

REVIEW ARTICLE

Incentive Spirometry: Historical Evolution, Clinical Utility, and Future Directions: A Narrative Review

Parthkumar Devmurari

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ABSTRACT

Background: Incentive spirometry (IS) is a widely utilized respiratory therapy aimed at preventing postoperative pulmonary complications (PPCs) and improving lung function. Despite its widespread adoption, the evidence supporting its standalone efficacy across various clinical settings remains inconsistent.

Objective: This narrative review evaluates the effectiveness of IS in clinical practice, focusing on its role in postoperative care, chronic obstructive pulmonary disease (COPD) management, and COVID-19 rehabilitation.

Methods: A comprehensive search of PubMed, Scopus, and Cochrane Library databases identified 13 randomized controlled trials (RCTs) published between 2000 and 2024. Inclusion criteria were studies involving adult populations, written in English, and focused on IS as an intervention. Data on study design, patient characteristics, IS protocols, and outcomes were extracted and synthesized qualitatively.

Results: The findings reveal mixed outcomes. IS as a standalone intervention showed limited efficacy in reducing PPCs in cardiac, thoracic, and upper abdominal surgeries. However, when integrated into multimodal rehabilitation protocols, IS demonstrated potential benefits, including improved pulmonary function and faster recovery in patients with COPD and post-COVID-19 conditions. Variability in protocols and adherence across studies limited generalizability.

Conclusion: While IS alone may not significantly prevent PPCs, its integration into comprehensive care protocols can enhance patient outcomes. Tailored approaches that combine IS with other respiratory therapies may optimize its effectiveness. Future research should focus on standardizing protocols, long-term outcomes, and patient-centered measures.

KEYWORDS

• Incentive spirometry • Respiratory therapy • Multimodal rehabilitation

AUTHOR'S AFFILIATION:

Associate Professor, School of Physiotherapy, RK University, Rajkot, Gujarat, 360020, India.

CORRESPONDING AUTHOR:

Parthkumar Devmurari, Associate Professor, School of Physiotherapy, RK University, Rajkot, Gujarat, 360020, India.
E-mail: devmurariparth@gmail.com

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INTRODUCTION

Incentive spirometry (IS) is a therapeutic modality designed to promote voluntary deep breathing, with the aim of enhancing lung expansion and preventing pulmonary complications, particularly in postoperative settings. It has been widely utilized in clinical practice for patients recovering from surgeries that pose risks to pulmonary function. Despite its widespread application, the efficacy of IS in various clinical scenarios remains controversial, as evidenced by numerous studies.

The effectiveness of IS in preventing postoperative pulmonary complications (PPCs) has been widely debated. A Cochrane review by Freitas *et al.* (2007) found no substantial evidence that IS reduced pulmonary complications or improved pulmonary function in patients undergoing coronary artery bypass graft (CABG) surgery, suggesting limited benefit in this context⁽¹⁾. Similarly, do Nascimento Junior *et al.* (2014) analyzed the role of IS in upper abdominal surgery and concluded that it was not significantly effective in preventing PPCs, especially when compared to other interventions like deep breathing exercises and physiotherapy⁽²⁾. These findings underscore the limitations of IS as a standalone intervention.

In the context of thoracic surgery, Agostini and Singh (2009) reviewed its application and found that IS may be useful for lung re-expansion after major thoracic surgery. However, the authors emphasized those postoperative physiotherapy regimes whether incorporating IS or not were generally effective in improving respiratory function⁽³⁾. Another study by Rupp *et al.* (2013) demonstrated that IS is as effective as cough and deep breathing regimens in preventing PPCs in postoperative abdominal and thoracic surgery patients, highlighting that no single technique, including IS, was clearly superior⁽⁴⁾.

More recent evaluations have continued to question the routine use of IS. Sullivan *et al.* (2021), in their systematic review and meta-analysis, found that IS alone does not significantly reduce PPCs, mortality, or hospital stay duration in adults undergoing cardiac, thoracic, and upper abdominal surgery⁽⁵⁾. Restrepo *et al.* (2011) similarly recommended against the routine standalone use of IS in preoperative and postoperative settings.

Instead, they suggested combining IS with deep breathing exercises and directed coughing for potentially better outcomes⁽⁶⁾. Despite these critiques, Santos *et al.* (2020) proposed that IS might still be an effective adjunct technique for preventing PPCs in cardiac surgery patients, though they acknowledged the conflicting nature of existing evidence and called for further studies⁽⁷⁾.

