ROLE OF PHYSIOTHERAPY IN PREVENTION AND TREATMENT OF EXERCISE INDUCED BRONCHOSPASM AND BRONCHIAL ASTHMA

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ABSTRACT

Exercise-induced bronchospasm and bronchial asthma are widespread respiratory disorders that can significantly limit physical activity and reduce quality of life. Physiotherapy plays an essential role in the prevention, management, and treatment of these conditions by improving airway function, boosting respiratory efficiency, and enhancing exercise capacity. This review examines the contribution of physiotherapy in managing exercise-induced bronchospasm and bronchial asthma through a combination of interventions such as breathing exercises, airway clearance techniques, postural drainage, and physical conditioning. By focusing on strategies that enhance lung function and decrease bronchial hyperresponsiveness, physiotherapists enable individuals with asthma or exercise-induced bronchospasm to engage in physical activity in a safe and effective manner. The review also highlights the scientific evidence supporting physiotherapy interventions and offers recommendations for incorporating these approaches into asthma management strategies to improve both short-term results and long-term respiratory health.

Introduction: Exercise-induced bronchospasm and bronchial asthma are prevalent respiratory conditions and can significantly limit an individual's capacity to participate in physical activities. Both conditions are characterized by inflammation, narrowing of the airways, and increased airway sensitivity, leading to symptoms like wheezing, coughing, shortness of breath, and chest tightness, particularly during exercise [1]. Physiotherapy plays a vital role in both the prevention and management of these conditions by employing various techniques to enhance respiratory function and improve the individual's quality of life [2]. Respiratory physiotherapy aims to strengthen the muscles involved in breathing, improve lung ventilation, and reduce airway resistance. These benefits help minimize the frequency and severity of asthma attacks triggered by physical exertion [3]. In addition to breathing exercises, physiotherapists guide patients on effective warm-up and cool-down routines, correct postural adjustments, and strategies for managing environmental triggers that can exacerbate asthma symptoms [4]. These practices collectively support better breathing during exercise.Personalized exercise programs, including aerobic conditioning, strength training, and flexibility exercises, are designed to improve overall fitness and lung function. Such programs not only alleviate the effects of exercise-induced bronchospasm and asthma but also increase exercise capacity, encouraging individuals to engage in physical activities more frequently [5]. Physiotherapy is a key component in managing exercise induced bronchial asthma. When combined with medications, it leads to long-term improvements in respiratory health, better symptom control, and an enhanced quality of life [6]. A comprehensive, holistic approach that integrates physiotherapists is essential to achieve optimal outcomes for individuals dealing with these respiratory conditions.Exercise-induced bronchospasm refer to a temporary narrowing of the airways that typically occurs within five to 15 minutes after physical exertion [7]. Although it is highly preventable, this condition is often underdiagnosed and can affect both aerobic fitness and overall well-being [8]. Diagnosis typically involves a detailed medical history, assessment of asthma triggers, and identification of exercise-induced bronchoconstriction symptoms. It may also include normal forced expiratory volume when at rest [9]. Treatment often begins with inhaled beta-agonists and may progress to anti-inflammatory medications or ipratropium bromide. This overview highlights the importance of physiotherapy in managing both exercise induced bronchospasmand asthma, incorporating methods like respiratory muscle training, diaphragmatic and pursed-lip breathing exercises, airway clearance techniques, and tailored exercise routines. These interventions are essential for helping individuals with asthma effectively manage their condition and maintain an active lifestyle [10].

Methodology

Study Design

This systematic review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The review aims to assess the effectiveness of physiotherapy interventions, including breathing exercises, inspiratory muscle training, physical conditioning, and airway clearance techniques, in improving asthma control, cardiopulmonary fitness, and quality of life in individuals with asthma across different age groups.

Eligibility Criteria

The inclusion and exclusion criteria were established based on the Population, Intervention, Comparison, Outcome, and Study Design (PICOS) framework:

- Population: Studies including children, adolescents, and adults diagnosed with asthma or exercise-induced bronchospasm.
- Intervention: Studies examining the effects of breathing exercises, inspiratory muscle training, physical training, or combined techniques.
- Comparison: Studies with a control group receiving standard care, education, or alternative physiotherapy interventions.

