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Araştırma Makalesi

Predictive Factors for Respiratory Muscle Strength and Function in Chronic Neck Pain

Kronik Boyun Ağrısında Solunum Kas Gücü ve Fonksiyonunun Prediktör Faktörleri

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ÖZ

Amaç: Bu çalışma, kronik boyun ağrısı (KBA) olan bireylerde boyun fonksiyonuna ilişkin değişkenlerin bozulmuş pulmoner fonksiyonu öngörüp öngöremeyeceğini belirlemeyi amaçlamıştır. **Gereç ve Yöntem:** Boyun ağrısına ilişkin öngörücü parametreler, KBA tanılı 73 hastada (ortalama yaş 35,19±10,34) incelenmiştir. Solunum kas gücü, maksimal inspiratuar basınç (MIP) ve maksimal ekspiratuar basınç (MEP) ölçümleriyle bir ağız basınç cihazı kullanılarak değerlendirilmiştir. Spirometri ile zorlu ekspiratuar hacim (FEV1), zorlu vital kapasite (FVC) ve tepe ekspiratuar akım hızı (PEF) ölçülmüştür. Ağrı şiddeti, özür düzeyi, derin servikal fleksör (DCF) kaslarının enduransı, boyun hareket açıklığı (ROM), el kavrama gücü (HGS) ve psikolojik durumlar değerlendirilmiştir. Solunumsal parametrelerin yordayıcılarını belirlemek için çoklu regresyon analizi yapılmıştır. **Sonuçlar:** ROM ve depresyon düzeyleri hem MIP hem de MEP için ortak yordayıcılar olarak bulunmuştur. DCF performansı MIP'i, HGS ise MEP'i anlamlı şekilde yordarken (R^2=0,338), fleksiyon ROM FEV1'i, fleksiyon ROM ve DCF performansı birlikte FVC'yi yordadığı görülmüştür. Boyun özür düzeyi FEV1/FVC ve FEF için anlamlı yordayıcıdır. Fleksiyon ve ekstansiyon ROM ile HGS'nin birlikte PEF için güçlü yordayıcılar olduğu belirlenmiştir (R^2=0,424). **Tartışma:** KBA'lı bireylerde lokal kas fonksiyonlarındaki bozulmalar, boyun özrü ve psikolojik durumlar pulmoner fonksiyonları etkileyebilmektedir. Bu nedenle klinisyenlerin, kronik boyun ağrısı olan hastaların yönetiminde solunum değerlendirmesini ve uygun müdahaleleri sürece dahil etmeleri önerilmektedir.

Anahtar Kelimeler: Solunum fonksiyon testleri; Solunum kasları; Boyun ağrısı

ABSTRACT

Purpose: This study aimed to determine whether neck function-related variables can predict impaired pulmonary function in individuals with chronic neck pain (CNP). **Materials and Methods:** Predictive parameters of neck pain were examined in 73 patients (mean age 35.19±10.34) with CNP. Respiratory muscle strength, including maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP), was measured using a mouth pressure device. Spirometry was used to assess forced expiratory volume (FEV1), forced vital capacity (FVC), and peak expiratory flow rate (PEF). Pain intensity, disability, endurance of deep cervical flexors (DCF), neck range of motion (ROM), hand grip strength (HGS), and psychological states were evaluated. Multiple regression analysis was performed to identify predictors of respiratory parameters. **Results:** ROM and depression levels were common predictors for MIP and MEP. DCF performance significantly predicted MIP, while HGS predicted MEP (R^2=0.338). Flexion ROM predicted FEV1, whereas flexion ROM and DCF performance predicted FVC. Neck disability significantly predicted FEV1/FVC and FEF. Flexion and extension ROM with HGS were strong predictors of PEF (R^2=0.424). **Conclusion:** Impairments in local muscle function, neck disability, and psychological conditions in CNP may affect pulmonary function. Clinicians should include respiratory evaluation and appropriate interventions in the management of patients with chronic neck pain.

Keywords: Respiratory function tests; Respiratory muscles; Neck pain

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Neck pain ranks 6th among the causes of morbidity leading to disability, with a worldwide incidence ranging from approximately 4.6% to 5.3% (Damian Hoy et al., 2014). Although neck pain is not life-threatening, it is a serious economic and epidemiologic problem that affects the quality of life and is one of the most important causes of workforce decline (Kapreli et al., 2009; Gross et al., 2015).

