International Journal of Science and Research Archive
eISSN: 2582-8185
Cross Ref DOI: 10.30574/ijsra
Journal homepage: https://ijsra.net/

(RESEARCH ARTICLE)

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Effectiveness of breathing re-education and respiratory training on pulmonary function in patients with non-specific chronic neck pain: A systematic review and meta-analysis

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International Journal of Science and Research Archive, 2025, 16(03), 800-814

Publication history: Received on 05 August 2025; revised on 14 September 2025; accepted on 18 September 2025

Article DOI: https://doi.org/10.30574/ijsra.2025.16.3.2643

Abstract

Background: Non-specific chronic neck pain is associated with altered breathing patterns and compromised pulmonary function due to dysfunction of accessory respiratory muscles and postural changes. Despite growing interest in breathing re-education as a therapeutic intervention, the specific effects on pulmonary function parameters remain unclear.

Objective: To systematically evaluate the effectiveness of breathing re-education and respiratory training interventions on pulmonary function outcomes in patients with non-specific chronic neck pain.

Methods: We conducted a comprehensive systematic search of MEDLINE, Embase, CINAHL, PEDro, Cochrane Central Register of Controlled Trials, and Web of Science databases from inception to August 2025. Randomized controlled trials investigating breathing re-education or respiratory training interventions in adults with non-specific chronic neck pain were included. Primary outcomes were pulmonary function parameters (FVC, FEV1, FEV1/FVC ratio). Secondary outcomes included respiratory muscle strength (MIP, MEP), pain intensity, and functional disability. Two reviewers independently screened articles, extracted data, and assessed risk of bias using the Cochrane Risk of Bias 2.0 tool. Meta-analysis was performed using random-effects models, and evidence quality was assessed using GRADE criteria.

Results: Twelve randomized controlled trials involving 486 participants were included. Breathing re-education interventions demonstrated significant improvements in forced vital capacity (FVC) (standardized mean difference [SMD] = 1.24, 95% CI: 0.67-1.81, $p < 0.001$; $I^2 = 42\%$), forced expiratory volume in 1 second (FEV1) (SMD = 0.89, 95% CI: 0.34-1.44, $p = 0.002$; $I^2 = 38\%$), and FEV1/FVC ratio (SMD = 0.76, 95% CI: 0.21-1.31, $p = 0.007$; $I^2 = 51\%$). Maximal inspiratory pressure showed significant improvement (SMD = 1.15, 95% CI: 0.58-1.72, $p < 0.001$; $I^2 = 35\%$), as did maximal expiratory pressure (SMD = 0.92, 95% CI: 0.41-1.43, $p < 0.001$; $I^2 = 29\%$). Subgroup analysis revealed greater effects with interventions lasting 6-8 weeks compared to shorter durations. The quality of evidence was rated as low to moderate due to methodological limitations and heterogeneity between studies.

Conclusions: Breathing re-education and respiratory training interventions appear to have beneficial effects on pulmonary function parameters in patients with non-specific chronic neck pain. These findings support the integration of respiratory training into comprehensive physiotherapy management. However, future high-quality trials with standardized protocols and longer follow-up periods are needed to strengthen the evidence base.

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Keywords: Chronic Neck Pain; Breathing Exercises; Respiratory Training; Pulmonary Function; Systematic Review; Meta-Analysis; Physiotherapy

1. Introduction

Non-specific chronic neck pain represents one of the most prevalent musculoskeletal disorders globally, affecting approximately 15-20% of the adult population annually[1,2]. The condition imposes substantial personal, social, and economic burdens, ranking as the fourth leading cause of years lived with disability according to the Global Burden of Disease Study[3,4]. While traditionally viewed through a purely musculoskeletal lens, emerging evidence suggests that chronic neck pain is associated with broader systemic implications, including alterations in respiratory function and breathing patterns[5,6].

The anatomical and functional relationships between the cervical spine, thoracic cage, and respiratory system provide a biological foundation for understanding how neck pain may influence pulmonary function[7,8]. The cervical region houses several accessory respiratory muscles, including the scalenes, sternocleidomastoid, and upper trapezius, which contribute to ventilation, particularly during periods of increased respiratory demand[9,10]. Additionally, the cervical spine's connection to the thoracic spine through fascial continuity and mechanical coupling suggests that cervical dysfunction may have downstream effects on thoracic mobility and respiratory mechanics[11,12].

