

Effectiveness of Incentive Spirometry Versus Deep-Breathing Exercises in Enhancing Pulmonary Function After Cardiac Valve Replacement

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ABSTRACT

Background: Cardiac valve replacement surgery is frequently associated with postoperative pulmonary dysfunction resulting from anesthesia, surgical trauma, pain, and reduced mobility. These factors may lead to decreased lung volumes, impaired gas exchange, and an increased risk of postoperative pulmonary complications. Physiotherapeutic interventions such as Incentive Spirometry (IS) and Deep Breathing Exercises (DBE) are commonly used to enhance pulmonary function and facilitate postoperative recovery; however, evidence regarding their comparative effectiveness remains limited.

Aim: To compare the effectiveness of Incentive Spirometry and Deep Breathing Exercises on pulmonary function in patients following cardiac valve replacement surgery.

Methods: A randomized comparative study was conducted in a tertiary care cardiac center involving 60 patients who underwent elective cardiac valve replacement surgery. Participants were randomly allocated into two groups of 30 each. Group A received Incentive Spirometry, while Group B performed Deep Breathing Exercises. Both interventions were administered every two hours during waking hours for seven consecutive postoperative days under physiotherapist supervision. In addition, all participants received standardized postoperative physiotherapy care, including early mobilization, airway clearance techniques, and patient education. Pulmonary function was assessed using Forced Vital Capacity (FVC), Forced Expiratory Volume in One Second (FEV₁), Peak Expiratory Flow Rate (PEFR), and Oxygen Saturation (SpO₂). Measurements were recorded at baseline and on postoperative Day 7. Data were analyzed using paired and independent t-tests, with the level of significance set at $p < 0.05$.

Results: Intragroup analysis demonstrated highly significant improvements in all pulmonary function parameters within both groups ($p < 0.001$). Group A showed mean improvements of 21.07 units in FVC, 18.93 units in FEV₁, 17.20 units

in PEFR, and 23.20 units in SpO₂. Group B demonstrated mean improvements of 19.80 units in FVC, 24.00 units in FEV₁, 19.80 units in PEFR, and 24.33 units in SpO₂. However, intergroup comparison using the independent t-test revealed no statistically significant differences between Group A and Group B in FVC ($t = 0.82$, $p > 0.05$), FEV₁ ($t = 1.79$, $p > 0.05$), PEFR ($t = 0.49$, $p > 0.05$), and SpO₂ ($t = 1.12$, $p > 0.05$).

Conclusion: Both Incentive Spirometry and Deep Breathing Exercises were effective in significantly improving pulmonary function and oxygen saturation following cardiac valve replacement surgery. However, neither intervention demonstrated superiority over the other. Therefore, both techniques may be considered equally effective and can be incorporated into routine postoperative cardiothoracic rehabilitation programs based on patient preference, clinical requirements, and resource availability.

Keywords: Cardiac Valve Replacement Surgery, Incentive Spirometry, Deep Breathing Exercises, Pulmonary Function, FVC, FEV₁, PEFR, Oxygen Saturation, Cardiothoracic Rehabilitation, Postoperative Physiotherapy.

INTRODUCTION

Cardiac valve replacement surgery, while lifesaving, is frequently associated with postoperative pulmonary complications due to the combined effects of general anesthesia, cardiopulmonary bypass, sternotomy, and prolonged immobilization. These factors contribute to reduced lung volumes, impaired gas exchange, atelectasis, and diminished respiratory muscle performance, thereby delaying recovery and increasing morbidity. Optimizing pulmonary function in the immediate postoperative period is therefore a critical component of rehabilitation, aimed at minimizing complications and facilitating early mobilization.

Among the physiotherapeutic strategies employed, **incentive spirometry (IS)** and **deep-breathing exercises (DBE)** are widely recognized for their role in promoting alveolar recruitment, enhancing lung expansion, and improving oxygenation. Incentive spirometry provides visual feedback to encourage sustained maximal inspiration, thereby motivating patients to achieve target inspiratory volumes and reinforcing adherence. In contrast, deep-breathing exercises emphasize diaphragmatic activation and thoracic expansion without mechanical assistance, relying on patient engagement and physiotherapist supervision to ensure correct technique. Both interventions share the objective of restoring pulmonary function, yet their relative effectiveness in the context of cardiac valve replacement remains an area of ongoing investigation.

