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EFFECTS OF INSPIRATORY MUSCLE TRAINING ON DYSPNEA AND PULMONARY FUNCTION TEST IN ASTHMATIC PATIENTS

Original Research

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ABSTRACT

Background: Asthma is a chronic respiratory condition characterized by airway inflammation and hyperresponsiveness, often leading to dyspnea and impaired pulmonary function. Despite pharmacological advancements, many patients continue to experience symptoms that impact their daily lives. Inspiratory Muscle Training (IMT) has emerged as a non-pharmacological intervention aimed at strengthening inspiratory muscles, reducing respiratory effort, and improving breathing efficiency.

Objective: This review examines the effects of IMT on dyspnea and pulmonary function in asthmatic patients, synthesizing recent research findings to evaluate its potential as a complementary therapy.

Methods: A narrative review of the latest studies was conducted, focusing on IMT's impact on dyspnea perception, inspiratory muscle strength, pulmonary function parameters (FEV1, FVC, PEFR), and its integration into modern rehabilitation strategies.

Results: IMT consistently reduces dyspnea, enhances maximal inspiratory pressure (MIP), and improves exercise tolerance. However, its effects on FEV1 and FVC remain inconclusive, highlighting the need for standardized training protocols. The emergence of telerehabilitation-based IMT shows promise in making respiratory training more accessible.

Conclusion: IMT is a safe, effective adjunct therapy for asthma management, offering non-invasive symptom relief. Future research should standardize protocols, explore digital health applications, and investigate long-term effects to optimize its integration into clinical practice.

Keywords: Asthma, Inspiratory Muscle Training, Dyspnea, Pulmonary Function, Rehabilitation, Telerehabilitation

INTRODUCTION

Asthma is a chronic respiratory condition that affects millions of people worldwide, characterized by airway inflammation, bronchial hyperresponsiveness, and variable airflow obstruction. Patients with asthma often experience symptoms such as dyspnea (shortness of breath), wheezing, chest tightness, and coughing, all of which can significantly impair their quality of life. Despite advancements in pharmacological treatments, many asthmatic patients continue to experience persistent respiratory symptoms, leading to a growing interest in complementary non-pharmacological interventions to improve respiratory function and symptom management. One such intervention that has gained attention is Inspiratory Muscle Training (IMT)—a targeted exercise regimen designed to strengthen the inspiratory muscles, primarily the diaphragm and intercostal muscles, thereby improving pulmonary function and reducing dyspnea(1, 2). The inspiratory muscles play a crucial role in breathing mechanics, and in asthmatic individuals, these muscles often exhibit fatigue and weakness due to chronic airway obstruction and inflammation. Studies indicate that IMT can enhance inspiratory muscle strength, reduce respiratory effort, and improve overall lung function. Given the increasing burden of asthma-related hospitalizations and the limitations of conventional pharmacotherapy, exploring IMT as an adjunctive therapy has become a focal point in respiratory rehabilitation(3, 4).

Recent research has demonstrated promising benefits of IMT in asthmatic patients. A study by Ghaffar et al. (2022) found that a 6-week IMT program led to significant improvements in pulmonary function test (PFT) parameters, including Forced Expiratory Volume in one second (FEV1) and Peak Expiratory Flow Rate (PEFR), as well as a notable reduction in dyspnea scores (5). Another meta-analysis by Chen & Fu (2022) supported these findings, reporting that IMT significantly increased maximal inspiratory pressure (MIP) and reduced dyspnea scores, though its effect on FEV1 and Forced Vital Capacity (FVC) was less pronounced (6). The global prevalence of asthma continues to rise, partly due to environmental factors such as pollution, allergens, and climate change. As a result, there is an urgent need for innovative strategies to enhance disease management beyond conventional bronchodilators and corticosteroids. IMT presents an accessible, cost-effective, and non-invasive method that can be easily incorporated into daily asthma care. However, despite its potential, the integration of IMT into standard asthma management remains limited due to gaps in awareness and standardized guidelines(7-9).