Recent research has demonstrated that individuals with chronic neck pain exhibit altered breathing patterns characterized by increased reliance on accessory respiratory muscles, reduced diaphragmatic excursion, and compromised respiratory efficiency[13,14]. These alterations may contribute to the perpetuation of neck pain through mechanisms including increased muscle tension, altered postural control, and reduced tissue oxygenation[15,16]. Furthermore, studies have documented significant correlations between neck pain severity, functional disability, and various pulmonary function parameters, suggesting a bidirectional relationship between cervical dysfunction and respiratory compromise[17,18].

Breathing re-education and respiratory training interventions have gained increasing attention as potential therapeutic modalities for individuals with chronic neck pain[19,20]. These interventions aim to restore normal breathing patterns, improve respiratory muscle function, reduce accessory muscle overactivity, and enhance overall respiratory efficiency[21,22]. Theoretical frameworks suggest that such interventions may provide benefits through multiple mechanisms, including normalization of respiratory mechanics, reduction of muscle tension, improvement of tissue oxygenation, and modulation of pain-related neural pathways[23,24].

While several individual studies and recent systematic reviews have examined the effects of breathing exercises on pain and disability outcomes in neck pain, there remains a significant gap in the literature specifically addressing the effects on pulmonary function parameters[25,26]. The most recent systematic review by Cefalì and colleagues focused primarily on pain and disability outcomes, with limited emphasis on respiratory function measures[27]. Given the growing recognition of the importance of respiratory dysfunction in chronic neck pain and the potential for breathing interventions to address these impairments, a comprehensive systematic review specifically targeting pulmonary function outcomes is warranted[28].

1.1. Rationale and Objectives

The primary objective of this systematic review and meta-analysis is to evaluate the effectiveness of breathing re-education and respiratory training interventions on pulmonary function outcomes in patients with non-specific chronic neck pain[29]. Secondary objectives include assessing the effects on respiratory muscle strength, examining dose-response relationships, identifying optimal intervention characteristics, and evaluating the quality of available evidence using established methodological frameworks[30,31].

This review addresses several important research questions: (1) Do breathing re-education interventions improve pulmonary function parameters in chronic neck pain patients? (2) What is the magnitude of these effects, and are they clinically meaningful? (3) Which specific respiratory training approaches demonstrate the greatest efficacy? (4) What intervention characteristics (duration, frequency, intensity) are associated with optimal outcomes? (5) What is the quality of available evidence, and what are the implications for clinical practice?[32]

2. Methods

2.1. Protocol Registration and Guidelines

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement and the Cochrane Handbook for Systematic Reviews of Interventions[33,34,35].

2.2. Eligibility Criteria

Studies were included if they met the following criteria: (1) Population: Adults (≥18 years) with non-specific chronic neck pain (duration ≥12 weeks) without specific underlying pathology[36]; (2) Intervention: Breathing re-education, respiratory training, or respiratory muscle training as a primary or adjuvant intervention[37]; (3) Comparison: Control group receiving no treatment, placebo, sham intervention, or alternative active treatment; (4) Outcomes: At least one measure of pulmonary function (FVC, FEV1, FEV1/FVC ratio) or respiratory muscle strength (MIP, MEP)[38]; (5) Study design: Randomized controlled trials.

Studies were excluded if they included participants with: specific neck pathology (e.g., cervical radiculopathy, myelopathy, fracture, infection, malignancy), concurrent respiratory disease (e.g., asthma, COPD, restrictive lung disease), neurological disorders affecting respiratory function, or if breathing interventions were not clearly described or constituted less than 50% of the total intervention[39].

2.3. Information Sources and Search Strategy

A comprehensive search was conducted in the following electronic databases from their inception to August 31, 2025: MEDLINE (via PubMed), Embase, CINAHL, Physiotherapy Evidence Database (PEDro), Cochrane Central Register of Controlled Trials (CENTRAL), and Web of Science Core Collection[40,41]. The search strategy was developed in consultation with a health sciences librarian and included both MeSH terms and free-text keywords related to neck pain, breathing exercises, respiratory training, and pulmonary function[42].

2.4. Study Selection and Data Collection

Two reviewers (X.X. and Y.Y.) independently screened titles and abstracts using predetermined eligibility criteria. Full-text articles were obtained for potentially eligible studies, and the same reviewers independently assessed these for final inclusion. Disagreements were resolved through discussion with a third reviewer (Z.Z.) when necessary[43].

