and reduce the incidence of postoperative respiratory complications. By integrating ACBT and BBT, patients may achieve superior outcomes, including reduced hospital stays, improved respiratory function, and enhanced quality of life (26).

Given the high prevalence of sternotomy procedures and the associated respiratory complications, exploring innovative and evidence-based strategies for postoperative care is imperative. This study aims to evaluate the combined effects of ACBT and BBT on airway clearance in post-sternotomy patients, providing a basis for improved clinical practices and patient outcomes.

METHODS

The methodology employed for this research was carefully designed and implemented to ensure the reliability and validity of the findings. This study was a randomized controlled trial (RCT), carried out with a sample size of 44 participants, divided equally into two groups of 22. The sample size estimation was conducted using the Epitool statistical software, considering an expected 10% loss rate, with inputs including a mean difference of 26.5 versus 24, variance of 6, a 95% confidence interval, a power of 0.8, and a two-tailed

test assumption. The sampling technique used was non-probability convenience sampling, and the participants were selected from Gulab Devi Hospital. The study was completed within a duration of seven months following the approval of the research synopsis. The inclusion criteria for participants encompassed individuals aged 41 to 70 years who had undergone their first sternotomy, exhibited stable vital signs post-surgery, and had been on mechanical ventilation for at least 24 hours after surgery. Both male and female participants were included. Conversely, patients who were vitally unstable, had undergone a second sternotomy, or had pre-existing conditions such as infections, renal failure, cardiac failure, cancer, tuberculosis, diaphragmatic injury, acute respiratory distress syndrome (ARDS), or deep venous thrombosis (DVT) were excluded from the study.

Data collection tools included a digital spirometer, which measured lung function parameters such as FEV1, FVC, and FEV1/FVC ratio, and the Breathlessness, Cough, and Sputum Scale (BCSS), a standardized questionnaire that assesses the severity of respiratory symptoms on a scale from 0 (no symptom) to 4 (severe symptom). The spirometry tests evaluated lung function, with the FEV1/FVC ratio ideally expected to be around 80% in healthy individuals. The BCSS served to quantify subjective symptoms such as dyspnea, sputum production, and cough severity. Recruitment involved selecting participants meeting the inclusion criteria through a simple random sampling method and assigning them to one of two groups using a lottery technique. Randomization ensured the unbiased allocation of participants, and single blinding was employed to ensure that the assessor was unaware of the group assignments. Group A underwent a combination of the Active Cycle of Breathing Technique (ACBT) and Buteyko breathing techniques, along with conventional physiotherapy, while Group B received Buteyko breathing techniques with conventional physiotherapy alone.

The interventions for Group A included two to three sessions per day, three days a week, with each session comprising 10-minute ACBT cycles interspersed with 5-minute breaks. The ACBT components included breathing control, thoracic expansion exercises, and the forced expiratory technique (FET). These exercises were complemented by Buteyko breathing techniques, which involved nasal breathing, breath holding for 2–3 seconds, and controlled exhalation. For Group B, Buteyko breathing techniques were applied in similar sessions without ACBT. Data collection was performed before and after the completion of the intervention sessions, following extubation and stabilization of the patients' vital signs. The statistical analysis was performed using SPSS version 25. Normal distribution was confirmed for FEV1 and FEV1/FVC using the Shapiro-Wilk test, while FVC and BCSS exhibited non-normal distributions. Parametric tests, including the independent sample t-test and paired sample t-test, were applied for normally distributed variables, while non-parametric tests, such as the Mann-Whitney U test and the Wilcoxon Signed Rank test, were used for non-normally distributed data. A p-value of less than 0.05 was considered statistically significant.

The study received ethical approval from the research and ethics committee of Riphah College of Rehabilitation and Allied Health Sciences, Riphah International University, Islamabad, under reference number REC/RCR & AHS/23/0377, dated November 23, 2023. The study design, data collection methods, and analysis ensured methodological rigor and adherence to ethical standards.