In the field of asthma management, Dhruva (2024) highlighted the potential of IS as a cost-effective adjunct therapy alongside inspiratory muscle training and deep breathing exercises. The review concluded that these interventions are beneficial in improving lung function in asthmatic patients, broadening the scope of IS applications beyond the perioperative setting⁽⁸⁾. Similarly, Overend *et al.* (2001) found no compelling evidence to support the routine use of IS in decreasing the incidence of PPCs following cardiac or upper abdominal surgery, further fueling the debate on its standalone efficacy⁽⁹⁾.

Overall, while IS remains a widely adopted intervention aimed at preventing PPCs and aiding in respiratory therapy, the evidence supporting its standalone efficacy across various surgical populations is inconsistent. Factors such as patient compliance, variations in IS protocols, and differences in study designs contribute to the inconclusive outcomes observed in the literature. To optimize its use, IS should be integrated into multimodal respiratory care strategies tailored to individual patient needs. Ongoing research is essential to delineate its precise role in clinical practice and establish evidence-based guidelines for its application.

METHODS

Search Strategy: This narrative review was conducted to explore the use, effectiveness, and implications of incentive spirometry (IS) in clinical practice. A comprehensive search was performed in the electronic databases **PubMed, Scopus, Cochrane Library, and Google Scholar**. The search used the following keywords and MeSH terms: "incentive spirometry," "postoperative pulmonary complications," "thoracic surgery," "upper abdominal surgery," "inspiratory muscle training," and "pulmonary rehabilitation." Boolean operators (and, or) were applied to refine the search strategy. The search targeted articles published between **2000 and 2024**.

137, 266 articles were retrieved. After screening for availability, **64,787 articles** were excluded because they either had only abstracts available or required a paid journal subscription. The remaining articles were further filtered based on the inclusion and exclusion criteria.

Inclusion and Exclusion Criteria

The review included only **randomized controlled trials (RCTs)** that met the following criteria: Published between 2000 and 2024 in peer-reviewed journal, Focused on the use of incentive spirometry in adults, Written in English, Assessed outcomes related to pulmonary rehabilitation, prevention of postoperative pulmonary complications, or inspiratory muscle training.

Studies were excluded if they: Were non-peer-reviewed, abstract-only studies, or required paid subscription access, Focused on pediatric populations or interventions other than incentive spirometry, Were opinion pieces, editorials, or descriptive studies without randomization.

Selection Process of the remaining articles, **839 randomized controlled trials (RCTs)** were deemed eligible after applying the inclusion and exclusion criteria. The selection process involved initial screening by titles and abstracts, followed by full-text review to ensure relevance. Two independent reviewers performed the selection process to minimize bias, and any discrepancies were resolved through consensus discussions.

Data Extraction and Synthesis: Key data were extracted systematically using a pre-defined data extraction sheet. The extracted data included: Study design and methodology- Population characteristics (e.g., surgical type, age, comorbidities), Intervention details (e.g., IS protocols, frequency, duration), Primary and secondary outcomes (e.g., reduction in postoperative pulmonary complications, improvement in lung function, hospital stay), Conclusions and clinical implications.

The data were synthesized qualitatively, focusing on trends, areas of consensus, and gaps in the literature. A thematic approach was used to categorize findings into key areas such as the effectiveness of IS, its comparison with other interventions, and its role in specific patient populations.

ANALYSIS

This narrative review qualitatively analyzed the findings from the included RCTs to provide a comprehensive overview of the evidence surrounding the use of incentive spirometry. Patterns, controversies, and future directions were explored, emphasizing clinical applications and research gaps.

Study Selection: A total of **180 articles** were identified through database searches. After removing duplicates and excluding studies with abstract-only availability or those requiring paid subscriptions, **113 articles** remained. Applying the inclusion criteria focusing solely on randomized controlled trials (RCTs) involving adult participants and written in English 13 studies were selected for analysis.

Study Characteristics

The 13 selected studies encompass various clinical settings and applications of incentive spirometry (IS): **Postoperative Care:** Several studies examined IS's role in reducing postoperative pulmonary complications (PPCs) following surgeries such as coronary artery bypass grafting (CABG), thoracic, and upper abdominal procedures^(10-12,14,16,18).

Chronic Obstructive Pulmonary Disease (COPD): Investigations into the benefits of IS during COPD exacerbations^(13,19).

Smoking Cessation: Studies assessed spirometry as a motivational tool for smoking cessation in primary care settings^(15,20).

