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Targeted Physiotherapy Treatment Approaches to Treat Diaphragmatic Dysfunction in Various Conditions: A Comprehensive Review

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Abstract

The term Diaphragm Dysfunction (DD) refers to a group of disorders in which the diaphragm does not function optimally, thereby impairing the breathing mechanism. This review aims to report available treatment protocols for diaphragm rehabilitation over the last 5 years.

Method: Comprehensive studies on DD were searched in online databases from 2016 – 2025. The search was conducted using databases such as Scopus, PubMed, Google Scholar, Clinical Key, Medline, etc. 10 articles met the inclusion criteria. These articles were studied thoroughly by the authors, and the analysis was documented in this literature review.

Result: The articles that were included in the review used a wide variety of outcome measures; commonly used were ultrasonography, 6-minute walk test (6-MWT), pulmonary function, etc. Different techniques, including breathing exercises, manual therapy, acupuncture, electrical stimulation, etc, were used as interventions. DD significantly impact the quality of life and respiratory function in individuals.

Conclusion: Physiotherapy-based interventions mentioned in this study show a positive effect in improving the strength and endurance of the diaphragm and overall respiratory mechanics. Short-term benefits are seen; further research is needed to establish protocols and evaluate long-term effects.

Keywords: *Breathing exercise, diaphragm dysfunction, manual therapy, ultrasonography.*

1. Introduction:

The diaphragm separates the thoracic and abdominal cavities. It is an important muscle that is responsible for breathing and is regulated by the phrenic nerves, which have their origin from the C3 to C5 spinal roots(1). Diaphragmatic dysfunction (DD) commonly occurs when there is a problem in the diaphragmatic muscles or the phrenic nerve. This dysfunction may range from a partial reduction in

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pressure generation due to muscle weakness to complete loss of function resulting from diaphragmatic palsy(2). Disorders that impair the contractile properties of the diaphragm muscle, neural innervation, or its mechanical linkage to the chest wall can result in DD. DD is associated with common respiratory symptoms like dyspnoea, decreased exercise tolerance, sleep disturbances, hypersomnia, etc.

In severely ill patients, mainly those on mechanical ventilation, diaphragm weakness can develop due to many reasons. One major factor is ventilator-induced diaphragm inactivity-when the diaphragm is not actively used due to the ventilator taking over the primary role of breathing. This reduction in movement can lead to diaphragm muscle atrophy and reduced function of the diaphragm over time. This causes reduced muscle use & can therefore lead to significant diaphragm dysfunction(1).

Difficulty in weaning from a ventilator can result from overall muscle weakness caused by prolonged critical illness, such as sepsis. Additionally, the use of systemic corticosteroids and neuromuscular blocking agents has been linked to challenges in discontinuing mechanical ventilation (3). Critical illness-related diaphragm dysfunction reduces the respiratory pump's ability to handle the increased workload caused by lung injury and fluid accumulation, which can result in prolonged respiratory failure and, ultimately, death(1).

Theoretically, any patient who needs mechanical ventilation is at risk for developing diaphragm weakness. However, certain clinical situations indicate the possibility of diaphragm abnormalities(4).

The presence of Abdominal paradox is a major indicator of severe diaphragm muscle weakness or bilateral diaphragm muscle paralysis. In such cases, there's contraction of intercostal muscles during inhalation, which causes the weakened diaphragm to move upward, resulting in the downward motion of the abdominal wall. While many healthcare providers believe ICU-acquired diaphragm weakness is temporary and doesn't significantly impact patient outcomes, recent studies suggest that diaphragm strength plays a crucial role in both the duration of mechanical ventilation weaning and ICU mortality rates. Ventilator-induced diaphragm dysfunction refers to the decrease in the diaphragm's ability to generate force, which is directly caused by the use of mechanical ventilation(1).

2. Material and Methodology:

Search terms and database

The keywords used for the research were "diaphragm dysfunction" and "Recent advances in physiotherapy". Various search engines such as PubMed, Google Scholar etc.

