



## Original Article

# The effects of forward head posture on expiratory muscle strength in chronic neck pain patients: A cross-sectional study

Özge Solakoğlu , Peyman Yalçın , Gülay Dinçer 

Department of Physical Medicine and Rehabilitation, Ankara University School of Medicine, Ankara, Turkey

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## ABSTRACT

**Objectives:** This study aims to investigate the relationship between forward head posture (FHP) and respiratory dysfunctions in patients with chronic neck pain.

**Patients and methods:** Between June 2014 and November 2016, a total of 99 patients (11 males, 88 females; mean age 54.1±9 years; range, 38 to 75 years) with chronic neck pain were evaluated for head posture by cervical lateral radiograph measuring the anterior head translation distance (FHPmm) and C7 vertebrae position (C7°). We examined the chest expansion by subtracting chest circumference from the level of xiphoid during maximal inspiration and expiration. Pain severity and neck disability were assessed using the Visual Analog Scale (VAS) and modified Neck Disability Index (MNDI), respectively. The respiratory functions were evaluated using spirometry tests, lung volumes, and maximal inspiratory and expiratory pressures (Pi<sub>max</sub> and Pe<sub>max</sub>, respectively).

**Results:** There was a negative correlation between the FHPmm with Pe<sub>max</sub>% (rho: -0.314; p=0.005). A negative correlation was also observed between C7° and Pe<sub>max</sub>, Pe<sub>max</sub>%, forced expiratory volume in one sec (FEV1)/forced vital capacity (FVC)%, forced expiratory flow (FEF)25-75%, and FEF75% (rho:-0.245, -0.349, -0.218, -0.214, and -0.259 respectively; p=0.028, 0.002, 0.035, 0.040, and 0.012, respectively). There was a positive correlation between neck disability and VAS scores (rho: 0.424; p<0.001), while there was a negative correlation between neck disability and chest expansion, maximum voluntary ventilation (rho: -0.201 and -0.217, respectively; p=0.049 and 0.046, respectively).

**Conclusion:** Based on our study results, FHP is associated with expiratory muscle weakness in chronic neck pain patients. To evaluate respiratory dysfunction, chest expansion tests may be useful, although these tests are not specific to muscle weakness. Interventions about FHP and neck pain should focus on the effects of respiratory muscle training.

**Keywords:** Chest expansion, forward head posture, maximal respiratory pressure, neck pain, respiratory function.

Neck pain is a common public health problem affecting the quality of daily life. It has shown that 84% of patients with chronic neck pain present faulty breathing patterns, affecting respiratory functions.<sup>[1]</sup> In normal breathing pattern, breathing should initiate with abdominal breathing rather than chest breathing and the chest should expand horizontal rather than vertical.<sup>[1]</sup> In the faulty upper chest breathing pattern, clavicles are lifted upward by overactivity of sternocleidomastoid (SCM), trapezius, and scalene muscles, contributing to the muscle imbalance.<sup>[1]</sup>

Muscle imbalance has an important role in forward head posture (FHP). As Janda<sup>[2]</sup> refers in upper crossed syndrome, superficial neck flexors (SCM and anterior scalene muscles) become tight; however, deep neck

flexor and extensor muscles tend to be lengthened and incapable. Also, upper trapezius, levator scapulae, and pectoralis muscles which play a role in forced inspiration become tight and shortened, while the rhomboid and serratus anterior muscles become loose and weak.<sup>[2,3]</sup> These imbalances result in rib cage dysfunctions, leading to respiratory dysfunction. Although FHP is thought to be one of the confounding factors for respiratory dysfunction, there is a limited number of head-to-head comparison studies.

