

REVIEW

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Chronic neck pain and respiratory dysfunction: a review paper

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Abstract

Background: Neck pain is one of the most frequently reported musculoskeletal complaints among adults; its prevalence in the world is ranging from 16.7 to 75.1%. It can have an impact on a person's physical, psychological, and social well-being. Along with pain, disability, muscle weakness, and alterations in the posture, neck pain patients are likely to develop affection of the respiratory function as reported in numerous studies. However, these patients are primarily managed with a musculoskeletal perspective with little or no emphasis to the changes observed in the respiratory system. There is a paucity of literature evaluating the need for respiratory rehabilitation in these patients.

Main body: All relevant published literature related to respiratory dysfunction in patients with chronic neck pain were critically reviewed in this study. Patients having chronic neck pain were found to have alterations in respiratory function in terms of reduced lung volumes, reduced chest mobility, and decreased respiratory muscle strength. Various factors such as decreased cervical range of motion, decreased strength of deep neck flexors and extensors, forward head posture, and pain are known to cause these dysfunctions. Respiratory system intervention in the form of breathing re-education and respiratory exercises are significantly proven to improve treatment outcomes.

Conclusion: There is limited literature relating to respiratory dysfunction and its management in neck pain patients. Incorporation of both respiratory and musculoskeletal assessments can enhance their treatment outcomes. Additionally, it can be suggested to consider intervention in the form of respiratory rehabilitation while strategizing treatment goals for these patients.

Keywords: Neck pain, Respiratory muscle, Respiratory system

Background

Neck pain is one of the most commonly reported musculoskeletal affection in the general population. It has a tremendous impact on the health and quality of life of the individual and on society as a whole. In a study which examined the cross-national prevalence of chronic pain conditions, 41.1% and 37.3% of subjects in developing and developed countries respectively reported chronic neck pain [1]. An overall prevalence rate of 19.3% was found for chronic pain in the Indian population [2]. In a

study carried out in a small urban primary health center in a city of central India, 3.11% population reported neck pain. The prevalence was found to be highest in the age group of 21–40 years followed by 41–60 years. The least affected were individuals younger than 20 years old [3]. Likewise, the global point prevalence of neck pain in 2017 was estimated to be 4.45% in the Arab population [4].

Various studies have reported the association of respiratory dysfunction in patients with chronic neck pain [5–10]. Patients with neck pain present with decreased strength of deep neck flexors and extensors, increased fatigability of superficial neck flexors, alterations in posture, limited range of motion, decreased proprioception, neck disability, and other psycho-social affections [9]. According to Kapreli et al., these factors are responsible for predisposition of respiratory dysfunction in

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these patients [6]. Reduction in lung volumes is a sensitive index of pulmonary disorders. Dimitriadis et al., in their study, reported reduced lung volumes in neck pain patients and observed a trend towards pulmonary restriction that may contribute to developing respiratory pathology in the long run [10].

A systematic review performed by Amir Hossein Kahl-ae et al. supports the evidence of functional pulmonary impairment, altered pulmonary volumes, reduced respiratory muscle strength, and faulty breathing pattern being observed in chronic neck pain patients [11]. Another review by Harneet et al. suggests the presence of respiratory dysfunction in chronic neck pain patients and that exercises targeting the respiratory muscles along with correct breathing patterns were found to be helpful in improving both cervical and respiratory functions [12]. These studies further reiterate the importance of respiratory retraining in improving both respiratory and musculoskeletal impairment in chronic neck pain patients [11, 12].

The current study critically reviewed all relevant published literature regarding the association of respiratory dysfunction in chronic neck pain patients and its management for the same. Chronic neck pain in the target population was defined as pain lasting for at least 3 months or more than that.

Methods

A literature search was conducted on PubMed, ResearchGate, Google Scholar, and MEDLINE databases. The studies published in the last 20 years from the year 2001 to 2021 were included in this review.