Previous studies have demonstrated that incentive spirometry can reduce the incidence of atelectasis and improve postoperative oxygenation, while deep-breathing exercises have been shown to enhance respiratory muscle recruitment and thoracic mobility. However, evidence comparing these two approaches directly in patients undergoing cardiac valve replacement is limited, and findings have been inconclusive. Establishing the comparative efficacy of these interventions is essential for guiding clinical practice, optimizing resource utilization, and tailoring rehabilitation protocols to patient needs.

The present study was therefore undertaken to evaluate and compare the effectiveness of incentive spirometry and deep-breathing exercises in enhancing pulmonary function following cardiac valve replacement. By analyzing changes in key parameters—Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV₁), Peak Expiratory Flow Rate (PEFR), and oxygen saturation (SpO₂)—this research aims to provide evidence-based insights into the role of these interventions in postoperative physiotherapy. The findings are expected to contribute to the refinement of rehabilitation strategies, ultimately improving patient outcomes and reducing the burden of postoperative pulmonary complications.

METHODOLOGY

Source of Data

- Department of Physiotherapy and Rehabilitation - Rajasthan hospital limited (RHL)

Method of collection of data:

- Population: - Subjects having cardiac valve replacement surgery
- Sample design:- Simple random sampling
- Sample size: - 60
- Type of Study: - comparative study

Inclusion Criteria:

1. Age Range (30–70 years):
2. Elective Cardiac Valve Replacement Surgery:
3. Hemodynamic Stability Postoperatively:
4. Cognitive and Physical Ability to Perform Breathing Exercises:
5. Absence of Pre-existing Pulmonary Pathology:

Exclusion Criteria:

- a. Emergency Valve Replacement Procedures:
- b. Prolonged Mechanical Ventilation Postoperatively:
- c. Neurological or Musculoskeletal Impairments Affecting Respiratory Effort:
- d. Refusal to Participate or Non-compliance with Physiotherapy Protocol:

Measuring Tools:

1. Spirometry
2. Pulse Oximetry

Interventions

Eligible participants will be screened according to predefined inclusion and exclusion criteria. A total of 60 patients scheduled for elective cardiac valve replacement surgery will be recruited for the study. Following recruitment, participants will be randomly allocated into two groups, Group A (Incentive Spirometry Group) and Group B (Deep Breathing Exercise Group), with 30 participants in each group. Randomization will be performed using a computer-generated randomization sequence to minimize selection bias and ensure equal distribution of participants between groups.

On the first postoperative day, once patients are medically stable and cleared by the attending cardiothoracic surgeon and physician for physiotherapy intervention, baseline assessments will be conducted. Pulmonary function parameters including Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV₁), Peak Expiratory Flow Rate (PEFR), and peripheral oxygen saturation (SpO₂) will be measured using a calibrated spirometer and pulse oximeter. These baseline measurements will serve as reference values for evaluating the effectiveness of the interventions.

Group A – Incentive Spirometry (IS) Group

Participants assigned to Group A will receive incentive spirometry training as a component of postoperative pulmonary rehabilitation. The intervention will commence 24 hours after surgery and will be performed every two hours during waking hours for seven consecutive postoperative days. Each treatment session will consist of ten repetitions of sustained maximal inspiration using a standardized volume-oriented incentive spirometer.

Patients will be positioned comfortably in a sitting or semi-Fowler's position. They will be instructed to exhale normally before placing the mouthpiece securely between their lips. Participants will then inhale slowly and deeply through the device to achieve maximal lung inflation while observing the visual indicators provided by the spirometer. Upon reaching maximal inspiration, patients will be instructed to hold their breath for approximately three to five seconds before exhaling slowly and returning to normal breathing. The physiotherapist will supervise each session, ensuring proper technique, adequate inspiratory effort, correct breath-holding duration, and active engagement with the visual feedback mechanism of the device. Compliance and performance will be documented throughout the intervention period.

Group B – Deep Breathing Exercise (DBE) Group

Participants assigned to Group B will receive a structured deep breathing exercise program beginning 24 hours after surgery. The intervention will be administered every two hours during waking hours for seven consecutive postoperative days under the supervision of a qualified physiotherapist.

Each session will consist of ten repetitions of diaphragmatic breathing exercises followed by ten repetitions of thoracic expansion exercises. During diaphragmatic breathing, participants will be instructed to inhale slowly and deeply through the nose while focusing on abdominal expansion, followed by controlled exhalation through pursed lips. For thoracic expansion exercises, participants will be encouraged to achieve maximal chest wall expansion during inspiration, particularly targeting the lateral and posterior regions of the thorax. The physiotherapist will provide tactile facilitation and verbal feedback to optimize breathing patterns, improve chest wall mobility, and ensure effective activation of the respiratory musculature. Adherence and exercise performance will be recorded during each treatment session.