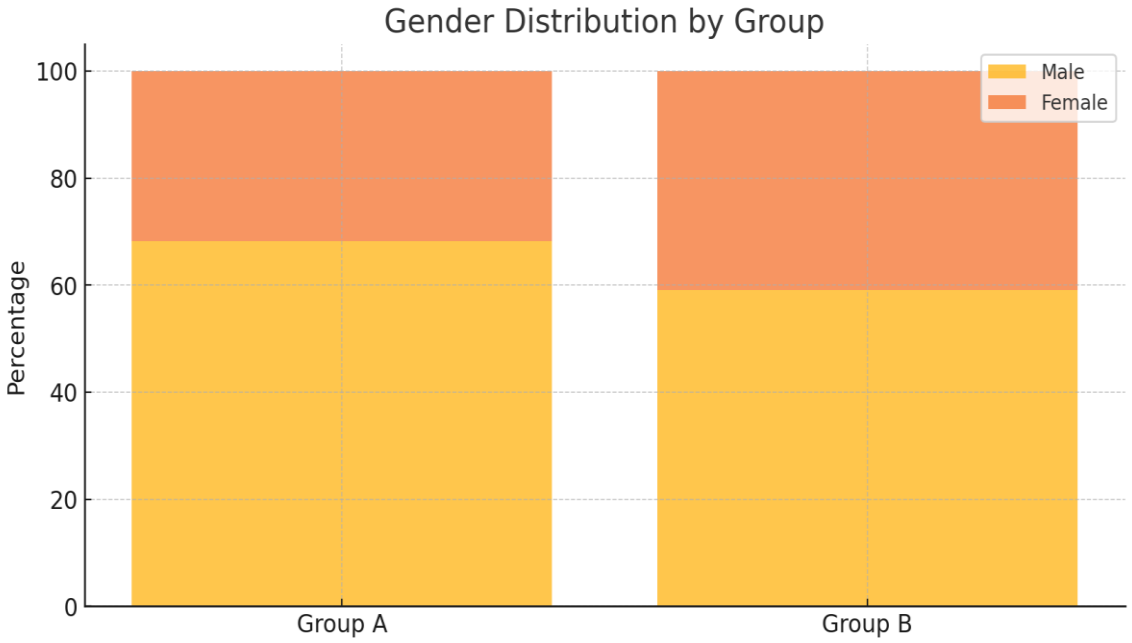
RESULTS

The results of this study are based on a sample size of 44 participants, equally divided into two groups: Group A and Group B, each consisting of 22 individuals. There were no withdrawals throughout the study. Demographic data revealed comparable baseline characteristics between the two groups. The mean age of participants in Group A was 53.77 years (±4.99), while Group B had a mean age of 54.40 years (±4.89). The mean height was 169 cm (±7.14) in Group A and 169.4 cm (±7.3) in Group B. The mean weight was 84 kg (±7.9) for Group A and 80 kg (±7.81) for Group B. The body mass index (BMI) was 26.82 (±3.45) for Group A and 27.11 (±3.65) for Group B. Gender distribution showed that Group A included 15 males (68.2%) and 7 females (31.8%), whereas Group B had 13 males (59.1%) and 9 females (40.9%). In terms of diabetes prevalence, Group A had 8 participants (36.4%) with diabetes and 14 participants (63.6%) without diabetes, while Group B had 11 participants (50%) each in diabetic and non-diabetic categories. Smoking habits were similar between the groups, with 7 smokers (31.8%) and 15 non-smokers (68.2%) in both groups. The Shapiro-Wilk test was performed to assess the normality of the data. Pre-treatment forced expiratory volume in the first second (FEV1) and the FEV1/forced vital capacity (FVC) ratio demonstrated normal distribution, while pre-treatment FVC and breathlessness, cough, and sputum scale (BCSS) scores did not follow a normal distribution. Accordingly, both parametric and non-parametric tests were utilized for statistical analyses. Paired sample t-tests and Wilcoxon Signed Rank tests were used for within-group comparisons, and independent sample t-tests and Mann-Whitney U tests were used for between-group comparisons.