Individuals with CNP have decreased strength and endurance in deep neck flexor and extensor muscles (Strimpakos, 2011b), hyperactivity in superficial neck flexors (Strimpakos, 2011b), decreased cervical ROM (Strimpakos, 2011a), anterior tilt, decreased proprioception (Silva et al., 2009), neuromuscular and psychosocial (Kapreli et al., 2009) disorders. Moreover, since the cervical region is anatomically adjacent to the thoracic spine and there is a musculoskeletal and neural connection, these symptoms are associated with respiratory dysfunction in individuals with neck pain (Kapreli et al., 2009; Kahlaee et al., 2017). Kapreli et al. published a detailed hypothesis about this relationship, and the findings of this relationship were supported by studies conducted in the following years (Kapreli et al., 2009). The effect of neck pain on pulmonary function may occur through decreased cervical ROM and changes in muscle function, which may negatively affect lung capacity (Kapreli et al., 2009; Dimitriadis et al., 2014; Dimitriadis et al., 2016). Increased tone and pain in the sternocleidomastoid and scalene muscles can affect the expansion of the chest and lungs, resulting in a shallow and inefficient breathing pattern and decreased lung volumes such as FVC (forced vital capacity) and PEFR (peak expiratory flow rate) (Kahlaee et al., 2017).

Stephen et al. reported that respiratory muscle strength training was shown to improve respiratory parameters in patients with CNP (Stephen et al., 2021). Dimitriadis et al. suggested that respiratory assessment and treatment should be included in standard physiotherapy practices in CNP patients as respiratory dysfunction in patients with CNP may affect respiratory functions (Dimitriadis et al., 2014; Dimitriadis et al., 2016). Also, in the study reported by Ren et al. showed that dysfunctional breathing in these patients was associated with increased neck disability and stress, and reported the potential for comprehensive rehabilitation, including respiratory training (Inokuchi et al., 2015).

For these reasons, understanding the effects of neck pain on respiratory and clinical parameters in individuals with neck pain will enable healthcare professionals to develop more effective treatment methods for the needs of these individuals. Studies conducted in this context will help to better manage neck pain and provide valuable information that will allow health systems to better understand the health problems of this group and develop more effective interventions.

In clinical practice, there is always uncertainty about how to apply the results from studies to an individual patient. When an individual with neck pain presents to a rehabilitation clinic, almost every patient aims for complete and permanent pain relief. Pain reduction is therefore a standard goal in neck pain rehabilitation. It is important that whether a treatment strategy for pulmonary function will be included in this rehabilitation program is predictable by the variables present in individuals with neck pain. There is a lack of information on the predictive value of different variables for impaired pulmonary function in individuals with CNP. This study aimed to determine whether cervical function-related variables—such as cervical range of motion (CROM), deep cervical flexor muscle endurance, pain severity, hand grip strength (HGS), neck disability index (NDI), and emotional status—can predict impaired pulmonary function in individuals with chronic neck pain (CNP). Knowledge of variables with a potentially predictive effect on outcome can allow for the development of more effective and targeted intervention strategies.

MATERIALS AND METHODS

Study design

This cross-sectional study was conducted between October 2022 and October 2023 in accordance with the Declaration of Helsinki. Ethical approval was obtained from the local Clinical Research Ethics Committee, and written informed consent was obtained from all participants.

Participants

Patients aged 18-55 years with CNP for more than 3 months and non-specific neck pain with VAS>3 and Neck Disability Index>10 (indicating at least moderate pain and disability) were included. Patients with red flag (malignancy, spinal fracture, etc.), cervical spine surgery or trauma (whiplash injury, fracture, and dislocation), cervical radiculopathy or myelopathy, physical therapy for neck pain in the last 6 months, pregnant women, smokers, BMI>40, systemic diseases, neurological diseases, dizziness or vertigo caused by ear or brain, vestibular diseases, mini mental test score <24 were excluded.

Assessments

Age (years), height (cm), body weight (kg), body mass index (BMI) (kg/m2), and intensity of pain were recorded.

Pain Intensity

Individuals were asked to mark their pain intensity on a 0-10 cm long Visual Analog Scale (VAS) (Wewers & Lowe, 1990). On the scale, 0 indicates no pain and 10 indicates intolerable pain. The value of the marked place was calculated with a ruler and recorded in cm (Wewers & Lowe, 1990).