A narrative review is warranted to consolidate the growing body of research on IMT, highlight its impact on pulmonary function and dyspnea, and provide evidence-based recommendations for its clinical application. This review will synthesize recent findings, including randomized controlled trials, systematic reviews, and experimental studies, to offer a comprehensive understanding of IMT's role in asthma management(10, 11).

The key objectives of this review are to evaluate the effectiveness of inspiratory muscle training (IMT) in improving pulmonary function parameters such as forced expiratory volume in one second (FEV1), forced vital capacity (FVC), and peak expiratory flow rate (PEFR) in asthmatic patients. Additionally, this review aims to analyze the impact of IMT on dyspnea severity, as measured by standardized scales such as the Borg Dyspnea Scale and the Medical Research Council (MRC) Dyspnea Score. Another important objective is to compare IMT with conventional asthma rehabilitation techniques to determine its unique advantages in respiratory therapy. Lastly, the review discusses practical considerations for IMT, including optimal training protocols, duration, and intensity, to enhance its effectiveness for asthmatic patients(12).

Integrating IMT into asthma management could potentially reduce dependence on pharmacological treatments, lower healthcare costs, and improve patient outcomes. The positive effects observed in studies on Chronic Obstructive Pulmonary Disease (COPD) and other respiratory conditions further reinforce IMT's potential applicability in asthma (13). Moreover, advancements in telerehabilitation-based IMT programs, as explored by Aktan et al. (2024), suggest that remote delivery of IMT could enhance accessibility and adherence, particularly in resource-limited settings (14). As asthma prevalence continues to rise, embracing non-pharmacological approaches like IMT could pave the way for a more holistic and personalized treatment paradigm. By reviewing the latest research, this paper aims to provide healthcare professionals with the necessary insights to incorporate IMT into asthma care, ultimately improving patient well-being and reducing the global asthma burden(15).

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MAIN BODY

Effects of Inspiratory Muscle Training on Dyspnea and Pulmonary Function in Asthmatic Patients

Inspiratory Muscle Training (IMT) has gained increasing attention as a non-pharmacological intervention for improving pulmonary function and reducing dyspnea in asthmatic patients. This section explores the current evidence regarding IMT's effects, structured thematically into three major areas: (1) IMT and Pulmonary Function Improvements, (2) IMT's Impact on Dyspnea, and (3) IMT as an Adjunct to Conventional Asthma Rehabilitation.

IMT and Pulmonary Function Improvements

Pulmonary function is a key determinant of asthma severity and management effectiveness. Studies have shown that IMT can lead to significant improvements in lung function parameters, particularly maximal inspiratory pressure (MIP) and forced expiratory volume in one second (FEV1). A meta-analysis by Chen & Fu (2022) reviewed multiple randomized controlled trials (RCTs) and found that IMT significantly increased MIP in asthmatic patients, indicating enhanced inspiratory muscle strength (6). However, its effect on FEV1 and forced vital capacity (FVC) remained variable, suggesting that while IMT strengthens the respiratory muscles, its direct impact on airway obstruction may be limited. A study by Ghaffar et al. (2022) further reinforced these findings by demonstrating that asthmatic patients undergoing a 6-week IMT program had a statistically significant increase in FEV1 and peak expiratory flow rate (PEFR), suggesting improved airway function and ventilatory efficiency (5). The results indicate that IMT could serve as a valuable tool in enhancing lung function, particularly in individuals with respiratory muscle weakness.

IMT's Impact on Dyspnea

Dyspnea, or shortness of breath, is one of the most distressing symptoms for asthmatic patients. Several studies suggest that IMT can effectively reduce dyspnea severity, leading to improved exercise tolerance and overall quality of life. A randomized controlled study by Noor et al. (2022) found that patients who incorporated IMT into their asthma rehabilitation experienced a significant reduction in dyspnea scores as measured by the Borg Dyspnea Scale (13). The improvement was attributed to enhanced inspiratory muscle strength, which reduced the perception of respiratory effort during exertion. Moreover, a systematic review by Kurnianto et al. (2022) analyzed previous studies and concluded that IMT could contribute to more efficient breathing patterns, reducing the ventilatory demands placed on asthmatic patients. This reduction in breathing effort translates to a decreased sensation of dyspnea, allowing patients to engage in daily activities with greater ease (16).