The intervention led to significant improvements in pulmonary function within both groups. Pre-therapy mean FEV1 in Group A was 0.65 liters (±0.12), which increased to 0.85 liters (±0.11) post-therapy ($p < 0.0001$). In Group B, the mean FEV1 pre-therapy was 0.80 liters (±6.70), and post-therapy it remained largely unchanged at 0.80 liters (±0.11) ($p = 0.0001$). The mean FEV1/FVC ratio in Group A increased from 75.63% (±7.14) pre-therapy to 79.13% (±5.40) post-therapy ($p = 0.02$). Similarly, Group B's mean FEV1/FVC ratio

improved from 76.81% (±6.07) pre-therapy to 79.18% (±6.41) post-therapy (p = 0.01). Both groups exhibited significant improvements in FVC values. Group A's mean FVC increased from 0.86 liters (±0.12) pre-therapy to 1.08 liters (±0.12) post-therapy (p < 0.0001), while Group B's mean FVC rose from 0.81 liters (±0.92) pre-therapy to 1.005 liters (±0.13) post-therapy (p < 0.0001). The BCSS scores also demonstrated significant improvement in both groups. In Group A, the mean BCSS score decreased from 52.31 (±14.81) pre-therapy to 16.22 (±8.91) post-therapy (p < 0.0001). Similarly, Group B's mean BCSS score dropped from 48.81 (±11.47) pre-therapy to 12.86 (±7.12) post-therapy (p < 0.0001). Between-group analysis using the Mann-Whitney U test revealed no statistically significant differences in pre-treatment FVC (p = 0.18) and BCSS scores (p = 0.143) between Groups A and B. However, a significant difference was observed in post-treatment FVC values between the groups (p = 0.03), favoring Group A. No significant differences were observed in BCSS scores post-treatment between the groups (p = 0.495).

Overall, the intervention significantly improved pulmonary function and reduced respiratory symptoms in both groups. However, Group A demonstrated greater improvement in key parameters such as FEV1, FVC, and BCSS scores, highlighting the potential added benefits of combining the Active Cycle of Breathing Technique (ACBT) with Buteyko breathing techniques compared to Buteyko techniques alone.



