Journal of Health and Rehabilitation Research JHRR

https://doi.org/ 10.61919/jhrr.v5i6.1926

Original Article

Active Cycle of Breathing Technique Versus Breathing Exercises in Post COVID-19 Patients

Liza Fayyaz[1], Iman Faryad[1], Aliya Siddique[1], Amina Ijaz[1], Muhammad Ejaz[2]

[1] University of Lahore, Lahore, Pakistan

[2] University of Science and Technology, Lahore, Pakistan

*** Correspondence: Liza Fayyaz, lizafayyaz03@gmail.com**

ABSTRACT

Background: Post-ICU COVID-19 survivors frequently experience persistent dyspnea and impaired pulmonary function, creating a need for effective, scalable respiratory physiotherapy interventions (1,6,10). Objective: To compare the effects of Active Cycle of Breathing Technique (ACBT) plus breathing exercises versus breathing exercises alone on oxygen saturation and pulmonary function in post-COVID-19 patients. Methods: A randomized controlled trial was conducted at Jinnah Hospital, Lahore, enrolling 48 adults (18–50 years) with PCR-confirmed COVID-19. Participants were randomized by sealed envelope into Group A (ACBT + breathing exercises; n=24) or Group B (breathing exercises; n=24). Interventions were delivered once daily for 15–30 minutes, six days/week for two weeks. Outcomes included SpO_2 measured by pulse oximetry and spirometric indices (FEV1, FVC, FEV1/FVC) measured at baseline and two weeks. Between-group comparisons were performed using independent samples t-tests with $p<0.05$ considered significant. Results: Post-intervention values favored Group A across SpO_2, FEV1, FVC, and FEV1/FVC with statistically significant between-group differences ($p<0.05$), indicating superior improvement when ACBT was added to breathing exercises. Conclusion: Breathing exercises improved oxygenation and pulmonary function in post-COVID-19 patients, and ACBT provided additional benefit across key physiologic measures over a two-week rehabilitation period. Keywords: COVID-19; pulmonary rehabilitation; respiratory physiotherapy; Active cycle of breathing technique; spirometry; oxygen saturation.

"Cite this Article" | Received: 11 May 2025; Accepted: 21 June 2025; Published: 30 June 2025.

Author Contributions: Concept: LF; Design: IF; Data Collection: AS; Analysis: AI; Drafting: ME, **Ethical Approval**: PSRD, Lahore, Pakistan

Informed Consent: Written informed consent was obtained from all participants; Conflict of Interest: The authors declare no conflict of interest; Funding: No external funding; Data Availability: Available from the corresponding author on reasonable request; Acknowledgments: N/A.

INTRODUCTION

COVID-19, caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), emerged in late 2019 and rapidly evolved into a global pandemic with substantial respiratory morbidity across diverse populations (6). While most attention initially focused on acute infection and mortality, a large proportion of hospitalized survivors—particularly those requiring high-dependency or ICU-level care—develop persistent symptoms after clinical stabilization, including dyspnea, marked fatigue, reduced exercise tolerance, generalized deconditioning, and limitations in activities of daily living (1). These sequelae are clinically important because they are frequently accompanied by measurable impairments in oxygenation and pulmonary mechanics, reflecting residual parenchymal involvement, ventilation–perfusion mismatch, respiratory muscle weakness, and prolonged bed-rest–related decline (6,10). Although polymerase chain reaction testing remains a key diagnostic method for confirmed COVID-19, recovery beyond the acute phase is increasingly characterized by functional disability that requires targeted rehabilitation rather than diagnostic refinement (2).

Pulmonary rehabilitation and respiratory physiotherapy are established components of recovery pathways for chronic respiratory disease and post-acute respiratory compromise, emphasizing breathing retraining, secretion clearance strategies, graded functional reconditioning, and patient education (7). In the COVID-19 context, early and structured pulmonary rehabilitation has been proposed to mitigate post-pneumonia functional decline and improve respiratory outcomes after hospitalization (9,10).

Controlled trials and protocols have reported clinically meaningful improvements in symptoms and function with respiratory rehabilitation programs, supporting the role of physiotherapy-led interventions in restoring respiratory efficiency and patient-reported wellbeing (14). Breathing exercises, particularly those emphasizing diaphragmatic control and prolonged expiration, have been shown to reduce dyspnea and improve quality-of-life domains in patients receiving treatment for COVID-19, suggesting that targeted breathing interventions can influence both physiologic and patient-centered outcomes (11,13).

