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Investigating the effects of head posture muscles' viscoelastic parameters on pulmonary and functional capacity in healthy individuals

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Cagtay Maden, Begumhan Turhan, Tuba Maden, Kezban Bayramlar
Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Hasan Kalyoncu University, Gaziantep, Turkey

Abstract

Introduction. Forward head posture (FHP) is known to have a large influence on respiratory function by weakening the respiratory muscles. This cross-sectional study is designed to examine the relationship between the tonus, stiffness, and elasticity of head posture muscles and pulmonary capacity.

Methods. Overall, 16 FHP and 17 non-forward head posture (NFHP) individuals were evaluated. The tonus, stiffness, and elasticity of the upper trapezius, semispinalis capitis, pectoral muscles, and sternocleidomastoid muscles were measured with a MyotonPRO® device. Functional capacity was assessed with the 6-minute walk test. Pulmonary function tests employed a spirometer. The Neck Disability Index was applied. FHP was determined by measuring the craniovertebral angle. Physical activity levels were evaluated with the Physical Activity Index.

Results. The study involved 18 (54.54%) female and 15 (45.45%) male students. Their mean age was 21.24 ± 1.82 years. Neck Disability Index scores were higher in participants with FHP than in NFHP individuals ($p = 0.037$). There were no significant differences in the myotonometric measurements of the analysed muscles between FHP and NFHP groups ($p > 0.05$). Physiological characteristics of FHP and NFHP participants were different in terms of vital capacity, forced vital capacity, forced expiratory volume in 1 second, and peak forced expiratory volume ($p < 0.05$).

Conclusions. Owing to the pulmonary capacity differences between FHP and NFHP individuals, it can be concluded that FHP affects pulmonary capacity. Also, pectoral muscles and semispinalis capitis muscles play an important role in thoracic expansion and therefore influence vital capacity.

Key words: muscle tonus, muscle stiffness, elasticity, forward head posture, pulmonary capacity

Introduction

Forward head posture (FHP), which is associated with many musculoskeletal complications, is one of the most common postural disorders of the cervical region [1, 2]. Static sedentary posture may cause recurrent muscle contractions in the neck and shoulder region, which subsequently lead to FHP [3]. Some muscles, such as the longus colli, sternocleidomastoid (SCM), semispinalis capitis (SSC), rectus capitis posterior, oblique capitis superior, erector spinae, splenius, suboccipitalis, upper trapezius (UT), and pectoral muscles (PM), are important to control the posture of the upper back, head, and neck [4]. FHP causes compressive loading on muscles, tissues, cervical spine, especially facet joints, and ligaments [5]. If FHP is maintained for a long time, the imbalance of the mentioned muscles causes pain, tension, and rounded shoulder posture. These changes result in implementing motor strategies to minimize the activities of muscles that are sensing pain and to compensate for these suppressed muscles [6]. Also, FHP weakens respiratory muscles and influences respiratory function [7]. The SCM, UT, scalene muscles, PM, and thoracolumbar erector spinal muscles are important accessory respiratory muscles involved in inspiration, and prolonged FHP weakens them, thereby decreasing their respiratory function [8]. Although previous research has investigated the effect of abnormal head posture on either pulmonary functions or viscoelastic properties (muscle tone, stiffness, and elasticity) of the related muscles, no study investigating both of them was encountered [7, 9, 10]. To our knowledge, no study has examined functional capacity in patients with abnormal head posture. This comparative, cross-sectional study is designed to determine the effects of head posture muscles' viscoelastic parameters on pulmonary and functional capacity in healthy individuals.

Subjects and methods

Participants and procedure

The participants were motivated as they had an important contribution to the study. The inclusion criteria were that the subjects did not have any known pulmonary, systemic, or muscular system disease or any neurological symptoms or neck pain affecting daily living activities. A convenience sample of 33 subjects (18 females, 15 males) from a university student population who met the inclusion criteria were involved in this study. Subjects who had headache or dizziness or were receiving steroids or muscle relaxants were excluded. The demographic data of individuals were noted. Myotonometric measurements and pulmonary function tests were applied by different researchers.

Myotonometric measurements

The measurements of muscle tone, stiffness, and elasticity were performed with a MyotonPRO® device (Myoton AS, Tallinn, Estonia), which is reliable for objective assessment of skeletal muscle tone, stiffness, and elasticity [11].