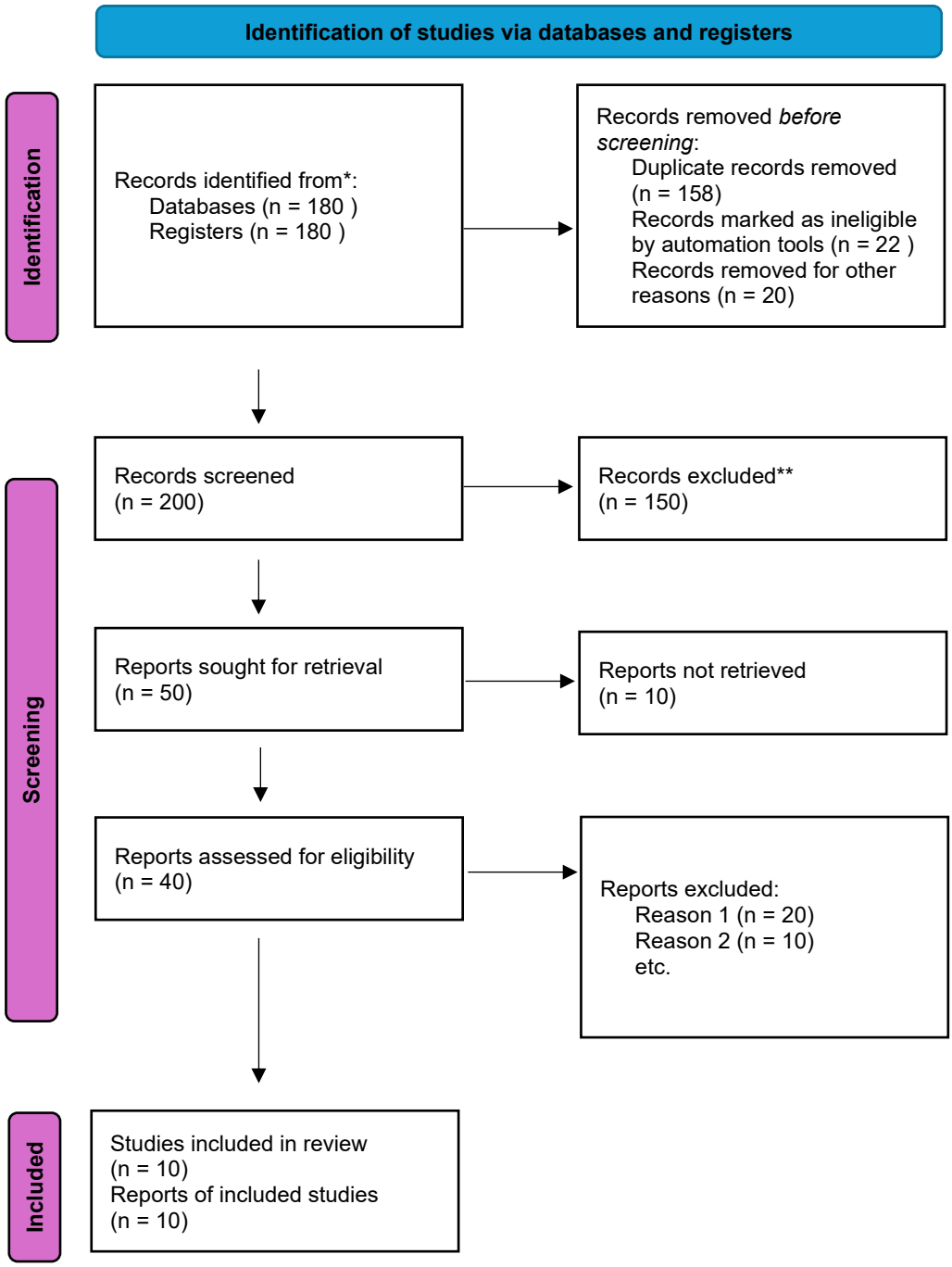


Figure 1 showing Prisma flowchart of the studies included in the review.

Study selection

The studies selected here for review were extracted using a systematic methodology, which has been explained as follows.

Data extraction

The total articles taken were 10, which were reviewed from the years 2016-2025. Articles selected were based on patients who are suffering from diaphragm dysfunction. This included different

techniques like Pilates, acupuncture, Manual therapy, etc.