Respiratory muscle function can be assessed directly by measuring the pressure developed throughout the maximum voluntary inspiratory and expiratory effort.<sup>[4]</sup> Maximal expiratory and inspiratory pressures (Pe<sub>max</sub> and Pi<sub>max</sub>, respectively)

**Corresponding author:** Özge Solakoğlu, MD. İstanbul Medeniyet Üniversitesi, Göztepe Eğitim ve Araştırma Hastanesi Fizik Tedavi ve Rehabilitasyon Kliniği, 34732 Kadıköy, İstanbul, Türkiye. e-mail: drozgekoseoglu@hotmail.com

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are critical to assess the muscle weakness, as they are remarkably reduced before a notable volume loss is seen in the vital capacity (VC).<sup>[5]</sup> Maximum voluntary ventilation (MVV) indicates the muscle strength, but it is less sensitive than  $P_{i_{max}}$  and  $P_{e_{max}}$ , as the MVV is approximately proportional to VC reduction.<sup>[6,7]</sup> The VC may lessen due to inspiratory or expiratory muscle weakness, limitation of full inspiration or impeding full expiration, respectively. Additionally, VC is affected by reduced compliance of lungs and chest wall, as well as respiratory muscle strength.<sup>[8,9]</sup> Expiratory muscle weakness results in an increasing residual volume (RV) due to inability to attain maximal expiration. Lessened expiratory muscle strength directly rises RV, and this effect may be accompanied by a decline in lung compliance, such that, in some patients, RV stays within normal limits. Also, the peak expiratory flow (PEF) rate may be associated with expiratory muscle weakness, as well as airway obstruction.

In patients with chronic neck pain, several studies have focused on reduced respiratory capacity, showing a decrease in MVV,  $P_{i_{max}}$ , and  $P_{e_{max}}$ .<sup>[10-12]</sup> In the present study, we aimed to investigate the relationship between FHP and respiratory functions in patients with chronic neck pain.

## PATIENTS AND METHODS

Between June 2014 and November 2016, a total of 99 patients (11 males, 88 females; mean age  $54.1 \pm 9$  years; range, 38 to 75 years) who were admitted to the Physical Medicine and Rehabilitation outpatient clinic with mechanical neck pain for at least once a week, lasting for at least three months were included in this study. Patients with neck trauma, cervical or thoracic vertebral surgery, cervical myelopathy, neuromuscular disease, inflammatory disease, lung disease including chronic obstructive pulmonary disease and asthma, major surgery within the last six months, a body mass index of  $\geq 40$  kg/m<sup>2</sup> and smoking history were excluded. A written informed consent was obtained from each patient. The study protocol was approved by the Ankara University Faculty of Medicine Ethics Committee (No. 04-170-14). The study was conducted in accordance with the principles of the Declaration of Helsinki.

### Forward head posture analyses

After a detailed medical history and anthropometric data were obtained from the patients, we obtained lateral cervical spine radiographs in the standing self-balance position which was achieved by instructing

the patient to complete wide amplitude cervical flexion and extension, step by step reducing to rest point where the patient felt himself/herself most comfortable and balanced. Previous studies have also confirmed that testing the self-balance position is repeatable.<sup>[13,14]</sup>

For FHP assessment, two measurements were obtained on radiograph using the Picture Archiving and Communication System (PACS, General Electric Healthcare, NY, USA) software. The first measurement was the anterior head translation distance which was described by Jackson et al.<sup>[15]</sup> In our study, this parameter was defined as the FHPmm. As shown in Figure 1, 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 in mm. Harrison et al.<sup>[16]</sup> suggested that an average of 15 mm of anterior head displacement was normal. In our study, the patients with  $>15$  mm anterior head displacement were assigned as the FHP group, while those with a displacement of  $\leq 15$  mm were assigned as normal head posture (NHP) group.