Correspondence address: Begumhan Turhan, Department of Physical Therapy and Rehabilitation, Faculty of Health Sciences, Hasan Kalyoncu University, Havaalani 8. Km, Şahinbey, Gaziantep, Turkey, e-mail: begum.aliosmanoglu@hku.edu.tr

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The participants were seated on a chair, with hands placed on the knees; UT, SSC, and SCM muscles were examined in this position. The pectoralis major muscle was examined in the supine position. UT was measured near the cervical triangular region via the line connecting the acromion to the C7 spinous process (Figure 1a). The pectoralis major muscle was measured at the intersection of the vertical line drawn from the midpoint of the clavicle and the horizontal line drawn from the axilla (Figure 1b). SSC was measured 4 cm below the mastoid process (Figure 1c). Measurements for SCM were performed on the midpoint of the *origo* and insertion of muscle (Figure 1d). The test areas were marked with a pen on the skin. The instrument was placed perpendicularly on the skin and measurements were conducted on both sides. Arithmetic averages were calculated after 3 measurements. The measurements were taken by the same researcher and at the same room temperature [12, 13].

Six-minute walk test

The subjects were asked to walk as fast as they could for 6 minutes along a 30-meter straight corridor. The test was performed twice within the same day, with an interval of half an hour. For each patient, the longer distance value from the 2 tests was used for statistical analysis. Heart rate and oxygen saturation were assessed by pulse oximetry before and after the test dyspnoea, general and quadriceps fatigue perceptions were recorded by using the modified Borg scale [14].

Pulmonary function tests

Forced expiratory volume in 1 second (FEV_1), forced vital capacity (FVC), the FEV_1/FVC ratio, peak expiratory flow (PEF), and vital capacity (VC) were measured with a spirometer (Cosmed Pony FX Spirometer, Italy). The test was performed in a sitting position. The best value was obtained from the 3 measurements which were 95% compatible with each other [15].

Physical Activity Index

The Physical Activity Index (FIT) was used to classify the individuals' physical activity levels. This research instrument assigned a score of 1–100 to a person's physical fitness level on the basis of its frequency, intensity, and time engaged. The physical activity score was obtained by multiplying the frequency, intensity, and time of the activity. In accordance with the FIT score, physical activity level is interpreted as sedentary (0–20), weak (21–40), normal (41–60), good (61–80), or very good (81–100) [16].

Neck Disability Index

The Neck Disability Index (NDI) was applied to assess how neck pain affected daily living activities. The Turkish version of NDI is an easy-to-understand, reliable, and valid tool to measure the pain and limitations of daily living activities caused by neck disorders [17]. NDI is consists of 10 questions about pain intensity, personal care, lifting goods, reading books, concentration, headache, working, driving, sleeping, and recreational activities. There are 6 options for each question, ranging from 0 to 5 points. The questionnaire is evaluated over a maximum of 50 points: 0–4 points mean no restriction, 5–14 points mean slight restriction, 15–24 points mean moderate restriction, 25–34 points mean severe restriction, and 35 points and above stand for complete restriction (with 50 points meaning full disability) [18].

Forward head posture assessment

FHP was assessed by a goniometric method, which is accepted as a reliable method. The participants were evaluated in a relaxed sitting position. To measure the craniovertebral angle of FHP, the centre of the goniometer was placed at the level of the orifice of the external ear, with the fixed arm pointing vertically towards the ceiling and the moving arm against the subject's 7th neck bone [19, 20]. The degrees of < 48° are regarded as indicative of FHP, and those > 48° are defined as non-forward head posture (NFHP) [21].

Statistical analysis

The SPSS software (version 23.0; SPSS Inc., Chicago, USA) was used to generate the statistics; *p*-values less than 0.05 were considered statistically significant. The Shapiro-Wilk test for normality evaluation assessed the data distribution. The significance of the differences between the average values measured in groups was tested with the parametric independent samples *t*-test because of normally distributed data and equal variance. Descriptive statistics were applied to summarize the demographic characteristics of the participants and all dependent variables. Pearson's correlation coefficient served to investigate the relationship between the tonus, stiffness, and elasticity of head posture muscles and pulmonary capacity.

