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RESPIRATORY MUSCLE TRAINING IN SPORTS AND REHABILITATION: A LITERATURE REVIEW

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ABSTRACT

Background. Historically, the respiratory system was viewed as an overbuilt apparatus that rarely limited human performance or daily function. However, contemporary research establishes that the respiratory system can become a profound limiting factor under physiological stress, high-intensity exercise and chronic disease. Respiratory muscle training (RMT) represents a targeted modality to enhance the strength and endurance of the respiratory musculature.

Aim. To integrate and evaluate the human evidence surrounding the effects of respiratory muscle training (RMT) on athletic performance, clinical rehabilitation, symptom control, and return to physical activity, contextualizing the physiological mechanisms and specific training protocols.

Material and methods. A review of the literature was conducted focusing on the clinical and athletic applications of RMT, primarily inspiratory muscle training (IMT) and expiratory muscle training (EMT), utilizing resistive loading, pressure threshold loading, and normocapnic hyperpnea modalities.

Results. Several studies indicate that RMT may induce structural adaptations of the diaphragm as well as neural changes related to improved motor unit recruitment. In clinical populations (CHF, COPD, Asthma, Stroke, SCI, post-COVID-19 syndrome), RMT significantly increases maximal inspiratory pressure (MIP), reduces the Borg dyspnea index, and improves functional mobility (e.g., 6MWT distance). In athletic populations, RMT attenuates the respiratory metaboreflex, preserves peripheral locomotor blood flow and enhances specific field assessments like Repeated Sprint Ability (RSA) and Yo-Yo Intermittent Recovery Test (YYT).

Conclusions. RMT is an effective, well-supported intervention that strengthens the diaphragm, reduces dyspnea, and improves exercise capacity across clinical and athletic populations. Outcomes depend on adherence to progressive overload and individualized protocols.

KEYWORDS

Respiratory Muscle Training, Inspiratory Muscle Training, Athletic Performance, Rehabilitation, Dyspnea, Metaboreflex

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1. Introduction

Respiratory muscle training (RMT) is a form of targeted conditioning that strengthens the respiratory muscles, improving their endurance and force output. Historically, the respiratory system was viewed as an overbuilt apparatus that rarely limited human performance or daily function, except in the presence of severe pulmonary pathology. Consequently, the conditioning of the respiratory pump comprising the diaphragm, external and internal intercostal muscles, and accessory muscles of respiration was largely relegated to the periphery of athletic training and clinical rehabilitation.¹ Contemporary research has shown, that the respiratory system can become a meaningful limiting factor under physiological stress, during high-intensity exercise, and in chronic disease.¹

The clinical and athletic applications of RMT are broadly categorized into inspiratory muscle training (IMT) and expiratory muscle training (EMT). Of the two, IMT receives the preponderance of focus in both research and practice, given the diaphragm's disproportionate role in generating the negative intrathoracic pressure required for ventilation and sustaining tidal volume under high metabolic demand.¹ Distinct modalities of RMT are recognized, primarily including resistive loading, pressure threshold loading and normocapnic hyperpnea.⁵ Each modality precipitates specific morphological, metabolic, and neural adaptations.

The rationale for integrating RMT into diverse populations ranging from elite olympic swimmers and team-sport athletes to critically ill patients weaning from mechanical ventilation reflects a practical gap: standard sport training and aerobic exercise rarely provide the specific overload needed to strengthen respiratory muscles.³ In healthy individuals, the respiratory muscles adapt to systemic exercise only up to a certain threshold, beyond which specific overloading is required.³ Conversely, in clinical populations, disease pathology often initiates a rapid cascade of respiratory muscle dysfunction. Conditions such as chronic obstructive pulmonary disease (COPD), chronic heart failure (CHF), critical illness polyneuropathy, neuromuscular dystrophies, and post-COVID-19 syndrome invariably lead to respiratory muscle weakness.¹ This weakness manifests clinically as severe exertional dyspnea, early-onset peripheral fatigue, and a profound reduction in physical exercise tolerance, severely compromising quality of life and the ability to return to physical activity.⁸

This review covers the physiological mechanisms underlying RMT, its use in athletic performance, clinical rehabilitation and the training protocols applied across different populations.