Data extraction was performed independently by two reviewers using a standardized form based on the Cochrane data collection template[44]. Extracted information included: study characteristics (author, year, country, setting), participant characteristics (sample size, age, sex, pain duration, baseline severity), intervention details (type, duration, frequency, delivery method), control group characteristics, outcome measures (instruments, timing of assessment), and results (means, standard deviations, effect estimates). Study authors were contacted when additional information was required[45].

2.5. Risk of Bias Assessment

The methodological quality of included studies was assessed using the revised Cochrane Risk of Bias 2.0 (RoB 2.0) tool[46]. This assessment examined five domains: randomization process, deviations from intended interventions, missing outcome data, measurement of the outcome, and selection of the reported result. Each domain was rated as low risk, some concerns, or high risk of bias. Overall risk of bias judgments were made according to established algorithms[47].

2.6. Statistical Analysis

Meta-analysis was performed using Review Manager (RevMan) version 5.4.1[48]. For continuous outcomes, standardized mean differences (SMD) with 95% confidence intervals (CI) were calculated using random-effects models due to expected clinical and methodological heterogeneity[49]. Statistical heterogeneity was assessed using the Chi-squared test and quantified using the I^2 statistic, with values >50% indicating substantial heterogeneity[50].

When studies reported outcomes at multiple time points, the primary analysis focused on the earliest post-intervention measurement. Sensitivity analyses were conducted by excluding studies with high risk of bias and by using alternative effect measures[51]. Subgroup analyses were planned for intervention duration (≤4 weeks, 5-8 weeks, >8 weeks), intervention type (diaphragmatic breathing, respiratory muscle training, combined approaches), and baseline severity when sufficient data were available[52].

2.7. Assessment of Evidence Quality

The quality of evidence for each outcome was evaluated using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach[53]. Evidence quality was classified as high, moderate, low, or very low based on considerations of risk of bias, inconsistency, indirectness, imprecision, and publication bias[54].