Additionally, as another method, C7 vertebrae position ( $C7^\circ$ ) was measured as described in the study of Morningstar<sup>[17]</sup> We measured the angle between line parallel to disc plane of C7 disc and a line constructed parallel to the base of the X-ray film, as shown in Figure 2. The  $C7^\circ$  is thought to be closely related to static alignment of the cervical spine and shown to be proportional with FHP and, therefore, it can be reduced with the treatment of FHP.<sup>[17,18]</sup>

### Chest expansion test

Chest expansion test is used as a thoracic spine examination way to check a reduction of costovertebral joint motion and to evaluate respiratory circumstances. In order to measure the mobility of the chest, the level of the xiphoid process was used as a landmark.<sup>[19]</sup> First, the patient's chest was wrapped with a tape measure. Second, the patient was asked to perform maximal inspiration and expiration. The difference in the chest circumferences between maximal inspiration and expiration was measured. The session was repeated twice, and the highest measurement was recorded.<sup>[20]</sup>

### Pain severity and disability

Pain severity was assessed using a 10-cm visual analog scale (VAS). Disability of the patients was measured using the modified Neck Disability Index (MNDI), which is a valid and reliable self-evaluation test for the Turkish population.<sup>[21]</sup>



Figure 1. Anterior head translation distance (FHPmm).



Figure 2. C7 vertebrae position (C7°).

### Spirometry, lung volume, and maximal respiratory pressure measurements

Respiratory functions were assessed by standard testing recommendations of the American Thoracic Society and European Respiratory Society (ATS/ERS) with Vmax™ Encore body plethysmography device and body cabin for lung volumes and maximal respiratory pressures (CareFusion Inc., Yorba Linda, CA, USA) calibrated in every session in room temperature (20 to 25°C).<sup>[22,23]</sup> The tests were performed by a single technician for three times obtaining the differences between each maneuver at a ratio of 5% or 200 mL. During the test sessions, the patient remained seated and used a nose clip. The best respiratory function performance by the patient was recorded.<sup>[23]</sup> The respiratory function parameters evaluated by spirometry included forced vital capacity (FVC), forced expiratory volume in one sec (FEV1), forced expiratory ratio (FEV1/FVC), forced expiratory flow (FEF25%, FEF50%, FEF75%, and FEF25-75%), PEF, and MVV. The reference values were obtained from the Hedenström's study for MVV and the ERS guideline (1993) for other parameters.<sup>[24-26]</sup>

The procedure for  $P_{i_{max}}$  and  $P_{e_{max}}$  assessment was explained and shown briefly. Nose clip was applied

to ensure that any air leak was prevented. A flanged mouthpiece was also used during the measurements, and the patients were requested to wrap their mouth around tightly. To measure the  $P_{e_{max}}$ , the patients were initially asked to inhale as much as they could and, then, to exhale at maximal exertion against the resistance of instrument for no less than one sec. To measure the  $P_{i_{max}}$ , the patients were asked to exhale as much as they could and, then, to inhale at maximal exertion against the resistance of instrument for no less than one sec. A total of 5 to 10 sessions were completed by the patients to confirm that three highest measurements varied by under 5% difference. The maximum measurement was noted. Reference values for  $P_{i_{max}}$  and  $P_{e_{max}}$  were obtained from the ATS/ERS 2009.<sup>[27]</sup> Lung volumes were tested three to five times in the body cabin by breathing a gas mixture containing helium. The best of VC, RV, and total lung capacity were recorded and, for these parameters, the reference values of the ERS guideline (1993) were used.<sup>[26]</sup> During each of the spirometry and mouth occlusion pressure measurement tests, the patients were encouraged to demonstrate their maximal effort. The measured values were defined as the abbreviation of the test. The predicted values were described as the patient's performance divided by reference values in

percentage (i.e.,  $P_{i_{max}}\%$  or  $P_{e_{max}}\%$ ). All the references used in the study were determined by age, sex, height, and weight.

### Statistical analysis

Due to missing data in the literature regarding the relationship between FHP and respiratory muscle strength, a power analysis and sample size calculation were unable to be performed prior to the study. Therefore, a post-hoc analysis was performed.