- Outcome: Assessment of lung function (e.g., peak expiratory flow rate, maximal inspiratory pressure), asthma symptom control, exercise capacity, and quality of life.
- Study Design: Randomized controlled trials , cohort studies, and systematic reviews published in peer-reviewed journals.

Search Strategy

A comprehensive literature search was conducted in databases including PubMed, Scopus, Web of Science, Cochrane Library, and Embase. The following keywords and MeSH terms were used:

- "Asthma" AND "exercise-induced bronchospasm" AND "physiotherapy interventions"
- "Breathing exercises" AND "inspiratory muscle training" AND "asthma management"
- "Physical conditioning" AND "airway clearance techniques" AND "lung function"

Additional manual searches were performed using the reference lists of included studies to identify relevant articles.

Study Selection

The retrieved studies were screened based on titles and abstracts. Full-text articles were reviewed for eligibility by two independent reviewers. Disagreements were resolved through discussion with a third reviewer.

Data Extraction and Synthesis

Data extraction was performed using a standardized form that included:

- Study details (author, year, population, sample size, study design)
- Intervention details (type, duration, and frequency of physiotherapy interventions)
- Outcome measures (asthma control, lung function parameters, exercise capacity, quality of life)
- Key findings and conclusions

Due to the heterogeneity of study designs and outcome measures, a qualitative synthesis of the findings was conducted. Where applicable, meta-analyses of similar outcomes were considered.

Risk of Bias Assessment

The Cochrane Risk of Bias (ROB 2) tool was used for RCTs, and the Newcastle-Ottawa Scale (NOS) was applied for observational studies. Studies were categorized into low, moderate, or high risk of bias based on randomization, blinding, allocation concealment, and follow-up completeness.

Limitations of the Review

Several limitations should be noted:

1. Heterogeneity in Study Design: The included studies varied significantly in sample sizes, intervention protocols, control groups, and outcome measures, making direct comparisons difficult.
2. Variability in Training Duration and Frequency: Differences in intervention length (ranging from four to 28 weeks) and session frequency (ranging from twice to three times per week) affected the comparability of results.
3. Lack of Standardization in Control Groups: Studies used diverse control conditions such as usual care, education, or alternative physiotherapy interventions, which could impact conclusions.
4. Limited Pediatric Data: Few studies focused on children with asthma, highlighting a gap in research on the efficacy of physiotherapy interventions for pediatric populations.
5. Potential Publication Bias: Positive results may have been overrepresented, while studies with negative or inconclusive findings may have been underreported