The inclusion criteria were studies published in the English language involving human subjects, studies analyzing respiratory function or pattern of breathing in chronic neck pain patients, and studies involving any respiratory intervention for the same. Exclusion criteria were studies that were published before 2001, the ones that did not assess the outcomes of interest including studies assessing acute or traumatic neck pain or pain associated because of any neurological cause. The related keywords included the following: “neck pain,” “chronic neck pain,” “respiratory function,” and “pulmonary function.” The title and abstract of the resulting articles were screened. The initial search yielded three hundred and sixty articles. Studies whose title is related to the topic, i.e., relationship between respiratory function in neck pain patients, were shortlisted, and after excluding researches for content irrelevance, a total of fifteen studies were finalized for this review. Fifteen studies included four randomized control trials, eight cross-sectional studies, two pilot studies, and one case-control study. Only papers reporting primary research were referred

in conducting this review. Four studies [5, 6, 11, 12] were not formally used to present review findings; instead, they were used to develop arguments presented in the introduction and in the general discussion of the study. Summary of the findings of all the relevant articles is presented in Table 1. Among the 15 studies reviewed, 13 studies included only neck pain patients and two of them included patients having other musculoskeletal pain also; 11 were only assessment based, and four of them studied the effect of a respiratory intervention on various parameters.

The Hailey et al. classification system was used to evaluate the quality of researches [24]. This system of classification includes five levels of categories ranging from grade A to E. Out of the total fifteen studies that were shortlisted, three studies [10, 13, 21] were graded A (high quality), seven studies [7–9, 15–17, 22] were B (good quality), four studies [23, 25–27] were C (fair to good quality), and one study [28] was D (poor to fair quality).

Main text

Assessment of respiratory function in patients with neck pain

Respiratory function can be best described by assessment of rib cage mobility, respiratory muscle strength, neck posture, and pulmonary function test results [5].

Chest mechanics

Chest mechanics refers to the kinematics involving respiratory muscles and their coordinated action to produce chest wall displacement [25].

Perri and Halford examined the respiratory function with the help of a self-developed “total faulty breathing scale” in neck pain patients. This scale assesses breathing patterns both during relaxed and deep breathing. The scoring is based on three main criteria during inhalation. The absence of outward lateral rib motion is graded as mild affection, lifting of the clavicles is graded as moderate affection, and paradoxical breathing is graded as severe affection in both relaxed and deep breathing. The scoring is done on an ordinal scale of 1, 2, and 3 for mild, moderate, and severe affection respectively. The findings of the above study demonstrated a higher incidence of faulty breathing mechanics in patients with neck pain [13].

Wirth et al. studied rib cage mechanics in patients with chronic neck pain by assessing the thoracic spine mobility using a hand-held, non-invasive electromechanical device called The Spinal Mouse (Idiag, Fehraltorf, Switzerland) which was used to determine the sagittal range of motion (ROM) of the thoracic spine. This test was conducted in the all-fours position to promote a greater range of motion. The device was

Table 1 The summary of results of the extracted data

Authors	Participants	Respiratory parameters	Musculoskeletal parameters	Other parameters	Intervention	Summary of results
Maria A. Perri et al. [13]	Neck pain = 36, other musculoskeletal pain = 46, no pain = 12	Breathing pattern	VAS	-	-	87.2% participants had some musculoskeletal pain. Out of these, 56.4% had faulty relaxed breathing and 75% had faulty breathing when taking a deep breath. Eighty-three percent of neck pain patients had faulty breathing pattern, and there was a significant correlation between VAS of neck pain and dysfunctional respiratory mechanics
Kapreli E et al. [9]	CNP = 12, healthy subjects = 12	FVC, VC, PEF, FEV1, FEV1/FVC, FEF and MW, P_{limax} and P_{emax}	FHP, VAS	NDI	-	CNP patients had significant reductions in P_{limax} , P_{emax} and MW in comparison with controls. A strong association between increased FHP and decreased respiratory muscle strength in neck pain patients was found. A negative correlation of P_{limax} and P_{emax} with FHP was seen
McLaughlin L et al. [14]	Neck pain = 12, back pain = 8, both = 9	ETCO ₂	Numerical pain rating scale (NPRS)	Patient-specific functional scale (PSFS)	Retraining in the form of manual therapy/ motor control approach, awareness training, and biofeedback with the capnograph	ETCO ₂ values decreased in all subjects. Significant improvement was seen in NPRS and PSFS. Breathing retraining improved ETCO ₂ , pain, and function in all patients