Statistical analysis was performed using the SPSS version 11.0 software (SPSS Inc., Chicago, IL, USA). The normality of data distribution was tested using the Shapiro-Wilk test of normality. Continuous variables were presented in mean  $\pm$  standard deviation (SD) if the data were normally distributed and in or median (min-max), if the data were non-normally distributed. Categorical variables were presented in number and frequency. To assess the correlation between continuous quantitative variables, the non-parametric correlation test of Spearman rho was used. Correlation coefficients in the order of 0.10 are "small," those of 0.30 are "medium," and those of 0.50 are "large" in terms of magnitude of effect sizes according to Cohen.<sup>[28]</sup> Describing the strength of the correlation, the guide that Evans suggested for the absolute value of rho was used. The Rho values between 0.00-0.19, 0.20-0.39, 0.40-0.59, 0.60-0.79, 0.80-1.0 were described as very weak, weak, moderate, strong, and very strong, respectively.<sup>[29]</sup> For continuous variables, to investigate whether there was a statistically significant difference between two independent groups, independent samples t-test was used for normally distributed data and the Mann Whitney-U test was used for non-normally distributed data. For categorical variables, the chi-square and Fisher's exact tests were carried out to analyze significant differences between the groups. A  $p$  value of  $<0.05$  was considered statistically significant.

## RESULTS

During the study, one patient refused lateral cervical radiograph and five patients rejected to perform respiratory function tests. Additionally, 13 patients were unable to complete respiratory function tests due to various reasons such as panic attack, lack of cooperation, or claustrophobia. Other data obtained for these patients were added to the analyses.

The median FHPmm was 20.5 (range, -9.2 to 52.7) mm, while the median  $C7^\circ$  was  $24^\circ$  (range,  $1^\circ$  to  $45^\circ$ ). The median VAS score was 5 (range, 0 to 10) cm, while the median MNDI score was 38% (range, 7 to 65%). No significant difference was found between the groups with respect to sex, age, BMI, neck disability, and pain score. Demographic and clinical characteristics of the patients in the NHP and FHP groups are shown in Table 1.

There was a weak, negative relationship between FHPmm with  $P_{e_{max}}\%$  for medium effect size ( $n=80$ , rho: -0.314,  $p=0.005$ ). The  $C7^\circ$  had a weak, negative relationship with  $P_{e_{max}}$  for small effect size and a weak, negative relationship with  $P_{e_{max}}\%$  for medium effect size ( $n=80$ , rho: -0.245, -0.349;  $p=0.028$ , 0.002). Similarly,  $C7^\circ$  had a weak, negative relationship with FEV1/FVC%, FEF25-75%, and FEF75% for small effect size ( $n=93$ , rho: -0.218, -0.214, -0.259;  $p=0.035$ , 0.040, 0.012). Correlation analysis results between the quantitative parameters and FHP indicators are shown in Table 2. According to the post-hoc power analysis, the relationship between the FHPmm and  $P_{e_{max}}\%$  had 83% power and the correlation between  $C7^\circ$  and  $P_{e_{max}}\%$  had 91% power for medium effect size at an alpha level of 0.05, while the correlation between  $C7^\circ$  and  $P_{e_{max}}$ , FEV1/FVC%, FEF25-75%, FEF75% had 61%, 57%, 55%, 73% power for small effect size at an alpha level of 0.05, respectively.

**TABLE 1**  
Demographic and clinical characteristics of patients in NHP and FHP groups

	NHP group (n=35)				FHP group (n=63)				<i>p</i>
	n	Mean $\pm$ SD	Median	Min-Max	n	Mean $\pm$ SD	Median	Min-Max	
Age (year)		52 $\pm$ 8.0				55.5 $\pm$ 9.3			0.063
Gender									0.091
Female	34				53				
Male	1				10				
Body mass index (kg/m <sup>2</sup> )		29.6 $\pm$ 3.9				29.5 $\pm$ 4.1			0.913
Modified Neck Disability Index			42	11-62			31.5	7-65	0.352
Visual analog scale			3	0-10			5	0-8	0.247

NHP: normal head posture; FHP: forward head posture; SD: Standard deviation.