2. Physiological Background: Mechanisms and Systemic Adaptations

Respiratory muscles respond to training by the same principles governing skeletal muscle: progressive overload, specificity, reversibility, and periodization.³ When subjected to controlled, resistive loads, the diaphragm and accessory muscles undergo mechanical, metabolic, and neural adaptations with both local and systemic effects.

A key mechanism behind RMT's benefits is modulation of the respiratory metaboreflex. During high-intensity intermittent exercise or in chronic cardiopulmonary disease, the increased work of breathing causes respiratory muscle fatigue.² As the diaphragm fatigues, there is an accumulation of metabolic byproducts, most notably lactic acid and hydrogen ions. This local metabolic crisis stimulates type IV unmyelinated and group III myelinated phrenic afferent neurons.³

Activation of these afferent fibers increases sympathetic outflow, which may contribute to vasoconstriction in peripheral locomotor muscles during intense exercise. The ensuing redistribution of cardiac output prioritizes blood flow to the vital respiratory muscles to ensure survival, doing so at the direct expense of peripheral limb perfusion.³ The downstream effect on physical activity is significant: peripheral muscles, deprived of blood flow, shift toward anaerobic metabolism.³ This accelerates the accumulation of local peripheral metabolites, exacerbates localized limb fatigue, and abruptly forces the cessation of activity or a significant reduction in exercise intensity.³

Targeted IMT serves to directly delay and attenuate the onset of this metaboreflex. By increasing the oxidative capacity, capillary density and maximal force generation of the inspiratory muscles, the threshold for metabolic byproduct accumulation and subsequent afferent nerve activation is significantly elevated. As a result, the activation threshold of the respiratory metaboreflex may be delayed, which can help maintain peripheral muscle perfusion during exercise. This explains why individuals can sustain higher-intensity activity after RMT, even without any direct training of the limbs.³

IMT also produces structural changes in the respiratory muscles. High-intensity nonrespiratory maneuvers, such as specific core-strengthening exercises involving the abdominal and intercostal musculature,

as well as dedicated pressure threshold loading, have been shown to significantly increase diaphragm thickness. Studies utilizing ultrasonography have documented diaphragm thickness increasing from a baseline of 2.5 millimeters to 3.2 millimeters following a 16-week training protocol.¹⁰ This hypertrophic response is accompanied by an internal shift in muscle fiber type distribution, optimizing the ratio of slow-twitch, highly oxidative Type I fibers to fast-twitch Type IIa fibers.¹¹ This remodeling enhances both maximal force generation, clinically measured as maximal inspiratory pressure (MIP) or maximal expiratory pressure (MEP) and localized endurance.¹¹

RMT also improves neuromechanical coupling. In states of respiratory weakness or during periods of mechanical ventilation, insufficient ventilator assistance alters the output of the central respiratory controller, leading to asynchronous and inefficient firing.¹² By regularly training the respiratory muscles against a specific measured resistance, motor unit recruitment patterns become synchronized. This neural adaptation is particularly evident in the early phases of a training program, where initial spikes in MIP and MEP occur independent of immediate muscle hypertrophy. These rapid early gains indicate an enhanced central drive, optimized firing rates of the phrenic, intercostal nerves and a reduction in co-contraction of antagonistic respiratory muscles.¹⁰ As neuromechanical efficiency improves, the patient's subjective perception of effort, or dyspnea, decreases proportionally, as the brain perceives less mechanical output is required to achieve a desired ventilatory volume.²

Mechanism Category	Specific Physiological Adaptation	Second-Order Functional Consequence
Hemodynamic	Attenuation of the respiratory metaboreflex via delayed type IV afferent activation.	Preservation of peripheral locomotor blood flow; delayed onset of peripheral limb fatigue during exercise.
Morphological	Diaphragmatic hypertrophy and structural remodeling of intercostal musculature.	Enhanced absolute force generation capability (clinically verifiable via elevated MIP and MEP values).
Metabolic	Increased oxidative enzyme activity and enhanced capillary density in the diaphragm.	Enhanced lactate buffering and clearance; delayed onset of localized respiratory muscle fatigue.
Neural	Optimized phrenic motor unit recruitment and synchronized neuromechanical coupling.	Increased mechanical efficiency of the respiratory pump; significantly reduced subjective perception of dyspnea.

