JHWCR
Journal of Health, Wellness, and Community Research
Volume III, Issue IV
Open Access, Double Blind Peer Reviewed.
Web: https://jhwcr.com, **ISSN**: 3007-0570
https://doi.org/10.61919/39cwgd20

Article

Resistive Diaphragmatic Training Versus Volume-Oriented Spirometry on Pulmonary Function Test and Functional Capacity in Asthmatic Patients

Maria Siddique[1], Hifza Naseer[2], Rubab Mirza[2], Usama Nasir[3], Qurat Ul Ain[4], Muhammad Ahmed Javed[1], Usman Iqbal Janjua[5*], Syeda Mahnoor Hassan[5]

1 Faculty of Rehabilitation and Allied Health Sciences, Riphah International University, Lahore, Pakistan
2 International Institute of Technology, Culture and Health Sciences, Gujranwala, Pakistan
3 Al Ain Institute of Medical Sciences, Gujranwala, Pakistan
4 Riphah International University, Lahore, Pakistan
5 Department of Physical Therapy, Elite College of Management Sciences, Gujranwala, Pakistan

Correspondence
usmanjanjua84@hotmail.com

Cite this Article

Received	2025-04-15
Revised	2025-04-25
Accepted	2025-05-02
Published	2025-05-14
Conflict of Interest	None declared
Ethical Approval	Respective Ethical Review Board
Informed Consent	Obtained from all participants
Data/supplements	Available on request.
Funding	None
Authors' Contributions	Concept and design: MS, HN, RM, UN, QUA, MAJ, UIJ, and SMH contributed to concept, design, data collection, analysis, and manuscript drafting

ABSTRACT

Background: Asthma is a prevalent chronic respiratory condition marked by airway inflammation and bronchoconstriction, significantly impairing pulmonary function and exercise tolerance. Despite pharmacologic advancements, non-pharmacological interventions like respiratory muscle training remain underutilized in clinical practice. There exists a need to compare the clinical efficacy of targeted breathing strategies to guide evidence-based physiotherapeutic care. **Objective**: This study aimed to compare the effects of resistive diaphragmatic training (RDT) and volume-oriented spirometry (VOS) on pulmonary function, functional capacity, and asthma control among patients with moderate asthma. **Methods:** A single-blinded randomized controlled trial was conducted with 50 participants (n = 50), aged 35–50 years, diagnosed with moderate asthma (FEV_1% ≥ 60% and <80%). Subjects were randomly allocated into two groups receiving either RDT or VOS alongside baseline physiotherapy for six weeks. Pulmonary function tests (FVC, FEV_1, FEV_1/FVC), the 6-Minute Walk Test (6MWT), and the Asthma Control Test (ACT) were administered at baseline and post-intervention. Data were analyzed using SPSS v25, applying the Mann-Whitney U and Wilcoxon Signed Rank tests ($p < 0.05$). Ethical approval was obtained, and all procedures adhered to the Declaration of Helsinki. **Results**: The RDT group showed significantly greater improvements in FVC (3.37 ± 0.57 vs. 3.32 ± 0.28; $p = 0.032$), FEV_1 (2.61 ± 0.73 vs. 2.29 ± 0.24; $p = 0.047$), FEV_1/FVC ratio (73.84 ± 5.57 vs. 68.36 ± 5.45; $p = 0.001$), 6MWT (490.16 ± 52.58 m vs. 414.28 ± 26.96 m; $p < 0.001$), and ACT scores (19.96 ± 1.21 vs. 14.44 ± 1.66; $p < 0.001$), indicating both statistical and clinical significance. **Conclusion**: Resistive diaphragmatic training is more effective than volume-oriented spirometry in enhancing lung function, functional capacity, and asthma control in patients with moderate asthma. Its incorporation into routine asthma rehabilitation may yield improved clinical outcomes and reduce disease

Keywords: Inspiratory Muscle Training, Spirometry, Pulmonary Rehabilitation, Diaphragmatic Breathing, Functional Capacity, Randomized Controlled Trial

INTRODUCTION

Asthma remains a significant global health concern characterized by chronic airway inflammation, variable airflow limitation, and bronchial hyperresponsiveness. Despite pharmacological advancements, many patients continue to experience poorly controlled symptoms and limitations in daily activities, underscoring the need for effective adjunctive therapies (1). In Pakistan, the burden of asthma is considerable, affecting approximately 4.3% of the population, with prevalence increasing by nearly 50% every decade (2,3). Such epidemiological trends highlight the necessity of integrating comprehensive management strategies that extend beyond medication. Among the non-pharmacological approaches, respiratory muscle training and breathing exercises have emerged as promising interventions to enhance pulmonary function and quality of life in asthmatic individuals (4,5).