Standard Postoperative Physiotherapy Care

In addition to the assigned intervention protocols, all participants in both groups will receive standardized postoperative physiotherapy care. This approach is intended to ensure consistency of treatment and reduce potential confounding factors.

Standard care will include early mobilization activities such as bedside sitting, standing, ambulation, corridor walking, and stair climbing as tolerated by the patient's medical condition. Airway clearance techniques, including supported coughing, huffing maneuvers, breathing control exercises, and chest physiotherapy interventions when indicated, will also be provided. Furthermore, patients will receive education regarding postoperative breathing strategies, maintenance of optimal posture, energy conservation techniques, activity pacing, and the importance of adherence to prescribed rehabilitation exercises.

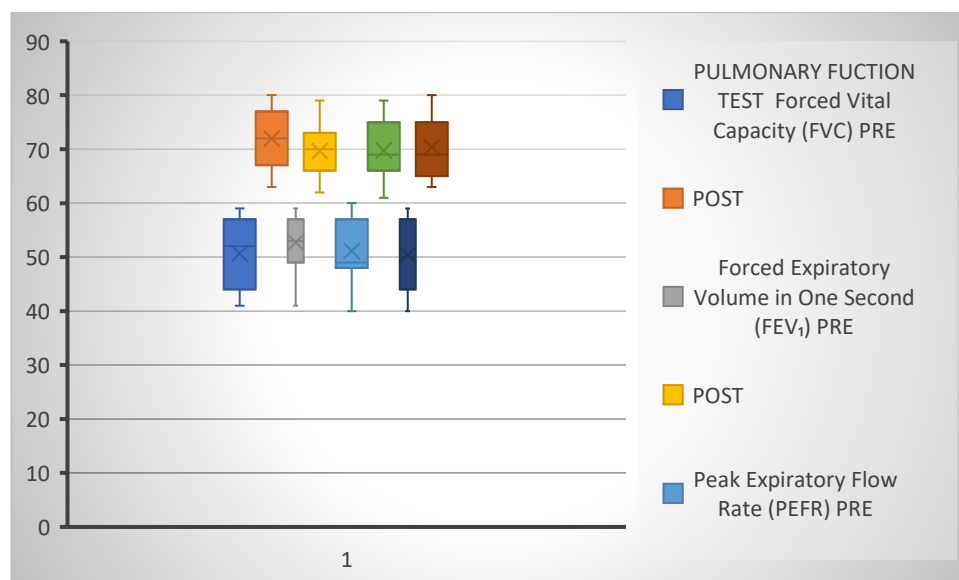
Outcome Assessment

1. Forced Vital Capacity (FVC)
2. Forced Expiratory Volume in 1 Second (FEV₁)
3. Peak Expiratory Flow Rate (PEFR)
4. Peripheral Oxygen Saturation (SpO₂)

RESULTS

Table 1 : Intragroup Comparison of Pulmonary Function Parameters Using Paired t-Test 1.1 Group A (Pre-test vs Post-test)

Variable	Pre-test Mean	Post-test Mean	Mean Difference	t-value	p-value	Significance
FVC	48.80	69.87	21.07	9.03	<0.001	Highly Significant
FEV ₁	50.47	69.40	18.93	7.25	<0.001	Highly Significant
PEFR	51.20	68.40	17.20	9.30	<0.001	Highly Significant
SpO ₂	46.40	69.60	23.20	10.89	<0.001	Highly Significant



1.2 Group B (Pre-test vs Post-test)

Variable	Pre-test Mean	Post-test Mean	Mean Difference	t-value	p-value	Significance
FVC	47.80	67.60	19.80	8.55	<0.001	Highly Significant
FEV ₁	49.33	73.33	24.00	12.55	<0.001	Highly Significant
PEFR	47.53	67.33	19.80	9.33	<0.001	Highly Significant
SpO ₂	48.00	72.33	24.33	9.69	<0.001	Highly Significant