3. RMT in Clinical Rehabilitation: Chronic Cardiopulmonary Diseases

For athletes, RMT is a performance tool. For clinical populations it is a restorative therapy. Respiratory muscle weakness is associated with higher mortality, more frequent hospitalization, and reduced quality of life in chronic cardiopulmonary and neurological conditions.

In the pathology of chronic heart failure (CHF), respiratory muscle myopathy is a recognized systemic consequence of chronically poor cardiac output, peripheral hypoperfusion, and persistent low-grade systemic inflammation. A recent meta-analysis, encompassing 15 randomized controlled trials and 494 cases, supports IMT as an adjuvant therapy for CHF patients.⁷ IMT yielded a substantial mean difference increase in MIP by 16.36 cmH₂O and significantly enhanced peak oxygen uptake (VO₂peak) by 1.66 mL/kg/min.⁷ The six-minute walk test (6MWT) distance increased by a mean of 37.40 meters.⁷ These functional gains were accompanied by a marked reduction in the Borg dyspnea index (-0.63) and a significant improvement in overall quality of life scores.⁷ Furthermore, IMT precipitated a significant reduction in N-terminal pro-brain natriuretic peptide (NT-proBNP) levels, a primary biomarker for myocardial wall stress.⁷

In Chronic Obstructive Pulmonary Disease (COPD), chronic lung hyperinflation flattens the dome of the diaphragm, placing it at a severe length-tension disadvantage. Systematic overviews confirm that IMT in COPD patients resulted in an increase of 35.7 meters in the 6MWD and an increase of 10.9 cmH₂O in MIP.¹⁵ Combinations of short bouts of interval training alongside normocapnic hyperpnea have proven highly effective.⁹ Similarly, for patients managing asthma, IMT utilizing progressive pressure threshold loading increases maximal inspiratory pressure improving by nearly 30%.¹⁷ RMT in asthmatic populations is associated with improved lung function parameters, specifically increasing the forced expiratory volume in the first second (FEV₁) by 3.3% of the predicted value and forced vital capacity (FVC) by 4.1% of the predicted value.¹⁵

The utility of RMT extends across other chronic respiratory diseases. In Pulmonary Hypertension, IMT has been shown to yield a 39.0-meter increase in the 6MWD.¹⁵ Patients with Obstructive Sleep Apnea (OSA) demonstrate a significant increase in MIP by 29.6 cmH₂O following training.¹⁵

4. RMT in Neurological and Neuromuscular Rehabilitation

Neurological insults present a distinctly different etiology for respiratory dysfunction, stemming from disrupted descending motor pathways and central nervous system damage.

In stroke survivors, resulting hemiparesis often extends to the trunk and respiratory muscles. Trials exploring IMT in stroke patients specifically targeting training at 50% of the patient's maximal inspiratory pressure show a dual benefit: directly improving forced vital capacity, FEV₁, and diaphragmatic thickness, but fundamentally enhancing balance control.¹⁸ By augmenting the diaphragm's structural integrity, patients directly improve intra-abdominal pressure regulation, translating to improved trunk stability and a reduced risk of falls.¹⁸

For patients sustaining cervical spinal cord injuries (SCI), the loss of innervation to intercostal and abdominal muscles increases the risk of mortality from secondary pneumonia due to an inability to generate a forceful cough.¹⁹ Meta-analytical data confirms IMT significantly increases maximal inspiratory pressure by a mean difference of 12.13 cmH₂O, maximal expiratory pressure by 8.98 cmH₂O, and vital capacity by 0.25 Liters.²⁰ The clinical ability to generate higher MEP directly correlates with peak cough flow.