3. Results:

Sr. no	Year	Author	Title of study	Intervention	Result	analysis
1)	2024	Nesma M. Allam et al.	Effect of Pilates exercises on pulmonary function, respiratory muscle strength, and functional capacity in patients with inhalation injury after flame thermal burn: A prospective randomized controlled trial.	Pilates-based exercise program	The result of the study suggests Pilates-based exercise program showed statistically significant improvement in pulmonary function, respiratory muscle strength, functional capacity in patients with inhalation injury.	It is found that the result and analysis is significant
2)	2023	Clément Medrinal et al.	Transcutaneous electrical diaphragmatic stimulation in mechanically ventilated patients: A randomised study	Transcutaneous Electrical Diaphragm Stimulation (TEDS	TEDS did not prevent diaphragm dysfunction or muscle atrophy, and there were no clinically significant improvements with TEDS.	No significant changes
3)	2023	Dimitrios Tsimouris et al.	The effect of manual therapy on diaphragm function in adults with asthma: Protocol for a randomized controlled trial	Manual therapy: MDRT (Manual Diaphragmatic Release Therapy) BRE (Breathing Retraining Exercises)	The study found that Manual Diaphragmatic Release Therapy (MDRT) improves diaphragm movement and respiratory function in asthma patients, making it an effective intervention.	It is found that the result and analysis is significant
4)	2023	Xin-yu Gan et al.	Early passive orthostatic training prevents diaphragm atrophy and dysfunction in	Early passive orthostatic training	Early passive orthostatic training with a tilt table preserves diaphragmatic	It is found that the result and analysis is

			intensive care unit patients on mechanical ventilation: A retrospective case-control study.		function and may improve respiratory outcomes in ICU patients on mechanical ventilation.	significant
5)	2022	Petros I. Tatsios et al.	The effectiveness of manual therapy in the cervical spine and diaphragm, in combination with breathing re-education exercises, in patients with Non-Specific chronic neck pain: Protocol for development of outcomes measure and a randomized controlled trial.	Cervical Manual Therapy (CMT) Diaphragmatic Manual Therapy (DMT) Breathing Re-education Exercises (BREx)	The result of this study suggests diaphragmatic release and breathing re-education can reduce pain and improve function in NSCNP patients.	It is found that the result and analysis is significant
6)	2022	Qiang Bao et al.	The effect of external diaphragmatic pacing on diaphragm function and weaning outcomes of critically ill patients with mechanical ventilation: A prospective randomized study.	Electrical diaphragm pacing	The results of this study suggest that **EDP therapy** can effectively reduce the time required for weaning and improve the chances of successful simple weaning in patients on mechanical ventilation.	It is found that the result and analysis is significant
7)	2021	Yuan SC et al.	Effect of acupuncture on diaphragmatic function in patient with AECOPD type II respiratory failure evaluated by ultrasound detection.	Acupuncture on diaphragmatic function	Acupuncture improves diaphragmatic function, oxygenation, and reduces ventilation and hospitalization time in AECOPD type II respiratory failure.	It is found that the result and analysis is significant
8)	2021	Surussawadi Bennett et al.	Effectiveness of the manual diaphragmatic stretching technique	Manual Diaphragmatic Stretching Technique (MDST)	A significant improvement in diaphragmatic mobility and chest	It is found that the result and

			on respiratory function in cerebral palsy: A randomized controlled trial.		expansion after six weeks of manual diaphragmatic stretching in spastic CP patients.	analysis is significant
9)	2021	Zehua Dong et al.	Early rehabilitation relieves diaphragm dysfunction induced by prolonged mechanical ventilation: A randomized control study.	The following rehabilitation was given : • **Level 0**: Turning unconscious patients every 2 hours. • **Levels 1–2**: Turning, joint range of motion exercises, and proper limb positioning for conscious patients who could sit up for 20 minutes, 3 times a day. • **Level 3**: Sitting on the edge of the bed with upper-limb anti-gravity training. • **Level 4**: Standing or sitting in a chair for 20 minutes daily, with lower-limb anti-gravity training. • **Level 5**: Patients actively moving from the bed and	Early rehabilitation improves diaphragm function and may aid in earlier ventilator weaning and extubation in ICU patients with prolonged MV.	It is found that the result and analysis is significant

				walking beside it.		
10)	2020	Hyun Sik Yoona et al.	Effects of dynamic core-postural chain stabilization on diaphragm movement, abdominal muscle thickness, and postural control in patients with subacute stroke: A randomized control trial.	Compare DNS (Dynamic neuromuscular stabilization) with NDT (Neurodevelopmental treatment)	The trial shows DNS training is more effective than NDT for improving postural control through diaphragm activation in hemiparetic stroke patients.	It is found that the result and analysis is significant

The aim is to identify different physiotherapy treatment approaches to treat DD in various conditions, to identify existing evidence and to focus on further investigation. In these 10 articles, various treatments related to DD have been discussed and reviewed

This entire review article is related to physiotherapy interventions to treat DD in various conditions.