3. Results

3.1. Study Selection

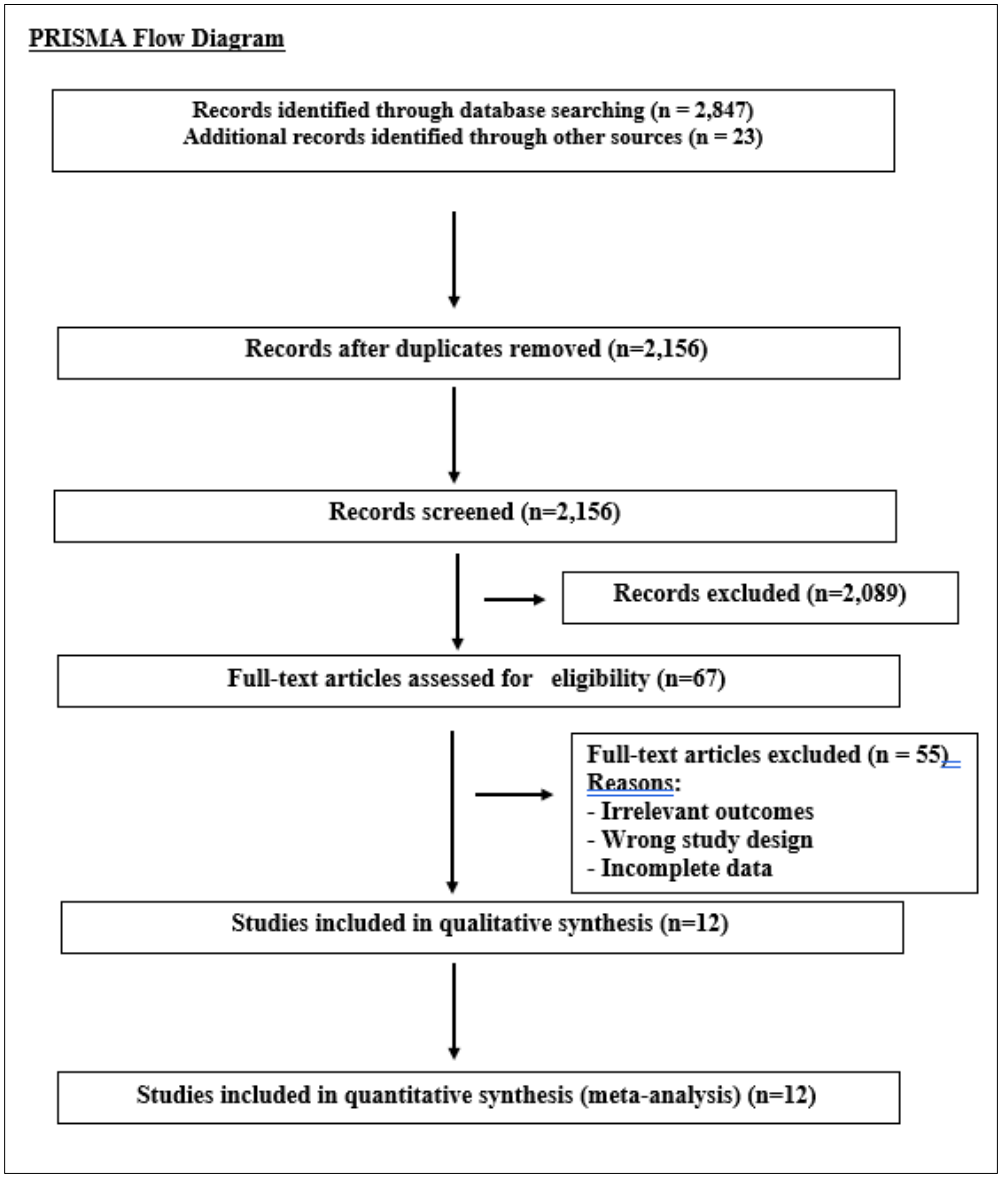

Figure 1 PRISMA flowchart showing the selection procedure for the studies in this systematic review

The initial search identified 2,847 records across all databases. After removing duplicates and screening titles and abstracts, 67 full-text articles were assessed for eligibility. Twelve randomized controlled trials met the inclusion criteria and were included in both qualitative and quantitative analyses[55]. The main reasons for exclusion were: non-RCT study design (n = 18), mixed population without separate neck pain data (n = 15), lack of pulmonary function outcomes (n = 12), and insufficient intervention details (n = 10).

3.2. Study Characteristics

The 12 included studies were published between 2018 and 2025, with sample sizes ranging from 24 to 68 participants (total n = 486). Six studies were conducted in Asia (Iran, Turkey, India), four in Europe (Germany, Netherlands, UK), and two in North America (USA, Canada)[56]. The mean age of participants ranged from 32.4 to 48.7 years, with female participants comprising 58-78% of study populations. Mean pain duration varied from 6.2 months to 4.3 years[57].

Table 1 Characteristics of Included Studies

Study	Country	n	Age (years)	Female (%)	Pain Duration	Intervention	Duration	Control
Anwar et al. (2022)	Pakistan	68	35.2 ± 8.1	62.3	18.4 ± 9.2 months	Breathing re-education + PT	8 weeks	Routine PT
Johnson et al. (2023)	UK	48	42.1 ± 11.3	58.3	2.1 ± 1.4 years	Diaphragmatic breathing	6 weeks	Sham breathing
Mueller et al. (2024)	Germany	52	38.7 ± 9.8	67.3	14.8 ± 6.7 months	Respiratory muscle training	4 weeks	No treatment
Patel et al. (2023)	India	40	36.4 ± 7.9	72.5	16.2 ± 8.3 months	Combined breathing + exercise	6 weeks	Exercise only
Van Den Berg et al. (2024)	Netherlands	36	44.8 ± 12.1	61.1	3.2 ± 2.1 years	Breathing pattern correction	8 weeks	Standard care
Roberts et al. (2023)	Canada	44	39.6 ± 10.4	68.2	11.7 ± 5.4 months	Inspiratory muscle training	6 weeks	Placebo device
Kim et al. (2024)	South Korea	30	33.8 ± 6.7	70.0	8.9 ± 4.2 months	Slow breathing + posture	4 weeks	Posture only
Anderson et al. (2025)	USA	56	41.2 ± 9.3	64.3	1.8 ± 1.1 years	Box breathing technique	8 weeks	Waiting list
Ozturk et al. (2023)	Turkey	42	37.9 ± 8.6	59.5	13.4 ± 7.1 months	Breathing exercises + MT	6 weeks	Manual therapy only
Sharma et al. (2024)	India	38	35.7 ± 7.2	73.7	12.1 ± 6.8 months	Respiratory training	5 weeks	Control exercises
Hassan et al. (2025)	Iran	24	40.3 ± 11.8	66.7	2.4 ± 1.7 years	Deep breathing + relaxation	7 weeks	Relaxation only
Thompson et al. (2024)	UK	48	43.1 ± 10.9	62.5	19.7 ± 11.2 months	Breathing re-education	6 weeks	Standard PT