PRISMA FLOWCHART of the study is shown in **[Figure 1]**

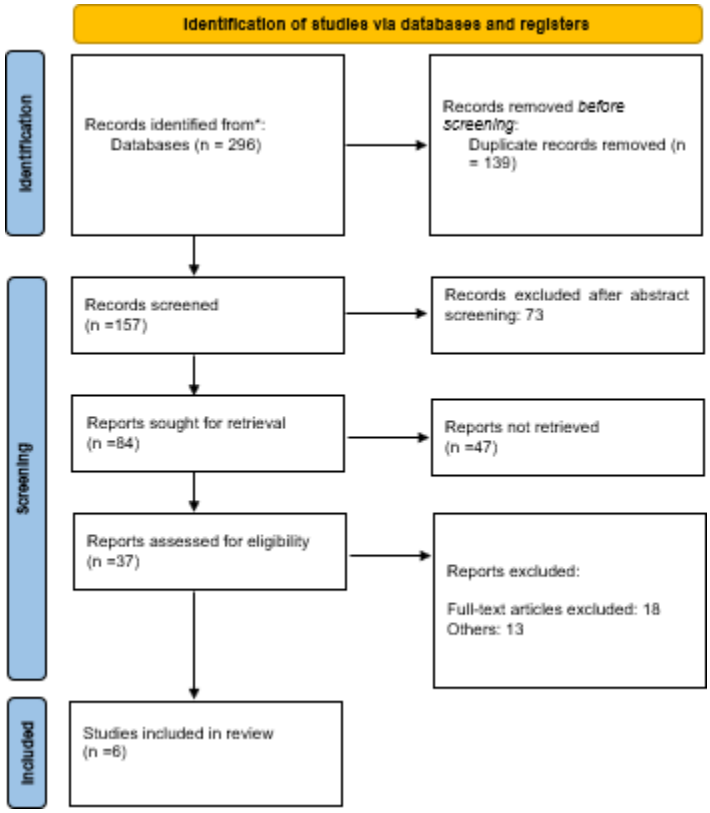

Figure 1: Prisma Flowchart of the Study

Discussion: Physiotherapy plays a vital role in both the prevention and treatment of exercise-induced bronchospasm and bronchial asthma, improving lung function, reducing symptoms, and enhancing overall quality of life [11]. It involves various strategies that help individuals manage these respiratory conditions more effectively [12]. One key approach is breathing exercises, where physiotherapists teach techniques like diaphragmatic breathing, pursed-lip breathing, and Buteyko breathing [13]. These methods improve breathing efficiency, increase lung capacity, and reduce the work of breathing, ultimately easing asthma symptoms and helping individuals manage their condition during physical activity [14].Additionally, airway clearance techniques, such as postural drainage and chest percussion, can help clear excess mucus from the lungs, reducing the risk of airway obstruction and improving airflow [15]. Exercise training and conditioning also play a crucial role. Physiotherapists design personalized exercise programs to improve cardiovascular fitness, increase exercise tolerance, and strengthen respiratory muscles [16]. Regular aerobic exercise not only improves the function of the cardiovascular and respiratory systems but also reduces the frequency and severity of asthma attacks [17].An important aspect of physiotherapy is education on trigger avoidance and management. Physiotherapists educate individuals on how to identify and avoid asthma triggers, such as environmental irritants and extreme temperatures, and how to incorporate proper warm-up and cool-down routines to minimize the risk of exercise-induced bronchospasm [18]. For individuals with more severe asthma, pulmonary rehabilitation can be implemented, which may include a personalized exercise regimen, nutritional guidance, and psychological support to address the emotional impact of chronic asthma [19].Furthermore, physiotherapists are involved in monitoring and adjusting interventions, using tools like

spirometry to assess lung function and developing individualized action plans to manage symptoms during physical activities. They also work to prevent deconditioning, which can occur if individuals avoid exercise due to fear of triggering asthma attacks [20]. By encouraging safe, gradual engagement in physical activity, physiotherapy helps improve fitness, lung function, and overall health.Ultimately, the role of physiotherapy in managing exercise induced bronchial asthma requires an individualized approach tailored to each person's specific asthma severity, exercise limitations, medical history, and triggers [21]. Physiotherapists continuously monitor progress to ensure interventions are effective and that patients feel supported throughout their rehabilitation journey. This comprehensive, multidisciplinary approach—combining breathing exercises, airway clearance, exercise conditioning, and education—plays a crucial role in improving the quality of life for individuals with respiratory conditions. [22]Subsequent studies have shown that breathing exercises can lead to improvements in quality of life, reduced medication use, and lower respiratory rates [23]. Breathing exercises have been found to help alleviate symptoms, reduce hyperventilation, and decrease anxiety and depression [24]. A 2011 review by Bruton et al., which included five of the studies from our analysis, concluded that breathing training may improve symptoms, enhance quality of life, and reduce reliance on rescue bronchodilators, aligning with our findings [25]. Regarding inspiratory muscle training, while it is known to improve peak inspiratory pressure, evidence supporting its clinical benefits for asthma patients has been inconsistent [26]. One review indicated that, in addition to improving peak inspiratory pressure, inspiratory muscle training can also lead to symptom reduction and decreased medication use [27].Physical training has shown improvements in cardiopulmonary endurance and fitness, including maximum oxygen uptake [28]. One review further highlighted significant improvements in quality of life and symptom reduction following physical training [29]. This shift in outcomes reflects an evolving focus from lung function to subjective measures like symptoms and quality of life, which are increasingly seen as more relevant to patient well-being. An analysis also identified a gap in research on the effects of physiotherapy for children with asthma [30]. Since asthma often starts in childhood, early intervention could improve a child's ability to engage in school and sports activities [31]. However, most studies in one review were conducted with adult populations, with only nine studies including children, and seven of those focused on physical exercises. While physical training shows promise for children, there is insufficient data on the effectiveness of breathing exercises and inspiratory muscle training for this age group to draw definitive conclusions [32].In clinical practice, physiotherapists often use a combination of techniques, but most of the randomized controlled trials included in our review focused on individual methods [33]. Only a few studies have explored the combination of physiotherapy techniques, with one indicating no significant difference between combined techniques and standard care [34]. This highlights the need for further investigation into the effectiveness of combined approaches, which may offer more promising results. In general, breathing exercises, inspiratory muscle training, and physical training show potential benefits for individuals with asthma, including improvements in disease-specific quality of life, cardiopulmonary fitness, maximal inspiratory pressure, and reductions in symptoms and medication use [35]. Physical training, in particular, seems to provide specific benefits for children with asthma, enhancing their quality of life. Therefore, integrating physiotherapy into asthma management plans is recommended [36]. While recent research suggests positive outcomes, additional studies are needed to validate these findings [37]. Future research should focus on the combined use of physiotherapy techniques, including breathing exercises, inspiratory muscle training, physical training, and airway clearance, and compare them to standard care in both adults and children with

