Original Article

The effect of incentive spirometry with early pulmonary rehabilitation on hospital stay of patients with chronic obstructive pulmonary disease exacerbation

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ABSTRACT

BACKGROUND: Incentive spirometry (IS) is a cost-effective, easy-to-use, and accessible device used peri-postoperative period for prevention or management of complications via maintaining maximum inhalation and open collapsed alveoli and resolving atelectasis. Although early pulmonary rehabilitation (PR) is known to reduce the length of stay (LOS), it is controversial whether the addition of IS provides a further contribution. This study aimed to investigate whether using IS in addition to early PR in patients with chronic obstructive pulmonary disease (COPD) exacerbation reduces LOS and whether it is a safe technique by assessing hemodynamic responses.

METHODS: One hundred thirty patients with acute exacerbation of COPD (AECOPD) during hospitalization were randomized to an early PR group and an additional IS group (PR + IS). LOS (days), pre-, and postsession hemodynamic responses were recorded.

RESULTS: The LOS was significantly lower in the PR + IS (5.34 days) group than in the PR group (7.17 days) ($P = 0.026$). Changes in respiratory rate (breaths/min) and oxygen saturation (%) were within the well-tolerated interval in both groups and there was a statistically significant difference in the PR + IS group ($P < 0.001$). Other hemodynamic changes were also within well-tolerated intervals, with no statistically significant differences between the groups ($P > 0.05$).

CONCLUSION: The usage of IS in addition to early PR in patients with AECOPD reduced LOS by approximately 1 day compared to PR alone. Furthermore, no significant signs of intolerance were observed, suggesting that IS was well-tolerated, similar to PR alone.

KEYWORDS

Acute exacerbation of chronic obstructive pulmonary disease, hemodynamic responses, incentive spirometry, length of stay, pulmonary rehabilitation

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Background

Acute exacerbation of chronic obstructive pulmonary disease (AECOPD) is defined as the worsening

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of patients' symptoms compared with day-to-day variations.[1] Exacerbations, whether they require outpatient care or hospitalization, influence the course of the disease and are associated with deterioration in clinical presentation. Approximately, people with COPD are admitted to the hospital for an exacerbation of one or four repeated hospitalizations per year that result in a length of hospital stay (LOS) of 7–10 days.[2,3] AECOPD accounts for a significant proportion of the direct costs associated with COPD, although this varies from country to country.[4]

Early pulmonary rehabilitation (PR) plays a key role in the management of AECOPD, as studies suggest it is a cost-effective intervention that reduces hospital admissions and healthcare costs while improving patients' quality of life.[5] In recent studies, PR programs have been proven to safely improve sputum clearance, and arterial blood gases, reduce the perceived level of dyspnea, and change the quality of life.[5-8] Incentive spirometry (IS) is a well-accepted device that facilitates maximal voluntary inspiration with visual feedback. It is widely used in clinical practice, particularly in postoperative and respiratory patients, to promote lung expansion, prevent atelectasis, and improve pulmonary function.[9,10] The IS may provide utilization of large pulmonary volumes and augmentation of transpulmonary and intra-alveolar pressure.[11] These changes may improve breathing capacity, and respiratory muscle activity and facilitate achieving total lung capacity.

Mucous plugging, acute infection, or bacterial activity, which may be caused by prolonged LOS associated with an acute exacerbation, could attribute to worsening symptoms and pulmonary function.[12] Despite the frequent use of IS, evidence regarding its effectiveness in patients with COPD exacerbation remains inconclusive, highlighting the need for further investigation.[13] Incorporating IS, a cost-effective, easy-to-use, and accessible device, into early PR may contribute to shorter LOS and improved hemodynamic stability. Although our study primarily focused on LOS and hemodynamic responses, a reduction in LOS could potentially have secondary benefits, such as lowering costs and minimizing the risk of hospitalization-related complications. Therefore, this study aimed to investigate whether the use of IS in addition to early PR in patients with COPD exacerbation reduces LOS and to evaluate its safety by assessing hemodynamic responses. The primary objective of the study was to determine the effect of IS on LOS, whereas the secondary objective was to assess its impact on hemodynamic stability.

Materials and Methods

Participants and study design

This study was designed as a prospective, randomized controlled clinical trial. Consecutive one hundred thirty patients with COPD (defined by the Global Initiative for COPD forced expiratory volume in 1 s [FEV_1]/forced vital capacity, 70%)[1] were admitted to a university hospital for an exacerbation included in the study. The inclusion criteria were as follows: Diagnosis of COPD exacerbation,[14] hemodynamic stability, and conscious and voluntary agreement to study. Patients with the presence of neurological, cardiovascular, and musculoskeletal conditions that could prevent performing the exercise, and having chronic respiratory diseases other than COPD were excluded.