© 2025 Authors. Open Access | Double-Blind Peer Reviewed | Licensed under CC BY 4.0 | Views and data are the authors' own; the journal is not liable for use.

Diaphragmatic dysfunction and reduced respiratory muscle strength are commonly observed in asthma, contributing to dyspnea, limited exercise tolerance, and impaired pulmonary mechanics. Consequently, inspiratory muscle training (IMT), especially through threshold loading devices, has been increasingly investigated for its ability to strengthen respiratory muscles, reduce airway resistance, and improve overall lung function. These techniques are simple, cost-effective, and easily adaptable for patient use, making them suitable for long-term asthma rehabilitation (6,7). Additionally, diaphragmatic breathing exercises, by promoting deep and controlled ventilation, improve the efficiency of the diaphragm and decrease accessory muscle recruitment, which is often excessive in individuals with asthma (8,9).

In contrast, incentive spirometry, particularly volume-oriented spirometry, is a well-established tool used to encourage sustained maximal inspiration and promote alveolar expansion. This technique offers visual feedback to patients, reinforcing proper inhalation patterns and supporting the maintenance of lung volumes (10). Its role in post-operative pulmonary care is well-documented, but its application in asthma management, particularly in enhancing pulmonary mechanics and functional capacity, is gaining attention. Volume-oriented devices are specifically designed to improve diaphragmatic excursion and maintain airway patency by enhancing lung compliance and transpulmonary pressure (11,12). These characteristics suggest that volume spirometry could be a valuable adjunct in asthma rehabilitation, although comparative data with resistive diaphragmatic training remains limited.

Previous studies have demonstrated that both IMT and spirometry contribute to improved pulmonary outcomes in individuals with chronic respiratory conditions. However, the magnitude and specificity of benefits vary across interventions and populations. For example, research indicates that IMT leads to significant improvements in Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV1), and inspiratory muscle strength in stable asthma patients (13,14). On the other hand, volume-oriented spirometry has been associated with enhanced lung expansion, improved oxygenation, and increased exercise tolerance, albeit with less consistent effects on specific spirometric indices (15). Despite these promising findings, there is a paucity of head-to-head comparisons between these two modalities in asthmatic populations, which poses a critical gap in evidence-based clinical decision-making.

Given the chronic nature of asthma and the functional limitations it imposes, physiotherapists and clinicians must identify the most effective strategies to optimize respiratory health. To date, the superiority of resistive diaphragmatic training versus volume-oriented spirometry in enhancing both pulmonary function and physical performance remains underexplored. Addressing this knowledge gap could significantly inform physiotherapeutic protocols and contribute to personalized asthma management. Therefore, the present study was designed to compare the effects of resistive diaphragmatic training and volume-oriented spirometry on pulmonary function parameters and functional capacity in individuals with moderate asthma. It was hypothesized that resistive diaphragmatic training would result in greater improvements in spirometric indices, exercise capacity, and asthma control scores compared to volume-oriented spirometry.

MATERIAL AND METHODS

This single-blind randomized controlled trial was conducted between March 2024 and February 2025 to evaluate and compare the effects of resistive diaphragmatic training and volume-oriented spirometry in patients diagnosed with moderate asthma. Participants were recruited through a non-probability convenient sampling technique from outpatient clinics of a regional medical center. A total of 50 patients, aged between 35 to 50 years, of both genders, were enrolled based on inclusion criteria that required a confirmed diagnosis of moderate asthma with a Forced Expiratory Volume in 1 second (FEV1%) between 60% and 80%. Patients with severe asthma requiring hospitalization, those with comorbidities such as heart disease, tuberculosis, stroke, physical limitations preventing exercise, or those undergoing home-based oxygen therapy were excluded. Informed consent was obtained from all participants prior to enrollment. Participants were randomly allocated into two intervention groups using a simple coin toss method, with Group A assigned to resistive diaphragmatic training and Group B to volume-oriented incentive spirometry.