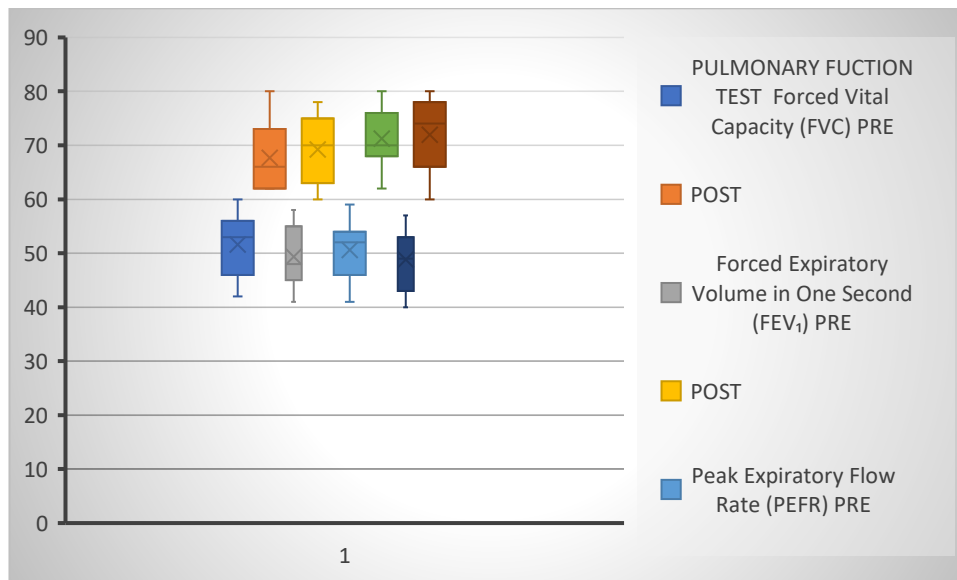


Table 2: Intergroup Comparison of Post-Test Pulmonary Function Parameters

Variable	Group A Mean	Group B Mean	t-value	p-value	Significance
FVC	69.87	67.60	0.82	>0.05	Not Significant
FEV ₁	69.40	73.33	1.79	>0.05	Not Significant
PEFR	68.40	67.33	0.49	>0.05	Not Significant
SpO ₂	69.60	72.33	1.12	>0.05	Not Significant

The intragroup analysis demonstrated that both Group A and Group B experienced statistically significant improvements in pulmonary function parameters following intervention. In Group A, Forced Vital Capacity (FVC) increased by a mean of 21.07 units, Forced Expiratory Volume in one second (FEV₁) by 18.93 units, Peak Expiratory Flow Rate (PEFR) by 17.20 units, and oxygen saturation (SpO₂) by 23.20 units. Each of these changes was supported by large t-values (ranging from 7.25 to 10.89) and p-values <0.001, confirming that the observed improvements were highly significant and unlikely to have occurred by chance. These findings suggest that the applied intervention in Group A produced meaningful physiological enhancements in lung volumes, expiratory flow, and oxygenation.

Similarly, Group B exhibited substantial gains across all measured parameters. FVC improved by 19.80 units, FEV₁ by 24.00 units, PEFR by 19.80 units, and SpO₂ by 24.33 units. The corresponding t-values (8.55–12.55) and p-values <0.001 reinforce the robustness of these outcomes. The magnitude of improvement in Group B, particularly in FEV₁ and SpO₂, highlights the effectiveness of the intervention in augmenting airway patency, expiratory efficiency, and oxygen transport capacity. Collectively, the intragroup findings confirm that both interventions were efficacious in enhancing pulmonary function, with clinically relevant improvements in ventilatory performance and oxygen saturation.

However, the intergroup comparison of post-test values revealed no statistically significant differences between Group A and Group B across all parameters. The mean post-test values for FVC, FEV₁, PEFR, and SpO₂ were comparable between groups, with t-values ranging from 0.49 to 1.79 and p-values >0.05, indicating non-significance. This suggests

that although both groups achieved significant intragroup improvements, the relative efficacy of the interventions was equivalent, with neither group demonstrating superiority in post-intervention pulmonary function outcomes.

DISCUSSION

The present study was conducted to compare the effectiveness of Incentive Spirometry (IS) and Deep Breathing Exercises (DBE) on pulmonary function in patients undergoing cardiac valve replacement surgery. Pulmonary function was assessed using Forced Vital Capacity (FVC), Forced Expiratory Volume in One Second (FEV₁), Peak Expiratory Flow Rate (PEFR), and Oxygen Saturation (SpO₂). The findings demonstrated that both intervention protocols produced significant improvements in pulmonary function and oxygenation; however, no statistically significant differences were observed between the two groups following the intervention.