The ethics committee of Bezmialem Vakif University (Date: 08/10/2019, Protocol number: 18/352) approved the study which was also registered to the ClinicalTrials.gov website (registration number: NCT04170361). The study was conducted on the ethical principles for human research as outlined by the Declaration of Helsinki. Written informed consent was obtained from each patient.

Patients were randomly allocated into either the early PR group (PR Group) or IS in addition to the early PR (PR + IS Group) using a numbered series of 130 prefilled envelopes specifying group assignments generated by a computer-based program. The physiotherapist responsible for patient assessments was blinded to group assignments, whereas another physiotherapist administered the early PR program to both groups.

An early PR program was started in the first 24 h after the day of hospitalization for both groups. Both groups received a comprehensive PR program once a day during hospitalization. In addition, the patients in the PR + IS group were informed and trained during PR sessions about how to use IS and were asked to perform 10 times at 2-h intervals daily. Patients were assessed before and immediately after the PR session on the 2nd day.

Outcome measures

Demographic variables such as patient age, sex, body mass index, and comorbidities were collected. The GOLD staging[15] was performed according to the last pulmonary function test results recorded during the routine follow-up of the patients. The hemodynamic responses of patients were obtained with arterial blood gases, heart rate (HR, beats/min), systolic blood pressure (SBP, mmHg), diastolic blood pressure (DBP, mmHg), oxygen saturation (SpO_2, %), and respiratory rate (RR, breaths/min) before and immediately after the PR session. The safety of the program was assessed based on predefined intolerance criteria, including an SBP change of more than 20 mmHg, a DBP change of more than 10 mmHg, an increase in HR of more than 20 beats/min, and a reduction in SpO_2 below 90%.[16] In addition, LOS was recorded for all patients in days.

Interventions

The early PR program consisted of diaphragmatic breathing exercises, thoracic expansion exercises, modified postural drainage, coughing techniques, lower-upper limb mobilization, and posture exercises. Breathing exercises were performed as 5 repetitions for two sets with the rest intervals of 5–6 tidal breaths between the sets to avoid respiratory muscle fatigue and hyperventilation.[17] Modified postural drainage with percussion was applied in a sitting position left and right sides for 20 min.[18] Posture exercises included shoulder flexion, biceps curls, wrist and ankle pumps, seated hip flexion, knee extension, trapezius stretch, shoulder girdle elevation (contract-relax), and shoulder roll exercises.[19] The exercises were applied as 5 repetitions of two sets. The exercises were supervised by the same physiotherapist and progressed according to the patient's feedback for each day.

IS was performed using 1200 cc capacity Triflo. After a maximal expiration, patients were encouraged to take slow maximal inspirations through the device's mouthpiece and hold each breath for as long as possible. It was performed at 2-h intervals as 10 repetitions with the rest intervals during the day while awake in the PR + IS group.[9]

Data analysis and sample size

Statistical analysis was conducted using the SPSS v. 26 statistical program (SPSS Inc., Chicago, IL, USA). The normality of the distribution of data was analyzed using Kolmogorov–Smirnov test. Paired sample *t*-test or Wilcoxon test and two Independent sample *t*-test or Mann–Whitney *U*-test were used for in-group comparisons of demographic variables and LOS depending on the distribution properties of the data, respectively. A mixed ANOVA was used to determine the difference in pre- and postsession hemodynamic responses between the PT + IS and PT groups. The results were considered significant with $P < 0.05$.

To determine sample size, G-Power 3.1 was used.[20] We estimated that a sample size of a minimum of 65 patients for each group would have a power of 80% to detect a minimum clinically significant difference between groups 30 ± 25 and 20 ± 19[21] of the LOS (days) which has the highest standard deviation among all variables, with an alpha value of 0.05.