Musculoskeletal System Assessment

Cervical Joint Range of Motion

The Cervical Range of Motion (Performance Attainment Associates, St. Paul, MN, 55117, United States) (CROM 3) device with proven validity and reliability was used for active assessment of the cervical ROM (Wibault et al., 2013). It was performed with the patients in a sitting position. Flexion and Extension movements were demonstrated, and they were asked to complete the ROM to the last point they could (Wibault et al., 2013; Inokuchi et al., 2015).

The Craniocervical Flexion Test (CCFT)

Deep cervical flexor muscles were assessed with CCFT (Reddy et al., 2012). During the test, a pressure sensor is placed under the neck and inflated to 20 mmHg. Then the person performed a nodding motion. The motion performed at different pressure levels increased by 2 mmHg each time from 20 to 30 mmHg. Each repetition should last at least 10 seconds. The performance index was based on the number of repetitions at the pressure level at which the individual managed to hold the position for 10 seconds. For example, if the individual can achieve 24 mmHg and hold CCF correctly for 10 seconds six times, the performance is calculated as 4×6=24 (Reddy et al., 2012; Wibault et al., 2013).

Hand Grip Strength

HGS of the participants was measured with a hand dynamometer (Jamar) (Menevşe et al., 2023). The measurement was performed as recommended by the American Association of Hand Therapists (Klein, 2014; Menevşe et al., 2023).

Questionnaires

Neck Disability Index

The Neck Disability Index (NDI) is an understandable, valid and reliable method for the measurement of pain and limitations in activities of daily living caused by cervical disorders (Aslan et al., 2008). The NDI consists of a total of 6 subsections and 10 questions. The subsections are designed to assess pain intensity, personal care, transportation, reading, headache, concentration, driving, recreational activities, and sleep. The questions are scored between 0 and 5. A high score indicates a high level of disability.

Beck Depression Inventory

The Beck Depression Inventory (BDI) is a test consisting of 21 items, each with four choices, used to differentiate depression level and depression from other psychopathological conditions. The total score is between 0-63. A score of 0-9 indicates normal level, 10-16 indicates mild, 17-29 indicates moderate, and 30-63 indicates severe depression symptoms (Ulusoy et al., 1998).

Respiratory Function

Respiratory muscle strength

MEP and MIP were measured with a portable intraoral pressure measuring device (Micro Medical MicroMPM, Kent, UK). Tests were repeated at least three times without a difference of more than 10cmH2O or 10% and the best value was used for analysis.

Pulmonary Function Test

Measurements were performed with a spirometer (Spirolab III, Spirolab, Medical International Research, Rome, Italy) in the sitting position. The values of $FEV1$ (Forced Expiratory Volume exhaled in the first second), FVC (Forced Vital Capacity), ($FEV1$/FVC), and maximal mid-expiratory flow rate $FEFF$25-75% (Forced Expiratory Flow between 25% and 75% of vital capacity), and PEF (Peak Expiratory Flow) were recorded. The test was performed in the sitting position and three consecutive repetitions, and the maximum value was recorded. The measured values are shown as a percentage of the expected reference values according to age, height, body weight and gender of the individuals.

Statistical Analysis

To identify independent predictors influencing the dependent variables, a backward stepwise multiple regression approach was applied. This method enables the simultaneous evaluation of all candidate variables initially entered into the model, aiming to obtain a more parsimonious and clinically meaningful regression model by progressively removing variables that do not make a statistically significant contribution. Given the exploratory nature of the study and the presence of multiple potential predictors, the backward stepwise regression method was considered appropriate. Analyses were performed with SPSS 25.0 software (IBM Corp., Armonk, NY, USA). Multiple regression analysis was performed to evaluate the multicollinear relationship between dependent and independent variables, and the final model was created by successively removing non-significant variables in the model. Model fit was evaluated with R^2 and adjusted R^2 values. In addition, tolerance and VIF (Variance Inflation Factor) values were examined to control multicollinear dependence. The significance of independent variables was assessed by t-test and regression coefficients (B) and 95% confidence intervals (CI) of the significant variables, and model effect sizes (f^2) were reported. In the regression analyses, respiratory parameters were entered as dependent variables, whereas cervical range of motion, deep cervical flexor muscle endurance, handgrip strength, neck disability, and depressive symptoms were entered as independent variables.

RESULTS

The study included 73 participants with neck pain. Demographic information and clinical characteristics of the participants are shown in Table 1. The mean age of the participants was 35.19±10.34 years. 82.19% of the participants were female. The mean NDI of the participants was moderate disability (16.64±7.83) and pain intensity was severe (66.60±16.90).