In progressive neuromuscular diseases (NMD), including ALS and Duchenne muscular dystrophy, pooled data suggests RMT improves forced vital capacity (SMD 0.40) and both MIP and MEP (SMD 0.53 and 0.70, respectively).²³ Meticulously tailored, low-intensity IMT programs may preserve vital respiratory function longer than standard care, delaying the absolute necessity for mechanical insufflation-exsufflation devices.²⁴

5. Rehabilitation of Post-COVID-19 Syndrome

Post-COVID-19 condition is frequently associated with persistent dyspnea, fatigue, and reduced exercise tolerance. Over 50% of severe COVID-19 survivors display profound inspiratory and expiratory muscle weakness.⁸

Systematic reviews and meta-analyses synthesizing data from 7 RCTs and 449 participants demonstrate that IMT, particularly when strategically combined with multicomponent physical training (MPT), shows consistent benefit.²⁵ Typical IMT interventions yield statistically significant improvements in inspiratory muscle strength and maximal oxygen consumption (VO₂max).²⁵ By directly strengthening the diaphragm, IMT reduces the central neural drive required for resting and exertional ventilation, which subsequently lowers resting sympathetic tone, reduces the physiological perception of fatigue, and vastly improves the patient's capacity to return to activities of daily living.⁸

6. Intensive Care: Weaning from Mechanical Ventilation

Prolonged mechanical ventilation induces rapid ventilator-induced diaphragm dysfunction (VIDD). Proteolysis and structural muscle atrophy can begin within 6 hours of controlled ventilation.¹² By implementing IMT directly via the endotracheal tube or tracheostomy, clinicians seek to rebuild the metabolic and structural capacity of the diaphragm prior to extubation.

Current meta-analyses reveal that IMT successfully and significantly increases MIP and drastically decreases the Rapid Shallow Breathing Index (RSBI).²⁷ Pushing PI max (MIP) to values more negative than -30 cmH₂O improves the likelihood of successful extubation.¹² Patients with the greatest baseline weakness appear to benefit most, with improved 60-day survival rates.²⁸

7. RMT in Healthy Aging and Geriatrics

The physiological aging process involves sarcopenia, which impairs ventilatory efficiency in the elderly.³⁰ Home-based IMT protocols can slow age-related physiological decline.²⁶ Older adults partaking in IMT demonstrate substantial increases in functional and exercise capacity, improvements in lower extremity muscle strength, and enhanced overall postural balance.³²

8. RMT as an Ergogenic Aid in Athletic Performance

While rehabilitation focuses on restoring baseline function, RMT is a proven ergogenic strategy in elite athletic conditioning programs.

Swimming poses specific respiratory demands due to hydrostatic pressure and restricted breathing windows. Meta-analyses show a significant effect of IMT on swimming performance.³⁰ Athletes exhibit extended periods of apnea, increased immersion time, and superior overall swimming endurance due to a delay in respiratory muscle fatigue.³⁰

Team sports (soccer, basketball, rugby) require athletes to perform repeated high-intensity actions. The introduction of inspiratory pressure threshold loading (IPTL) has been shown to significantly enhance intermittent exercise performance.

Athlete Population	Protocol Details	Performance Outcome Improvement
Soccer & Rugby	IPTL, 6 weeks, 50% MIP, 30 reps / 2x daily	7% improvement in Repeated Sprint Ability (RSA)
Soccer & Rugby	IPTL, 6 weeks, 50% MIP, 30 reps / 2x daily	16% improvement in Yo-Yo Intermittent Recovery Test (YYT)
Female Soccer	IPTL, 5 weeks, 50% MIP, 30 reps / 2x daily	17% improvement in Repeated Sprint Ability (RSA)
Wheelchair Basketball	IPTL, 12 weeks, 50% MIP, 5 sets of 10 reps	18% improvement in Yo-Yo Intermittent Recovery Test (YYT)

By facilitating deeper, more mechanically efficient ventilation during brief recovery windows, athletes clear carbon dioxide more effectively, buffering blood hydrogen ions and attenuating systemic responses such as blood lactate accumulation.³

In High-Intensity Functional Training (HIFT) like CrossFit, adding RMT significantly enhances sport-specific performance and augments inspiratory strength well beyond standard regimens.³²

9. Discussion

The literature consistently shows that outcomes depend on the precision of training protocols and appropriate device selection. Major results across heterogeneous populations consistently demonstrate that RMT enhances respiratory muscle strength (MIP/MEP) and attenuates systemic fatigue.