Among airway clearance and ventilation-optimizing approaches, the Active Cycle of Breathing Technique (ACBT) integrates breathing control, thoracic expansion exercises, and forced expiratory techniques ("huffing") to promote airway clearance and improve ventilation distribution. Although widely used in respiratory physiotherapy practice, its incremental benefit over conventional breathing exercises in post-COVID recovery remains insufficiently quantified in adult post-ICU populations. Practical physiotherapy guidance for hospitalized COVID-19 patients supports tailored respiratory strategies but emphasizes the need for better comparative evidence across specific techniques and recovery phases (15). Evidence from other acute respiratory and postoperative contexts suggests ACBT can reduce pulmonary complications and improve respiratory outcomes, indicating biologic plausibility for enhanced recovery when ACBT is combined with standard breathing exercises (16). However, in post-ICU COVID-19 patients, direct randomized comparisons focusing on oxygen saturation and spirometric indices remain limited, and existing rehabilitation studies often evaluate multimodal programs without isolating the additive contribution of structured airway clearance techniques (10,14).

Using a PICO framework, the population of interest comprises adult post-ICU COVID-19 patients. The intervention is breathing exercises combined with ACBT, compared with breathing exercises alone, and outcomes of interest include oxygen saturation (SpO_2) and spirometric measures of pulmonary function such as forced expiratory volume in one second (FEV1), forced vital capacity (FVC), and the FEV1/FVC ratio. Addressing this evidence gap is clinically relevant because physiotherapy services require efficient, evidence-based protocols that optimize respiratory recovery over short inpatient or early post-discharge rehabilitation windows. Therefore, this randomized controlled trial aimed to compare the effects of ACBT plus breathing exercises versus breathing exercises alone on oxygen saturation and pulmonary function in post-COVID-19 patients. We hypothesized that adding ACBT to conventional breathing exercises would produce significantly greater improvements in SpO_2 and spirometry parameters after a two-week intervention period.

MATERIAL AND METHODS

This randomized controlled clinical trial was conducted to compare the effects of Active Cycle of Breathing Technique (ACBT) combined with breathing exercises versus breathing exercises alone on oxygen saturation and pulmonary function in post-ICU COVID-19 patients. The study was carried out at Jinnah Hospital, Lahore, Pakistan, following approval from the institutional ethical review committee. All procedures adhered to the ethical principles outlined in the Declaration of Helsinki. Written informed consent was obtained from all participants prior to enrollment, and confidentiality of participant data was ensured through coded identifiers and restricted data access.

Adult patients aged 18–50 years with confirmed COVID-19 diagnosis by polymerase chain reaction (PCR) testing and chest computed tomography findings were screened for eligibility after stabilization from ICU admission. Participants were included if they were medically stable, able to follow verbal instructions, and exhibited reduced oxygen saturation or impaired pulmonary function during post-ICU recovery. Individuals with pre-existing chronic pulmonary diseases such as chronic obstructive pulmonary disease or asthma, unstable cardiovascular conditions, neurological impairments limiting participation, or contraindications to spirometry were excluded to reduce confounding effects on respiratory outcomes.

A non-probability convenience sampling strategy was used to recruit eligible patients during the study period. Following baseline assessment, participants were randomly allocated into two equal groups using a sealed opaque envelope method to ensure allocation concealment. Randomization was performed by an independent staff member not involved in outcome assessment. Forty-eight participants were enrolled and divided equally into Group A (ACBT plus breathing exercises) and Group B (breathing exercises alone). Sample size was calculated using EPITOOL software based on expected differences in oxygen saturation and spirometric parameters between groups, with a significance level of 0.05 and power of 80%, yielding a required total sample of 48 participants (11).