asthma [38].**[Table 1]** presents a combination of different intervention methods, such as breathing exercises, inspiratory muscle training, and physical conditioning, along with the corresponding outcome measures related to asthma and exercise-induced bronchospasm and emphasizes the significance of physiotherapy in managing these conditions.

Table 1: Physiotherapy Interventions for Asthma Management

Study	Year	Population	Intervention	Outcome Measures	Key Findings	Conclusion
Belli S et al. [38]	2021	Children with asthma	Physical conditioning, airway clearance techniques	Cardiopulmonary fitness, quality of life, peak flow measurements	Physical conditioning improved overall fitness and reduced asthma symptoms in children	Physical training is particularly beneficial for children with asthma in improving quality of life.
Chung Y et al. [39]	2021	Adults with exercise induced bronchospasm and asthma	Breathing exercises, inspiratory muscle training	Disease-specific quality of life, exercise capacity, asthma symptoms	Significant improvement in exercise capacity and reduction in asthma symptoms after physiotherapy	Breathing exercises and inspiratory muscle training are effective in improving exercise tolerance.
Santino TA et al.[40]	2020	Adults with asthma	Combined techniques (breathing exercises + physical training)	Maximal inspiratory pressure, pulmonary function tests	No significant difference between combined techniques and usual care	Combined techniques may not offer additional benefit over standard care, suggesting need for further research.
Xiang Y et al.[41]	2024	Children and adolescents with asthma	Airway clearance techniques, inspiratory muscle training	Symptom control, peak expiratory flow rate	Airway clearance techniques alongside inspiratory muscle training	Airway clearance and inspiratory muscle training offer significant benefits for

					improved symptom control and lung function	pediatric asthma management.
Silve IS et al.[42]	2013	Mixed age groups (adults & children)	Inspiratory muscle training, physical conditioning	Maximal inspiratory pressure, exercise capacity, asthma symptoms	Inspiratory muscle training and physical conditioning improved exercise tolerance and quality of life	Physiotherapy interventions can improve lung function and exercise tolerance in both adults and children.
Ang J et al.[43]	2022	Adults and adolescents with asthma	Aerobic exercise, inspiratory muscle training	Cardiopulmonary fitness, asthma control	Aerobic exercise combined with inspiratory muscle training showed improvements in asthma control and fitness	Combined aerobic exercise and inspiratory muscle training enhance asthma control and fitness levels.