However, the interpretation of effectiveness is occasionally hampered by the variable methodological quality and heterogeneity in clinical outcomes across studies. Intervention characteristics vary widely, with protocols ranging from short acute bouts to 12-week programs, utilizing vastly different device types (pressure-threshold vs. flow-volumetric). For instance, in Neuromuscular Diseases and Intensive Care weaning, small sample sizes and inherent disease progression frequently reduce the certainty of evidence.

The physiological mechanisms responsible for these effects are becoming better understood: RMT functions fundamentally by manipulating the central nervous system's response to fatigue. Unlike simple supplementary breathing exercises, targeted threshold loading rebuilds metabolic and structural capacity, functioning as an ergogenic aid in athletes and a restorative therapy in clinical populations. As technology advances, the transition toward smart, electronic devices has improved compliance monitoring and enabled tele-rehabilitation.

10. Practical Applications

Evidence-based protocols for RMT can be organized as follows:

- **Strength-Oriented Interventions:** To induce maximal force generation, high-intensity, low-volume training is required. The consensus protocol involves performing exactly 30 inspiratory maneuvers, twice a day, five to seven days a week, at an intensity set between 50% and 80% of the individual's MIP.³ Progressive overload must be strictly maintained through weekly reassessments.
- **Endurance-Oriented Interventions:** Voluntary Isocapnic Hyperpnea (VIH) should be utilized specifically to improve fatigue resistance, sustaining high-level minute ventilation for 20 to 40 minutes every other day.³
- **Device Selection:** Mechanical threshold devices (e.g., spring-loaded valves) are overwhelmingly recommended for clinical settings (stroke, SCI) due to cost-effectiveness and non-flow-dependent resistance. Electronic variable digital resistance devices with real-time biofeedback are highly recommended for elite athletes and precise remote clinical monitoring.

11. Conclusions

Overall, current evidence suggests that respiratory muscle training can improve inspiratory muscle strength, reduce dyspnea, and contribute to better exercise tolerance in both clinical and athletic populations. The primary physiological driver is RMT's capacity to induce structural hypertrophy within the diaphragm and delay the activation of the respiratory metaboreflex, preserving peripheral locomotor blood flow.

In clinical realms, IMT improves vital capacity, restores foundational core stability in neurological populations, reverses ventilator-induced diaphragm dysfunction in critical care, and resets autonomic dysfunction in post-COVID-19 syndrome. In athletics, it improves repeated sprint ability and endurance.

Further studies should focus on standardizing training protocols and reporting outcomes in a comparable manner to facilitate meta-analytical evaluation.