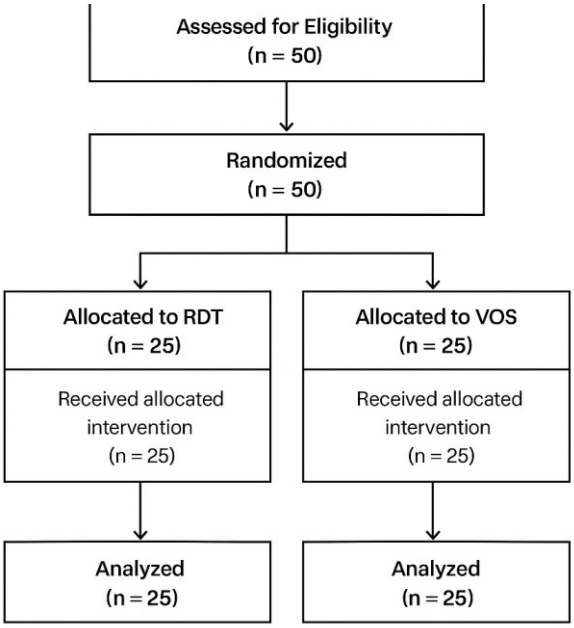

Figure 1 CONSORT Flowchart

All subjects underwent a baseline educational session lasting approximately 30 minutes that included guidance on self-management, asthma triggers, symptom recognition, and medication adherence. Baseline physiotherapy treatment included purse-lip breathing exercises administered to both groups. Group A received resistive diaphragmatic training using a threshold loading device based on the American College of Sports Medicine (ACSM) recommendations. This device provides adjustable inspiratory resistance ranging from 9 to 41 cmH2O. Participants performed 30 inspiratory efforts per session, twice daily, three times a week for six weeks. The training intensity was maintained at 30–60% of the participant's maximal inspiratory

pressure (MIP), and breathing frequency was kept low to avoid hyperventilation. Sessions were conducted under physiotherapist supervision with rest periods incorporated to prevent fatigue. Group B underwent volume-oriented incentive spirometry using the Coach 2 device, which allowed slow, deep inhalations with visual feedback. Patients were seated upright with proper posture and instructed to inhale to maximum lung volume, hold their breath for 3–5 seconds, and perform three repetitions per set, with up to ten attempts per session. Three sets were administered with one-minute rest between sets, three times weekly for six weeks, under similar supervision.

Outcomes were assessed using validated tools at baseline and after six weeks of intervention. Primary outcomes included spirometry measures such as Forced Vital Capacity (FVC), FEV1, and FEV1/FVC ratio, assessed using standardized spirometry. Secondary outcomes included functional capacity evaluated by the 6-Minute Walk Test (6MWT) and asthma control assessed using the Asthma Control Test (ACT). Assessments were conducted following standardized protocols to ensure reliability and reproducibility. This study adhered to the principles of the Declaration of Helsinki. Ethical approval was obtained from the relevant institutional review board. All participants provided informed consent, and confidentiality was ensured through anonymized data handling and restricted access to identifiable information.

Data was analyzed using the Statistical Package for the Social Sciences (SPSS) version 25. The Shapiro-Wilk test was used to assess normality. As data were not normally distributed, non-parametric tests were applied. Between-group comparisons were made using the Mann-Whitney U test, while within-group comparisons utilized the Wilcoxon Signed Rank test. A significance level of $p<0.05$ was considered statistically significant. No imputation for missing data was required, and the analysis was conducted by protocol.

RESULTS

A total of 50 participants with moderate asthma were enrolled and evenly allocated to two intervention groups: Group A (Resistive Diaphragmatic Training, RDT) and Group B (Volume-Oriented Incentive Spirometry, VOS). The mean age in both groups was identical at 45.80 years, with standard deviations of ±4.463 in Group A and ±3.416 in Group B, indicating a comparable age distribution. Gender distribution was skewed towards females in both groups, with Group A comprising 92% females and Group B comprising 96% females. The FEV_1/FVC ratio was also significantly greater in Group A (73.84 ± 5.573) than Group B (68.36 ± 5.453), with a highly significant p value of 0.001, reflecting enhanced airflow dynamics and lung efficiency in the RDT group.