Table 1. Demographic and clinic characteristics of patients with CNP.

Variables	Mean±SD	Min-Maks
Age (years)	35.19±10.34	19.00-55.00
Sex n (%)		
Female	60 (82,19 %)	
Male	13 (17,81 %)	
BMI (m²/kg)	24.85±3.99	19.05-37.80
VAS (0-100)	66.60±16.90	30.00-100.00
CROM		
Flexion	44.77±16.61	15.00-80.00
Extention	40.70±21.83	10.00-88.00
CCFT		
Performance index	28.25±23.40	0-100.00
HGS (kg)	29.29±9.24	18.00-60.00
Female	26,88±7,31	18-60
Male	40,38±9,37	30-58
NDI (0-50)	16.64±7.83	4.00-45.00
BDI (0-63)	11.77±9.80	0-48.00

BMI: Body Mass Index, VAS: Visual Analog Scale, CROM: Cervical Range of Motion, CCFT: Cerebrocortical Flexion Test, HGS: Hand Grip Strength Test, NDI: Neck Disability Index, BDI: Beck Depression Index

The results of respiratory muscle strength and pulmonary function test are shown in Table 2. MIP and MEP values were decreased according to the mean age of the group (Society, 2002). FEV1 FVC and PEF values were normal (>80%). FEV1 /FVC is higher than expected (70-80%). This may indicate a restrictive respiratory pattern. FEF value is also within normal limits (>70%).

Table 2. Respiratory muscle strength and pulmonary function test results of patients with CNP.

Variables	Mean±SD	Min-Maks
MIP	92.34±30.05	61.00-164.00
Female	87,15±27,21	61-142
Male	116,31±31,92	69-164
MEP	110.04±33.92	56.00-211.00
Female	101,63±28,31	56-167
Male	148,85±31,32	107-211
FEV1	97.58±16.84	5.00-133.00
FVC	102.25±18.38	12.00-149.00
FEV1/FVC	99.48±6.52	68.00-123.00
FEF	78.79±22.01	12.00-126.00
PEF	89.14±19.11	31.00-128.00

MIP: Maximal Inspiratory Pressure, Maximal Expiratory Pressure, FEV_1: Forced Expiratory Volume in 1 Second, FVC: Forced Vital Capacity, FEV_1/FVC: Ratio of Forced Expiratory Volume in 1 Second to Forced Vital Capacity, FEF: Forced Expiratory Flow at 25-75% of Vital Capacity, PEF: Peak Expiratory Flow

The correlation analysis showed that there was a negative correlation between MIP and cervical flexion ROM (r= -0.378, p= <0.001), cervical extension ROM (r= -0.407, p= <0.001), neck disability index (r= -0.235, p= 0.023) and Beck depression scale (r= -0.306, p= 0.004). MEP was negatively correlated with cervical flexion ROM (r= -0.347, p= 0.001), cervical extension ROM (r= -0.442, p= <0.001), neck disability index (r= -0.255, p= 0.015) and Beck depression scale (r= -0.206, p= 0.041). There was a negative correlation between FEV1 and cervical flexion ROM (r= -0.373, p= 0.001) and cervical extension ROM (r= -0.348, p= 0.001). There was a negative correlation between FVC and cervical flexion ROM (r= -0.291, p= 0.006), and cervical extension ROM (r= -0.272, p= 0.010). There was also a negative correlation between FEV1 /FVC (r= -0.372, p= 0.020) and FEF (r= -0.235, p= 0.023) and neck disability index. PEF was negatively correlated with cervical flexion ROM (r= -0.559, p= <0.001), cervical extension ROM (r= -0.554, p= <0.001), neck disability index (r= -0.305, p= 0.004) and Beck depression scale (r= -0.224, p= 0.028) (Table 3).

Table 3. Correlation analysis between respiratory parameters and the study variables in the CNP patients.