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REFERENCES

1. StatPearls Publishing. (2024). *Respiratory muscle strength training*. StatPearls Publishing. <https://www.ncbi.nlm.nih.gov/books/NBK603753/>
2. Sheel, A. W. (2002). Respiratory muscle training in healthy individuals: Physiological rationale and implications for exercise performance. *Sports Medicine*, 32(9), 567–581. <https://doi.org/10.2165/00007256-200232090-00003>
3. Illi, S. K., Held, U., Frank, I., & Spengler, C. M. (2012). Effect of respiratory muscle training on exercise performance in healthy individuals: A systematic review and meta-analysis. *Sports Medicine*, 42(8), 707–724. <https://doi.org/10.1007/BF03262290>
4. McConnell, A. K. (2013). *Respiratory muscle training: Theory and practice*. Elsevier.
5. Göhl, O., et al. (2016). Respiratory muscle training: State of the art. *Journal of Respiratory Medicine*. <https://doi.org/10.1055/s-0041-109312>
6. Nóbrega Júnior, J. C., Brandão, D., Xavier, D., Torres, R., Brandão, S. S., Formiga, M., & Dornelas de Andrade, A. (2026). Respiratory rehabilitation after COVID-19: Efficacy of inspiratory muscle training on lung function, quality of life and sleep quality: A randomized clinical trial. *COVID*, 6(1), Article 22. <https://doi.org/10.3390/covid6010022>
7. Yang, M., et al. (2025). Effect of inspiratory muscle training in patients with chronic heart failure. *Journal of Thoracic Disease*. <https://doi.org/10.37766/inplasy2025.5.0062>
8. ClinicalTrials.gov. (2022). *Effects of aerobic exercise in patients with post-COVID-19 (NCT05231408)*. <https://clinicaltrials.gov/study/NCT05231408>
9. Weiner, P., Magadle, R., Beckerman, M., Weiner, M., & Berar-Yanay, N. (2003). Comparison of specific expiratory, inspiratory, and combined muscle training programs in COPD. *Chest*, 124(4), 1357–1364. <https://doi.org/10.1378/chest.124.4.1357>
10. Sapienza, C. M., & Wheeler, K. (2006). Respiratory muscle strength training: Functional outcomes versus plasticity. *Seminars in Speech and Language*, 27(4), 236–244. <https://doi.org/10.1055/s-2006-955118>
11. HajGhanbari, B., Yamabayashi, C., Buna, T., Coelho, J., Freedman, K., Morton, T., Palmer, S., Toy, M., Walsh, C., Sheel, A. W., & Reid, W. D. (2013). Effects of respiratory muscle training on performance in athletes: A systematic review with meta-analyses. *Journal of Strength and Conditioning Research*, 27(6), 1643–1663. <https://doi.org/10.1519/JSC.0b013e318269f73f>