Results

One hundred and 48 patients admitted to the hospital with exacerbation were assessed for eligibility. Eighteen patients dropped out due to being hospitalized in intensive care ($n = 9$), declined to participate ($n = 5$), and were hemodynamically unstable ($n = 4$). Thus, 130 patients with AECOPD were randomized in the study [Figure 1]. The comparison of the demographic and clinical features of the patients between the groups is given in Table 1. There were no significant differences between the PR and PR + IS groups ($P > 0.05$). The LOS of the groups is presented in Figure 2 and the LOS was significantly lower in the PR + IS (5.34 days) group than in the PR group (7.17 days) ($P = 0.026$). The hemodynamic responses of the groups pre- and post-session were altered in both groups except DBP ($P < 0.05$) Furthermore, the SpO_2 value in the PR group did not change statistically between pre- and postsession. The statistically significant interactions

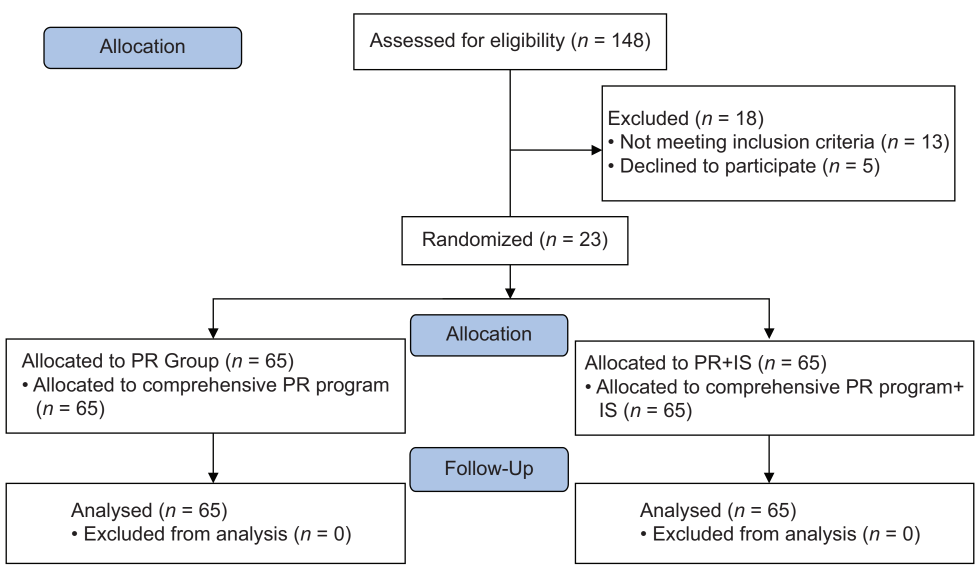

Figure 1: CONSORT flow diagram of the study.
IS = Incentive spirometry, PR = Pulmonary rehabilitation.

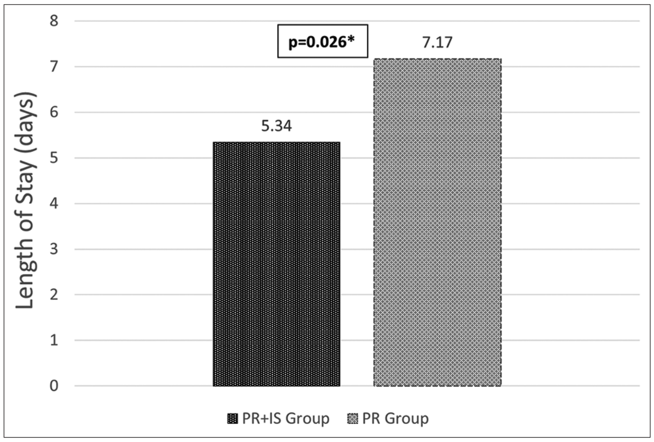

Figure 2: The length of stay of the groups.
IS = Incentive spirometry, PR = Pulmonary rehabilitation.

were determined in RR and SpO_2 parameters between the groups ($P < 0.001$) [Table 2].

Discussion

This study was conducted to evaluate the effects of IS added to early PR during hospitalization in patients with AECOPD. The findings indicate that incorporating IS into early PR may contribute to a reduction in LOS by approximately 1 day compared to early PR alone. Furthermore, the additional improvements observed in SpO_2 and RR, along with the maintenance of other hemodynamic responses within a well-tolerated range, support the safety and potential benefits of integrating IS into early PR for patients with AECOPD.