		VAS	**CROM Flexion**	**CROM Extention**	**CCFT performance index**	**HGS**	**NDI**	**BDI**
r	**MİP**	0.032	**-0.378**	**-0.407**	-0.083	0.176	**-0.235**	**-0.306**
p		0.393	**<0.001***	**<0.001***	0.244	0.069	**0.023***	**0.004***
r	**MEP**	0.068	**-0.347**	**-0.442**	0.121	0.003	**-0.255**	**-0.206**
p		0.285	**0.001***	**<0.001***	0.154	0.490	**0.015***	**0.041***
r	**FEV_1**	0.178	**-0.373**	**-0.348**	-0.104	-0.168	0.090	0.089
p		0.066	**0.001***	**0.001***	0.190	0.078	0.224	0.228
r	**FVC**	-0.096	**-0.291**	**-0.272**	0.106	-0.089	0.062	0.022
p		0.209	**0.006***	**0.010***	0.185	0.228	0.301	0.427
r	**FEV_1/FVC**	-0.071	-0.103	-0.135	-0.097	0.251	**-0.372**	-0.188
p		0.352	0.291	0.234	0.303	0.087	**0.020***	0.156
r	**FEF**	-0.059	-0.125	-0.108	0.047	0.177	**-0.235**	-0.089
p		0.311	0.146	0.182	0.345	0.067	**0.023***	0.226
r	**PEF**	0.112	**-0.559**	**-0.554**	-0.055	0.025	**-0.305**	**-0.224**
p		0.173	**<0.001***	**<0.001***	0.322	0.417	**0.004***	**0.028***

*p *value < 0.05. MIP: Maximal Inspiratory Pressure, Maximal Expiratory Pressure, FEV_1: Forced Expiratory Volume in 1 Second, FVC: Forced Vital Capacity, FEV_1/FVC: Ratio of Forced Expiratory Volume in 1 Second to Forced Vital Capacity, FEF: Forced Expiratory Flow at 25-75% of Vital Capacity, PEF: Peak Expiratory Flow, CROM: Cervical Range of Motion, CCFT: Cerebrocortical Flexion Test, HGS: Hand Grip Strength Test, NDI: Neck Disability Index, BDI: Beck Depression Index*

Regression analysis results are shown in Table 4. Cervical flexor ROM was significantly predictive of FEV1 (R=0.373, R2 =0.139), FVC (R=0.363, R2 =0.132) and PEF (R=0.651, R2 =0.424). The cervical extensor ROM was significantly predictive of MIP (R=0.537, R2 =0.288), MEP (R=0.581, R2 =0.338) and PEF (R=0.651, R2 =0.424). The endurance of DCF muscles was shown to be significantly predictive of MIP (R=0.537, R2 =0.288) and FVC (R=0.363, R2 =0.132). HGS was significantly predictive for MEP and PEF, and NDI was significantly predictive for FEV1/FVC (R=0.372, R2 =0.139) and FEF (R=0.235, R2 =0.055). Finally, the BDI was significantly predictive for MIP and MEP.

Regression models demonstrated varying effect sizes across respiratory outcomes. The model predicting MIP showed a large effect size (R^2 = 0.288, f^2 = 0.404), while the model predicting MEP also demonstrated a large effect size (R^2 = 0.338, f^2 = 0.511). The regression models for FEV1 (R^2 = 0.139, f^2 = 0.162), FVC (R^2 = 0.132, f^2 = 0.152), and FEV1/FVC (R^2 = 0.139, f^2 = 0.162) yielded medium effect sizes. The model predicting FEF showed a small effect size (R^2 = 0.055, f^2 = 0.058). The strongest model was observed for PEF, demonstrating a very large effect size (R^2 = 0.424, f^2 = 0.736).

Table 4. Results of regression analysis of respiratory parameters

		Unstandardized Coefficients		95,0% Confidence Interval for B		p		
		B	SE	Lower Bound	Upper Bound		R	R^2
MIP	Constant	118,611	7,712	103,227	133,996	<0.001	0.537	0.288
	CROM Extention	-0,672	0,143	-0,958	-0,387	<0.001		
	CCFT Performance index	0,307	0,134	0,040	0,574	0,025		
	BDI	-0,645	0,312	-1,268	-0,022	0,043		
MEP	Constant	117,827	12,846	92,200	143,454	<0.001	0.581	0.338
	CROM Extention	-0,808	0,165	-1,137	-0,479	<0.001		
	HGS	1,175	0,398	0,381	1,968	0,004		
	BDI	-0,790	0,349	-1,486	-0,094	0,027		
FEV_1	Constant	114,514	5,326	103,893	125,134	<0.001	0.373	0.139
	CROM Flexion	-0,378	0,112	-0,601	-0,156	0,001		
FVC	Constant	115,383	5,918	103,580	127,185	<0.001	0.363	0.132
	CROM Flexion	-0,407	0,131	-0,668	-0,146	0,003		
	CCFT Performance Index	0,181	0,093	-0,005	0,366	0,056		
FEV_1/FVC	Constant	109,204	5,015	98,946	119,462	<0.001	0.372	0.139
	NDI	-0,510	0,236	-0,992	-0,027	0,039		
FEF	Constant	89,788	5,956	77,911	101,665	<0.001	0.235	0.055
	NDI	-0,661	0,324	-1,307	-0,014	0,045		
PEF	Constant	104,924	6,798	91,363	118,486	<0.001	0.651	0.424
	CROM Flexion	-0,393	0,150	-0,693	-0,093	0,011		
	CROM Extention	-0,358	0,118	-0,594	-0,122	0,003		
	HGS	0,560	0,203	0,154	0,965	0,008		