Table 1. Post-Intervention Spirometric Measures between Groups

Spirometry Parameter	Group A (RDT) Mean ± SD	Group B (VOS) Mean ± SD	p-value
Forced Vital Capacity (FVC)	3.3696 ± 0.57350	3.3264 ± 0.28138	0.032
Forced Expiratory Volume (FEV_1)	2.6136 ± 0.72674	2.2940 ± 0.24130	0.047
FEV_1/FVC Ratio (%)	73.84 ± 5.573	68.36 ± 5.453	0.001

Functional Capacity (6-Minute Walk Test) At baseline, there was no statistically significant difference in 6MWT distances between the groups ($p = 0.207$), indicating a comparable starting point. After six weeks, Group A showed a marked increase in walking distance (490.16 ± 52.581 meters) compared to Group B (414.28 ± 26.961 meters), with $p < 0.001$. This large improvement in the RDT group suggests a clinically meaningful enhancement in functional capacity.

Table 2. 6-Minute Walk Test (6MWT)

Time Point	Group A (RDT) Mean ± SD	Group B (VOS) Mean ± SD	p-value
Baseline	430.88 ± 53.767	409.56 ± 27.059	0.207
Post 6 Weeks	490.16 ± 52.581	414.28 ± 26.961	<0.001

Asthma Control (Asthma Control Test – ACT) At baseline, both groups demonstrated comparable ACT scores, with no significant difference ($p = 0.478$). Following the 6-week intervention, Group A had a significantly higher ACT score (19.96 ± 1.207) compared to Group B (14.44 ± 1.660), indicating greater perceived asthma control and symptom management in the RDT group. The difference was statistically significant ($p < 0.001$) and likely reflect both functional and symptomatic benefits attributable to resistive diaphragmatic training.

Table 3. Asthma Control Test (ACT) Scores

Time Point	Group A (RDT) Mean ± SD	Group B (VOS) Mean ± SD	p-value
Baseline	12.84 ± 2.561	12.24 ± 1.715	0.478
Post 6 Weeks	19.96 ± 1.207	14.44 ± 1.660	<0.001

Interpretation and Summary The results demonstrate statistically and clinically significant improvements in pulmonary function, exercise tolerance, and asthma control among participants who underwent resistive diaphragmatic training compared to those who engaged in volume-oriented spirometry. The effect sizes were particularly notable for the FEV_1/FVC ratio, 6MWT distance, and ACT scores, suggesting meaningful functional and symptomatic gains. The uniform

baseline characteristics between groups support the internal validity of the findings, while the consistent direction and magnitude of changes across multiple outcome measures reinforce the superiority of RDT as a targeted respiratory intervention for asthma rehabilitation. Specifically, the Forced Vital Capacity (FVC) was significantly higher in Group A (3.3696 ± 0.57350) than in Group B (3.3264 ± 0.28138) with p = 0.032. Similarly, Forced Expiratory Volume in one second (FEV_1) was higher in Group A (2.6136 ± 0.72674) compared to Group B (2.2940 ± 0.24130), with p = 0.047.

DISCUSSION

The findings of this randomized controlled trial highlight the superior efficacy of resistive diaphragmatic training (RDT) compared to volume-oriented spirometry (VOS) in improving pulmonary function, functional capacity, and asthma control in patients with moderate asthma. This improvement was evidenced by statistically significant gains in Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV_1), FEV_1/FVC ratio, 6-Minute Walk Test (6MWT) distance, and Asthma Control Test (ACT) scores in the RDT group. These results are consistent with prior investigations demonstrating that inspiratory muscle training (IMT), particularly when implemented through threshold loading devices, significantly enhances inspiratory muscle strength and lung function in stable asthma populations (4,13,18). The observed improvements in pulmonary parameters can be attributed to the mechanical load imposed on the diaphragm during RDT, which enhances muscle endurance and efficiency, resulting in better ventilatory mechanics and reduced airway resistance.