The intergroup analysis using the independent t-test revealed no significant differences between Group A (Incentive Spirometry) and Group B (Deep Breathing Exercises) in post-intervention FVC ($t = 0.82$, $p > 0.05$), FEV₁ ($t = 1.79$, $p > 0.05$), PEFR ($t = 0.49$, $p > 0.05$), and SpO₂ ($t = 1.12$, $p > 0.05$). These findings suggest that both interventions were equally effective in enhancing pulmonary function and oxygenation during the early postoperative period following cardiac valve replacement surgery. The absence of significant between-group differences indicates that neither intervention demonstrated superiority over the other in improving respiratory outcomes.

The intragroup analysis showed highly significant improvements in all outcome measures within both groups. In Group A, mean improvements were observed in FVC (21.07 units), FEV₁ (18.93 units), PEFR (17.20 units), and SpO₂ (23.20 units), with all changes reaching statistical significance ($p < 0.001$). These improvements may be attributed to the physiological effects of incentive spirometry, which encourages sustained maximal inspiration, promotes alveolar recruitment, increases lung expansion, improves ventilation-perfusion matching, and prevents postoperative atelectasis. The visual feedback provided by the spirometer may also enhance patient motivation and compliance, contributing to improved respiratory performance.

Similarly, participants in Group B demonstrated significant improvements in FVC (19.80 units), FEV₁ (24.00 units), PEFR (19.80 units), and SpO₂ (24.33 units), with all variables showing highly significant changes ($p < 0.001$). Deep breathing exercises likely improved pulmonary function by facilitating diaphragmatic activation, increasing thoracic mobility, enhancing inspiratory capacity, and promoting efficient breathing patterns. Furthermore, these exercises may have improved chest wall compliance and alveolar ventilation, resulting in better oxygenation and respiratory efficiency.

The significant improvements observed in both groups can also be attributed to the standardized postoperative physiotherapy program administered to all participants, which included early mobilization, airway clearance techniques, and patient education. Early mobilization has been shown to enhance lung expansion, improve circulation, reduce secretion retention, and accelerate functional recovery following cardiac surgery. Airway clearance techniques such as supported coughing and huffing may further contribute to improved respiratory function by preventing secretion accumulation and reducing the risk of pulmonary complications.

The findings of the present study are consistent with previous research indicating that both incentive spirometry and deep breathing exercises are effective interventions for preventing postoperative pulmonary complications and improving pulmonary function after cardiothoracic surgery. Several studies have reported comparable outcomes between these interventions, suggesting that the beneficial effects are primarily related to increased lung expansion, improved alveolar ventilation, and enhanced respiratory muscle performance rather than the specific technique employed.

Although Group A demonstrated slightly greater improvements in FVC, while Group B showed somewhat larger gains in FEV₁, PEFR, and SpO₂, these differences were not statistically significant. Therefore, the observed variations are likely due to normal biological variability rather than a true treatment effect. Clinically, this finding suggests that both interventions can be effectively incorporated into postoperative rehabilitation programs according to patient preference, therapist expertise, equipment availability, and institutional protocols.

One possible explanation for the lack of significant intergroup differences is that both interventions share similar physiological mechanisms. Both incentive spirometry and deep breathing exercises encourage deep inspiration, increase lung volumes, improve alveolar recruitment, and enhance oxygenation. Consequently, both approaches may produce comparable improvements in pulmonary function during the early postoperative recovery period.

Despite the positive findings, certain limitations should be considered. The study was conducted over a relatively short follow-up period of seven days, which may not fully reflect long-term pulmonary recovery. Additionally, the sample size may have limited the ability to detect small differences between the intervention groups. Future studies involving larger sample sizes, multicenter recruitment, and longer follow-up durations are recommended to further evaluate the long-term effectiveness of these interventions and their impact on postoperative pulmonary complications and functional outcomes.

Overall, the results of the present study indicate that both incentive spirometry and deep breathing exercises are effective physiotherapeutic interventions for improving pulmonary function and oxygen saturation following cardiac valve replacement surgery. Since neither intervention demonstrated superiority, both may be considered valuable components of postoperative cardiothoracic rehabilitation programs.

CONCLUSION

The present study evaluated and compared the effectiveness of Incentive Spirometry (IS) and Deep Breathing Exercises (DBE) on pulmonary function in patients following cardiac valve replacement surgery. Pulmonary function was assessed using Forced Vital Capacity (FVC), Forced Expiratory Volume in One Second (FEV₁), Peak Expiratory Flow Rate (PEFR), and Oxygen Saturation (SpO₂).