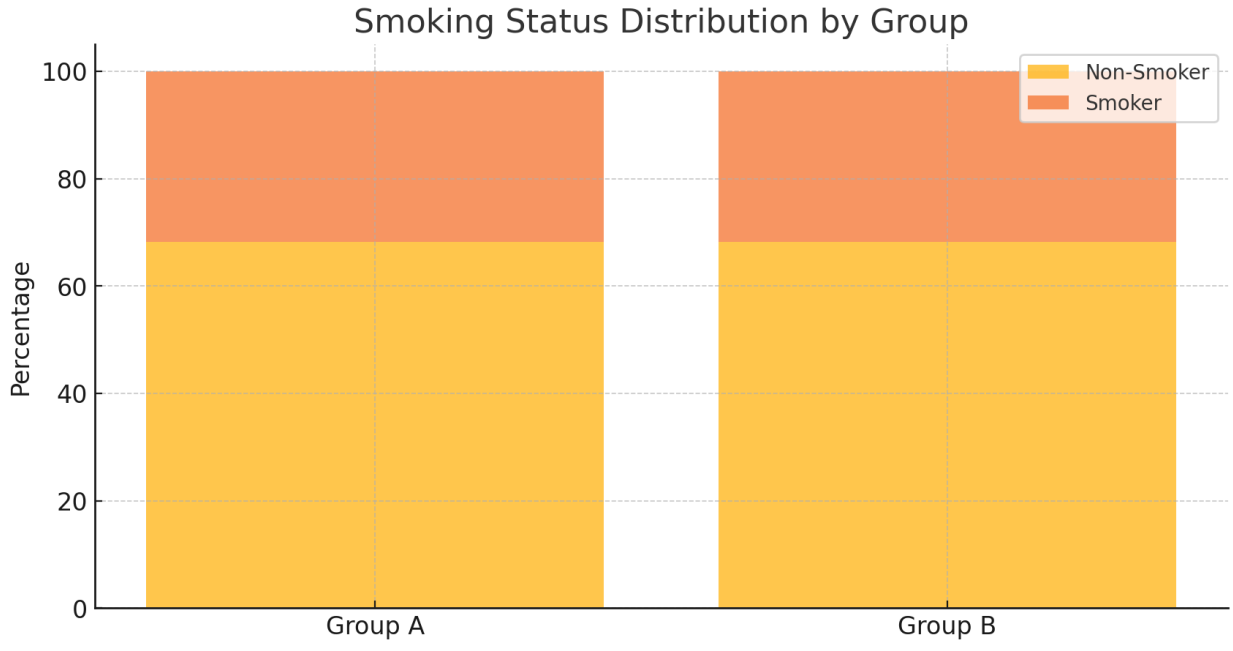


Table 1 Demographics Data Table

Group	Mean Age (years)	Height (cm)	Weight (kg)
Group A	53.77	169.0	84.0
Group B	54.4	169.4	80.0

Table 2 Pulmonary Function Test Results (FEV1 and FEV1/FVC)

Parameter	Group A (Mean ± SD)	Group B (Mean ± SD)	p-value
Pre FEV1 (L)	0.65 ± 0.12	0.80 ± 6.70	< 0.0001
Post FEV1 (L)	0.85 ± 0.11	0.80 ± 0.11	< 0.0001
Pre FEV1/FVC (%)	75.63 ± 7.14	76.81 ± 6.07	0.02
Post FEV1/FVC (%)	79.13 ± 5.40	79.18 ± 6.41	0.01

Table 3 FVC and BCSS Results

Parameter	Group A (Mean ± SD)	Group B (Mean ± SD)	p-value
Pre FVC (L)	0.86 ± 0.12	0.81 ± 0.92	< 0.0001
Post FVC (L)	1.08 ± 0.12	1.01 ± 0.13	< 0.0001
Pre BCSS	52.31 ± 14.81	48.81 ± 11.47	< 0.0001
Post BCSS	16.22 ± 8.91	12.86 ± 7.12	< 0.0001

DISCUSSION

The findings of this study highlight the significant impact of combining the Active Cycle of Breathing Technique (ACBT) with Buteyko breathing techniques on improving pulmonary function and reducing respiratory symptoms in post-sternotomy patients. Both groups demonstrated improvements in pulmonary function tests and respiratory symptoms, but Group A, which received the combined intervention, exhibited significantly greater benefits. This indicates the synergistic potential of ACBT and Buteyko techniques in enhancing postoperative recovery. The improvement in forced expiratory volume in the first second (FEV1) and forced vital capacity (FVC) in Group A underscores the efficacy of the combined approach in enhancing lung mechanics and clearing bronchial secretions. These results align with previous studies that have established the benefits of ACBT in improving lung expansion and secretion clearance in postoperative patients (12, 15). Similarly, the use of Buteyko techniques in improving carbon dioxide tolerance and reducing respiratory rate has been well-documented (21). The integration of these two techniques may have offered complementary mechanisms, with ACBT targeting mechanical aspects of lung function and Buteyko enhancing respiratory efficiency.

Although both groups showed significant improvement in Breathlessness, Cough, and Sputum Scale (BCSS) scores, Group A exhibited a more pronounced reduction in symptoms. This reflects the added benefit of combining interventions to address both pulmonary function and symptom control comprehensively. However, the lack of a significant difference in some parameters between groups, such as FEV1/FVC ratio, suggests that the additive effects of the combined intervention may vary depending on the specific respiratory outcome measured. The strengths of this study include the randomized controlled trial design, which minimized biases and ensured robust comparisons between groups. The use of standardized tools such as spirometry and BCSS provided reliable and quantifiable measures of pulmonary function and symptoms. Furthermore, the study's focus on a clinically relevant population of post-sternotomy patients adds to its practical applicability. However, certain limitations should be considered. The relatively small sample size may limit the generalizability of the findings to larger and more diverse populations. Additionally, the study relied on self-reported adherence to breathing techniques, which could introduce variability in intervention fidelity.