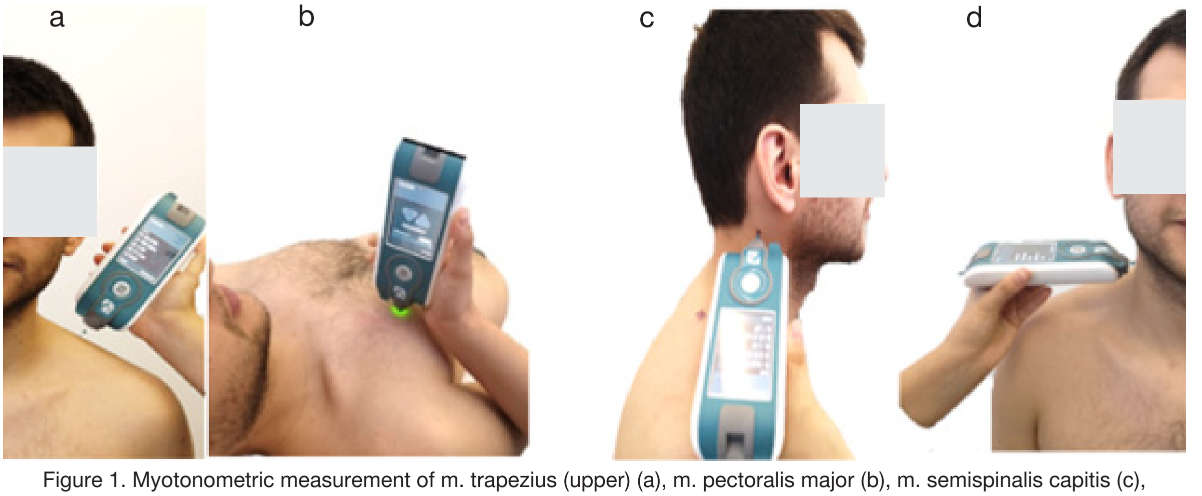

Figure 1. Myotonometric measurement of m. trapezius (upper) (a), m. pectoralis major (b), m. semispinalis capitis (c), m. sternocleidomastoideus (d)

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Human Research Ethics Committee of the Hasan Kalyoncu University (decision number: 2019/24).

Informed consent

Informed consent has been obtained from all individuals included in this study.

Results

The study involved 18 (54.54%) female and 15 (45.45%) male students. Their mean age was 21.24 ± 1.82 (min.: 18, max.: 25) years. In 79% of the participants, the dominant side was right (p = 0.015). A total of 21 (63.6%) subjects were smokers; they all had a smoking history of fewer than 10 pack-years (2.39 ± 3.25 pack-years). The mean body mass index of the participants equalled 22.09 ± 3.16 (min.: 16.49, max.: 28.09). All subject characteristics were similar except for body mass index. Overall, 16 (48.48%) participants had FHP with an average craniovertebral angle < 48°. The subjects' characteristics are presented in Table 1.

A total of 14 (42.4%) participants were sedentary; 10 (30.3%) had weak, 2 (6.1%) normal, and 7 (21.2%) good physical activity. As indicated by the subjects' NDI scores, 6 (18.2%) of them had moderate, 19 (57.6%) mild, and 8 (24.2%) none disability related to the neck. NDI scores were higher in participants with FHP than in NFHP individuals (p = 0.037).

There were no statistically significant differences between the right and left side in terms of myotonometric measurements ($p > 0.05$). PM tonus, stiffness, and elasticity were statistically significant different between genders ($p < 0.05$). There was no difference in terms of gender in the myotonometric measurements of other muscles ($p > 0.05$). The highest stiffness and tonus values were recorded for PM in all participants, and the lowest referred to SSC. Also, the highest elasticity values were measured in PM, the lowest in UT. There were no significant differences in the myotonometric results of the analysed muscles between the FHP and NFHP groups ($p > 0.05$). The myotonometric measurements are depicted in Table 2.

The pulmonary function values of the participants are presented in Table 3. The functional capacity of FHP and NFHP individuals were similar ($p > 0.05$). The physiological properties were different between these groups for VC (l), FEV_1 (l), FEV_1 (%), PEF (l), FVC (l), FVC (%) ($p < 0.05$).

There were low negative correlations between PM tonus and VC (l) (r = –0.348, p = 0.047), PM tonus and FVC (r = –0.355, p = 0.043), SSC tonus and VC (%) (r = –0.366, p =

Table 1. Demographic and clinical characteristics (median ± *SD*) of participants

Characteristics	Females (n = 18)	Males (n = 15)	Median	Min–max	p
Age (years)	21.47 ± 1.56	20.83 ± 2.20	21.00 ± 1.82	18–25	0.386
BMI (kg/m^2)	20.98 ± 2.66	24.03 ± 3.14	22.15 ± 3.16	16.49–28.09	0.010*
CVA (°)	51.38 ± 5.92	48.91 ± 8.05	50.00 ± 7.00	40–65	0.111
FIT score	26.42 ± 21.30	46.00 ± 22.64	24.00 ± 23.48	2–80	0.230
NDI score	10.09 ± 5.24	8.83 ± 6.33	10.00 ± 23.48	1–22	0.565