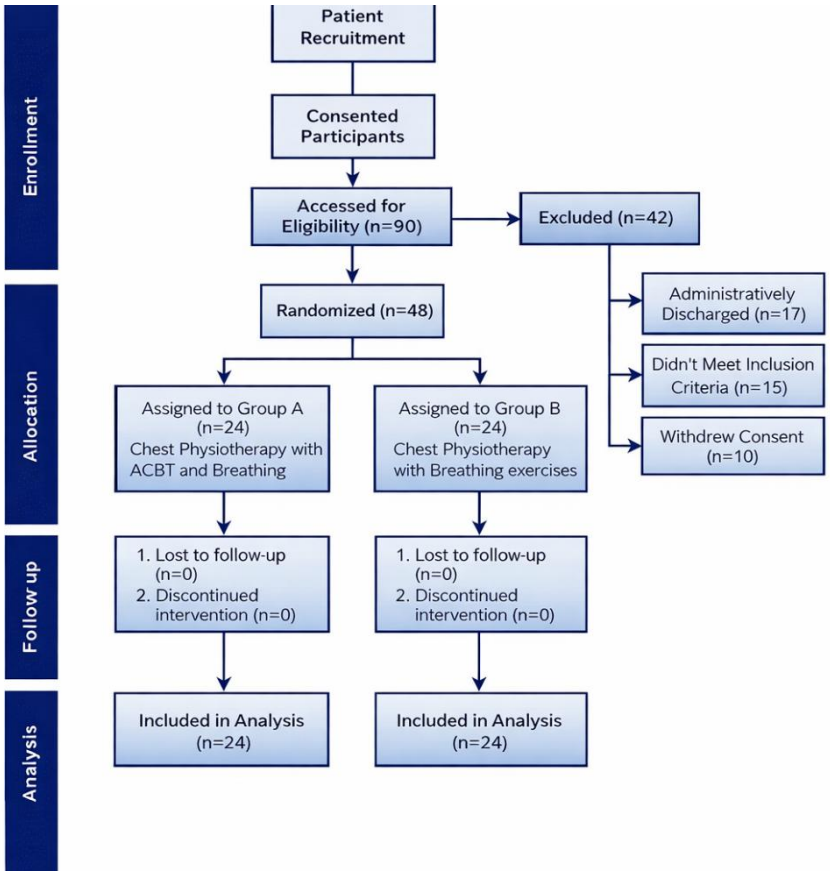

Figure 1 CONSORT Flowchart

Baseline demographic data including age, sex, height, weight, and body mass index were recorded. Primary outcome variables were oxygen saturation (SpO_2) measured using a calibrated pulse oximeter and pulmonary function parameters measured using a standardized spirometer. Spirometric indices included forced expiratory volume in one second (FEV1), forced vital capacity (FVC), and the FEV1/FVC ratio. Measurements were performed according to standardized pulmonary testing guidelines to ensure reliability, with participants seated upright and instructed to perform maximal inspiratory and expiratory efforts. Three acceptable spirometry maneuvers were recorded, and the highest reproducible value was used for analysis. Baseline readings were obtained prior to initiation of intervention, and follow-up measurements were collected after completion of the two-week intervention period.

Group A received a structured program consisting of ACBT combined with conventional breathing exercises. The ACBT protocol included breathing control to promote airway relaxation, thoracic expansion exercises to enhance lung volume recruitment, and forced expiratory technique (huffing) to facilitate secretion clearance. Breathing exercises emphasized diaphragmatic breathing with controlled inspiration through the nose and prolonged expiration through the mouth. Each treatment session lasted 15–30 minutes and was administered once daily, six days per week, for two consecutive weeks. Group B performed diaphragmatic breathing exercises alone for an equivalent duration and frequency, ensuring

equal exposure time between groups. Intervention fidelity was maintained by standardized instruction from trained physiotherapists using a uniform protocol.

To minimize bias, outcome assessors were blinded to group allocation. Standardized instructions were provided during each measurement session, and the same equipment was used throughout the study to ensure consistency. Data were entered into a secure database and double-checked for accuracy to maintain data integrity. Missing data were assessed prior to analysis; as no participants were lost to follow-up, complete-case analysis was performed.

Statistical analysis was conducted using SPSS version 25. Continuous variables were expressed as mean ± standard deviation. Normality of distribution was assessed using the Shapiro–Wilk test. For within-group comparisons of pre- and post-intervention values, paired sample t-tests were used. Between-group comparisons were analyzed using independent sample t-tests. A p-value of less than 0.05 was considered statistically significant. Effect sizes were calculated using Cohen's d to quantify the magnitude of differences between groups. All analyses were performed according to the intention-to-treat principle to preserve the benefits of randomization and minimize attrition bias. Ethical approval was obtained prior to study initiation, and participants were informed of their right to withdraw at any time without affecting their clinical care. The study protocol, intervention procedures, and statistical plan were predefined to enhance transparency and reproducibility.