Table 1 (continued)

Authors	Participants	Respiratory parameters	Musculoskeletal parameters	Other parameters	Intervention	Summary of results
Dimitriadis Z et al. [8]	CNP = 45, healthy subjects = 45	MIP and MEP	VAS, strength of neck flexors and extensors, endurance of deep neck flexors, cervical range of movement, FHP	NDI, Baecke Questionnaire of Habitual Physical Activity, Hospital Anxiety and Depression Scale, Tampa Scale for Kinesiophobia, Pain Catastrophizing Scale	-	CNP patients had weak neck flexors and extensors, reduced cervical mobility, and impaired deep neck flexors. A reduction in MIP and MEP was found in CNP patients. MIP was significantly correlated with the strength of neck flexors, extensors, kinesiophobia, and catastrophizing. MEP was significantly correlated with the strength of neck flexors, extensors, pain intensity, NDI, kinesiophobia, and catastrophizing
Dimitriadis Z et al. [10]	CNP = 45, healthy subjects = 45	VC, FEV1, FVC, PEF, FEF, and MW	Neck muscle strength, cervical range of motion, endurance of deep neck flexors, FHP	Hospital Anxiety and Depression Scale, Tampa Scale for Kinesiophobia, Pain Catastrophizing Scale, NDI	-	Reduced neck extensor strength, reduced active cervical mobility, and impaired function of the deep neck flexors were found in CNP patients. VC and MW were significantly correlated with neck muscle strength, pain intensity, and kinesiophobia. PEF was significantly correlated with neck muscle strength and pain intensity

Table 1 (continued)

Authors	Participants	Respiratory parameters	Musculoskeletal parameters	Other parameters	Intervention	Summary of results
Wirth B et al. [7]	CNP = 19, healthy subjects = 19	FVC, PEF, FEV1, FEV1/FVC, FEF, MVV, P_{imax} , P_{emax} and chest expansion	CROM, forward head posture, thoracic mobility, and neck flexor muscle endurance	NDI	-	P_{imax} , P_{emax} and MVV were reduced in CNP patients but were not statistically significant. Cervical mobility was significantly reduced in all movements, but no change was noted in thoracic spine mobility, chest mobility, FHP, and endurance of the neck flexor muscle. MVV and neck motions had significant and fair relations with thoracic flexion and chest mobility. Significant and fair correlations were seen between thoracic flexion and neck muscle endurance, chest expansion, and FHP. NDI had a significant correlation to P_{imax} , P_{emax} and MVV
Yalcinkaya H et al. [15]	CNP = 80, healthy subjects = 80	VO_2 max, FVC, FEV1, FEV1/FVC, PEF, MVV	Handgrip, back-leg strengths, trunk flexibility, pain pressure threshold	Daily physical activity, body composition, NDI, Beck Anxiety Inventory (BAI), Beck Depression Inventory (BDI), Pittsburgh Sleep Quality Index (PSQI), and Short-Form health survey (SF-36)		Handgrip, back-leg strengths, suboccipital and paraspinal-C7 pain pressure threshold, and health-related quality of life (HRQoL) were lower, whereas PSQI, BAI, and BDI were higher in female patients with CNP compared to healthy controls. VO_2 max and HRQoL were lower, and body fat percentage and PSQI were higher in male patients with CNP compared to healthy controls. Trunk flexibility and PFT values were not significantly different between the patients and the controls in both genders