Prolonged LOS is a critical factor due to its association with increased disease burden, as it accelerates the decline in pulmonary function, contributes to lower extremity muscle dysfunction, exacerbates poor health status, raises healthcare costs, and adversely impacts survival outcomes in patients with AECOPD.[22,23] These challenges have prompted researchers to explore the efficacy of novel interventions aimed at reducing LOS, with evidence indicating that the implementation of early PR may lead to a substantial decrease in LOS.[24,25] Although additional mechanical devices to standard PR such as flutter, threshold inspiratory muscle training, etc., have been used in stable COPD patients, demonstrating improvements in the lung function as evaluated by FEV_1, usage of antibiotics and mucolytic, and the number of acute exacerbations, they have rarely been used in patients with AECOPD.[26-28] Osadnik *et al*. showed that the application of adjunct positive expiratory pressure (PEP) therapy to a standard 30-min walking program could not minimize LOS in patients with AECOPD. Contrary, a recent study revealed that using PEP devices reduced LOS more than standard pharmacological management of AECOPD.[7] These

Table 1: Comparison of baseline demographic and clinical characteristics of all participants.

	PR group, *n* (%)	PR + IS group, *n* (%)	*P*
Age (years)	71.2±9.4	68.2±10.6	0.09
Gender			
Male	44 (67.7)	38 (58.5)	0.27
Female	21 (32.3)	27 (41.5)	
BMI (kg/m^2)	25.14±3.73	25.94±4.26	0.63
Pulmonary function			
FVC (pred%)	53.38±21.86	50.79±16.19	0.357
FEV_1 (pred%)	44.81±19.82	47.88±17.06	0.185
PEF (pred%)	47.44±18.91	45.14±23.76	0.341
Severity of COPD			
GOLD I	16 (24.61)	12 (18.46)	0.71
GOLD II	14 (21.53)	20 (30.76)	
GOLD III	23 (35.38)	24 (30.9)	
GOLD IV	12 (18.46)	9 (13.84)	
Arterial blood gases			
pH	6.87±2.02	5.66±3.14	0.099
pO_2 (mmHg)	56.21±14.57	60.53±13.85	0.337
pCO_2 (mmHg)	45.20±15.50	49.33±14.34	0.380
HCO_3 (mEq/L)	30.61±8.00	30.60±7.87	0.994
SaO_2 (%)	85.28±8.71	89.53±6.53	0.259
Number of comorbidities			
0	6 (9.23)	5 (7.69)	0.74
1–3	46 (70.76)	49 (75.83)	
>3	13 (20)	11 (16.92)	
Comorbid conditions			
Coronary artery disease	20 (30.76)	21 (32.3)	0.58
Arrhythmia	35 (53.84)	38 (58.5)	
Chronic kidney disease	8 (12.30)	10 (15.38)	
Hypertension	32 (49.23)	30 (46.15)	
Cancer	3 (4.61)	3 (4.61)	

Data are presented as mean±SD or *n* (%). BMI=Body mass index, COPD=Chronic obstructive pulmonary disease, FEV_1=Forced expiratory volume in 1 s, FVC=Forced vital capacity, IS=Incentive spirometry, PEF=Peak expiratory flow, PR=Pulmonary rehabilitation, pH=Potential of hydrogen, pO_2=Partial pressure of oxygen, pCO_2=Partial pressure of carbon dioxide, HCO_3=Concentration of bicarbonate, SaO_2=Arterial oxygen saturation, GOLD=Global initiative chronic obstructive lung disease, SD=Standard deviation

findings have been based on the beneficial effects of PEP; improving tidal volume, decreasing functional residual capacity, keeping the small airways open, and increasing ventilation in the peripheral airways via collateral passages.[28,29] Most of the effects of PEP as mentioned above are also attributed to IS in the literature, although PEP and IS have different bases methodologically.[30,31] It is claimed that the usage of IS also results in an augmentation of transpulmonary pressure, inspiratory volumes, and alveolar stability according to deep inspiration and controlled flow.[32] Besides, in our study, patients in the PR + IS group demonstrated a reduction in the LOS of approximately 1 day compared to applying early PR alone. This finding of our study may be related to the adjunctive effects of IS in enhancing lung compliance and reducing transpulmonary pressure gradients due to airway obstruction in patients with AECOPD.[33,34]

Table 2: Hemodynamic responses of the groups before and immediately after pulmonary rehabilitation.