In 2024, Nesma M. Allam et al. used a Pilates-based exercise program to improve pulmonary function in patients with inhalation injury and significant improvement was seen(5). In 2023, Clement Medrinal et al. used transcutaneous electrical diaphragm stimulation (TEDS) for treating diaphragm dysfunction and found that TEDS didn't show any significant improvement. Whereas in the same year, Xin-yu Gan, the intervention given was early passive orthostatic training on a tilt table, which improved diaphragmatic function in the patient(6,7). In 2022, Qiang Bao et al. used electrical diaphragm pacing to treat diaphragm dysfunction, and significant improvement was seen(8). In 2021, Zehua Dong et al. gave early mobilisation to improve diaphragm dysfunction, and it was incorporated in 5 levels and showed significant improvement in diaphragm function in patients; along with that, one more study, in the same year, conducted by Yuan SC he gave acupuncture on diaphragmatic function as an intervention, and it improved oxygenation and diaphragm function(9,10). In 2020, Yoona HS et al. took 2 interventions, i.e DNS with NDT and compared which is more effective in treating diaphragm dysfunction. We found that DNS was effective and helped in improving posture control through diaphragm activation in a hemiparetic stroke patient(11). In 2021, Surussawadi Bennett et al. reported the positive effect of the manual diaphragmatic stretching technique in 2022, whereas Petros I. Tatsios et al. and Dimitrios Tsimouris et al. published a protocol for Manual Diaphragmatic Release Therapy. These protocols give a framework but do not report outcomes of treatment. (12–14).

The reviewed studies conclude by highlighting the variety of physiotherapy techniques used to treat DD in different circumstances. Every therapeutic modality shows promise in enhancing diaphragm function and associated results, from Pilates and acupuncture to manual therapy and transcutaneous electrical diaphragmatic stimulation. Despite the encouraging outcomes of certain treatments, such as external diaphragmatic pacing and manual therapy, others, including transcutaneous electrical diaphragmatic stimulation, require further research. Large-scale trials to evaluate the long-term efficacy of physiotherapy for DD should be the main focus of future research. Understanding the processes of improvement in illnesses like AECOPD, combining manual therapy and Pilates, and determining the

best treatment parameters are important areas. In order to customize interventions and enhance results, patient-specific aspects should also be taken into account.

4. Discussion:

This review aims to identify different physiotherapy treatments used to treat DD in various conditions. It focuses on existing evidence and explains how they help in improving diaphragm dysfunction and where more research is needed.

A study on patients with inhalation injury following a flame thermal burn was done to assess the effect of Pilates exercise on pulmonary function and the strength of the respiratory muscles. We see intervention were found to be effective, here author conclude that the focus was on controlled breathing, core muscle activation and postural alignment, which helped in strengthening the diaphragm and respiratory muscles. The breathing technique used in Pilates helped improve diaphragm movement, rib cage expansion, and lung ventilation. It also reduces the restrictive effect and stiffness of the chest wall caused by burns. The coordination between mind-body and neuromuscular control developed through Pilates helped to improve breathing patterns and posture. We also see improvement in the 6-minute walk distance, which enhanced endurance, aerobic capacity, and circulation(5). Another study done on mechanically ventilated patients to assess the impact of TEDS on diaphragm dysfunction found that interventions like TEDS didn't have any significant improvement, as it did not improve diaphragm function, as it only stimulated superficial muscle fibres beneath the electrode and did not recruit the whole diaphragm. Because of weak, unsynchronised and short-duration contractions, the stimulation sessions were short and not synchronised with inspiration, which caused limited physiological activation and the phrenic nerve, which helps in activating the diaphragm, was not recruited; hence, TEDS did not prevent DD(6). Manual therapy techniques are used in the treatment of diaphragm dysfunction, which include (MDRT, DMT, MDST). These techniques have been used to investigate or are proposed for various conditions like asthma, non-specific chronic neck pain and cerebral palsy, as they target the zone of apposition and surrounding structures of the diaphragm. Bennett et al. reported that MSDT had a positive impact on diaphragm mobility and chest expansion in children with CP. The other two studies presented protocols for planned RCT which evaluated diaphragmatic manual therapy in patients with NSNP and asthma, respectively. These protocols provide a rationale for future trials but do not report treatment outcomes(12–14).