Future prospects:

The role of physiotherapy in the prevention and treatment of exercise-induced bronchospasm and bronchial asthma has already proven to be significant, but future advancements in both understanding and technology could further enhance its impact. Here are some key future prospects for physiotherapy in the management of these conditions:

1. Personalized and data-driven treatment

As technology and wearable devices continue to evolve, the future of physiotherapy for asthma and exercise induced bronchospasm could be more personalized. Physiotherapists could use data from wearable sensors that track heart rate, breathing patterns, and oxygen saturation during exercise to develop more targeted exercise regimens. Real-time data will allow physiotherapists to monitor patients' progress and make adjustments to the exercise plan, ensuring optimal results for each individual. [44]

2. Integration of telehealth and virtual physiotherapy

The rise of telemedicine and virtual health services has the potential to revolutionize how physiotherapy is delivered to individuals with asthma or exercise induced bronchial asthma, especially for those in remote or underserved areas. Virtual consultations could enable physiotherapists to guide patients through exercise routines, breathing exercises, and even remote

monitoring of symptoms. Virtual training could also improve patient adherence to prescribed exercises, as it would allow individuals to access physiotherapy resources conveniently from home [45].

3. Improved breathing techniques and innovations:

New and more effective breathing techniques are likely to emerge as research into respiratory health continues. Innovations in techniques like diaphragmatic breathing, pursed-lip breathing, and respiratory muscle training could evolve, and physiotherapists may incorporate more advanced methodologies. These techniques, when combined with real-time biofeedback, can help patients achieve optimal breathing control, reducing both the frequency and severity of asthma and exercise induced bronchospasm symptoms during physical activities [46].

4. Exercise-physiology focused approaches:

As exercise science continues to progress, physiotherapists will likely refine exercise regimens that specifically target lung function and aerobic capacity in individuals with asthma or exercise induced bronchospasm. These programs may evolve to incorporate not just general aerobic exercises, but also specialized interval training, strength training, and flexibility exercises tailored to the unique needs of these patients. Greater emphasis may be placed on balancing cardiovascular fitness with respiratory strength, which could improve both lung function and endurance [47].

5. Multidisciplinary approach and collaboration:

A more integrated, multidisciplinary approach to managing exercise induced bronchospasm and asthma is expected in the future. Physiotherapists could work even more closely with pulmonologists, allergists, and exercise physiologists, among other healthcare professionals, to create holistic, patient-centered treatment plans. By focusing on all aspects of the patient's health—such as nutrition, medication management, environmental control, and exercise therapy—the overall effectiveness of asthma and exercise induced bronchospasm management will improve [48].

6. Increased education and awareness:

As research continues, physiotherapists may increasingly focus on patient education, ensuring individuals understand their condition and how to manage it effectively during exercise. With advancements in mobile health apps and platforms, physiotherapists could provide continuous education, sending patients reminders, tips, and support to help them control symptoms during physical activities. Education would also extend to the public, helping to raise awareness about the role of physiotherapy in managing asthma and exercise induced bronchospasm [49].

7. Innovative respiratory muscle training devices:

The development of new respiratory muscle training devices could provide even more targeted and effective therapy for individuals with asthma and exercise induced bronchospasm. These devices may help strengthen the muscles involved in breathing, improving lung capacity and airflow. Such tools could be integrated into physiotherapy practices to enhance the efficacy of treatments and offer patients a more comprehensive approach to improving respiratory function.

8. Long-term monitoring and prevention strategies:

Future physiotherapy treatments could incorporate more long-term monitoring systems to track improvements in lung function and physical performance. Wearables could allow for continuous monitoring of respiratory patterns and oxygen levels, with physiotherapists able to intervene when necessary. This preventive approach could minimize exacerbations and hospitalizations, ensuring individuals with asthma or exercise induced bronchospasm maintain better control of their symptoms over time [50].

9. Enhanced airway management tchniques

Advances in airway clearance techniques—such as oscillating positive expiratory pressure devices and high-frequency chest wall oscillation—may become more integrated into physiotherapy. These tools could be tailored to individuals with asthma or exercise induced bronchospasm to promote better mucus clearance, reduce airway inflammation, and optimize lung ventilation. As these devices become more sophisticated and accessible, they could offer more efficient ways to manage the respiratory symptoms associated with these conditions [51].