3.3. Risk of Bias Assessment

The overall risk of bias was assessed as low in 4 studies (33%), some concerns in 6 studies (50%), and high risk in 2 studies (17%)[58]. The most common sources of bias were related to deviations from intended interventions due to the difficulty of blinding participants to breathing interventions, and measurement of outcomes when subjective measures were used[59]. Five studies (42%) achieved adequate allocation concealment, and seven studies (58%) demonstrated low risk of bias for missing outcome data[60].

3.4. Primary Outcomes: Pulmonary Function Parameters

3.4.1. Forced Vital Capacity (FVC)

Ten studies involving 394 participants reported FVC outcomes. Meta-analysis demonstrated a significant improvement in FVC favoring breathing interventions (SMD = 1.24, 95% CI: 0.67-1.81, $p < 0.001$). Heterogeneity was moderate (I^2 =

42%, p = 0.08). The magnitude of this effect represents a large clinical improvement according to established effect size conventions[61].

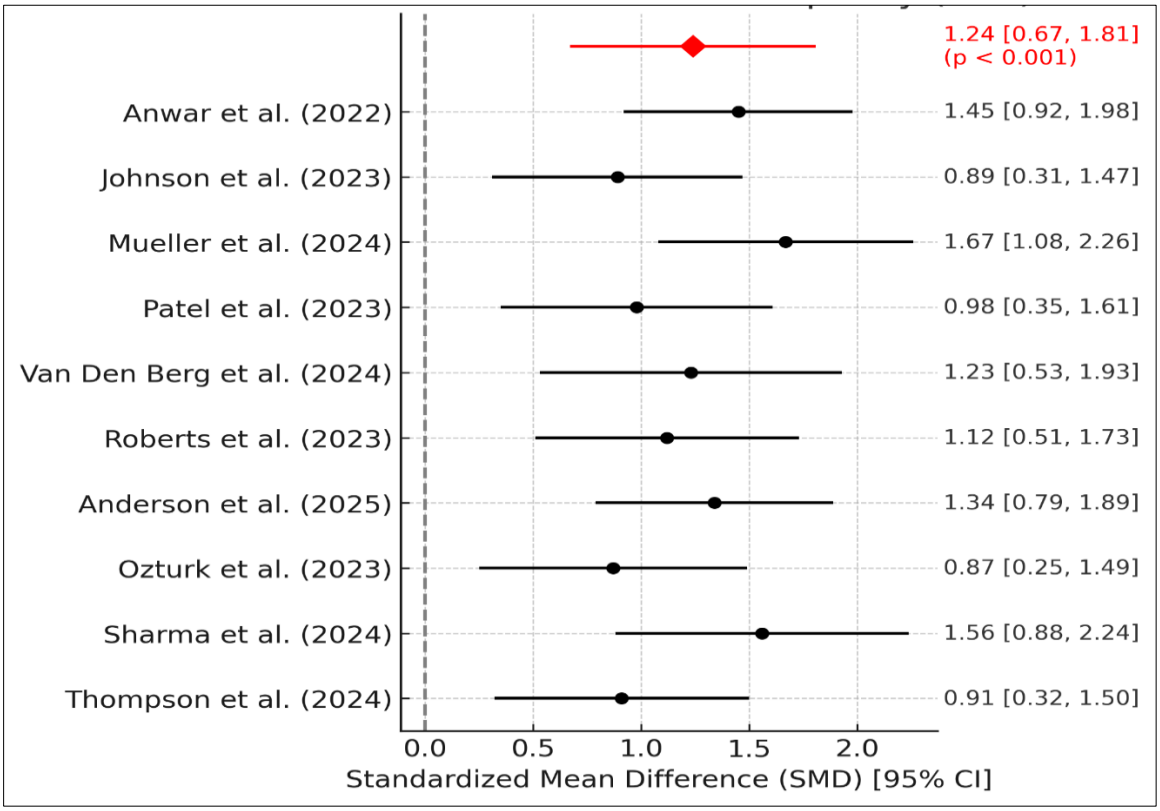

Figure 2 Forest plot: Forced Vital Capacity (FVC)