These findings align with the work of Wang et al., who showed that IMT combined with physical training significantly improved FEV_1, FVC, and overall respiratory muscle function in asthma patients (18). Similarly, a study by Chung et al. reported that 12 weeks of IMT led to improved inspiratory muscle strength and spirometric outcomes, corroborating the present study's findings on the benefits of targeted diaphragmatic strengthening (4). While the current trial employed a 6-week intervention duration, the magnitude of change observed suggests that even shorter-term programs may yield meaningful clinical outcomes. Furthermore, the significant post-intervention gains in functional capacity, as measured by 6MWT, reinforce the value of RDT in addressing exercise intolerance—a frequent limitation in asthma resulting from dynamic hyperinflation, ventilatory inefficiency, and deconditioning (1,5).

The improvement in ACT scores observed in the RDT group underscores not only physiological benefits but also symptomatic and self-perceived control over asthma, which has important implications for quality of life and medication adherence. These outcomes echo findings from studies demonstrating that IMT reduces dyspnea, improves physical activity levels, and lowers reliance on bronchodilators (6,9). The mechanisms behind these improvements are multifactorial, involving enhanced neuromuscular coordination, increased diaphragmatic excursion, and reduced work of breathing during exertion. In contrast, while VOS was associated with modest improvements in outcomes, its effect size was smaller, likely due to its emphasis on sustained inspiration without progressive muscular overload. Incentive spirometry remains a valuable tool for encouraging lung expansion and alveolar recruitment, yet its utility may be more pronounced in post-operative or immobilized populations rather than in stable asthma patients seeking functional improvement (10,11,15).

A notable strength of this study is its use of validated outcome measures and a structured, supervised intervention protocol, which enhanced internal validity and ensured adherence. The sample size was sufficient to detect statistically significant differences; however, the predominance of female participants may limit generalizability to male asthma populations. Additionally, while simple randomization minimized allocation bias, the use of non-probability sampling may have introduced selection bias, restricting external validity. The absence of blinding among participants and physiotherapists could have influenced performance outcomes, although objective measures like spirometry mitigate this risk.

Another limitation is the focus on short-term outcomes; the study did not evaluate the sustainability of benefits or long-term adherence to home-based respiratory training. Moreover, important dimensions such as quality-of-life indices, inflammatory biomarkers, and psychological health were not assessed, which could have enriched the multidimensional understanding of treatment impact. Combining RDT with VOS may also yield synergistic effects, a hypothesis that warrants empirical testing in future trials.

To advance the current findings, future research should explore the integration of RDT into multidisciplinary asthma rehabilitation programs and assess its impact across diverse age groups, asthma severities, and comorbid conditions. Investigating its effects on systemic inflammation, healthcare utilization, and health-related quality of life could also provide comprehensive insights into its therapeutic value. Larger multicenter trials with stratified random sampling, longer follow-up periods, and gender-balanced cohorts are needed to enhance generalizability and establish clinical guidelines.

This study provides compelling evidence that resistive diaphragmatic training is a more effective intervention than volume-oriented spirometry for improving lung mechanics, exercise tolerance, and asthma control in patients with moderate asthma. These findings support the inclusion of targeted inspiratory muscle training as a core component of physiotherapeutic asthma management, offering a practical, scalable strategy to enhance patient outcomes and reduce disease burden.

CONCLUSION

This randomized controlled trial demonstrated that resistive diaphragmatic training is more effective than volume-oriented spirometry in enhancing pulmonary function, functional capacity, and asthma control among patients with moderate asthma. Consistent with the study objective, the results revealed significantly greater improvements in FVC, FEV_1, FEV_1/FVC ratio, 6-Minute Walk Test distance, and Asthma Control Test scores in the resistive training group. These findings highlight the clinical relevance of integrating resistive diaphragmatic training into standard physiotherapy protocols for asthma

rehabilitation, offering a practical and non-pharmacological approach to optimize respiratory outcomes. From a research perspective, the study supports further investigation into long-term effects, gender-specific responses, and combined modalities to establish comprehensive, evidence-based respiratory care strategies for asthmatic individuals.