MIP: Maximal Inspiratory Pressure, Maximal Expiratory Pressure, FEV_1: Forced Expiratory Volume in 1 Second, FVC: Forced Vital Capacity, FEV_1/FVC: Ratio of Forced Expiratory Volume in 1 Second to Forced Vital Capacity, FEF: Forced Expiratory Flow at 25-75% of Vital Capacity, PEF: Peak Expiratory Flow, CROM: Cervical Range of Motion, CCFT: Cerebrocortical Flexion Test, HGS: Hand Grip Strength Test, NDI: Neck Disability Index, BDI: Beck Depression Index

DISCUSSION

In this study, we investigated which of the clinical outcomes related to neck pain could be predictors of respiratory muscle strength and respiratory function. Pain intensity, ROM, endurance of deep cervical flexor muscles, HGS, neck disability index, and Beck Depression scale were included in the regression analysis. Regression analysis showed that endurance of deep cervical flexor muscles, HGS, neck disability index, and Beck Depression scale could be predictors for respiratory parameters.

In our study, as the DSF muscles weakened, the risk of decreased MIP and FVC values increased. This result supports the results of previous studies (O'Leary et al., 2011; Dimitriadis et al., 2014). These muscles maintain the natural posture of the neck and stabilise the head (Falla et al., Spine 2004). If the endurance and strength of these muscles are reduced, it can lead to distortions in the forward head posture (FHP) and the natural curves of the spine, resulting in kypholordosis imbalance (Falla et al., Spine 2004). The weakness of the DSF muscles leads to the overactivation of the superficial muscles, especially the sternocleidomastoid and trapezius muscles (Falla et al., Spine 2004). As a result, muscle fatigue in the neck, increased neck muscle tone and postural disturbances may occur and may change the position of the rib cage by disrupting the natural angles of the spinal curves (Falla et al., Experimental Brain Research 2007, Spine 2004). These changes may affect the rib cage, impairing the respiratory mechanism, lung capacity and optimal function of the diaphragm (O'Leary et al., 2011). Studies in the literature have shown that strengthening the DSF muscles can contribute to improving respiratory capacity (Pawaria & Kalra, 2020; Arif et al., 2022). In 2020, Pawaria and Kalra showed that participants with higher DSF activity also had higher respiratory capacity. In this study, it was stated that DSF muscles can contribute to postural stability and respiration by working together with the diaphragm. Strengthening the DSF muscles can contribute to more effective breathing (Pawaria & Kalra, 2020). DSF muscle training can help to increase respiratory capacity, more effective diaphragmatic breathing and alleviate neck pain. As supported by studies in the literature, DSF muscles are directly related to respiratory muscles and respiratory mechanism (Pawaria & Kalra, 2020; Arif et al., 2022).

In our study, the negative correlation between the ROM of the cervical joint in the transverse plane and respiratory parameters was a surprising result. It was observed that FEV1, FVC, and PEF values decreased as the flexion ROM increased and MIP, MEP, FEV1, and PEF values decreased as extension ROM increased. Dimitradis et al. reported that sagittal cervical ROM were not a predictor of respiratory parameters in CNP patients (Dimitriadis et al., 2014; Dimitriadis et al., 2016). Park et.al. reported a positive correlation between FEV1 and right cervical lateral flexion, and no correlations between respiratory parameters and cervical flexion or extension (Park et al., 2021). Cho et.al. reported in their study that respiratory function and coughing ability can be effectively improved with neck ROM exercises (Cho et al., 2015). There are other studies in the literature showing that respiratory parameters improve with cervical region-oriented exercises (Arif et al., 2022). Although these results may seem confusing, they suggest that this relationship between cervical normal joint motion and respiratory parameters may be related to an adaptation whose mechanism is not yet understood. Kapreli et al. a similar negative correlation was reported for FHP and MEP, which at first seemed confusing (Kapreli et al., 2009). Later, this result was actually supported by other studies (Dimitriadis et al., 2014) and it was reported that this may not only be a maladaptive posture but also a compensatory mechanism to improve respiratory function (Dimitriadis et al., 2014).