The absence of long-term follow-up is another limitation, as it restricts conclusions about the sustained benefits of the intervention. While short-term improvements were evident, the persistence of these effects beyond the study period remains uncertain. Moreover, the study did not evaluate potential adverse effects or challenges in implementing the combined techniques, such as patient fatigue or difficulties in adherence, which could affect feasibility in real-world clinical settings. The findings contribute to the growing evidence supporting the role of physiotherapy in postoperative care for cardiac and thoracic surgeries. The study strengthens the case for incorporating multimodal respiratory rehabilitation strategies to optimize recovery outcomes. However, the lack of significant differences in some parameters between groups raises questions about whether combining these techniques is consistently superior to

individual approaches. This warrants further investigation to explore the mechanisms underlying the observed effects and to identify patient subgroups that may benefit most from combined interventions.

Future research should consider larger sample sizes, extended follow-up periods, and the inclusion of objective measures of adherence and intervention fidelity. Exploring the cost-effectiveness of combined interventions could also provide valuable insights for healthcare systems, particularly in resource-constrained settings. Despite its limitations, this study provides a solid foundation for integrating ACBT and Buteyko techniques into postoperative rehabilitation protocols, offering a promising avenue for improving patient outcomes in sternotomy patients.

CONCLUSION

The study concluded that both the Active Cycle of Breathing Technique (ACBT) and Buteyko breathing techniques were effective in improving respiratory outcomes for post-sternotomy patients. These techniques enhanced respiratory secretion clearance, lung expansion, and ventilation while reducing pulmonary complications such as pneumonia and atelectasis. Additionally, they improved oxygenation, alleviated dyspnea, and shortened hospital stays, contributing to overall patient recovery. However, the combination of ACBT and Buteyko techniques demonstrated superior efficacy compared to either approach alone. This combination was found to be both safe and beneficial, offering a comprehensive and effective intervention for post-sternotomy respiratory rehabilitation.

AUTHOR CONTRIBUTIONS

Author	Contribution
Amina Saeed	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Muhammad Ashir Rehman Malik	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Subayyal Iftikhar	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Neelum Mehmood	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Anam Waris	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Iqra Ghafor	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

REFERENCES

1. Sellin C, Sand U, Demianenko V, Schmitt C, Schäfer B, Schier R, et al. Comparison of pulmonary outcome in minimally invasive (TCRAT) and full sternotomy CABG. Thorac Cardiovasc Surg. 2024.
2. Hussain S, Swystun AG, Caputo M, Angelini GD, Vohra HA. A review and meta-analysis of conventional sternotomy versus minimally invasive mitral valve surgery for degenerative mitral valve disease focused on the last decade of evidence. Perfusion. 2024;39(5):988-97.
3. Wiens K, Hayden KA, Park L, Colwell S, Coltman C, King-Shier KM. Post-sternotomy movement strategies in adults: a scoping review. Eur J Cardiovasc Nurs. 2024;zvad109.
4. Bottiger B, Klapper J, Fessler J, Shaz BH, Levy JH. Examining bleeding risk, transfusion-related complications, and strategies to reduce transfusions in lung transplantation. Anesthesiology. 2024;140(4):808-16.
5. He R, Zhang K, Zhou C, Pei C. Effect of right anterolateral thoracotomy versus median sternotomy on postoperative wound tissue repair in patients with congenital heart disease: A meta-analysis. Int Wound J. 2024;21(1):e14343.