BMI – body mass index, CVA – craniovertebral angle, FIT – Physical Activity Index, NDI – Neck Disability Index
* $p < 0.05$ is statistically significant

Table 2. Mean values of myotonometric measurements

Myotonometric measurements		Females (n = 18)	Males (n = 15)	p	FHP (n = 16)	NFHP (n = 17)	p	All participants
Tone (Hz)	UT	11.97 ± 0.88	13.21 ± 2.33	0.100	12.58 ± 2.25	12.28 ± 0.78	0.622	12.87 ± 1.64
	PM	15.43 ± 2.50	13.68 ± 0.93	0.007*	14.85 ± 1.98	14.74 ± 2.48	0.890	14.80 ± 2.22
	SCM	13.59 ± 0.98	15.37 ± 3.99	0.154	15.00 ± 3.45	13.51 ± 1.15	0.113	14.23 ± 2.61
	SSC	12.70 ± 1.36	13.16 ± 1.85	0.466	12.46 ± 1.67	13.26 ± 1.35	0.143	12.42 ± 1.54
Stiffness (N/m)	UT	193.71 ± 27.03	215.91 ± 19.33	0.241	203.68 ± 24.96	200.00 ± 27.02	0.811	201.78 ± 22.24
	PM	291.85 ± 32.48	227.41 ± 23.44	0.008*	270.81 ± 24.98	266.17 ± 30.33	0.873	268.42 ± 31.98
	SCM	192.42 ± 26.79	245.66 ± 38.21	0.534	235.68 ± 14.19	189.29 ± 29.93	0.135	211.78 ± 24.55
	SSC	192.80 ± 36.12	210.08 ± 39.63	0.195	192.68 ± 29.01	205.11 ± 26.93	0.573	199.09 ± 10.40
Elasticity (log)	UT	1.04 ± 0.18	1.03 ± 0.23	0.836	1.07 ± 0.23	1.01 ± 0.16	0.391	1.04 ± 0.19
	PM	1.34 ± 0.22	1.15 ± 0.22	0.028*	1.31 ± 0.27	1.22 ± 0.20	0.298	1.27 ± 0.24
	SCM	1.22 ± 0.15	1.10 ± 0.22	0.116	1.19 ± 0.23	1.17 ± 0.15	0.719	1.18 ± 0.19
	SSC	1.20 ± 0.17	1.09 ± 0.186	0.119	1.10 ± 0.17	1.22 ± 0.17	0.083	1.16 ± 0.18

UT – m. trapezius (upper), PM – m. pectoralis major, SCM – m. sternocleidomastoideus, SSC – m. semispinalis capitis
FHP – forward head posture, NFHP – non-forward head posture
* $p < 0.05$ is statistically significant

Table 3. Pulmonary function values of participants

Parameters	Median	Min–Max	FHP (n = 16)	NFHP (n = 17)	p
VC (l)	4.01 ± 0.91	3.12–6	3.54 ± 0.69	4.50 ± 0.86	0.002*
VC (%)	84.09 ± 4.28	80–99	86.62 ± 6.61	81.70 ± 9.14	0.086
FEV_1 (l)	3.73 ± 0.83	3.01–5.45	3.41 ± 0.49	4.15 ± 0.85	0.004*
FEV_1 (%)	91.96 ± 9.77	75–111	88.11 ± 7.45	96.06 ± 10.47	0.019*
PEF (l)	7.00 ± 1.89	4.07–10.57	6.23 ± 1.44	7.83 ± 2.00	0.015*
PEF (%)	82.27 ± 11.12	62–106	79.52 ± 11.80	83.31 ± 13.06	0.389
FVC (l)	4.31 ± 0.91	2.87–6.18	3.87 ± 0.69	4.79 ± 0.90	0.003*
FVC (%)	91.72 ± 9.10	73–106	89.76 ± 9.02	95.87 ± 8.34	0.042*
FEV_1/FVC (%)	93.30 ± 8.22	81–111	92.12 ± 7.65	94.41 ± 8.81	0.432
6-minute walk test	607.12 ± 36.68	432–732	587.87 ± 23.77	625.23 ± 34.58	0.287
Heart rate	92.18 ± 15.93	68–113	92.37 ± 11.31	92.88 ± 11.84	0.901
Δ heart rate	118.84 ± 24.71	64–167	108.81 ± 19.95	118.29 ± 25.55	0.120
O_2 saturation	97.00 ± 1.90	92–99	96.62 ± 2.24	97.35 ± 1.49	0.287
Δ O_2 saturation	97.24 ± 1.27	94–99	96.87 ± 1.25	97.58 ± 1.22	0.110
Borg score	0.02 ± 0.11	0–1	0.01 ± 0.32	0.01 ± 0.45	0.107
Δ Borg score	1.48 ± 2.33	0–7	1.17 ± 1.83	0.75 ± 1.39	0.109
LEF score	0.03 ± 0.17	0–1	0.03 ± 0.21	0.05 ± 0.24	0.332
Δ LEF score	3.06 ± 2.64	0–9	4.23 ± 2.96	1.81 ± 1.51	0.127