Table 1 (continued)

Authors	Participants	Respiratory parameters	Musculoskeletal parameters	Other parameters	Intervention	Summary of results
Yeampattanaporn O et al. [16]	CNP = 36	Pulmonary function test, chest expansion	Pain intensity, CROM, neck muscle activity		Re-education of breathing patterns for 30 min	The pain intensity and the muscle activity were significantly decreased after re-education. The CROM and chest expansion at the lower rib cage was significantly increased after re-education
Moawd A et al. [17]	CNP = 47, healthy subjects = 47	VC, IC, ERV, VT, FEV1, FVC, and FEV1/FVC. MIP and MEP	CROM			CNP patients had a significant reduction in CROM for extension, lateral flexion, and rotation. Significant differences were seen between the groups in IC, ERV, FEV1, and FVC. No difference was seen in FEV1/FVC. CNP patients were found to have significantly reduced MIP and MEP
Wirth B et al. [18]	Neck pain = 15	VC, FVC, FEV, PEF, MEF, and MVV. P_{imax} , P_{emax} , and respiratory endurance test	Cervical and thoracic ROM, endurance of cervical muscles, forward head posture; craniocervical angle	Neck disability index, Bournemouth questionnaire, patient global impression change	Respiratory muscle endurance training—5 sessions of 30 min/week for 4 weeks	RMET increased respiratory endurance test, VC, MVV, chest expansion (axillary level), P_{imax} , P_{emax} , and endurance of neck flexors, whereas it decreased NDI and Bournemouth score significantly
Vikram M et al. [19]	CNP = 10 (5 in the control group and 5 in the experimental group)	MVV, chest expansion	Graduated numbered visual analog scale, cervical ROM	NDI	Routine physiotherapy for both groups. Additional respiratory exercise program for the experimental group	Significant increase in MVV and reduction in pain was found posttreatment in the experimental group as compared to the control group
Ibailo ´pez-de-Uralde-Villanueva et al. [20]	CNP = 44, healthy subjects = 31	MIP, MEP, FVC, FEV1, FEV1/FVC, PEF	Pain intensity, CROM, FHP, and strength of cervical muscles	NDI, kinesiophobia, Pain Catastrophizing Scale, Hospital Anxiety and Depression Scale	–	Significant reduction in MIP, MEP, and CROM was found in neck pain patients, whereas no statistically significant reduction was found in the values of FEV1 and PEF

Table 1 (continued)

Authors	Participants	Respiratory parameters	Musculoskeletal parameters	Other parameters	Intervention	Summary of results
Cheon JH et al. [21]	CNP = 48, healthy subjects = 30	MIP, MEP	Cervical lordotic curvature, thoracic kyphotic curvature, thoracic sagittal range of motion	NDI	-	In males, thoracic sagittal ROM _{MEP-MIP} and MEP showed a significant difference between the control group and the CNP group. In females, thoracic kyphotic curvature, thoracic sagittal ROM _{MEP-MIP} , MIP, and MEP were significantly different between the CNP group and the no cervical pain group. Thoracic kyphotic curvature and thoracic sagittal ROM _{MEP-MIP} was significantly correlated with NDI, MEP, and MIP in all participants
Solakoglu Ö et al. [22]	Neck pain = 99	Chest expansion, FVC, FEV1, FEV1/FVC, FEF25%, FEF50%, FEF75%, and FEF25-75%, PEF, MVV, P _{emax} and P _{emax}	VAS, FHP	MNDI	-	A negative correlation between the FHP and expiratory muscle strength was observed. Similarly, a negative correlation between C7 vertebra position and P _{emax} FEV1/FVC, FEF 25%, FEF 50%, FEF 75%, and FEF 25-75% was found. Also, a negative correlation was found between neck disability and chest expansion, MVV
Awadallah M F [23]	Neck pain = 75, healthy subjects = 75	FVC, FEV1, FEV1/FVC, FEF 25-75%, PEFR	VAS, CROM	NDI	-	FVC, FEV1, FEF 25-75%, and PEFR were found to be reduced in neck pain patients with higher FEV1/FVC values indicating a restrictive pattern