6. Sudin A, Chong C, Hassan R. Incidence and factors associated with post-sternotomy pain syndrome in the National Heart Institute, Malaysia. J Cardiothorac Vasc Anesth. 2024;38(2):466-74.
7. Minns S, Tosh W, Moorjani N. Anaesthesia for adult cardiac surgery requiring repeat sternotomy. BJA Educ. 2024;24(1):23-30.
8. Zhang D, Li S, Wang N, Tan H-Y, Zhang Z, Feng Y. The cross-talk between gut microbiota and lungs in common lung diseases. Front Microbiol. 2020;11:301.
9. Cai Y, Hao Z, Gao Y, Ping W, Wang Q, Peng S, et al. Coronavirus disease 2019 in the perioperative period of lung resection: a brief report from a single thoracic surgery department in Wuhan, People's Republic of China. J Thorac Oncol. 2020;15(6):1065-72.
10. Yang IA, Jenkins CR, Salvi SS. Chronic obstructive pulmonary disease in never-smokers: risk factors, pathogenesis, and implications for prevention and treatment. Lancet Respir Med. 2022;10(5):497-511.
11. Akintoye OO, Adu BG, Otorkpa MJ, Olayode OO, Fodop S, Alemede PO, et al. The current state of minimally invasive cardiac surgery in Africa: a systematic review and meta-analysis. Cardiothorac Surg. 2024;32(1):15.
12. Baig B, Anwar M, Rasheed M, Rasul A, Fiaz A, Faisal S. Comparative effects of Buteyko breathing technique and active cycle of breathing technique on dyspnea and quality of life in patients with chronic obstructive pulmonary disease. J Health Rehabil Res. 2024;4(1):250-5.
13. Wood J, Chung F, Cecins N. Airway clearance techniques. In: Cardiopulmonary physical therapy. Routledge; 2024. p. 277-87.
14. Burile GC, Chandankhede V, Sewani Y, Arya N, Fating T. Optimizing early recovery through timely mobilization in nephrectomy patients: a case report. Cureus. 2024;16(3).
15. Main E, Dixon E, Murray N. Physiotherapy. In: Hodson and Geddes' cystic fibrosis. CRC Press; 2024. p. 601-24.
16. Wei J, Liu C, Shi L, Liu Y, Lu H. One-pot synthesis of organic–inorganic network hydrogels with high extensibility, self-healing, self-adhesive, 3D-printing, and antibacterial properties. ACS Appl Polym Mater. 2024.
17. Cai S, Yao J, Han M, Luo X, Yu Y, Lu X, et al. The effect of cognition in combination with an ACBT on dyspnea-related kinesiophobia in patients with moderate to severe COPD: quasirandomized controlled trial study. Geriatr Nurs. 2024;56:138-47.
18. Tripathi A, Sankari A. Postural drainage and vibration. StatPearls. 2024.
19. Edbrooke L, Abo S, Denehy L. Efficacy of prehabilitation in abdominal cancer surgery. In: Recent strategies in high-risk surgery. Springer; 2024. p. 81-101.
20. Kusumaningtyas M, Handari HK. Buteyko breathing technique effectively improves cardiorespiratory endurance in students. Indones J Med. 2024;9(3):364-8.
21. Vagedes K, Kuderer S, Ehmann R, Kohl M, Wildhaber J, Jörres RA, et al. Effect of Buteyko breathing technique on clinical and functional parameters in adult patients with asthma: a randomized, controlled study. Eur J Med Res. 2024;29(1):42.
22. Bhattacharya U, Dutta A. Efficacy of advanced allied interventions for dyspnoea, exercise capacity, and quality of life among the geriatric population: a literature review. J Clin Diagn Res. 2024;18(4).
23. Skuban R. The Buteyko method: how to improve your breathing for better health and performance in all areas of life. Skuban Academy; 2024.
24. Mahmoud Abo El-Fadl N, Mohammed Mahmoud D. Buteyko breathing technique versus pranayama technique on asthma control among asthmatic patients. J Nurs Sci Benha Univ. 2024;5(2):728-54.
25. Peddibhotla SM, Nair A, Joby A. The effect of halotherapy in chronic respiratory disease: an adjunct to physiotherapy - a narrative review. Int J Pharm Investig. 2024;14(2).
26. Janani R, Kumar S. The effect of active cycle of breathing technique with threshold IMT device on functional capacity among bronchial asthma patients. 2024.
27. Kothari DS, Nieri CA, Tanenbaum ZG, Linker LA, Rangarajan SV. Mind-body therapies in the management of otolaryngologic disease: a state-of-the-art review of randomized controlled trials. Otolaryngol Head Neck Surg. 2024;170(1):45-60.
28. Mavkar SS, Shukla MP. Effect of Buteyko breathing technique as an adjunct to routine physiotherapy on pulmonary functions in patients undergoing off-pump coronary artery bypass surgery: a randomized controlled trial. Indian J Crit Care Med. 2024;28(3):280.
29. Abdullah RT, Hamza RA, Mahbuba WA. Effectiveness of preoperative breathing exercises on postoperative lung function outcomes for patients with cardiac surgery. Curr Probl Cardiol. 2024:102784.
30. Joshi N, Singh A. Comparative study of the effect of segmental breathing exercise and deep breathing exercise in CABG patients.
31. Abo-Zaid SY, Yousef NM, Hassan MM, Mohammed AA, Saffan AMM, Shehata MM, et al. Efficacy of Acapella on spirometer measures in patients with bronchiectasis.