Hemodynamic responses	PR group			PR + IS group			Between groups difference		
	Presession	Postsession	*P*	Presession	Postsession	*P*	*F*	η^2	*P*
HR (beats/min)	86.78±13.51	90.17±14.80	0.010	86.51±13.76	90.88±14.38	<0.001	0.403	0.003	0.527
SBP (mmHg)	125.86±15.65	128.98±17.83	0.040	124.84±13.8	127.90±13.96	0.022	0.001	0.000	0.976
DBP (mmHg)	74.20±11.31	75.00±9.47	0.533	74.10±9.65	75.00±9.47	0.769	0.042	0.000	0.838
SpO_2 (%)	93.85±3.45	93.15±4.31	0.062	93.07±3.81	94.88±3.06	<0.001	31.973	0.216	<0.001
RR (breaths/min)	27.00±5.27	29.54±5.35	<0.001	27.63±5.57	27.37±6.25	0.632	14.642	0.112	<0.001

HR=Heart rate, SBP=Systolic blood pressure, DBP=Diastolic blood pressure, IS=Incentive spirometry, PR=Pulmonary rehabilitation, SpO_2=Oxygen saturation, RR=Respiratory rate

Another study on patients undergoing upper abdominal surgery attributed the reduced hospital LOS to improved oxygenation, shorter mechanical ventilation duration, and a lower incidence of postoperative atelectasis. By enhancing lung expansion and airway clearance, IS supports better respiratory function, reducing complications and facilitating faster recovery.[35] Another possible explanation for early discharge hospital may be that patients in the PR + IS group practiced more deep and slow breathing helped by visual feedback which may have improved breathing control and tidal volume more than the PR group.

Considering the economic burden of COPD, it was observed that exacerbations account for a significant proportion of the direct costs associated with the disease. A recent study in our country showed that from a payer perspective, the annual direct medical cost per patient for the management of exacerbated and hospitalized COPD cases was $3729.[36] Annual direct costs for managing COPD patients vary internationally, with reported ranges of $2088–$9893.[37] Prolonged LOS was shown as one of the major predictors of high hospitalization costs in AECOPD.[38] Little is known about the cost-effectiveness of varied PR settings, especially on AECOPD, some studies suggest that it may be beneficial to the healthcare system, while in others the cost-effectiveness is uncertain.[39,40] Leemans *et al*. examined the cost-effectiveness of PR interventions for patients with COPD through a systematic review of 11 trials involving 3261 participants. The authors stated that PR interventions focussing on exercise training and chest PT are likely to be cost-effective.[41] Another systematic review concluded that different rehabilitation settings have the potential to be cost-effective.[39] Furthermore, a recent study found that applying early PR during COPD hospitalization leads to cost savings and enhanced quality of life.[42] Comparable studies in the literature have demonstrated that early PR interventions may reduce LOS in patients with AECOPD by 42% to 62%.[43,44] In our study, although the absence of a control group that did not receive PR limits our ability to support claims from other studies that early PR reduces LOS, it is noteworthy that in our PR group, the LOS was 7 days, the minimum duration within the commonly reported average of 7–10 days.[2] Considering the older age and comorbidities of our cases, we may speculate that the advantages of early PR were also observed in our study. Furthermore, it was found that PR with the addition of IS led to an earlier discharge, with an average LOS reduced to 6 days. Given the cost of IS and the expense associated with an additional day of hospitalization, it is not difficult to indirectly infer that using the IS in addition to early PR is cost-effective.

In the systemic reviews and meta-analysis, the early PR techniques which may include different types of exercises, breathing methods, and education are found safe in different studies. In addition, adverse events associated with early PR are reported rarely but the intensity of the treatment has been still arguable.[5,8,34] The safety of IS in AECOPD patients is unclear because, to our best knowledge only two studies utilized IS during hospitalization.[45,46] These studies have presented no adverse effect of IS, but any other early PR techniques did not perform in addition to IS in contrast to the present study. Therefore, we need to assess hemodynamic responses to determine the safety and tolerability of additional usage of IS in our study. Considering a change in SBP of more than 20 mmHg and DBP of more than 10 mmHg, an increase in HR of more than 20 beats/min and a decrease in SpO_2 below 90% as signs of intolerance,[16] the findings of our study showed that patients well-tolerated IS added to early PR. In our study, the addition of IS was found to provide hemodynamic changes similar to those observed with early PR, which has already been proven to be safe. In addition, it is known that IS reduces RR, improves breathing capacity, enhances control of respiration, and provides effective inspiration[47,48] which supports lower RR and higher SpO_2 values of the PR + IS group than the PR group in the current study. The superiority of one-session PR + IS on RR and SpO_2 may have contributed to the recovery and resulted in earlier discharge than the PR group.