**TABLE 2**  
Correlation analysis results of FHP predictors\*

	FHP (mm)		C7°	
	rho	p	rho	p
FHP (mm)	-	1	0.417	0.000
C7° (°)	0.417	<0.001	1	.
Age	0.130	0.201	0.117	0.251
BMI (kg/m <sup>2</sup> )	-0.038	0.709	-0.032	0.757
VAS (cm)	-0.035	0.730	-0.109	0.284
MNDI (%)	-0.122	0.232	-0.140	0.170
Chest expansion (cm)	0.027	0.792	-0.111	0.284
FVC (%)	-0.029	0.783	-0.050	0.633
FEV1 (%)	-0.010	0.923	-0.129	0.219
FEV1/FVC (%)	-0.059	0.572	-0.218	0.035
PEF (%)	0.019	0.858	-0.061	0.562
FEF25-75%	-0.036	0.723	-0.214	0.040
FEF25%	0.037	0.723	-0.083	0.430
FEF50%	-0.088	0.402	-0.202	0.053
FEF75%	-0.067	0.522	-0.259	0.012
MVV (L/min)	0.048	0.662	-0.103	0.353
MVV (%)	-0.021	0.850	-0.127	0.252
VC (%)	-0.113	0.298	0.014	0.894
RV (%)	0.053	0.627	0.032	0.767
TLC (%)	-0.073	0.504	0.024	0.828
RV/TLC (%)	-0.072	0.510	-0.028	0.794
Pi <sub>max</sub> (cmH <sub>2</sub> O)	-0.042	0.704	-0.091	0.411
Pi <sub>max</sub> %	-0.102	0.360	-0.101	0.363
Pe <sub>max</sub> (cmH <sub>2</sub> O)	-0.186	0.099	-0.245	0.028
Pe <sub>max</sub> (%)	-0.314	0.005	-0.349	0.002

\* Spearman correlation analysis; FHP: Forward head posture; C7°: C7 vertebrae position; BMI: Body mass index; VAS: Visual Analog Scale; MNDI: Modified Neck Disability Index; FVC: Forced vital capacity; FEV1: Forced expiratory volume in one sec; PEF: Peak expiratory flow; FEF: Forced expiratory flow; MVV: Maximum voluntary ventilation; VC: Vital capacity; RV: Residual volume; TLC: Total lung capacity; Pi<sub>max</sub>: Maximal inspiratory pressure; Pe<sub>max</sub>: Maximal expiratory pressure.

In addition, there was a correlation between the chest expansion test and some of the respiratory function tests. Table 3 presents the correlation analysis results of chest expansion with some prespecified respiratory functions. Significantly correlated variables or variables related to muscle strength were included in Table 3.

There was a moderate positive correlation between neck disability and VAS for medium effect size (rho: 0.424, p<0.001), while a weak, negative correlation between neck disability and chest expansion, MVV for small effect size was observed (rho: -0.201, -0.217; p=0.049, 0.046). No significant correlation was observed between neck disability and other respiratory function tests.

**DISCUSSION**

In our study, a weak relationship between FHP and expiratory muscle weakness was found, while no significant relationship was observed between FHP and inspiratory muscle strength. In the literature, the number of studies investigating the relationship between FHP and respiratory functions is limited; however, studies about chronic neck pain and respiration have demonstrated important data. Kapreli et al.<sup>[10]</sup> showed that chronic neck pain was associated with decreased MVV, Pi<sub>max</sub>, and Pe<sub>max</sub>; however, decreases in Pi<sub>max</sub> and Pe<sub>max</sub> were associated with FHP. Dimitriadis et al.<sup>[11]</sup> also found that FHP was a predictor of expiratory muscle weakness, but not of the inspiratory muscle strength and these findings are consistent with our results. Conversely, Wirth et al.<sup>[12]</sup> suggested that FHP was not a predictor of Pi<sub>max</sub> or Pe<sub>max</sub>. In their studies, Kapreli et al.,<sup>[10]</sup> Dimitriadis et al.,<sup>[11]</sup> and Wirth et al.<sup>[12]</sup> enrolled a population with moderate-to-severe disability, mild-to-moderate disability, and mild disability using the MNDI, respectively. Dimitriadis et al.<sup>[11]</sup> found a negative correlation between disability and Pe<sub>max</sub>,