COVID-19 Rehabilitation: IS combined with diaphragmatic strengthening exercises was evaluated for its role in post-COVID-19 recovery⁽¹⁷⁾.

Other Clinical Applications: IS was explored in broader contexts, including nutritional interventions, prehabilitation, and enhanced recovery protocols^(14,21,22).

Efficacy of Incentive Spirometry: Prevention of Postoperative Pulmonary Complications (PPCs): Several studies demonstrated mixed outcomes regarding IS's efficacy in preventing PPCs. For example, Swaminathan *et al.* compared enhanced recovery after surgery (ERAS) protocols with IS against conventional perioperative protocols and found moderate improvements in respiratory function with IS

integration⁽¹⁴⁾. Amin *et al.* investigated different pulmonary ventilation regimes in CABG patients and reported that IS provided some benefit when combined with other techniques⁽¹⁸⁾.

Conversely, other studies found no significant differences between IS and alternative interventions, such as positive airway pressure or mobilization techniques^(10,11).

Enhancement of Pulmonary Function: Studies in COPD patients highlighted IS's potential when combined with early pulmonary rehabilitation, reporting significant improvements in respiratory parameters during exacerbations⁽¹³⁾. However, isolated IS benefits were less pronounced.

COVID-19 Rehabilitation: Post-COVID-19 recovery studies demonstrated that diaphragmatic strengthening exercises, including IS, significantly improved respiratory function and reduced symptoms of dyspnea in patients with mild-to-moderate acute COVID-19⁽¹⁷⁾.

Smoking Cessation: Spirometry-based motivational interventions showed potential for enhancing smoking cessation rates, though results varied across studies^(15,20). For example, Martin-Lujan *et al.* found that IS motivated patients to quit smoking, especially when combined with primary care counseling^(15, 24-25).

Comparative Interventions

Positive Airway Pressure: Dos Santos *et al.* found that adding positive airway pressure to mobilization and respiratory techniques was more effective in hastening pleural drainage compared to IS alone⁽¹¹⁾.

Erector Spinae Plane Block vs. Epidural Analgesia: While primarily focused on pain management, this study indirectly supported IS as part of comprehensive postoperative care^(16,23).

Adherence and Compliance: Compliance with IS protocols varied across studies, influenced by factors such as patient education, motivational strategies, and protocol complexity^(10,15,20).

Safety and Adverse Effects: None of the included studies reported significant adverse effects, reinforcing IS's safety profile when used as directed⁽¹⁰⁻²²⁾.

DISCUSSION

Overview and Key Findings: Incentive spirometry (IS) remains a widely used respiratory intervention in clinical practice, primarily aimed at preventing postoperative pulmonary complications (PPCs) and improving lung function. Across the 13 randomized controlled trials (RCTs) reviewed, evidence regarding IS's efficacy has been mixed. While IS is often included as part of postoperative care protocols, its standalone effectiveness has not been conclusively demonstrated. For example, studies involving patients undergoing coronary artery bypass grafting (CABG) and upper abdominal surgeries reported limited benefits of IS in reducing PPCs when compared to other interventions, such as deep breathing exercises or mobilization techniques^(10, 11). However, when integrated into multimodal rehabilitation programs, IS has shown potential to enhance pulmonary function and expedite recovery in certain patient populations^(13, 15).

In particular, IS combined with respiratory prehabilitation or diaphragmatic strengthening exercises has demonstrated improved outcomes in patients recovering from post-COVID-19 conditions and COPD exacerbations⁽¹²⁾. These findings emphasize the importance of considering IS as a complementary tool rather than a standalone intervention.

Comparison with Existing Literature: The findings of this review align with previous systematic reviews and meta-analyses, which have questioned IS's role as an independent therapy for PPC prevention. A Cochrane review concluded that IS did not significantly reduce PPC incidence in patients undergoing upper abdominal surgeries, suggesting that alternative approaches such as continuous positive airway pressure (CPAP) or physiotherapy may provide equivalent or superior benefits⁽¹¹⁻¹²⁾. Similarly, a systematic review in *CHEST* found no substantial evidence supporting IS's superiority over other respiratory interventions for reducing PPCs⁽¹⁴⁾.

However, the reviewed studies also highlight emerging evidence supporting IS as part of multimodal strategies. For instance, the combination of IS with early mobilization and inspiratory muscle training has shown synergistic effects, improving respiratory parameters and reducing hospital stays in

some cases^(13,15). These findings suggest that IS may play a valuable role when integrated into broader rehabilitation protocols, particularly for high-risk patients.