Study limitations

Although we claim that reducing LOS is indirectly a cost-effective approach, the fact that we could not perform a detailed financial analysis is one of the limitations of our study. Considering that fatigue has been identified as a potential hazard of IS, the absence of fatigue assessment represents a limitation of our study. Another limitation of this study is the lack of functional assessments or specific tests evaluating functional status. Since improvements in functional capacity could influence hospital discharge, incorporating such assessments would have provided a more comprehensive understanding of the relationship between early PR, IS use, and patient outcomes. Even if the present study was not specifically designed to evaluate the general management of AECOPD during hospitalization, the amount of corticosteroid and antibiotics or supplemental oxygen usage were not recorded which may be considered as a limitation of our study. Because these data could provide additional clues on how are benefits to symptoms of patients.

Conclusion

Incorporating IS into early PR for patients with AECOPD may contribute to a more efficient recovery process by reducing hospital LOS. Furthermore, no significant signs of intolerance were observed, suggesting that IS was well-tolerated, similar to PR alone. However, further studies specifically assessing safety and feasibility are warranted to confirm these findings. In addition, further research is needed to evaluate the clinical efficacy and cost-effectiveness of IS to determine whether its use is justifiable from an economic perspective.

Authors' contributions

MK, HDK, HU, MZ, FO, and HNG contributed to the design. MK, HDK, HU, and MZ also contributed to data collection, analysis, and interpretation. MK, HDK, and HU prepared the initial manuscript. FO and HNG revised the manuscript critically for important intellectual content. All authors edited, reviewed, and approved the final manuscript. All authors are responsible for the contents and integrity of this manuscript.

Ethical statement

The ethics committee of Bezmialem Vakif University (Date: 10/2019, Protocol number: 18/352) approved the study, which was also registered to the ClinicalTrials.gov website (registration number: NCT04170361). The study was conducted on the ethical principles for human research as outlined by the Declaration of Helsinki.

Patient consent

The written informed consent was obtained from all patients for this study.

Data availability statement

The data are available from the corresponding author upon reasonable request.

Acknowledgements

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Conflict of interest

There are no conflicts of interest.

References

1. Vogelmeier CF, Criner GJ, Martínez FJ, Anzueto A, Barnes PJ, Bourbeau J, *et al*. Global strategy for the diagnosis, management, and prevention of chronic obstructive lung disease 2017 report: GOLD executive summary. Arch Bronconeumol 2017;53:128-49.
2. Mittmann N, Kuramoto L, Seung SJ, Haddon JM, Bradley-Kennedy C, Fitzgerald JM. The cost of moderate and severe COPD exacerbations to the Canadian healthcare system. Respir Med 2008;102:413-21.
3. Miravitlles M, Ferrer M, Pont A, Zalacain R, Alvarez-Sala JL, Masa F, *et al*. Effect of exacerbations on quality of life in patients with chronic obstructive pulmonary disease: A 2 year follow up study. Thorax 2004;59:387-95.
4. Iheanacho I, Zhang S, King D, Rizzo M, Ismaila AS. Economic burden of Chronic Obstructive Pulmonary Disease (COPD): A systematic literature review. Int J Chron Obstruct Pulmon Dis 2020;15:439-60.
5. Machado A, Matos Silva P, Afreixo V, Caneiras C, Burtin C, Marques A. Design of pulmonary rehabilitation programmes during acute exacerbations of COPD: A systematic review and network meta-analysis. Eur Respir Rev 2020;29:200039.
6. Basri R, Tahir M, Naseem M. Short-term effects of chest physiotherapy in acute exacerbation of chronic obstructive pulmonary disease. J Med Sci 2017;25:323-7.
7. Osadnik CR, McDonald CF, Miller BR, Hill CJ, Tarrant B, Steward R, *et al*. The effect of positive expiratory pressure (PEP) therapy on symptoms, quality of life and incidence of re-exacerbation in patients with acute exacerbations of chronic obstructive pulmonary disease: A multicentre, randomised controlled trial. Thorax 2014;69:137-43.
8. Rice H, Harrold M, Fowler R, Watson C, Waterer G, Hill K. Exercise training for adults hospitalized with an acute respiratory condition: A systematic scoping review. Clin Rehabil 2020;34:45-55.
9. Restrepo RD, Wettstein R, Wittnebel L, Tracy M. Incentive spirometry: 2011. Respir Care 2011;56:1600-4.
10. Eltorai AE, Szabo AL, Antoci V Jr., Ventetuolo CE, Elias JA, Daniels AH, *et al*. Clinical effectiveness of ıncentive spirometry for the prevention of postoperative pulmonary complications. Respir Care 2018;63:347-52.
11. Wattie J. Incentive spirometry following coronary artery bypass surgery. Physiotherapy 1998;84:508-14.
12. Kjærgaard JL, Juhl CB, Lange P, Wilcke JT. Early pulmonary rehabilitation after acute exacerbation of COPD: A randomised controlled trial. ERJ Open Res 2020;6:00173-2019.
13. Overend TJ, Anderson CM, Lucy SD, Bhatia C, Jonsson BI, Timmermans C. The effect of incentive spirometry on postoperative pulmonary complications: A systematic review. Chest 2001;120:971-8.
14. Rodriguez-Roisin R. Toward a consensus definition for COPD exacerbations. Chest 2000;117:398S-401S.