CNP chronic neck pain, VAS visual analog scale, NDI neck disability index, NPRS numeric pain rating scale, PSFS patient-specific functional scale, CROM cervical range of motion, MNDI modified neck disability index, FHP forward head posture, VC vital capacity, FVC forced vital capacity, FEV1 forced expiratory volume in 1 s, PEF peak expiratory flow, MVV maximum voluntary ventilation, MIP maximal inspiratory pressure, MEP maximal expiratory pressure, PFT pulmonary function test, IC inspiratory capacity, ERV expiratory reserve volume, VT tidal volume, RMET respiratory muscle endurance training, ROM_{MEP-MIP} range of motion between MEP and MIP, FEF 25-75% forced expiratory flow at 25-75%, PEFR peak expiratory flow rate, P_{emax} maximal inspiratory pressure, P_{emax} maximal expiratory pressure

rolled down the spine starting with the 7th cervical vertebra (C7) and ending at the 3rd lumbar vertebra (L3). The measurements were performed in the neutral, maximally flexed, and maximally extended trunk positions. Mobility between neutral and flexed position (thoracic flexion) and neutral and extended position (thoracic extension) was calculated [7].

Wirth in the same study assessed chest mobility at the level of the xiphoid process using the measure tape method. The measuring tape was drawn tight around the patient's chest. The patient was asked to perform maximal inspiration and maximal expiration, and the difference in the circumference of the chest was noted. The measurement was taken twice and the average of the two readings was noted.

The findings revealed a decrease in chest expansion in patients with chronic neck pain [7].

Özge Solakoğlu et al., in their study, measured mobility of the chest using a tape measure and correlated its findings with respiratory parameters in patients having chronic neck pain. The findings suggested that chest expansion was correlated to respiratory parameters that included forced vital capacity (FVC)%, peak expiratory flow (PEF)%, maximum voluntary ventilation (MVV), MVV%, and maximal inspiratory mouth pressure ($P_{i\max}$) and maximal expiratory mouth pressure ($P_{e\max}$). However, this study did not show any relation of chest expansion with forward head posture (FHP) [22].

Ji Hong Cheon et al. investigated the correlation between thoracic mobility and respiratory muscle strength in chronic neck pain patients. Thoracic kyphotic curvature, thoracic sagittal ROM, maximal inspiratory pressure (MIP), and maximal expiratory pressure (MEP) were assessed. Thoracic kyphotic curvature and thoracic sagittal ROM between MEP and MIP (thoracic sagittal ROM_{MEP-MIP}) were measured using flexicurve. Thoracic kyphotic curvature was measured by placing the flexicurve at the C7 spinous process through the 12th thoracic vertebra (T12) spinous process. The angle was measured by calculating the distance with the help of a formula. The participants had a mean angle of $29.30^\circ \pm 3.72^\circ$. For calculating the thoracic sagittal ROM_{MEP-MIP}, the thoracic kyphotic curvature at MEP was subtracted by the thoracic kyphotic curvature at MIP. It was observed that thoracic mobility during forced respiration was reduced in patients having chronic neck pain, and it correlated well with respiratory muscle strength. The findings suggested that impairment of respiratory strength in chronic neck pain patients may be attributed to changes in the biomechanics of the cervicothoracic spine and rib cage [21].

Pulmonary function

Pulmonary function test is a non-invasive tool used for the assessment of lung function which provides an objective information regarding the diagnosis of lung diseases [26].