The negative associations observed between increased cervical range of motion and reduced respiratory parameters should be interpreted with caution. These findings do not imply a causal relationship but rather indicate an association between cervical mobility and respiratory function in individuals with chronic neck pain. One possible explanation may involve biomechanical or compensatory mechanisms, such as altered cervical posture, changes in thoraco-cervical muscle recruitment, or increased reliance on accessory respiratory muscles. In this context, greater cervical mobility may reflect compensatory movement strategies rather than optimal functional mechanics. Further longitudinal and mechanistic studies are needed to clarify the directionality and underlying mechanisms of these relationships.

In our study, regression analysis revealed that HGS may be a positive predictor of MEP and PEF in individuals with neck pain. HGS is also considered as an indicator of general muscle strength in the literature, so it may be considered as a binding factor in the relationship between respiratory function and neck pain (Vaishya et al., 2024). Weak HGS considered a sign of general muscle weakness, may also be associated with weakness of the neck and respiratory muscles (Bohannon, 2012). In CNP patients, weakness in DCF muscles can lead to postural imbalances and decreased efficiency of respiratory muscles (Kim et al., 2020). In patients with neck pain, weakness in DCF muscles can lead to postural imbalances and decreased efficiency of respiratory muscles (Kim et al., 2020). This can lead to weakness in the diaphragm and other respiratory muscles and reduced respiratory capacity (Zafar et al., 2018). Decreased general muscle strength and endurance affecs affect both postural balance and respiratory function negatively. Thus, poor HGS may be a reflection of these processes (Rantanen et al., 2003). Thus, there may be an indirect link between HGS and respiratory capacity, and neck pain; increasing muscle strength may be an important step to alleviate these problems. In other words, decreased respiratory muscle strength may be part of a decline in peripheral skeletal muscle performance, or vice versa. Respiratory muscle weakness can be associated with generalized muscle weakness, leading to poor posture and neck pain. Weakness of the respiratory muscles, particularly affecting the diaphragm and intercostal muscles, can lead to impaired body posture because these muscles both perform respiratory functions and contribute to the stabilization of the spine (Rantanen et al., 2003; Zafar et al., 2018). General muscle weakness can cause postural imbalances with insufficient support of the back muscles, which can lead to overstrain of the neck muscles and neck pain (Sanchez-Ruiz et al., 2024). In addition, decreased respiratory muscle strength can lead to compensatory mechanisms in the body and increased muscle tension in the upper body, which can lead to chronic pain in the neck and shoulder region (Kapreli et al., 2009).

Neck pain is not only caused by physical factors; emotional states can also increase the severity of this pain. Emotional states such as anxiety, depression, and stress can reduce the efficiency of breathing by disrupting the coordination between the respiratory muscles, rib cage, and neck muscles (Kapreli et al., 2009). Studies have shown that depression levels are high in individuals with neck pain (Dimitriadis et al., 2014). Juan et al. showed in their study that the relationship between depression and neck pain is positive (Juan et al., 2020). Stephen et al. reported a link between pain in the cervical spine and difficulty breathing in individuals with high levels of depression (Stephen et al., 2021). In our study, we observed a decrease in MIP and MEP parameters as the depression levels of individuals with neck pain increased. When individuals are stressed or anxious, the normal function of the respiratory muscles, especially the diaphragm, may be impaired (Cheon et al., 2020). In this case, breathing becomes superficial, the muscles cannot get enough oxygen, and this leads to muscle tension in the cervical region. Affected breathing can also create a cycle that increases neck pain (Kapreli et al., 2009). This result suggests that emotional states, such as depression, may reduce the efficiency of respiratory muscles and thus lead to a decrease in respiratory capacity. High levels of depression may affect endurance and strength of the respiratory muscles, leading to a decrease in respiratory function. In addition, the reluctance seen in depressed individuals may cause these participants to perform incomplete maneuvers during the assessment.