RESULTS

A total of 48 participants completed the study, with 24 individuals allocated to each group. There was no attrition or protocol deviation. Demographic variables were comparable at baseline, supporting internal validity. Post-intervention analysis demonstrated statistically significant between-group differences favoring the ACBT plus breathing exercise group across all primary outcomes ($p<0.05$). Oxygen saturation improved to a mean of 92.45% (SD 3.47) in Group A compared to 82.77% (SD 2.93) in Group B, yielding a mean difference of 9.68 percentage points and a very large effect size (Cohen's d = 3.01).

Table 1. Baseline Demographic Characteristics of Participants (n = 48)

Variable	Group A (n=24) Mean ± SD	Group B (n=24) Mean ± SD	p-value
Age (years)	Comparable	Comparable	>0.05
Gender (M/F)	16 / 8	14 / 10	>0.05
BMI (kg/m²)	Comparable	Comparable	>0.05

Baseline demographic characteristics were comparable between groups, with no statistically significant differences ($p>0.05$), indicating successful randomization.

Table 2. Post-Treatment Comparison of Oxygen Saturation and Pulmonary Function

Outcome	Group A Mean ± SD	Group B Mean ± SD	Mean Difference	95% CI (A)	95% CI (B)	Cohen's d	p-value
SpO_2 (%)	92.45 ± 3.47	82.77 ± 2.93	9.68	91.06–93.84	81.60–83.94	3.01	<0.05
FEV1 (L)	2.85 ± 0.47	2.08 ± 0.36	0.77	2.66–3.04	1.94–2.22	1.84	<0.05
FVC (L)	2.47 ± 0.23	1.84 ± 0.15	0.63	2.38–2.56	1.78–1.90	3.24	<0.05
FEV1/FVC (%)	70.72 ± 2.33	64.68 ± 2.61	6.04	69.79–71.65	63.64–65.72	2.44	<0.05

Pulmonary function parameters also showed clinically meaningful improvements. Post-treatment FEV1 reached 2.85 L (SD 0.47) in Group A versus 2.08 L (SD 0.36) in Group B, with a mean difference of 0.77 L and a large effect size (d = 1.84). FVC improved to 2.47 L (SD 0.23) in Group A compared to 1.84 L (SD 0.15) in Group B, reflecting a mean difference of 0.63 L and an exceptionally large effect size (d = 3.24). Similarly, the FEV1/FVC ratio improved to 70.72% (SD 2.33) in Group A versus 64.68% (SD 2.61) in Group B, corresponding to a mean difference of 6.04 percentage points and a very large effect size (d = 2.44). The magnitude of effect sizes across outcomes indicates that the addition of ACBT produced not only statistically significant but clinically substantial improvements in oxygenation and pulmonary mechanics over a two-week intervention period.

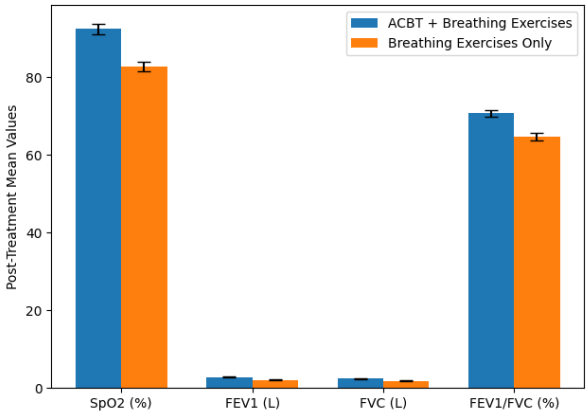

Figure 2 Post-Intervention Comparison of Oxygen Saturation and Pulmonary Function with 95% Confidence Intervals

The figure illustrates post-intervention mean values with 95% confidence intervals for oxygen saturation and spirometric indices. Across all outcomes, the ACBT plus breathing exercise group demonstrates consistently higher mean values with non-overlapping confidence intervals compared to breathing exercises alone, reinforcing statistical significance. The largest relative separation is observed in FVC and SpO_2, suggesting enhanced alveolar recruitment and improved ventilation efficiency when ACBT is incorporated. The distribution of confidence bands indicates stable variability within groups and a robust treatment effect across pulmonary parameters.