32. AbdElmawla Elsaid RA, Zahran WE-k, Elsaid Hafez DM. Comparison of the effects of Buteyko and diaphragmatic breathing technique on improving pulmonary functions and asthma control among patients with bronchial asthma. Egypt J Nurs Health Sci. 2023;4(3):57-75.
33. Allam ZA, Aysha ZMS, Mahmoud OFT, Mohamed SS, Weheida SM. Effect of active cycle breathing technique on airway clearance among patients who underwent cardiac surgery. Tanta Sci Nurs J. 2023;29(2):172-88.
34. Fazal AIA, Fatema K, Islam MW, Salek S, Kibria MG. Effectiveness of incentive spirometry to reduce pulmonary complications and improve respiratory parameters after coronary artery bypass graft surgery: a narrative review. J Clin Respir Dis Care. 2023;9:02.
35. Lu H-B. Active cycle of breathing technique: a respiratory modality to improve perioperative outcomes in patients with lung cancer. Thorac Cancer. 2022;26(2):176-82.
36. Zhong J, Zhang S, Li C, Hu Y, Wei W, Liu L, et al. Active cycle of breathing technique may reduce pulmonary complications after esophagectomy: a randomized clinical trial. Thorac Cancer. 2022;13(1):76-83.
37. Jage B, Thakur A. Effectiveness of Acapella along with institutional-based chest physiotherapy techniques on pulmonary functions and airway clearance in postoperative CABG patients. Hong Kong Physiother J. 2022;42(2):81-9.
38. Nishi K, Dinesh S, Jayesh P. Short-term effects of combination of ACBT, chest mobility exercises, and TENS on chest expansion, PEFR, and pain perception post-abdominal surgeries: RCT. Int J Health Sci Res. 2022;12(7):271-8.
39. Afshan N, Ahmad S, Shahid S, Fatima A. Effect of Buteyko breathing technique and incentive spirometer on breath control pause in post-cardiac surgery patients. Rawal Med J. 2020;45(4):970-.
40. Derakhtanjani AS, Jaberi AA, Haydari S, Bonabi TN. Comparison of the effect of active cyclic breathing technique and routine chest physiotherapy on pain and respiratory parameters after coronary artery graft surgery: a randomized clinical trial. Anesthesiol Pain Med. 2019;9(5).
41. Lamuvel MW, Kazi A, Gunjal S, Jaiswal A. Effect of ACBT and TENS on pulmonary function and pain perception in abdominal surgeries: a randomized controlled trial. Int J Health Sci Res. 2016;6(6):211-7.
42. Hussain MN, Sheraz S, Razzaq A, Malik AN. Active cycle of breathing techniques improves post-operative pulmonary complications in coronary artery bypass graft surgery patients. Pak Heart J. 2022;55(2):186-90.
43. Topalovic M, Das N, Burgel P-R, Daenen M, Derom E, Haenebalcke C, et al. Artificial intelligence outperforms pulmonologists in the interpretation of pulmonary function tests. Eur Respir J. 2019;53(4).
44. Stanojevic S, Kaminsky DA, Miller MR, Thompson B, Aliverti A, Barjaktarevic I, et al. ERS/ATS technical standard on interpretive strategies for routine lung function tests. Eur Respir J. 2022;60(1).
45. Jacobson PK, Lind L, Persson HL. The exacerbation of chronic obstructive pulmonary disease: which symptom is most important to monitor? Int J Chron Obstruct Pulmon Dis. 2023:1533-41.
46. Pednekar S, Gaikwad P. Comparison of ELTGOL therapy versus ACBT on breathlessness, cough and sputum production; exercise capacity and quality of life in middle-aged bronchiectasis patients. Int J Physiol Nutr Phys Educ. 2023;1:25-37.