Pulmonary function test is performed using an electronic spirometer (Spirolab II; SDI Diagnostics Inc., Easton, MA, USA, and Spirobank II USB MIR, Rome, Italy) with reference to the guidelines of The American Thoracic Society of Standardization of Spirometry and European Respiratory Society (ATS/ERS) [9, 10, 15, 17, 20] or with the help of a Master Scope PC spirometer (Jaeger, Hoechberg, Germany) [7].

The parameters of pulmonary function test that were commonly assessed in the studies relating to neck pain patients were forced FVC, vital capacity (VC), PEF, forced expiratory volume in 1 s (FEV1), FEV1/FVC, forced expiratory flow (FEF25-75%; FEF25%, FEF50%, FEF75%), and MVV [7, 9, 10, 15, 17, 20].

Kapreli et al. were the first to provide evidence of pulmonary function affection in chronic neck pain patients. The pilot findings of this study comparing chronic neck pain patients with healthy controls revealed that patients with chronic neck pain had reduced values of FEV1, FVC, and FEV1/FVC ratio ($p > 0.05$) and MVV ($p < 0.00$) [9].

Dimitriadis et al., in his study conducted on a larger sample size, confirmed the trends seen in the previously mentioned study. His study finding reported that chronic neck pain patients presented with significantly decreased VC, expiratory reserve volume, FVC, and MVV. Two patients with neck pain were found to have a mild restriction (percent predicted FVC < lower limit of normal but ≥ 70 , no reduction in FEV1/FVC) [10].

The findings of the study done by Moawd et al. provided additional support to the findings of the previous studies. It reported significant reductions in VC, inspiratory capacity (IC), expiratory reserve volume (ERV), FEV1, and FVC in patients with chronic neck pain [17].

The Ibai López-de-Uralde-Villanueva study in patients with chronic nonspecific neck pain and healthy controls showed statistically significant differences for FEV1 and FVC but not the ratio FEV1/FVC between the two groups [20].

However, the study done by Yalcinkaya et al., comparing patients with chronic neck pain and healthy controls separately for males and females, did not show a significant difference in values of FEV1, FVC, FEV1/FVC, PEF, FEF 25–75%, and MVV between the genders [15].

A recent study done by Awadallah M F et al. examined the relationship between respiratory function and chronic neck pain. It was found that chronic neck pain patients had reduced pulmonary parameters that

included FVC, FEV1, FEF 25–75%, and PEF. Fifty-two percent of the participants presented with reduced FEV1/FVC values indicating a restrictive pattern [23].

Özge Solakoğlu in his study assessed pulmonary function in neck pain patients with the help of VmaxTM Encore body plethysmography device and body cabin. The neck pain patients were assessed for forward head posture (FHP) and divided into 2 groups. One group had patients who had FHP and the other group included patients having normal head posture (NHP). A weak negative correlation between FHP and FEV1/FVC%, FEF 25–75%, and FEF75% was found [22].

Respiratory muscle strength

Respiratory muscle function can be assessed directly by measuring the pressure developed throughout the maximum voluntary inspiratory and expiratory effort [22, 27]. Maximal expiratory and inspiratory pressures (P_{emax} and P_{imax} respectively) are critical to assess the muscle weakness of respiratory muscles. MIP expressed as P_{imax} measures inspiratory muscle strength whereas MEP expressed as P_{emax} measures expiratory muscle strength. MVV also indicates the muscle strength, but it is less sensitive than P_{imax} and P_{emax} [22] as the MVV is approximately proportional to VC reduction [7, 8].