15. Patel N. An update on COPD prevention, diagnosis, and management: The 2024 GOLD report. Nurse Pract 2024;49:29-36.
16. 2011 ENA Emergency Nursing Resources Development Committee, Naccarato M, Leviner S, Proehl J, Barnason S, Brim C, *et al.* Emergency nursing resource: Orthostatic vital signs. J Emerg Nurs 2012;38:447-53.
17. Amini M, Gholami M, Aabed Natanzi H, Shakeri N, Haddad H. Effect of diaphragmatic respiratory training on some pulmonary indexes in older people with chronic obstructive pulmonary disease. Iran J Ageing 2019;14:332-41.
18. Poncin W, Schrøder C, Oliveira A, Herrero-Cortina B, Cnockaert P, Gely L, *et al*. Airway clearance techniques for people with acute exacerbation of COPD: A scoping review. Eur Respir Rev 2025;34:240191.
19. Tsui AY, Chau RM, Cheing GL, Mok TY, Ling SO, Kwan CH, *et al*. Effect of chest wall mobilization on respiratory muscle function in patients with severe Chronic Obstructive Pulmonary Disease (COPD): A randomized controlled trial. Respir Med 2023;220:107436.
20. Faul F, Erdfelder E, Lang AG, Buchner A. G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav Res Methods 2007;39:175-91.
21. Matsui H, Jo T, Fushimi K, Yasunaga H. Outcomes after early and delayed rehabilitation for exacerbation of chronic obstructive pulmonary disease: A nationwide retrospective cohort study in Japan. Respir Res 2017;18:68.
22. Abdulai RM, Jensen TJ, Patel NR, Polkey MI, Jansson P, Celli BR, *et al*. Deterioration of limb muscle function during acute exacerbation of Chronic Obstructive Pulmonary Disease. Am J Respir Crit Care Med 2018;197:433-49.
23. Tsimogianni AM, Papiris SA, Stathopoulos GT, Manali ED, Roussos C, Kotanidou A. Predictors of outcome after exacerbation of chronic obstructive pulmonary disease. J Gen Intern Med 2009;24:1043-8.
24. Torres-Sánchez I, Cruz-Ramírez R, Cabrera-Martos I, Díaz-Pelegrina A, Valenza MC. Results of physiotherapy treatments in exacerbations of Chronic Obstructive Pulmonary Disease: A systematic review. Physiother Can 2017;69:122-32.
25. McCarthy B, Casey D, Devane D, Murphy K, Murphy E, Lacasse Y. Pulmonary rehabilitation for chronic obstructive pulmonary disease. Cochrane Database Syst Rev 2015;2015:CD003793.
26. Bhowmik A, Chahal K, Austin G, Chakravorty I. Improving mucociliary clearance in Chronic Obstructive Pulmonary Disease. Respir Med 2009;103:496-502.
27. Morgan SE, Mosakowski S, Giles BL, Naureckas E, Tung A. Variability in expiratory flow requirements among oscillatory positive expiratory pressure. Can J Respir Ther 2019;56:7-10.
28. Milan S, Bondalapati P, Megally M, Patel E, Vaghasia P, Gross L, *et al*. Positive expiratory pressure therapy with and without oscillation and hospital length of stay for acute exacerbation of Chronic Obstructive Pulmonary Disease. Int J Chron Obstruct Pulmon Dis 2019;14:2553-61.
29. Fagevik Olsén M, Lannefors L, Westerdahl E. Positive expiratory pressure – Common clinical applications and physiological effects. Respir Med 2015;109:297-307.
30. de Alvarenga GM, Remigio Gamba H, Elisa Hellman L, Ganzert Ferrari V, Michel de Macedo R. Physiotherapy ıntervention during level I of pulmonary rehabilitation on Chronic Obstructive Pulmonary Disease: A systematic review. Open Respir Med J 2016;10:12-9.
31. American Association for Respiratory Care. AARC clinical practice guideline: Incentive spirometry. Respir Care 1991;36:1402–5.
32. Neupane K, Jamil RT. Physiology, transpulmonary pressure. In: *StatPearls*. Treasure Island (FL): StatPearls Publishing; 2024.