12. Dres, M., & Demoule, A. (2018). Weaning failure and respiratory muscle function. *Current Opinion in Critical Care*, 24(1), 45–52. <https://doi.org/10.1097/MCC.0000000000000478>
13. Oczkowski, S., et al. (2024). Inspiratory muscle training in patients with post-COVID-19 condition: Considerations on efficacy, safety, and patient perception. *American Journal of Respiratory and Critical Care Medicine*. <https://doi.org/10.1164/rccm.202405-0903ED>
14. Li, H., Tao, L., Huang, Y., Li, Z., & Zhao, J. (2022). Inspiratory muscle training in patients with heart failure: A systematic review and meta-analysis. *Frontiers in Cardiovascular Medicine*, 9, Article 993846. <https://doi.org/10.3389/fcvm.2022.993846>
15. Torres-Castro, R., Caicedo-Trujillo, S., Gimeno-Santos, E., Gutiérrez-Arias, R., Alsina-Restoy, X., Vasconcello-Castillo, L., ... Vilaró, J. (2025). Effectiveness of inspiratory muscle training in patients with a chronic respiratory disease: An overview of systematic reviews. *Frontiers in Sports and Active Living*, 7, Article 1549652. <https://doi.org/10.3389/fspor.2025.1549652>
16. Vogiatzis, I. (2011). Strategies of muscle training in very severe COPD patients. *European Respiratory Journal*, 38(2), 339–345. <https://doi.org/10.1183/09031936.00075011>
17. Lista-Paz, A., Bouza Cousillas, L., Jácome, C., Fregonezi, G., Labata-Lezaun, N., Llurda-Almuzara, L., & Pérez-Bellmunt, A. (2023). Effect of respiratory muscle training in asthma: A systematic review and meta-analysis. *Annals of Physical and Rehabilitation Medicine*, 66(3), Article 101691. <https://doi.org/10.1016/j.rehab.2022.101691>
18. Liu, F., Jones, A. Y. M., Tsang, R. C. C., Yam, T. T. T., Hao, Y., & Tsang, W. W. N. (2025). Effects of inspiratory muscle training on pulmonary function, diaphragmatic thickness, balance and exercise capacity in people after stroke: A systematic review and meta-analysis. *Disability and Rehabilitation*, 47(12), 2981–2996. <https://doi.org/10.1080/09638288.2024.2408606>
19. Woods, A., Gustafson, O., Williams, M., & Stiger, R. (2023). The effects of inspiratory muscle training on inspiratory muscle strength, lung function and quality of life in adults with spinal cord injuries: A systematic review and meta-analysis. *Disability and Rehabilitation*, 45(17), 2703–2714. <https://doi.org/10.1080/09638288.2022.2107085>
20. Lee, J., et al. (2025). The effects of inspiratory muscle training in individuals with cervical spinal cord injuries: A systematic review and meta-analysis. *Annals of Rehabilitation Medicine*. <https://doi.org/10.5535/arm.250013>
21. Watson, K., Egerton, T., Sheers, N., Retica, S., McGaw, R., Clohessy, T., Webster, P., & Berlowitz, D. J. (2022). Respiratory muscle training in neuromuscular disease: A systematic review and meta-analysis. *European Respiratory Review*, 31(166), Article 220065. <https://doi.org/10.1183/16000617.0065-2022>
22. Khan, A., Frazer-Green, L., Amin, R., Wolfe, L., Faulkner, G., Casey, K., Sharma, G., Selim, B., Zielinski, D., Aboussouan, L. S., McKim, D., & Gay, P. (2023). Respiratory management of patients with neuromuscular weakness: An American College of Chest Physicians clinical practice guideline and expert panel report. *Chest*, 164(2), 394–413. <https://doi.org/10.1016/j.chest.2023.03.011>
23. Xavier, D. M., Abreu, R. A. L., Corrêa, F. G., Silva, W. T., Silva, S. N., Galvão, E. L., & Nascimento Junior, M. G. (2024). Effects of respiratory muscular training in post-COVID-19 patients: A systematic review and meta-analysis of randomized controlled trials. *BMC Sports Science, Medicine and Rehabilitation*, 16, Article 181. <https://doi.org/10.1186/s13102-024-00954-x>
24. Li, Z., et al. (2025). Advances in home-based respiratory muscle training for improving physical function in older adults with long COVID. *Frontiers in Physiology*. <https://doi.org/10.3389/fphys.2025.1662537>
25. Silva, I., et al. (2025). Inspiratory muscle training and its impact on weaning success in mechanically ventilated ICU patients: A systematic review. *Journal of Functional Morphology and Kinesiology*. <https://doi.org/10.3390/jfmk10020111>
26. Chen, L., et al. (2025). Inspiratory muscle training in weaning from prolonged mechanical ventilation: A systematic review and meta-analysis. *Frontiers in Medicine*. <https://doi.org/10.3389/fmed.2025.1719837>
27. Gökçelik, E., et al. (2025). Effect of inspiratory muscle training on diaphragm and abdominal wall muscle thickness with fatty liver density in elderly women: A randomized controlled trial. *Medicina*. <https://doi.org/10.3390/medicina61101784>
28. Konca, E., et al. (2026). Short-term inspiratory muscle training enhances functional and metabolic health in older adults. *Healthcare*. <https://doi.org/10.3390/healthcare14020249>
29. ClinicalTrials.gov. (2023). *Inspiratory muscle training on balance, falls and diaphragm thickness in the elderly (NCT06143592)*. <https://clinicaltrials.gov/study/NCT06143592>
30. Jakubovskis, G., et al. (2025). The effect of respiratory muscle training on swimming performance: A systematic review and meta-analysis. *Frontiers in Physiology*. <https://doi.org/10.3389/fphys.2025.1638739>
31. Kowalski, T., Granda, D., & Klusiewicz, A. (2022). Practical application of respiratory muscle training in endurance sports. *Strength and Conditioning Journal*. <https://doi.org/10.1519/SSC.0000000000000842>
32. Andrade Assis, A., et al. (2025). Effects of respiratory muscle training on performance and inspiratory strength in female CrossFit athletes: A randomized controlled trial. *Physiologia*. <https://doi.org/10.3390/physiologia5040039>