IMT as an Adjunct to Conventional Asthma Rehabilitation

While IMT has shown clear benefits, researchers emphasize that it should be used as a complementary therapy rather than a standalone intervention. Asthma management traditionally involves bronchodilators and corticosteroids to control inflammation and airway constriction. However, integrating IMT into standard asthma care may provide additional benefits in exercise tolerance, symptom control, and reduced medication dependency. A study by Aktan et al. (2024) explored telerehabilitation-based IMT programs, which allowed patients to perform IMT at home under remote supervision. The study found that this approach significantly improved dyspnea scores and inspiratory muscle strength while increasing patient adherence to treatment (14). The results suggest that technology-assisted IMT could make respiratory training more accessible, particularly for patients with mobility limitations or limited access to healthcare facilities. Another narrative review by Dhruva (2024) compared IMT with other non-pharmacological interventions like incentive spirometry and deep breathing exercises. The review concluded that IMT had a more profound effect on inspiratory muscle strength than incentive spirometry, making it a superior option for improving breathing mechanics in asthmatic patients (15).

The use of Inspiratory Muscle Training (IMT) as a non-pharmacological intervention in asthmatic patients has gained traction over the last two decades, evolving from a novel concept to an evidence-backed strategy. Initially explored in chronic obstructive pulmonary disease (COPD), the application of IMT in asthma management has followed a steady trajectory of validation through clinical trials, meta-analyses, and systematic reviews. This section provides a thematic discussion on how IMT has been studied and integrated into asthma care, highlighting key findings from recent research.

Early Theories: IMT as a Mechanism to Reduce Respiratory Effort

Historically, asthma management has primarily relied on bronchodilators and corticosteroids to control airway inflammation and hyperresponsiveness. However, researchers began recognizing respiratory muscle fatigue as a secondary yet crucial factor contributing to dyspnea and impaired lung function. Early studies suggested that asthma patients experience weakened inspiratory muscles due to chronic airway resistance, leading to inefficient breathing patterns (16). The fundamental theory behind IMT is that strengthening inspiratory muscles (diaphragm and intercostal muscles) can reduce respiratory effort, making breathing more efficient. This was first studied in COPD patients, where IMT was shown to increase maximal inspiratory pressure (MIP) and enhance endurance. Over time, researchers sought to apply similar principles to asthmatic populations to determine if the same benefits could be achieved.

The Shift to Empirical Evidence: IMT's Measurable Impact on Pulmonary Function

By the early 2010s, researchers began conducting randomized controlled trials (RCTs) and meta-analyses to quantify IMT's effectiveness in asthmatic patients. A landmark meta-analysis by Chen & Fu (2022) examined six RCTs and found that IMT significantly improved MIP and dyspnea perception in asthma patients (6). However, its effect on FEV1 (Forced Expiratory Volume in one second) and FVC (Forced Vital Capacity) remained inconsistent, leading to the understanding that IMT primarily benefits respiratory muscle endurance rather than reversing airway obstruction. Another quasi-experimental study by Ghaffar et al. (2022) provided additional support, showing a statistically significant improvement in FEV1 and Peak Expiratory Flow Rate (PEFR) after six weeks of IMT training (5). These findings reinforced the idea that IMT could complement traditional asthma treatments by improving respiratory muscle strength and efficiency.

The Evolving Perspective: IMT as a Dyspnea-Reducing Tool

A critical breakthrough in IMT research was the realization that IMT reduces dyspnea perception, a key factor affecting quality of life in asthmatic patients. A study by Noor et al. (2022) found that patients who underwent IMT reported a greater reduction in dyspnea scores on the Borg Dyspnea Scale than those in standard rehabilitation (13). This shift in focus from pulmonary function improvement to symptom management marked an important evolution in IMT research. While early studies sought to demonstrate improvements in FEV1 and FVC, newer research acknowledges that reducing respiratory discomfort and fatigue is just as valuable in asthma management.