Looking forward, physiotherapy will continue to be a cornerstone in the prevention and management of exercise-induced bronchospasm and bronchial asthma. The future of physiotherapy in these areas will likely be characterized by personalized, data-driven approaches, greater integration with technology and telemedicine, and a more comprehensive, collaborative approach to treatment. Innovations in exercise regimens, breathing techniques, and airway management are expected to enhance therapeutic outcomes, ultimately helping individuals with asthma and exercise induced bronchospasm lead active, healthy lives with improved symptom control [52].

Conclusion: Physiotherapy plays a vital role in the prevention and treatment of exercise-induced bronchospasm and bronchial asthma. By focusing on improving breathing techniques, strengthening respiratory muscles, conditioning the body through exercise, and providing education on asthma management, physiotherapy helps patients lead an active and healthy life while minimizing the impact of asthma and bronchospasm. Through a comprehensive approach, physiotherapists empower individuals to manage their condition, reduce the frequency of attacks, and enhance their overall quality of life.

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References

1. Bindels PJ, van der Wouden JC, Ponsioen BP, Brand PL, Salomé PL, Van Hensbergen W, et al. NHG-StandaardAstmabijkinderen (Tweede herziening). Huisarts Wet. 2006; 49(11):557-72.
2. Geijer RMM, Chavannes NH, Muris JWM, Sachs APE, Schermer T, Smeele IJM, et al. NHG-StandaardAstmabijvolwassenen (Tweede herziening). Huisarts Wet. 2007; 50:537-51.
3. Dennis J. Alexander technique for chronic asthma. Cochrane Database Syst Rev. 2000 ;(2):CD000995.
4. Holloway E, Ram FS. Breathing exercises for asthma. Cochrane Database Syst Rev. 2004 ;(1):CD001277.
5. Ghuman A, Choudhary P, Kasana J, Kumar S, Sawhney H, Bhat R, Kashwani R. A Systematic Literature Review on the Composition, Health Impacts, and Regulatory Dynamics of Vaping. Cureus. 2024 Aug 3;16(8):e66068
6. Ram FS, Robinson SM, Black PN, Picot J. Physical training for asthma. Cochrane Database Syst Rev. 2005;(4):CD001116.
7. Ram FS, Wellington SR, Barnes NC. Inspiratory muscle training for asthma. Cochrane Database Syst Rev. 2003;(4):CD003792.
8. Kambam, Greeshma & REGELMANN, DAVID. (2024). THE ASSOCIATION BETWEEN SECONDHAND SMOKE AND CHRONIC OBSTRUCTIVE PULMONARY DISEASE AMONG US ADULTS: NATIONAL HEALTH AND

NUTRITION EXAMINATION SURVEY 2017-2020. CHEST. 166. A4731. 10.1016/j.chest.2024.06.2846.