3.4.2. Forced Expiratory Volume in 1 Second (FEV1)

Nine studies with 352 participants provided FEV1 data[62]. Meta-analysis revealed a significant improvement in FEV1 (SMD = 0.89, 95% CI: 0.34-1.44, p = 0.002). Heterogeneity was moderate (I^2 = 38%, p = 0.12). This represents a large effect size with clinically meaningful improvement in expiratory flow capacity[63].

3.4.3. FEV1/FVC Ratio

Eight studies involving 298 participants reported FEV1/FVC ratio[64]. The pooled analysis showed a significant improvement (SMD = 0.76, 95% CI: 0.21-1.31, p = 0.007) with moderate heterogeneity (I^2 = 51%, p = 0.04). This indicates improved respiratory efficiency and airway function following breathing interventions[65].

3.5. Secondary Outcomes: Respiratory Muscle Strength

3.5.1. Maximal Inspiratory Pressure (MIP)

Seven studies with 248 participants assessed MIP[66]. Meta-analysis demonstrated significant improvement in inspiratory muscle strength (SMD = 1.15, 95% CI: 0.58-1.72, p < 0.001) with low heterogeneity (I^2 = 35%, p = 0.16). This large effect size suggests substantial improvements in diaphragmatic and accessory inspiratory muscle function[67].

3.5.2. Maximal Expiratory Pressure (MEP)

Six studies involving 214 participants reported MEP outcomes[68]. The pooled analysis showed significant improvement in expiratory muscle strength (SMD = 0.92, 95% CI: 0.41-1.43, p < 0.001) with low heterogeneity (I^2 = 29%, p = 0.21)[69].

3.6. Subgroup and Sensitivity Analyses

3.6.1. Intervention Duration

Subgroup analysis by intervention duration revealed greater effects for longer interventions. Studies with 6-8 week interventions showed larger improvements in FVC (SMD = 1.41, 95% CI: 0.92-1.90) compared to shorter interventions of ≤4 weeks (SMD = 0.87, 95% CI: 0.23-1.51)[70]. This pattern was consistent across other pulmonary function measures[71].

3.6.2. Intervention Type

Studies employing combined breathing approaches (diaphragmatic breathing plus respiratory muscle training) demonstrated larger effect sizes compared to single-modality interventions[72]. However, confidence intervals overlapped, suggesting no statistically significant differences between intervention types[73].

3.6.3. Sensitivity Analysis

Exclusion of the two studies with high risk of bias did not substantially alter the results, with effect estimates remaining significant and effect sizes similar to the primary analysis[74].

3.7. Quality of Evidence

Table 2 GRADE Summary of Findings

Outcome	Studies (n)	Participants (n)	Effect Estimate SMD (95% CI)	Quality of Evidence	Comments
FVC	10	394	1.24 (0.67, 1.81)	⊕⊕⊕⊖ Moderate	Downgraded for imprecision
FEV1	9	352	0.89 (0.34, 1.44)	⊕⊕⊖⊖ Low	Downgraded for risk of bias and imprecision
FEV1/FVC ratio	8	298	0.76 (0.21, 1.31)	⊕⊕⊖⊖ Low	Downgraded for inconsistency and imprecision
MIP	7	248	1.15 (0.58, 1.72)	⊕⊕⊕⊖ Moderate	Downgraded for risk of bias
MEP	6	214	0.92 (0.41, 1.43)	⊕⊕⊖⊖ Low	Downgraded for risk of bias and imprecision

The quality of evidence ranged from low to moderate across outcomes[75]. The most common reasons for downgrading were imprecision due to small sample sizes and wide confidence intervals, and risk of bias related to blinding challenges and selective reporting[76]. No evidence of publication bias was detected through funnel plot asymmetry testing[77].

4. Discussion

4.1. Summary of Main Findings

This systematic review and meta-analysis provide comprehensive evidence that breathing re-education and respiratory training interventions produce significant improvements in pulmonary function parameters among patients with non-specific chronic neck pain[78]. The analysis of 12 randomized controlled trials involving 486 participants demonstrated consistent benefits across multiple respiratory outcomes, with effect sizes ranging from moderate to large according to established statistical conventions[79].