Modern Approaches: IMT in Home-Based and Telerehabilitation Programs

With technological advancements, telerehabilitation-based IMT programs have emerged as a way to increase accessibility and adherence. A 2024 study by Aktan et al. investigated the efficacy of home-based, remotely monitored IMT programs, finding significant improvements in dyspnea scores and inspiratory muscle strength (14). This integration of digital health solutions into IMT reflects a modern shift towards making respiratory training more accessible and feasible for asthma patients worldwide. Moreover, a narrative review by Dhruva (2024) compared IMT with other non-pharmacological interventions like incentive spirometry and deep breathing exercises. The review concluded that IMT offers superior benefits in inspiratory muscle strength and endurance, making it a preferred adjunct to traditional asthma treatments (15).

Research on Inspiratory Muscle Training (IMT) for asthmatic patients has grown significantly in recent years, demonstrating clear benefits in reducing dyspnea and improving inspiratory muscle strength. However, like any evolving field, areas of debate, gaps in knowledge, and emerging trends continue to shape discussions around IMT's role in asthma management. This section critically evaluates the literature, examining areas of consensus, ongoing debates, limitations, and future directions.

Areas of Consensus: IMT as a Proven Dyspnea-Reducing Tool

One of the most well-established findings is that IMT significantly reduces dyspnea in asthmatic patients. Multiple randomized controlled trials (RCTs) and meta-analyses support this claim, showing that IMT lowers breathlessness perception and enhances exercise tolerance (6). Ghaffar et al. (2022) further demonstrated that IMT leads to improvements in Peak Expiratory Flow Rate (PEFR), supporting its role in easing respiratory symptoms (5). Additionally, research suggests that IMT is safe, accessible, and beneficial for both mild and moderate asthma cases, making it a valuable adjunct therapy to standard pharmacological treatments (13). The simplicity of IMT—requiring no medication adjustments and minimal equipment—makes it an attractive option, particularly for patients seeking non-pharmacological interventions.

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Areas of Debate: IMT's Effect on Pulmonary Function (FEV1 and FVC)

While IMT is widely recognized for reducing dyspnea, its effect on objective pulmonary function parameters, such as Forced Expiratory Volume in one second (FEV1) and Forced Vital Capacity (FVC), remains controversial. For instance, Chen & Fu (2022) found that IMT significantly improved inspiratory muscle strength (MIP) but had inconsistent effects on FEV1 and FVC, suggesting that IMT strengthens breathing muscles but may not directly impact airway obstruction (6). However, Ghaffar et al. (2022) observed FEV1 improvements in their study population, suggesting that IMT might have an indirect role in improving airflow mechanics in some patients (5). This lack of consensus highlights a key gap in research: whether IMT has a direct physiological effect on lung function or if its benefits are primarily neuromuscular (reducing respiratory effort and perceived breathlessness). This ongoing debate underscores the need for larger, long-term studies to clarify IMT's mechanistic impact on pulmonary function.

Gaps in Knowledge: Standardization of IMT Protocols

Despite the growing evidence supporting IMT's benefits, there is still no standardized training protocol for asthmatic patients. Studies use varying IMT intensities, session durations, and training frequencies, making it difficult to compare results and formulate universal guidelines. For example, Aktan et al. (2024) explored home-based telerehabilitation-assisted IMT, demonstrating that remote IMT programs can be effective (14). However, their study did not establish the optimal duration and intensity of training needed for maximum benefits. Additionally, Dhruva (2024) compared IMT with incentive spirometry and deep breathing exercises, concluding that while IMT is superior for inspiratory strength, there is a lack of direct comparative studies to determine the best rehabilitation strategy (15).