9. Turner LA, Turner LA, Mickleborough TD, McConnell AK, Stager JM, et al. Effect of inspiratory muscle training on exercise tolerance in asthmatic individuals. Med Sci Sports Exerc. 2011; 43(11):2031-8.
10. Mendes FA, Gonçalves RC, Nunes MP, Saraiva-Romanholo BM, et al. Effects of aerobic training on psychosocial morbidity and symptoms in patients with asthma: a randomized clinical trial. Chest. 2010; 138(2):331-7.
11. Bott J, Blumenthal S, Buxton M, Ellum S, Falconer C, et al. Guidelines for the physiotherapy management of the adult, medical, spontaneously breathing patient. Thorax. 2009; 64(Supp)l:i1-51.
12. van der Giessen LJ, Gulmans VAM, Lucas T, van der Lugt M, Hendriks HJ. KNGF richtlijnAstmabijkinderen. Ned Tijdschr Fysioth. 2005;115:s1-47.
13. Lima EV, Lima WL, Nobre A, dos Santos AM, et al. Inspiratory muscle training and respiratory exercises in children with asthma. J Bras Pneumol. 2008;34(8):552-8.
14. Shaw BS, Shaw I. Pulmonary function and abdominal and thoracic kinematic changes following aerobic and inspiratory resistive diaphragmatic breathing training in asthmatics. Lung. 2011; 189(2):131-9.
15. Cowie RL, Conley DP, Underwood MF, Reader PG. A randomised controlled trial of the Buteyko technique as an adjunct to conventional management of asthma. Respir Med. 2008; 102(5):726-32.
16. Grammatopoulou EP, Skordilis EK, Stavrou N, Myrianthefs P, Karteroliotis K, Baltopoulos G, Koutsouki E. The effect of physiotherapy-based breathing retraining on asthma control. J Asthma. 2011; 48(6):593-601.
17. Holloway EA, West RJ. Integrated breathing and relaxation training (the Papworth method) for adults with asthma in primary care: a randomised controlled trial. Thorax. 2007; 62(12):1039-42.
18. Slader CA, Reddel HK, Spencer LM, et al. Double blind randomised controlled trial of two different breathing techniques in the management of asthma. Thorax. 2006; 61(8):651-6.
19. Thomas M, McKinley RK, Mellor S, Watkin G. Breathing exercises for asthma: a randomised controlled trial. Thorax. 2009;64(1):55-61.
20. Chiang LC, Ma WF, Huang JL, Tseng LF, Hsueh KC. Effect of relaxation-breathing training on anxiety and asthma signs/symptoms of children with moderate-to-severe asthma: a randomized controlled trial. Int J Nurs Stud. 2009; 46(8):1061-70.
21. Meuret AE, Ritz T, Wilhelm FH, Roth WT. Targeting pCO(2) in asthma: pilot evaluation of a capnometry-assisted breathing training. Appl Psychophysiol Biofeedback. 2007; 32(2):99-109.
22. Sodhi C, Singh S, Dandona PK. A study of the effect of yoga training on pulmonary functions in patients with bronchial asthma. Indian J Physiol Pharmacol. 2009; 53(2):169-74.
23. Moreira A, Delgado L, Haahtela T, Fonseca J, et al. Physical training does not increase allergic inflammation in asthmatic children. Eur Respir J. 2008; 32(6):1570-5.
24. Basaran S, Guler-Uysal F, Ergen N, Seydaoglu G, et al. Effects of physical exercise on quality of life, exercise capacity and pulmonary function in children with asthma. J Rehabil Med. 2006; 38(2):130-5.