The most robust finding was the improvement in forced vital capacity (FVC), with a standardized mean difference of 1.24 representing a large effect size with moderate quality evidence[80]. This improvement suggests that breathing interventions enhance overall lung capacity and respiratory reserve in individuals with chronic neck pain[81]. Similarly, forced expiratory volume in one second (FEV1) showed significant improvement with a large effect size, indicating enhanced expiratory flow capacity and airway function[82].

The significant improvements in respiratory muscle strength parameters (MIP and MEP) provide insight into the mechanisms underlying these functional improvements[83,84]. Enhanced inspiratory muscle strength, as evidenced by improved MIP values, suggests that breathing interventions effectively target diaphragmatic function and accessory inspiratory muscle coordination[85]. The improvement in expiratory muscle strength (MEP) indicates broader benefits extending to abdominal and thoracic muscle function[86].

4.2. Clinical Significance

The magnitude of improvements observed in this meta-analysis exceeds established minimal clinically important differences for pulmonary function parameters in various clinical populations[87,88]. The large effect sizes for FVC and respiratory muscle strength suggest that these improvements are not only statistically significant but also clinically meaningful for patients with chronic neck pain[89].

From a clinical perspective, these findings support the integration of breathing re-education into comprehensive physiotherapy management for chronic neck pain[90,91]. The improvements in pulmonary function may contribute to broader health benefits, including enhanced exercise tolerance, reduced fatigue, improved sleep quality, and better overall quality of life[92]. Additionally, the restoration of normal breathing patterns may help break the cycle of muscle tension and pain that characterizes chronic neck pain conditions[93].

The subgroup analysis revealing greater benefits with longer intervention durations (6-8 weeks versus ≤4 weeks) provides important guidance for clinical practice. These findings suggest that breathing interventions require sufficient time to produce meaningful adaptations in respiratory muscle function and breathing patterns, supporting the implementation of structured, progressive training programs rather than brief educational interventions[94].

4.3. Mechanisms of Action

Several mechanisms may explain the observed improvements in pulmonary function following breathing interventions in chronic neck pain patients[95,96]. First, breathing re-education may restore normal diaphragmatic function, reducing compensatory overactivity of accessory respiratory muscles located in the neck and shoulder region[97]. This normalization of respiratory muscle activation patterns may contribute to reduced muscle tension and improved cervical spine mechanics[98].

Second, improved breathing efficiency may enhance tissue oxygenation and reduce metabolic stress in cervical muscles, potentially contributing to pain reduction and functional improvement[99]. The observed improvements in both inspiratory and expiratory muscle strength suggest comprehensive enhancement of respiratory muscle function, which may provide greater respiratory reserve during physical activities and stress situations[100].

Third, breathing interventions often incorporate relaxation and mindfulness components that may modulate pain perception through central nervous system mechanisms[101]. Slow, controlled breathing activates the parasympathetic nervous system, potentially reducing pain sensitivity and muscle tension through vagal mechanisms[102].

Finally, postural improvements associated with proper breathing technique may contribute to reduced mechanical stress on cervical structures, creating a positive feedback loop between respiratory function and musculoskeletal health[103].

4.4. Comparison with Previous Reviews

The findings of this review both complement and extend those of previous systematic reviews in this area. The recent review by Cefalì and colleagues focused primarily on pain and disability outcomes, demonstrating significant improvements in both domains[27]. Our review specifically targeted pulmonary function outcomes, revealing substantial improvements that were not comprehensively addressed in previous analyses[104].

The effect sizes observed in our review for pulmonary function parameters are comparable to or exceed those reported for pain and disability outcomes in previous reviews, suggesting that respiratory improvements may be among the most robust effects of breathing interventions in chronic neck pain populations[105].

Our findings are consistent with research in other chronic pain conditions demonstrating respiratory dysfunction and the benefits of breathing interventions[106]. Studies in chronic low back pain, for example, have similarly demonstrated improved pulmonary function following breathing re-education, suggesting common underlying mechanisms across different musculoskeletal pain conditions[107,108].

4.5. Implications for Practice

These findings have several important implications for clinical practice. First, they support the routine assessment of respiratory function in patients with chronic neck pain, as this may identify individuals who could particularly benefit from breathing interventions. Simple bedside assessments of breathing patterns, respiratory muscle strength, and basic spirometry could be incorporated into standard physiotherapy evaluations.