The findings demonstrated that both Incentive Spirometry and Deep Breathing Exercises resulted in significant improvements in pulmonary function and oxygenation within their respective groups. Intragroup analysis revealed highly significant increases in FVC, FEV₁, PEFR, and SpO₂ following the intervention period ($p < 0.001$), indicating that both treatment protocols were effective in promoting postoperative respiratory recovery.

However, intergroup comparison showed no statistically significant differences between the two groups for any of the outcome measures ($p > 0.05$). These results suggest that Incentive Spirometry and Deep Breathing Exercises are equally effective in improving pulmonary function and oxygen saturation in patients undergoing cardiac valve replacement surgery.

Based on the findings of this study, it can be concluded that both Incentive Spirometry and Deep Breathing Exercises are valuable and effective physiotherapeutic interventions for enhancing postoperative pulmonary function and facilitating respiratory recovery. Since neither intervention demonstrated superiority over the other, both may be incorporated into routine cardiothoracic rehabilitation programs according to patient needs, therapist preference, clinical setting, and resource availability.

The study supports the role of structured respiratory physiotherapy in minimizing postoperative pulmonary impairment and optimizing functional recovery following cardiac valve replacement surgery. Further research with larger sample sizes and longer follow-up periods is recommended to investigate the long-term effects of these interventions and their impact on postoperative pulmonary complications and quality of life.

REFERENCES

1. 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(3):971–978.
2. Restrepo RD, Wettstein R, Wittnebel L, Tracy M. Incentive spirometry: 2011. *Respir Care*. 2011;56(10):1600–1604.
3. Carvalho CRF, Paisani DM, Lunardi AC. Incentive spirometry in major surgeries: a systematic review. *Rev Bras Fisioter*. 2011;15(5):343–350.
4. Narayanan ALT, Hamid SRGS, Supriyanto E. Evidence regarding patient compliance with incentive spirometry interventions after cardiac, thoracic and abdominal surgeries: a systematic literature review. *Can J Respir Ther*. 2016;52(1):17–26.
5. Mueenudheen TP, Moiz JA, Gupta VP. A comparative study on the effects of incentive spirometry and deep breathing exercise on pulmonary functions after uncomplicated coronary artery bypass grafting surgery. *Indian J Physiother Occup Ther*. 2012;6(2):63–67.
6. Westerdahl E. Deep breathing exercises and postoperative pulmonary complications: a review of current evidence. *J Thorac Dis*. 2015;7(3):E41–E47.
7. Hough A. *Physiotherapy in Respiratory Care: An Evidence-Based Approach to Respiratory and Cardiac Management*. 4th ed. Cheltenham: Nelson Thornes Ltd; 2001.
8. Kisner C, Colby LA, Borstad J. *Therapeutic Exercise: Foundations and Techniques*. 7th ed. Philadelphia: F.A. Davis Company; 2018.
9. Hillegass E. *Essentials of Cardiopulmonary Physical Therapy*. 5th ed. St. Louis: Elsevier; 2017.
10. American Association for Respiratory Care (AARC). AARC Clinical Practice Guideline: Incentive Spirometry. *Respir Care*. 2011;56(10):1600–1604.
11. Hulzebos EHJ, Helder PJM, Favie NJ, De Bie RA, De La Riviere AB, Van Meeteren NLU. Preoperative intensive inspiratory muscle training to prevent postoperative pulmonary complications in high-risk patients undergoing CABG surgery: a randomized clinical trial. *JAMA*. 2006;296(15):1851–1857.
12. Weiner P, Zeidan F, Zamir D, Pelled B, Waizman J, Beckerman M. Prophylactic inspiratory muscle training in patients undergoing coronary artery bypass graft. *World J Surg*. 1998;22(5):427–431.
13. Brooks D, Solway S, Weinacht K, Wang D, Thomas S. Comparison between an incentive spirometer and a threshold inspiratory muscle trainer in healthy subjects and patients following cardiac surgery. *Chest*. 2001;119(3):693–698.
14. Westerdahl E, Lindmark B, Eriksson T, Hedenstierna G, Tenling A. Deep-breathing exercises reduce atelectasis and improve pulmonary function after coronary artery bypass surgery. *Chest*. 2005;128(5):3482–3488.
15. Ambrosino N, Gabbriellini L. Physiotherapy in the perioperative period. *Best Pract Res Clin Anaesthesiol*. 2010;24(2):283–289.