**TABLE 3**  
Correlation analysis of chest expansion with prespecified respiratory functions\*

	FVC (%)	FEV1 (%)	FEF 25-75%	PEF (%)	MVV	MVV (%)	Pi <sub>max</sub>	Pi <sub>max</sub> (%)	Pe <sub>max</sub>	Pe <sub>max</sub> (%)	VC
Chest expansion											
r	0.291	0.303	0.316	0.251	0.470	0.306	0.315	0.186	0.375	0.132	0.218
p	0.006	0.004	0.003	0.016	<0.001	0.005	0.005	0.097	0.001	0.248	0.045

\* Spearman correlation analysis; FVC: Forced vital capacity; FEV1: Forced expiratory volume in one sec; FEF: Forced expiratory flow; PEF: Peak expiratory flow; MVV: Maximum voluntary ventilation; Pi<sub>max</sub>: Maximal inspiratory pressure; Pe<sub>max</sub>: Maximal expiratory pressure; VC: Vital capacity.

while Wirth et al.<sup>[12]</sup> found no significant relation of the  $P_{i_{max}}$  and  $P_{e_{max}}$  with disability. In our study, we found a relationship between neck disability and MVV, but not with  $P_{i_{max}}$  or  $P_{e_{max}}$  in our patients with moderate disability. The differences between the aforementioned studies may be the consequences of the variances of disabilities of the study populations. In the current study, the relationship between FHPmm and  $P_{e_{max}}\%$  was weak for small effect size and relationship between  $C7^\circ$  and  $P_{e_{max}}\%$  was weak for medium effect size. On the other hand, no significant relationship was observed between FHPmm and  $P_{e_{max}}$ , while there was a weak relationship between  $C7^\circ$  and  $P_{e_{max}}$ . The  $P_{e_{max}}\%$  indicates the predicted percent of the expiratory muscle strength. We suggest that, during patient evaluation, it is essential to use the predicted percent values to consider expiratory muscle weakness.

In the literature, Han et al.<sup>[30]</sup> found that the FVC, FEV1, FEV1/FVC%, and MVV in FHP patients tended to decrease more than that of normal individuals, while Kang et al.<sup>[31]</sup> found a relationship between FHP and FVC in healthy population. In our study, a weak, negative correlation between  $C7^\circ$  and FEV1/FVC%, FEF25-75%, FEF75% for small effect size was found. In a study, it was found that patients with asthma had their head more anteriorly.<sup>[19]</sup> It is thought that, due to elevated inspiratory loading in obstructive respiratory pathologies, postural changes are induced. An increased activity of erector spinae, latissimus dorsi, pectoralis major, and trapezius, as well as displacement of the diaphragm to a disadvantageous position may change to postural alignment.<sup>[32,33]</sup> In our population, patients diagnosed with asthma and other obstructive lung diseases were excluded; however, according to our results, we can speculate that FHP may be one of the initial signs of obstructive lung disease which may not manifest significantly. A weak correlation with FHP and obstructive lung disease parameters should be noted for further conclusions. Further studies are needed to confirm our findings.