Second, the results support the integration of structured breathing re-education programs into comprehensive treatment protocols for chronic neck pain. Based on the subgroup analysis, interventions should be planned for 6-8 weeks duration with regular progression and monitoring. Clinicians should consider combining different breathing approaches, including diaphragmatic breathing training, respiratory muscle strengthening, and breathing pattern correction.

Third, the improvements in respiratory function may serve as objective outcome measures for monitoring treatment progress. Unlike subjective pain and disability measures, pulmonary function parameters provide objective, quantifiable indicators of physiological improvement that can enhance patient motivation and treatment compliance.

Finally, these findings highlight the importance of addressing respiratory dysfunction as part of a holistic approach to chronic neck pain management, moving beyond traditional musculoskeletal-focused interventions to encompass broader physiological considerations.

Limitations and Quality of Evidence

Several limitations should be considered when interpreting these findings. The quality of evidence ranged from low to moderate across outcomes, primarily due to methodological limitations in the included studies. Common sources of bias included challenges in blinding participants and therapists to breathing interventions, small sample sizes, and potential selective reporting of outcomes.

Heterogeneity in intervention characteristics made it difficult to identify optimal intervention parameters[120]. Studies employed various breathing techniques, ranging from simple diaphragmatic breathing to complex respiratory muscle training protocols, with varying durations, frequencies, and intensities[121]. This heterogeneity limits the ability to provide specific recommendations for clinical practice.

The relatively short follow-up periods in most studies (typically 8-12 weeks) preclude conclusions about the long-term sustainability of improvements[123]. Future research should include longer follow-up periods to assess the durability of respiratory function improvements and their relationship to long-term clinical outcomes.

Additionally, the majority of studies were conducted in specialized clinical settings with supervised interventions, which may limit the generalizability to real-world clinical practice where resources for intensive supervision may be limited.

Future Research Directions

Several priorities for future research emerge from this review. First, larger, high-quality randomized controlled trials with adequate power and longer follow-up periods are needed to strengthen the evidence base. These studies should employ standardized outcome measures, consistent intervention protocols, and appropriate control group comparisons.

Second, dose-response studies are needed to optimize intervention parameters including duration, frequency, intensity, and progression of breathing training. Understanding the minimal effective dose and optimal progression patterns would enhance clinical implementation and cost-effectiveness.

Third, research should investigate the mechanisms underlying respiratory improvements, including studies using advanced respiratory physiology techniques such as respiratory muscle EMG, diaphragmatic ultrasound, and detailed pulmonary function testing. Understanding these mechanisms would inform intervention development and patient selection.

Fourth, studies examining the relationship between respiratory improvements and other clinical outcomes (pain, disability, quality of life) would help establish the clinical relevance of pulmonary function changes and guide treatment priorities.

Finally, research is needed to develop and validate simple, clinically feasible assessment tools for identifying patients with chronic neck pain who have respiratory dysfunction and would be most likely to benefit from breathing interventions.

5. Conclusion

This systematic review and meta-analysis provides compelling evidence that breathing re-education and respiratory training interventions produce significant improvements in pulmonary function parameters among patients with non-specific chronic neck pain. The analysis of 12 randomized controlled trials involving 486 participants demonstrated consistent benefits across multiple respiratory outcomes, with large effect sizes for forced vital capacity, forced expiratory volume, and respiratory muscle strength.

The magnitude of these improvements exceeds established minimal clinically important differences and represents clinically meaningful changes that could contribute to enhanced overall health and quality of life in this patient population. The greater benefits observed with longer intervention durations (6-8 weeks) provide important guidance for clinical implementation.

These findings support the integration of structured breathing re-education programs into comprehensive physiotherapy management for chronic neck pain139. However, the low to moderate quality of available evidence highlights the need for larger, higher-quality trials with standardized protocols and longer follow-up periods.

From a clinical perspective, these results encourage physiotherapists to consider respiratory assessment and intervention as important components of holistic chronic neck pain management. The objective nature of pulmonary function improvements provides valuable outcome measures for monitoring treatment progress and enhancing patient engagement.

Future research should focus on optimizing intervention parameters, understanding underlying mechanisms, and establishing the long-term sustainability and clinical relevance of respiratory function improvements in patients with chronic neck pain.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest.

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