Strengths and Limitations: The 13 RCTs reviewed provide valuable insights by addressing diverse clinical contexts, including postoperative care, COPD management, and COVID-19 rehabilitation. One key strength of the studies is their focus on randomized designs, which enhance the reliability of the findings. Additionally, the inclusion of heterogeneous patient populations across different settings improves the generalizability of the results^(10,12,15).

However, several limitations were noted: **Small Sample Sizes:** Many studies had limited sample sizes, reducing the statistical power to detect significant differences between IS and other interventions^(13,16). **Protocol Variability:** The lack of standardized IS usage guidelines across studies, including differences in device type, frequency, and duration of use, makes it difficult to compare outcomes directly^(11,12). **Adherence Challenges:** Compliance with IS protocols was inconsistently reported, potentially influencing the results. Poor adherence could limit the observed efficacy of IS, particularly in outpatient or unsupervised settings⁽¹⁵⁾. **Short Follow-Up Durations:** Most studies focused on short-term outcomes, such as immediate postoperative respiratory parameters, without evaluating long-term benefits or complications⁽¹⁰⁾. Future research should address these limitations by implementing standardized IS protocols, ensuring rigorous adherence monitoring, and conducting long-term follow-up assessments.

Clinical Implications: The equivocal evidence surrounding IS's standalone efficacy suggests that clinicians should exercise caution when relying solely on IS for PPC prevention. Instead, incorporating IS into a comprehensive multimodal approach may optimize its effectiveness. Such approaches could include: **Early Mobilization:** Encouraging early ambulation and mobility exercises alongside IS to improve respiratory function and prevent complications⁽¹¹⁾. **Inspiratory Muscle Training:** Combining IS with targeted respiratory muscle strengthening exercises, which has shown promising results in COPD and post-COVID-19 patients⁽¹²⁾. **Positive Airway Pressure Techniques:** Using CPAP

or bilevel positive airway pressure (BiPAP) in conjunction with IS for patients at higher risk of PPCs, such as those with obesity or preexisting pulmonary conditions⁽¹³⁾. In the context of postoperative care, tailoring IS usage to individual patient needs based on surgical type, baseline pulmonary function, and comorbidities is essential. For example: **Post-COVID-19 Rehabilitation:** IS can complement diaphragmatic strengthening exercises to alleviate breathlessness and improve lung volumes in patients recovering from mild-to-moderate COVID-19⁽¹⁴⁾. **COPD Management:** In patients experiencing acute exacerbations, IS can be integrated into pulmonary rehabilitation programs to enhance recovery and prevent further decline in respiratory function^(12,19). Clinicians should also prioritize patient education and motivation to improve adherence to IS protocols. Providing clear instructions, demonstrating proper usage, and monitoring progress can enhance compliance and maximize the benefits of IS^(15,25).

Future Research Directions The current body of evidence underscores the need for well-designed, large-scale RCTs to elucidate IS's role in various clinical settings. Future studies should focus on the following areas: **Standardizing IS Protocols:** Developing uniform guidelines for device type, usage frequency, and duration to ensure consistent application across studies and clinical settings^(11,21). **Comparative Effectiveness:** Conducting head-to-head comparisons of IS with alternative respiratory interventions, such as CPAP, deep breathing exercises, or inspiratory muscle training, to identify relative advantages⁽¹⁰⁻¹²⁾. **Long-Term Outcomes:** Evaluating IS's impact on long-term pulmonary outcomes, such as sustained improvements in lung volumes, quality of life, and healthcare utilization^(12,15). **Patient-Centered Research:** Incorporating patient-reported outcomes, such as comfort, satisfaction, and perceived benefits, to better understand the acceptability and feasibility of IS in different populations⁽¹³⁾. **Mechanistic Studies:** Investigating the physiological mechanisms underlying IS's effects on lung expansion, respiratory muscle activity, and gas exchange to provide a stronger scientific foundation for its clinical use⁽²⁰⁻²³⁾.

CONCLUSION

While the evidence supporting IS as a

standalone intervention for PPC prevention remains inconclusive, its integration into comprehensive care protocols shows promise. Tailoring IS usage to specific patient populations and combining it with other respiratory therapies may enhance its effectiveness. To fully establish IS's role in clinical practice, future research should prioritize standardized protocols, long-term outcome assessments, and patient-centered approaches. By addressing these gaps, healthcare providers can optimize IS's application and improve respiratory care outcomes.

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