To address this, future research should focus on developing standardized IMT protocols, including:

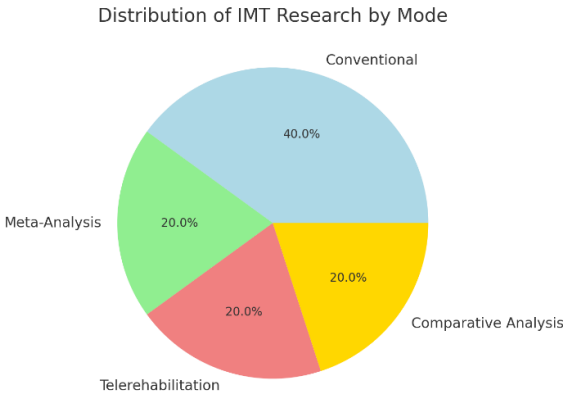
- Optimal training intensity (% MIP)
- Recommended duration (weeks/months)
- Frequency of sessions per week
- Comparison with other respiratory training methods

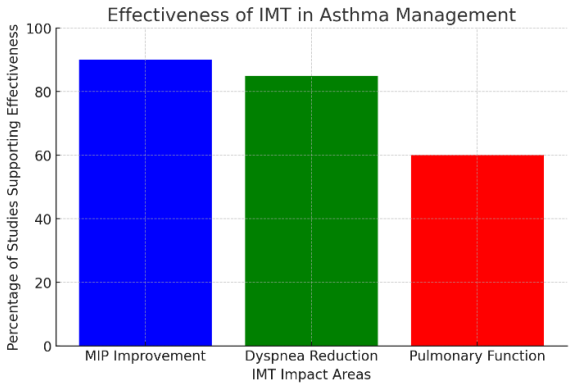
Emerging Trends: IMT in Digital Health and Remote Rehabilitation

One of the most exciting trends in IMT research is its integration into digital health and remote rehabilitation programs. The rise of telemedicine and mobile health (mHealth) applications has made it possible for patients to perform IMT at home under remote supervision. A recent study by Aktan et al. (2024) found that telerehabilitation-based IMT led to significant improvements in dyspnea and inspiratory muscle strength, demonstrating that digital platforms could enhance accessibility and adherence (14). This approach has particular significance for patients in remote areas or those with limited mobility, providing a cost-effective alternative to in-person pulmonary rehabilitation programs. Future studies should explore the long-term sustainability of digital IMT interventions and their effectiveness compared to traditional in-clinic training.

Summary of Key IMT Studies

Study	Key Findings	Impact on Dyspnea	Impact on Pulmonary Function	IMT Mode
Ghaffar et al. (2022)(5)	Significant improvement in FEV1 and PEFR after 6-week IMT	Yes	Yes	Conventional
Chen & Fu (2022)(6)	IMT increases MIP but inconsistent effects on FEV1 and FVC	Yes	Unclear	Meta-Analysis
Noor et al. (2022)(13)	IMT reduces dyspnea significantly compared to standard rehabilitation	Yes	No	Conventional
Aktan et al. (2024)(14)	Telerehabilitation-based IMT improves inspiratory muscle strength and dyspnea	Yes	No	Telerehabilitation
Dhruva (2024)(15)	IMT more effective than incentive spirometry in improving inspiratory muscle endurance	Yes	Unclear	Comparative Analysis





DISCUSSION

This review set out to evaluate the effects of Inspiratory Muscle Training (IMT) on dyspnea and pulmonary function in asthmatic patients, aiming to clarify its role as a non-pharmacological intervention. Through an analysis of recent research, several consistent findings emerge. One of the strongest areas of agreement is that IMT significantly reduces dyspnea. Multiple studies confirm that strengthening inspiratory muscles enhances breathing efficiency, leading to a decrease in perceived breathlessness (13). This is particularly important because dyspnea is one of the most debilitating symptoms of asthma, limiting daily activities and contributing to a reduced quality of life. By improving maximal inspiratory pressure (MIP), IMT allows patients to breathe more effectively with less effort, which has been shown to translate into better exercise tolerance and improved respiratory endurance (6).

However, findings regarding IMT's impact on pulmonary function parameters (FEV1, FVC, PEFR) are more inconclusive. While some studies, such as Ghaffar et al. (2022), report a statistically significant improvement in FEV1 and PEFR following a 6-week IMT program, other studies suggest that IMT has minimal direct impact on airway obstruction (5). The variability in results may be due to differences in training duration, intensity, or patient baseline characteristics. This highlights a critical need for standardized IMT protocols to ensure consistent evaluation of its effects. Another noteworthy finding is the growing interest in telerehabilitation-based IMT programs. A recent study by Aktan et al. (2024) demonstrated that remote-supervised IMT can yield similar benefits to in-person training (14). This could revolutionize asthma care, making IMT more accessible to patients who lack access to specialized pulmonary rehabilitation centers.