REFERENCES

1. de Lima FF, Pinheiro DHA, Carvalho CRF. Physical Training in Adults with Asthma: An Integrative Approach on Strategies, Mechanisms, and Benefits. Front Rehabil Sci. 2023;4:1115352.
2. Khan MA. Monthly and Seasonal Prevalence of Asthma and Chronic Obstructive Pulmonary Disease in the District Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan. Egypt J Bronchol. 2022;16(1):63.
3. Habib FZ, Mahmood SU, Muhammad A, Shah U, Muzaffar S, Naqvi SS. Prevalence of Undiagnosed Chronic Obstructive Pulmonary Disease (COPD) and Asthma in Underserved Rural Sindh, Pakistan. Chest. 2023;164(4):A5039.
4. Chung Y, Huang TY, Liao YH, Kuo YC. Twelve-Week Inspiratory Muscle Training Improves Respiratory Muscle Strength in Adult Patients With Stable Asthma: A Randomized Controlled Trial. Int J Environ Res Public Health. 2021;18(6):3267.
5. Zampogna E, Zappa M, Spanevello A, Visca D. Pulmonary Rehabilitation and Asthma. Front Pharmacol. 2020;11:542.
6. Janani R, Kumar S. The Effect of Active Cycle of Breathing Technique With Threshold IMT Device on Functional Capacity Among Bronchial Asthma Patients. 2024.
7. Kusumawardani RI, Tinduh D, Poerwandari D, Marhana IA, Melaniani S. The Effectiveness of Incentive Spirometry Exercise on Pulmonary Function in COVID-19 Survivors: A Randomized Controlled Trial Study. Bali Med J. 2023;12(1):539–44.
8. Mazroei R, Monemi Gohari E, Ghadermazi M, Latifi N, Hojjati H. The Effect of Home-Based Pulmonary Rehabilitation on Asthmatic Pediatric Quality of Life. J Health Rep Technol. 2023;9(3):e137577.
9. Hamad SH, Hadi AH, Mohr M, Mahadevan SP, Kzar MH. The Effect of Threshold Loading Training and an Innovative Respiratory Training Device With Lower Torso Sports Training in Asthma Patients: A Randomized Trial. Biomed Res Int. 2023;2023:3049804.
10. Wang Q, Yang F, Gao L, Gao W. Effects of Inspiratory Muscle Training and High-Intensity Interval Training on Lung Function and Respiratory Muscle Function in Asthma. Respir Care. 2022;67(11):1465–75.
11. Amin R, Alaparthi GK, Samuel SR, Bairapareddy KC, Raghavan H, Vaishali K. Effects of Three Pulmonary Ventilation Regimes in Patients Undergoing Coronary Artery Bypass Graft Surgery: A Randomized Clinical Trial. Sci Rep. 2021;11(1):6730.
12. Franklin E, Anjum F. Incentive Spirometer and Inspiratory Muscle Training. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023.
13. Shetty N, Samuel SR, Alaparthi GK, Amaravadi SK, Joshua AM, Pai S. Comparison of Diaphragmatic Breathing Exercises, Volume, and Flow-Oriented Incentive Spirometry on Respiratory Function in Stroke Subjects: A Non-Randomized Study. Ann Neurosci. 2020;27(3–4):232–41.
14. Astuti LW, Huriah T. Combination of Diaphragmatic Breathing With Therapeutic Walking Exercise to Increase Peak Expiratory Flow Rate in Asthma Patients. Front Nurs. 2022;9(4).
15. Lista-Paz A, Cousillas LB, Jacome C, Fregonezi G, Labata-Lezaun N, Llurda-Almuzara L, et al. Effect of Respiratory Muscle Training in Asthma: A Systematic Review and Meta-Analysis. Ann Phys Rehabil Med. 2023;66(3):101691.
16. Awolola EO, Maharaj SS. Inspiratory Versus Expiratory Incentive Spirometry: A Randomised Control Trial Study Protocol. S Afr J Physiother. 2023;79(1):1841.
17. Yu-Lin A. The Benefits of Early Pulmonary Rehabilitation With Incentive Spirometer Among Chronic Obstructive Pulmonary Disease Patients With Exacerbation of Chronic Obstructive Pulmonary Disease. Malays J Med Sci. 2024;79(5):561.