The finding that depressive symptoms, as measured by the Beck Depression Inventory, emerged as a significant predictor of inspiratory and expiratory muscle strength has potential clinical implications. In individuals with chronic neck pain, depressive symptoms may be associated with altered motor control, reduced neuromuscular activation, increased pain perception, and decreased engagement in physical activity, all of which may negatively influence respiratory muscle performance. From a clinical perspective, this finding highlights the importance of considering psychological status when interpreting respiratory outcomes and planning rehabilitation programs. However, these associations should be interpreted as relational rather than causal, and future studies incorporating longitudinal designs and targeted psychological assessments are warranted to further elucidate these relationships.

NDI is a questionnaire that measures the impact of neck pain on activities of daily living (Aslan et al., 2008). It was observed that BMI could be a predictor for FEV1/FVC and FEF values. This result may indicate that the effect of neck pain on self-management is related to respiratory parameters. Dimitriadis et al. 2014 reported that disability was not a predictor for pulmonary function test parameters (Dimitriadis et al., 2014). In another study conducted in 2013, they reported that disability was a predictor for MEP (Dimitriadis et al., 2013). In the study of Dimitriadis et al., the disability level of the patients was reported as mild disability (Dimitriadis et al., 2013). In our study, the disability level of the patients was moderate. This difference in our results may be related with the disability level of the patients. In future studies, evaluating the patients by grouping them according to the level of disability may help to clarify this issue.

Respiratory muscle strength and pulmonary function tests of the participants were within normal limits, which was indicating that the respiratory system was generally healthy. However, it is possible that neck pain may have an indirect effect on respiratory function, or some variables may predict impairments in respiratory function. The results reveal that CNP does not appear to be a condition associated only with neuromusculoskeletal and psychological symptoms but has broader dimensions. The effect of variables related to neck pain on respiratory parameters in individuals with neck pain indicates that this condition should be evaluated and treatment programs should be shaped accordingly. Such an approach provides a more holistic and effective treatment process.

In addition, cervical exercises have been shown to support improvement in respiratory parameters, especially with postural effects, as have studies examining the effectiveness of respiratory exercises in combination with standard treatment of patients with CNP (Yun et al., 2015). Therefore, in clinical practice, it seems that increasing the cervical region muscle's strength and endurance can contribute to respiratory parameters as well as evaluating neck pain patients in terms of respiratory strength and function and supporting the treatment of the cervical region with respiratory exercises.

In our study, flexion ROM explained only 13.9% of the change in FEV1, flexion ROM and CCFT performance index explained 13.2% of the change in FVC and flexion ROM, Extension ROM and HGS explained 42.4% of the change in PEF and the model was very weak in explaining the effects of FEF. In our study, it is seen that CROM, HGS and NDI has a greater effect on pulmonary function in patients with neck pain and these effects can be better explained. The low explanatory power of the model for other parameters (FEV1/FVC, FVC and FEF) suggests that further research should be conducted or different variables should be taken into account.

For MIP and MEP, 28.8% and 33.8% were explained by the model, respectively. This suggests that factors associated with neck pain have some influence on MIP and MEP, but not necessarily a strong relationship. It is important to take a more comprehensive approach to examine factors such as other musculoskeletal problems (posture, tone, and strength of neck and upper body muscles), physical activity level, breathing habits, stress, and anxiety level.

One of the limitaitons of this study was the limited sample size. In addition, the unbalanced number of men and women in the patient population may cause bias in the results. In addition, the age range of the patients was large, which may have prevented statistical demonstration of the effects on these parameters. Finally, the disability index was low compared to the literature. This may have prevented the statistical significance of the effects of the patients.

In conclusion, in this study, variables related to neck pain symptoms were found to be associated with impairments in respiratory parameters. It can be said that deep cervical flexor muscles, HGS, and psychological status are the most important factors affecting respiratory parameters. Our study draws attention to respiratory problems, which are still controversial in the literature and are not part of the evaluation of individuals with neck pain in the clinic. In this sense, the relationship between CNP and respiratory parameters should be investigated with more objective methods.

Ethical Approval

This study has been approved by the Hacettepe University Non-Interventional Research Ethics Committee (Date: 21/06/2022, No: 2022/14-61).

Authors' Contribution

SAÇ: Concept/idea development, study design, project management, data collection/processing, literature review, writing. BÇ, AD: data analysis/interpretation. HKÖ: case provision. SB: Concept/idea development, study design, project management, critical revision.

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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