Weakness of the diaphragm is very common in ICU patients. A study found that early passive orthostatic training prevents diaphragm atrophy and dysfunction. The patient was made to go from supine to an upright position, causing the gravitational displacement of the diaphragm and abdominal contents, which caused phrenic nerve activation. This results in maintaining diaphragm thickness and function and improved oxygenation, thereby preventing diaphragm weakness(7). Another study says that in critically ill patients with mechanical ventilation, where external diaphragmatic pacing as an intervention was given to wean the patients from the ventilator was found to be effective. EDP directly stimulated the phrenic nerve, which led to rhythmic contraction of the diaphragm, thereby maintaining the diaphragm during mechanical ventilation(8). In ventilated patients with DD, early rehabilitation was found to be effective as it activates the diaphragm and respiratory muscles. Improving contractility and strength of the diaphragm also enhances ventilation efficiency and oxygen exchange, which helps in early weaning(9).

A study on patients with AECOPD type II respiratory failure stated that the acupuncture used was effective as it improved diaphragmatic function by stimulating respiratory-related acupoints, which

enhanced the diaphragm contractility and led to improved gas exchange. The acupuncture points used were: Dingchuan (EX-B1), Feishu (BL13), Taiyuan (LU9), Danzhong (CV17), Zhongwan (CV12). The bedside ultrasound confirmed the improved diaphragmatic activity(10).

Hyun Sik Yoon et al. (2020) conducted a study in patients with subacute stroke to determine the effect of dynamic core posture chain stabilisation on diaphragm movement, abdomen and posture. Comparison between the DNS (dynamic neuromuscular stabilisation) and NDT (neurodevelopmental treatment) was done; we found DNS training is effective as it focuses on coordinated activation of the integrated spinal stabilisation system, which includes the diaphragm, transversus abdominis, internal oblique, pelvic floor and deep spinal stabilisers. It also restored the movement patterns and neuromuscular coordination between the diaphragm and abdominal core muscles. Unlike the NDT, which only focused on trunk muscles(11).

To further support the findings of included studies, additional literature has been included to provide broader clinical context. These studies were not a part of a formal systematic review and are discussed separately to support the included evidence.

A study examined the effect of an 8-week complex training program, including diaphragm training, on deep stabiliser muscles in low back pain. The training group showed significant improvement in diaphragm thickness in the supine position, an increase in thickness of the stabiliser muscles and improvement in VAS pain. This supports the diaphragm's dual role in respiration and postural control. Improving diaphragm strength can contribute to lumbar stability, regulate intra-abdominal pressure and improve trunk stiffness(15).

Evaluating the AECOPD patients by comparing graded exercises with conventional rehabilitation. Graded exercise rehabilitation had improvement in 6MWT, improved clinical outcomes, reduced NIV, and reduced hospital stay duration. They also improved diaphragm thickening fraction and diaphragm mobility, which indicated improved mechanical disadvantage and respiratory muscle fatigue. A strong correlation between improvement of diaphragm mobility and 6MWT provides strong evidence that improving diaphragm mobility improves activity tolerance in AECOPD(16).

Diaphragm-targeted myofascial release (MFR) on patients with GRED. The study reports significant improvement in patients with GRED; there was improvement in the severity and frequency of the disease with improved quality of life and reduced use of a proton pump inhibitor. It is effective because it may increase the pressure at the esophagogastric junction (EGJ), which makes the valves between the stomach and esophagus close better, and this reduces the reflux, improving diaphragm mobility and breathing. It also stimulates the vagus nerve around the crural diaphragm, reducing the pain signal(17).

Ebtesam N Nagy et al (2022) studied selected men with persistent symptoms of Post COVID-19 syndrome and compared the manual diaphragmatic release plus inspiratory muscle training versus only inspiratory muscle training. In the combined group, there was improvement in respiratory muscle function and blood pressure, which suggests of autonomic and cardiovascular regulation. Other improvements were in dyspnea, fatigue and 6MWT; this support diaphragmatic release enhances the benefits of IMT in post-COVID patients(18).

5. Conclusion:

This study emphasizes how various physiotherapy interventions can significantly improve DD in various conditions. A summary of research says that different approaches, like Manual therapy, DNS, external diaphragmatic pacing (EDP), acupuncture, and passive orthostatic training, Pilates-based exercise program, etc show promising results in enhancing diaphragm mobility and function; however, TEDS did not show significant benefits. These interventions show potential; further research is needed to optimise protocols and assess long-term outcomes.

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Conflicts of interest- There are no conflicts of interest.

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