25. Mendes FA, Almeida FM, Cukier A, Stelmach R, et al. Effects of aerobic training on airway inflammation in asthmatic patients. Med Sci Sports Exerc. 2011; 43(2):197-203.
26. Turner S, Eastwood P, Cook A, Jenkins S. Improvements in symptoms and quality of life following exercise training in older adults with moderate/severe persistent asthma. Respiration. 2011; 81(4):302-10.
27. Fanelli AE, Cabral AL, Neder JA, Martins MA. Exercise training on disease control and quality of life in asthmatic children. Med Sci Sports Exerc. 2007; 39(9):1474-80.
28. Flapper BC, Duiverman EJ, Gerritsen J, Postema K, van der Schans CP. Happiness to be gained in paediatric asthma care. Eur Respir J. 2008; 32(6):1555-62.
29. Wang JS, Hung WP. The effects of a swimming intervention for children with asthma. Respirology. 2009; 14(6):838-42.
30. Wicher IB, Ribeiro MA, Marmo DB, Santos CI. Effects of swimming on spirometric parameters and bronchial hyperresponsiveness in children and adolescents with moderate persistent atopic asthma. J Pediatr. 2010;86(5):384-90.
31. Onur E, Kabaroğlu C, Günay O, Var A, et al. The beneficial effects of physical exercise on antioxidant status in asthmatic children. AllergolImmunopathol. 2011; 39(2):90-5.
32. Yoo Y, Choung JT, Yu J, Kim DK, Choi SH, Koh YY. Comparison of percentage fall in FVC at the provocative concentration of methacholine causing a 20% fall in FEV1 between patients with asymptomatic bronchial hyperresponsiveness and mild asthma. Chest. 2007; 132(1):106-11.
33. Castro-Rodriguez JA, Navarrete-Contreras P, Holmgren L, Sanchez I, Caussade S. Bronchial hyperreactivity to methacholine in atopic versus nonatopic asthmatic schoolchildren and preschoolers. J Asthma. 2010; 47(8):929-34.
34. Cockcroft DW. Direct challenge tests: Airway hyperresponsiveness in asthma: its measurement and clinical significance. Chest. 2010;138(2 Suppl):18S-24S.
35. Beggs S, Foong YC, Le HC, Noor D, Wood-Baker R, Walters JA. Swimming training for asthma in children and adolescents aged 18 years and under. Cochrane Database Syst Rev. 2013 ;(4):CD009607.
36. Joschtel B, Gomersall SR, Tweedy S, Petsky H, Chang AB, Trost SG. Effects of exercise training on physical and psychosocial health in children with chronic respiratory disease: a systematic review and meta-analysis. BMJ Open Sport Exerc Med. 2018; 4(1):e000409.
37. Gomes AM, Rocha-E-Silva M. Exercise and its interactions with various aspects of man and animal lives. Acta Ortop Bras. 2012; 20(6):356-66.
38. Belli S, Prince I, Savio G, Paracchini E, Cattaneo D, Bianchi M, Masocco F, Bellanti MT, Balbi B. Airway Clearance Techniques: The Right Choice for the Right Patient. Front Med (Lausanne). 2021;4;8:544826.
39. Chung Y, Huang TY, Liao YH, Kuo YC. 12-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.
40. Santino TA, Chaves GS, Freitas DA, Fregonezi GA, Mendonça KM. Breathing exercises for adults with asthma. Cochrane Database Syst Rev. 2020;3(3):CD001277.
41. Xiang Y, Luo T, Chen X, Zhang H, Zeng L. Effect of inspiratory muscle training in children with asthma: a systematic review and meta-analysis of randomized controlled trials. Front Pediatr. 2024;12:1367710
42. Silva IS, Fregonezi GA, Dias FA, Ribeiro CT, Guerra RO, Ferreira GM. Inspiratory muscle training for asthma. Cochrane Database Syst Rev. 2013;2013(9):CD003792.

43. Ang J, Moussa R, Shaikh S, Mele S. Effects of aerobic exercise on asthma control and quality of life in adults: a systematic review. J Asthma. 2022;60(5):845–55.
46. Wu X, Gao S, Lian Y. Effects of continuous aerobic exercise on lung function and quality of life with asthma: a systematic review and meta-analysis. J Thorac Dis. 2020; 12(9):4781-4795.
47. Eichenberger PA, Diener SN, Kofmehl R, Spengler CM. Effects of exercise training on airway hyperreactivity in asthma: a systematic review and meta-analysis. Sports Med. 2013; 43(11):1157-70.
48. Soo WF, Tan NC. The influence of caregivers' knowledge and understanding of asthma aetiology on domiciliary management of children with asthma. Singapore Med J. 2014; 55(3):132-6.
49. Ritz T, Meuret AE, Wilhelm FH, Roth WT. Changes in pCO2, symptoms, and lung function of asthma patients during capnometry-assisted breathing training. Appl Psychophysiol Biofeedback. 2009; 34(1):1-6.
50. Jeter AM, Kim HC, Simon E, Ritz T, Meuret AE. Hypoventilation training for asthma: a case illustration. Appl Psychophysiol Biofeedback. 2012;37(1):63-72.
51. Brandao DC, Lima VM, Filho VG, Silva TS, Campos TF, Dean E, de Andrade AD. Reversal of bronchial obstruction with bi-level positive airway pressure and nebulization in patients with acute asthma. J Asthma. 2009; 46(4):356-61.
52. Ritz T, Dahme B, Roth WT. Behavioral interventions in asthma: biofeedback techniques. J Psychosom Res. 2004; 56(6):711-20.