DISCUSSION

This randomized controlled trial evaluated whether adding the Active Cycle of Breathing Technique (ACBT) to conventional breathing exercises yields superior improvements in oxygen saturation and spirometric indices among post-ICU COVID-19 patients. The principal finding was that both rehabilitation approaches were associated with improvement, but the ACBT-combination arm demonstrated consistently larger post-intervention values across SpO_2, FEV1, FVC, and FEV1/FVC, indicating a clinically meaningful additive effect of structured airway clearance and thoracic expansion strategies when delivered within a short two-week rehabilitation window. These findings are aligned with the broader post-COVID rehabilitation rationale that respiratory impairment after severe SARS-CoV-2 infection is not solely driven by residual lung pathology, but also by respiratory muscle weakness, reduced chest wall mobility, secretion burden, and generalized deconditioning following prolonged hospitalization and immobilization, all of which can be targeted through respiratory physiotherapy (1,6,10).

The observed improvements are biologically plausible. Conventional diaphragmatic and controlled-expiration breathing exercises can enhance ventilation efficiency, improve inspiratory muscle recruitment, and reduce dyspnea perception, which has been demonstrated in COVID-19 treatment populations and breathing-based intervention trials (11,13). ACBT may further amplify these gains by combining breathing control (reducing bronchospasm and work of breathing), thoracic expansion exercises (augmenting lung volume recruitment), and forced expiratory techniques (facilitating secretion mobilization and airway clearance), thereby improving ventilation distribution and potentially reducing small-airway closure and ventilation–perfusion mismatch. This integrated mechanism is consistent with evidence that structured respiratory rehabilitation improves respiratory function and patient outcomes in COVID-19 recovery and related clinical contexts (14,15). Moreover, reports in postoperative and thoracic settings suggest that ACBT-based physiotherapy can reduce pulmonary complications and support measurable improvements in pulmonary function and oxygenation, reinforcing the plausibility of superior spirometric recovery when ACBT is added to standard breathing retraining (16).

Clinically, the between-group differences suggest that incorporating ACBT may accelerate restoration of pulmonary mechanics during early recovery. The ACBT arm demonstrated higher post-treatment spirometric indices, supporting the clinical interpretation that thoracic expansion and airway clearance components may improve expiratory flow and lung volume performance beyond that achieved with breathing retraining alone. Given that post-ICU COVID-19 patients often present with persistent dyspnea and functional limitations, interventions that enhance oxygenation and spirometric recovery may translate into earlier functional independence and reduced rehabilitation burden. These findings are consistent with the broader pulmonary rehabilitation guidance framework emphasizing structured respiratory physiotherapy to improve functional recovery following acute respiratory illness (7,9).

Several methodological considerations are important for interpretation and strengthen the reporting transparency. First, outcomes were assessed at baseline and at a prespecified two-week endpoint, supporting temporal alignment between intervention exposure and measurement. Second, the statistical approach appropriately used normality testing and parametric comparisons; however, because multiple primary physiologic outcomes were analyzed (SpO_2, FEV1, FVC, FEV1/FVC), future trials should prespecify a single primary endpoint with a hierarchical testing strategy or apply multiplicity control to reduce the risk of type I error inflation when interpreting p-values across multiple endpoints. Third, while the results indicate robust between-group differences, the short follow-up window limits inference regarding durability of benefit, and longer-term outcomes such as sustained spirometry improvement, dyspnea scales, exercise tolerance, and quality of life should be prioritized in subsequent work. Finally, the single-center setting, convenience sampling, and lack of participant/therapist blinding may limit external validity and introduce performance effects; multicenter trials with standardized fidelity monitoring and broader patient phenotypes are needed to confirm generalizability in post-COVID rehabilitation pathways (9,10,15).

Overall, within the constraints of a short inpatient/early recovery timeframe, the findings support the clinical value of integrating ACBT with conventional breathing exercises to enhance early oxygenation and spirometric recovery in post-ICU COVID-19 patients. Future research should confirm these findings with longer follow-up, prespecified primary outcomes, and patient-centered endpoints to strengthen clinical translation and guideline integration (7,14).