Özge Solakoğlu in his study on the effects of forward head posture on expiratory muscle strength in chronic neck pain patients assessed maximal respiratory pressures using a digital mouth pressure meter also known as micro respiratory pressure meter (MicroRPM by CareFusion Inc., Yorba Linda, CA, USA). Patients were requested to wrap their mouth around the flanged mouthpiece tightly. A nose clip was applied to ensure that any air leak was prevented. To measure the P_{emax} , the patients were initially asked to inhale as much as they could and, then, to exhale at maximal exertion against the resistance of the instrument for no less than 1 s. To measure the P_{imax} , the patients were asked to exhale as much as they could and, then, to inhale at maximal exertion against the resistance of the instrument for no less than 1 s. The results of this study observed a weak relationship between FHP and expiratory muscle strength, whereas no significant relationship was observed between FHP and inspiratory muscle strength [22].

Similar assessment techniques have been used by Wirth B, Dimitriadis Z, Kapreli E, IbaiLo´pez-de-Uralde-Villanueva, and Moawd et al. in their studies that measured maximal mouth pressures using a digital mouth pressure meter (MicroRPM[®]) and the accompanying PUMA PC software [7–9, 17, 20]. In all these studies, MIP and MEP were both significantly reduced in patients with chronic neck pain [7–9, 17, 20].

Reduction in respiratory muscle strength in chronic neck pain patients is attributed to the increased activity level of sternocleidomastoid and anterior scalene. Since the increased activity levels of these muscles put them at risk of early fatigue, it causes impairments in the cervical and thoracic spine and the rib cage. Imbalance of neck stabilizer and mobilizer muscles disrupts the optimal activation of respiratory muscles. Thus, alteration in the rib cage mechanics causes respiratory dysfunction [11].

Posture

Forward head posture (FHP) commonly seen in patients with neck pain is caused by a reduced strength of deep flexors and extensors which in turn cause muscle imbalance and segmental instability [6]. It is also associated with changes in the thoracic spine and reduction of thoracic mobility. These morphological changes are believed to cause impairment in respiratory function [28].

Wirth B, Dimitriadis Z, and Kapreli E assessed the forward head posture with the help of a digital picture taken in the lateral view for each subject. Cranio-vertebral angle being the angle between the line extending from the tragus of the ear to the C7 spinous process and the horizontal line through C7 was calculated with the 3D drawing program (Auto-CAD 2000; Autodesk Inc., San Raphael, CA, USA) [7–10].

A pilot study conducted by Kapreli et al. in chronic neck pain patients and healthy controls suggested that forward head posture was associated with the lung function parameters in the patients with neck pain [8]. However, similar studies performed by Dimitriadis, Wirth et al., and IbaiLo´pez-de-Uralde-Villanueva did not find any significant differences in head posture when compared in patients with chronic neck pain and healthy controls [7, 8, 20].

Özge Solakoğlu et al. investigated the relationship between FHP and respiratory dysfunctions in chronic neck pain patients. For the assessment of FHP, two measurements were obtained through radiographs using the Picture Archiving and Communication System (PACS, General Electric Healthcare, NY, USA) software. In the first one, the anterior head translation distance which is the perpendicular distance between the vertical line from the posterior inferior corner of C7 and the vertical line from the posterior superior edge of the vertebral body of C2 was measured and was recorded in millimeters. Patients with an anterior head translation distance of >15 mm were assigned as the FHP group, and those with a displacement of ≤15 mm were assigned as the normal head posture group. In the second method, C7 vertebrae position (C7°) was measured through the angle between the line parallel to the disc plane of the C7 disc and a line constructed parallel to the base of the X-ray

film. The $C7^\circ$ is closely related to the static alignment of the cervical spine and was thought to be proportional to FHP [24]. This study demonstrated a weak relationship between FHP mm and $P_{\text{emax}}\%$ for small effect size and a weak relationship between $C7^\circ$ and $P_{\text{emax}}\%$ for medium effect size [22].

Management of respiratory dysfunction in chronic neck pain

There is a paucity of literature concerning the management of respiratory dysfunction in chronic neck pain.