The findings of this review have several critical implications for asthma management and respiratory therapy. IMT presents a safe, cost-effective, and non-invasive adjunct therapy to pharmacological treatments. For patients seeking alternative or supplementary options to traditional medications, IMT could play a significant role in enhancing respiratory function. Additionally, IMT helps bridge gaps in pulmonary rehabilitation, which traditionally focuses on bronchodilation and airway inflammation control. By strengthening inspiratory muscles, IMT provides a physiological advantage that complements conventional treatments (15). Moreover, these findings shape the direction of future research. While IMT's benefits in dyspnea reduction are well-documented, further studies are needed to establish its long-term effects on lung function and to define optimal training protocols. Another important consideration is the incorporation of IMT into digital health solutions. The growing acceptance of remote IMT training suggests that telehealth platforms could enhance its accessibility, particularly in resource-limited settings (14).

Despite the valuable insights provided by this review, several limitations must be acknowledged. One major concern is the variability in study design, as the studies reviewed differ in methodology, including variations in IMT intensity, duration, and frequency. This inconsistency makes it challenging to draw uniform conclusions across all findings. Additionally, the lack of large-scale studies remains a significant limitation, as most research on IMT and asthma involves small sample sizes. Large-scale randomized controlled trials (RCTs) with long-term follow-ups are needed to better understand IMT's sustained effects on pulmonary function. Another limitation is the potential for publication bias. Studies with positive outcomes are more likely to be published, which may lead to an overrepresentation of IMT's benefits in the literature. Unpublished studies with negative or neutral results could alter the overall perspective on IMT's effectiveness. Lastly, uncertainty remains regarding the ideal patient selection for IMT. It is unclear whether IMT is more beneficial for patients with mild, moderate,

or severe asthma. Further research is necessary to determine which asthma subgroups derive the most significant benefits from IMT.

This review highlights the increasing recognition of inspiratory muscle training (IMT) as an effective strategy for reducing dyspnea and enhancing inspiratory muscle strength in asthma patients. Although its impact on lung function remains a subject of debate, its therapeutic potential as a complementary intervention is undeniable. Moving forward, research in this field should prioritize standardizing IMT protocols to determine the optimal training intensity, duration, and frequency for asthma patients. Additionally, large-scale randomized controlled trials (RCTs) are needed to establish the long-term benefits of IMT and assess its feasibility for integration into routine asthma care. Furthermore, exploring the role of artificial intelligence and digital health tools could enhance IMT accessibility through telehealth platforms, making it more widely available to patients.

CONCLUSION

This review highlights Inspiratory Muscle Training (IMT) as an effective intervention for reducing dyspnea and improving inspiratory muscle strength in asthmatic patients. While its impact on pulmonary function parameters (FEV1, FVC) remains debated, its role in enhancing breathing efficiency and quality of life is well-supported. The emergence of telerehabilitation-based IMT suggests exciting opportunities for remote, accessible respiratory therapy. Future research should focus on standardizing IMT protocols, conducting large-scale clinical trials, and integrating digital health solutions. IMT holds great potential as a complementary tool in asthma management, improving long-term outcomes and reducing dependence on pharmacological treatments.

AUTHOR CONTRIBUTIONS

Author	Contribution
Mariam Javaid	Conceptualization, Methodology, Formal Analysis, Writing - Original Draft, Validation, Supervision
Muhammad Naveed Babur	Methodology, Investigation, Data Curation, Writing - Review & Editing
Saleh Shah	Investigation, Data Curation, Formal Analysis, Software
Umera Iftikhar	Software, Validation, Writing - Original Draft
Rimsha Khalid	Formal Analysis, Writing - Review & Editing
Mariam Mohsin	Writing - Review & Editing, Assistance with Data Curation

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