In our study, we assessed FHP directly measuring the distance and the angle between specific anatomical landmarks on X-ray imaging. In the literature, it was also used to mark the projections of the anatomical landmarks on side profile photograph to measure the angle between landmarks.<sup>[10-12]</sup> However, it was shown that variances of the length of the spinous processes and the depth of overlying soft tissue might cause differences between the alignment of the vertebral bodies and visible cervical curve.<sup>[34]</sup> Surface measurements tend to detect head more anteriorly,

resulting in FHP to overestimate.<sup>[14,35]</sup> In our study, we performed postural examination based on directly vertebral column and, therefore, X-ray imaging was preferred to prevent overestimation. This may be one of the reasons clarifying the differences between the results of the studies.

Furthermore, FHP primarily affects the neck muscles and these muscles are usually accessory inspiratory muscles. However, we found no significant correlation between the inspiration muscle strength and FHP in our study. We believe that the hyperactive muscles (SCM, anterior scalene, and upper trapezius muscles) may produce more power leading to  $P_{i_{max}}$  levels to stay in normal range, despite muscle fatigue.

In their study, Kang et al.<sup>[31]</sup> showed that FHP was correlated with FVC; however, we revealed no such correlation in our study. In the aforementioned study, only patients with a distance between the vertical line from acromion process and external acoustic meatus of at least 5 cm in visual posture analysis, which implicated severe FHP were included. In general, FVC is markedly impaired after the loss of the  $P_{e_{max}}$  and  $P_{i_{max}}$  values, suggesting that it is not a sensitive test and may not detect mild respiratory functional anomalies.<sup>[6,7]</sup> In the study of Kang et al.,<sup>[31]</sup>  $P_{i_{max}}$  and  $P_{e_{max}}$  values were missing, precluding to draw further conclusions. Therefore, we recommend performing maximal respiratory pressures earlier to detect patients with respiratory muscle weakness.

In our study, chest expansion test was found to be correlated with most of the respiratory functions test including FVC%, PEF%, MVV, MVV%, and  $P_{i_{max}}$  and  $P_{e_{max}}$ . However, we found no significant correlation with FHP, and our results indicate that chest expansion is related to respiratory muscle weakness, but not specific to it, and may be useful to predict patients who have respiratory dysfunction. In the literature, Wirth et al.<sup>[12]</sup> found a correlation between FHP and chest expansion, but Wirth et al.<sup>[12]</sup> measured the chest expansion twice and recorded the mean values of the measurements. We consider that the highest value should be added to analyses, as the test is a performance-based test and it may be appropriate to add the highest value as in the respiratory function tests.<sup>[23]</sup>

The main limitation of our study was a high female/male ratio; however, no significant difference was found between the groups with regard to the distribution of FHP. Eighteen patients were unable to complete some steps of respiratory function tests, which were unexpectedly high. The main strength of our study was, however, that the relationship

between FHP and respiratory muscle strength was directly investigated for the first time in patients with chronic neck pain. Although previous studies investigating the relationship between neck pain and respiratory muscle strength give a clue that the severity of neck disability may be an important indicator for respiratory dysfunction, further investigations about the relationship between the disability and respiratory dysfunction are still needed. Also, chest expansion test may give useful information about respiratory dysfunction, but the relationship between FHP and chest mobility still remains to be elucidated.

In conclusion, FHP is the most common postural disorder mainly affecting the biomechanics of the neck and upper extremities, as well as respiration. We recommend evaluating respiratory functions in addition to posture examination given the fact that most of the patients with neck pain have a faulty breathing pattern. Thus, we believe that finding out respiratory dysfunction in FHP is important to tailor the treatment protocol. We also recommend researchers to examine the effects of respiration training on FHP and neck pain in further studies. Expiratory muscle strengthening exercises may be useful, as well as re-education of breathing pattern and posture exercises. We recommend examining chest expansion testing to patients with chronic neck pain. In case of faulty breathing pattern, chest expands vertically rather than horizontally, leading to decreased chest expansion. It may help to determine respiratory dysfunction and revise the treatment protocol.

#### **Declaration of conflicting interests**

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

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