33. Burgstaller G, Oehrle B, Gerckens M, White ES, Schiller HB, Eickelberg O. The instructive extracellular matrix of the lung: Basic composition and alterations in chronic lung disease. Eur Respir J 2017;50:1601805.
34. Zhang D, Zhang H, Li X, Lei S, Wang L, Guo W, *et al*. Pulmonary rehabilitation programmes within three days of hospitalization for acute exacerbation of Chronic Obstructive Pulmonary Disease: A systematic review and meta-analysis. Int J Chron Obstruct Pulmon Dis 2021;16:3525-38.
35. Su H, Zhang J, Liu Y, Peng H, Zhang L. Pre and postoperative nurse-guided incentive spirometry versus physiotherapist-guided pre and postoperative breathing exercises in patients undergoing cardiac surgery: An evaluation of postoperative complications and length of hospital stay. Medicine (Baltimore) 2022;101:e32443.
36. Polatlı M, Oksuz E, Malhan S. Economic burden and key cost drivers of managing hospitalized chronic obstructive pulmonary disease patients admitted with an exacerbation in Türkiye: A cost of illness study from payer perspective. Turkiye Klinikleri Arch Lung 2022;21:39–50.
37. Foo J, Landis SH, Maskell J, Oh YM, van der Molen T, Han MK, *et al*. Continuing to confront COPD ınternational patient survey: Economic ımpact of COPD in 12 countries. PLoS One 2016;11:e0152618.
38. Baha A, Köktürk N, Baysan C, Öztürk B, Cengiz SK, Varol Y, *et al*. Factors associated with ıncreasing costs in severe Chronic Obstructive Pulmonary Disease exacerbation: Turkish Thoracic Society Chronic Obstructive Pulmonary Disease assembly. Thorac Res Pract 2024;25:17-25.
39. Liu S, Zhao Q, Li W, Zhao X, Li K. The cost-effectiveness of pulmonary rehabilitation for COPD in different settings: A systematic review. Appl Health Econ Health Policy 2021;19:313-24.
40. Mosher CL, Belman M, Garvey C, Casaburi R. Pulmonary rehabilitation in Chronic Obstructive Pulmonary Disease: Medicine's best-kept secret that could save medicare a billion dollars a year. Ann Am Thorac Soc 2023;20:1397-9.
41. Leemans G, Taeymans J, Van Royen P, Vissers D. Respiratory physiotherapy interventions focused on exercise training and enhancing physical activity levels in people with chronic obstructive pulmonary disease are likely to be cost-effective: A systematic review. J Physiother 2021;67:271-83.
42. Mosher CL, Nanna MG, Jawitz OK, Raman V, Farrow NE, Aleem S, *et al*. Cost-effectiveness of pulmonary rehabilitation among US adults with Chronic Obstructive Pulmonary Disease. JAMA Netw Open 2022;5:e2218189.
43. Bourbeau J, Julien M, Maltais F, Rouleau M, Beaupré A, Bégin R, *et al*. Reduction of hospital utilization in patients with chronic obstructive pulmonary disease: A disease-specific self-management intervention. Arch Intern Med 2003;163:585-91.
44. Cecins N, Geelhoed E, Jenkins SC. Reduction in hospitalisation following pulmonary rehabilitation in patients with COPD. Aust Health Rev 2008;32:415-22.
45. Basoglu OK, Atasever A, Bacakoglu F. The efficacy of incentive spirometry in patients with COPD. Respirology 2005;10:349-53.
46. El-Koa AA, Eid HA, Abd Elrahman SR, El Kalashy MM. Value of incentive spirometry in routine management of COPD patients and its effect on diaphragmatic function. Egypt J Bronchol 2023;17:8.
47. Parreira VF, Tomich GM, Britto RR, Sampaio RF. Assessment of tidal volume and thoracoabdominal motion using volume and flow-oriented incentive spirometers in healthy subjects. Braz J Med Biol Res 2005;38:1105-12.
48. Santos TV, Ruas G, Sande de Souza LA, Volpe MS. Influence of forward leaning and incentive spirometry on inspired volumes and inspiratory electromyographic activity during breathing exercises in healthy subjects. J Electromyogr Kinesiol 2012;22:961-7.