Yeampattanaporn O et al. evaluated the immediate effects of breathing re-education in 36 chronic neck pain patients. Subjects in the study were re-educated with three breathing patterns for 30 min. Pain, cervical range of motion, chest expansion and upper trapezius, anterior scalene, and sternocleidomastoid muscle activity were recorded before and after the intervention. The pain intensity and the muscle activity were significantly decreased, whereas the cervical range of motion and chest expansion at the lower rib cage were significantly increased after the intervention. The study suggests incorporation of breathing re-education has a potential to change breathing patterns and cause an increase in chest expansion and improvement in the cervical range of motion [16].

B. Wirth et al., in his study, demonstrated the effects of 4-week respiratory muscle endurance training (RMET) on chronic neck pain. RMET was performed with a SpiroTiger, a hand-held device that allows for hyperpnoea ensuring normocapnia by partial CO_2 rebreathing from a bag. The participants performed five sessions of RMET per week. This study concluded that RMET significantly increased MVV, P_{imax} , and P_{emax} . During RMET, neck disability significantly decreased, while neck flexor endurance and chest wall expansion increased. Reduction in hyperventilation and hypocapnia were attributed to the effects of respiratory muscle endurance training [18].

Laurie McLaughlin et al. studied the short-term effects of breathing retraining on pain intensity, functional status, and end-tidal CO_2 (ET CO_2) in patients with neck and back pain. A muscle strategy problem was identified, and a manual therapy or motor control approach was implemented. Awareness training and biofeedback with capnography and manual therapy to restore mobility were used to retrain breathing. Significant improvement in pain, function, and ET CO_2 after the intervention was noted. The study suggests assessing breathing dysfunction using capnography can be incorporated into a manual therapy approach which may in turn improve patient outcome [14].

In a pilot study conducted by Vikram Mohan et al., effects of respiratory exercises on chronic neck pain

patients were assessed. Ten participants were divided into control and experimental groups. The control group received routine physiotherapy sessions which included electrotherapeutic modalities for pain, stretching of neck muscles, and range of motion exercises. The experimental group received routine physiotherapy sessions and a respiratory exercise program which included diaphragmatic breathing exercise, volume-oriented device incentive spirometer, and pursed lip breathing exercise. The exercises were carried out with supervision two times per week for a period of 8 weeks. The study concluded that respiratory exercise program significantly improved the endurance of respiratory muscles and reduced pain in patients having chronic neck pain [19].

Conclusion

Patients having chronic neck pain present with altered chest mechanics, abnormalities in pulmonary function tests, and decreased strength of respiratory muscles. Neck pain was also found to be associated with neck disability, decreased cervical mobility, reduced strength of cervical flexors and extensors, and presence of forward head posture and psychological parameters like kinesiophobia and pain catastrophizing. Looking at the available literature, it is clear that there are very few studies that have extensively evaluated the effect of respiratory intervention in these patients. This seems to have been a largely ignored aspect of both assessment and management strategy of patients presenting with neck pain. Therefore, comprehensive protocol inclusive of assessment of respiratory function and incorporation of respiratory therapies in the form of breathing re-education and breathing retraining should be undertaken in these patients. This could certainly enhance the treatment outcomes and largely benefit the patients to achieve faster recovery.

Abbreviations

ROM: Range of motion; FVC: Forced vital capacity; PEF: Peak expiratory flow; MVV: Maximum voluntary ventilation; MIP: Maximal inspiratory pressure; MEP: Maximal expiratory pressure; VC: Vital capacity; FEV1: Forced expiratory volume in 1 second; FEF: Forced expiratory flow; IC: Inspiratory capacity; ERV: Expiratory reserve volume; FHP: Forward head posture; NHP: Normal head posture; RMET: Respiratory muscle endurance training; ET CO_2 : End-tidal CO_2 .

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SPN and VP have conceptualized the topic; SPN and CSP have done the literature search and prepared the content of the manuscript. SPN and VP have reviewed, edited, and approved the final draft. All authors have read and approved the final manuscript.

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Competing interests

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