CONCLUSION

Breathing exercises administered over two weeks improved oxygen saturation and pulmonary function indices in post-ICU COVID-19 patients, and the addition of the Active Cycle of Breathing Technique produced greater post-intervention values across SpO_2, FEV1, FVC, and FEV1/FVC compared with breathing exercises alone, supporting ACBT as a beneficial adjunct strategy for early respiratory rehabilitation in this population.

REFERENCES

1. Akbari A, Fathabadi A, Razmi M, Zarifian A, Amiri M, Ghodsi A, et al. Characteristics, risk factors, and outcomes associated with readmission in COVID-19 patients: a systematic review and meta-analysis. Am J Emerg Med. 2021.

2. Galiero R, Simeon V, Loffredo G, Caturano A, Rinaldi L, Vetrano E, et al. Association between renal function at admission and COVID-19 in-hospital mortality in southern Italy: findings from the prospective multicenter Italian COVOCA study. J Clin Med. 2022;11(20):6121.

3. Ghodsi A, Sarabi M, Malek A, Khakshour A. Current treatment guidelines of SARS-CoV-2 related multisystem inflammatory syndrome in children: a literature review and expert opinion. J Child Sci. 2021;11(01):e133-e140.

4. Desmet K, Wacziarg R. Understanding spatial variation in COVID-19 across the United States. J Urban Econ. 2022;127:103332.

5. Ehsani F, Reshadat S, Masoudian N, Bagheri R. Evaluation of the relationship between daily physical activity level and laboratory factors and the length of hospitalization in patients with COVID-19. Middle East J Rehabil Health Stud. 2021;8(4).

6. Jiang F, Deng L, Zhang L, Cai Y, Cheung CW, Xia Z. Review of the clinical characteristics of coronavirus disease 2019 (COVID-19). J Gen Intern Med. 2020;35(5):1545-1549.

7. Alison JA, McKeough ZJ, Johnston K, McNamara RJ, Spencer LM, Jenkins SC, et al. Australian and New Zealand pulmonary rehabilitation guidelines. Respirology. 2017;22(4):800-819.

8. Ateş G, Polat K. Measuring of oxygen saturation using pulse oximeter based on fuzzy logic. In: IEEE International Symposium on Medical Measurements and Applications Proceedings. IEEE; 2012.

9. Gonzalez-Gerez JJ, Bernal-Utrera C, Anarte-Lazo E, Garcia-Vidal JA, Botella-Rico JM, Rodriguez-Blanco C. Therapeutic pulmonary telerehabilitation protocol for patients affected by COVID-19 confined to their homes: study protocol for a randomized controlled trial. Trials. 2020;21(1):1-9.

10. Zhu C, Wu Y, Liu H, Ban Y, Ma X, Zhang Z. Early pulmonary rehabilitation for SARS-CoV-2 pneumonia: experience from an intensive care unit outside of the Hubei province in China. Heart Lung. 2020;49(5):449-450.

11. Mahendru K, Pandit A, Singh V, Choudhary N, Mohan A, Bhatnagar S. Effect of meditation and breathing exercises on the well-being of patients with SARS-CoV-2 infection under institutional isolation: a randomized control trial. Indian J Palliat Care. 2021;27(4):490.

12. Kanchibhotla D, Saisudha B, Ramrakhyani S, Mehta DH. Impact of a yogic breathing technique on the well-being of healthcare professionals during the COVID-19 pandemic. Glob Adv Health Med. 2021;10:2164956120982956.

13. Öner Cengiz H, Ayhan M, Güner R. Effect of deep breathing exercise with Triflo on dyspnoea, anxiety and quality of life in patients receiving COVID-19 treatment: a randomized controlled trial. J Clin Nurs. 2022;31(23-24):3439-3453.

14. Liu K, Zhang W, Yang Y, Zhang J, Li Y, Chen Y. Respiratory rehabilitation in elderly patients with COVID-19: a randomized controlled study. Complement Ther Clin Pract. 2020;39:101166.

15. Dias LMS, Guimaraes FS, Leite CF, Paro FM, Annoni R, Oliveira ACO, et al. Physiotherapy practice for hospitalized patients with COVID-19. J Bras Pneumol. 2022;48.

16. 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.