VC – vital capacity, FEV_1 – forced expiratory volume in 1 second, PEF – peak expiratory flow, FVC – forced vital capacity
Δ – after 6-minute walk test, LEF – lower extremity fatigue, FHP – forward head posture, NFHP – non-forward head posture
* $p < 0.05$ is statistically significant

Table 4. Correlations between myotonometric measurements and pulmonary function values

Parameters	VC (l)	FVC (l)	VC (%)	FEV_1/FVC (%)
PM tonus	r = –0.348 p = 0.047	r = –0.355 p = 0.043	–	–
SSC tonus	–	–	r = –0.366 p = 0.036	–
PM stiffness	r = –0.348 p = 0.047	–	–	–
SSC elasticity	–	–	–	r = 0.388 p = 0.026

PM – m. pectoralis major, SSC – m. semispinalis capitis
VC – vital capacity, FVC – forced vital capacity
FEV_1 – forced expiratory volume in 1 second
$p < 0.05$ is statistically significant

0.036), PM stiffness and VC (l) (r = –0.348, p = 0.047). A low positive correlation was observed between SSC elasticity and FEV_1/FVC (%) (r = 0.388, p = 0.026) (Table 4). There were no correlations between the other muscles' myotonometric measurements and pulmonary function values ($p > 0.05$).

Discussion

The aim of this study was to evaluate the relationship between the tonus, stiffness, and elasticity of the head posture muscles and pulmonary capacity and functional capacity. The major findings of the study are similar to those of some previous studies; there was no difference in tonus, stiffness, or elasticity values of the evaluated muscles in individuals with NFHP and FHP [1, 9].

In our study, myotonometric measurements were repeated 3 times and their averages were recorded. The measurements were performed on both the left and right sides. The fact that the left and right sides were similar in terms of myotonometric measurements may be due to the absence of any abnormal condition in our participants that would cause body asymmetry. Similar to our study, there are studies in the literature that did not present any difference between the dominant side and the non-dominant one.

Mooney et al. [22] stated that there was no difference between the stiffness, tonus, or elasticity of the biceps brachii muscle in healthy young men with an average age of 25.8 ± 4.1 years. Mroczek et al. [23] reported that myotonometric measurements of lower limb muscles in athletes were different only in the posterior muscles in terms of right and left side, but no difference was observed in other muscle groups. Similarly, there was no difference between the dominant and non-dominant sides in the results obtained by Bailey et al. [13], who determined the myotonometric values in healthy individuals. Although there was no difference between the dominant and non-dominant sides in our study, we suggest that it is important to establish reference values for the symmetry levels of certain muscles.

Similarly to some studies in the literature, we observed that the investigated muscles (SCM, UT, PM, SSC) were not different between FHP and NFHP individuals in terms of tonus, stiffness, or elasticity. Eshaghi Moghadam et al. [1] determined that there was no difference between FHP and NFHP subjects in terms of the SCM muscle thickness. Kocur et al. [9] found no difference between FHP and NFHP individuals in tonus, stiffness, or elasticity properties of the SCM and UT muscles. Considering that 81.8% of the participants in our study represented mild or no disability in accordance with NDI, it can be stated that FHP is not closely related to the viscoelastic features of asymptomatic neck muscles.

However, Park et al. [24] reported that in individuals with severe clinical symptoms such as headache or neck pain together with FHP, the tonus, stiffness, and elasticity characteristics of the muscles were different from those in NFHP individuals. The fact that the individuals in our study sample did not have clinical symptoms such as pain, numbness in the upper extremity, tingling, loss of strength, headache, or dizziness may be one of the reasons for the similar results on FHP and NFHP individuals. The difference between the FHP and NFHP groups in terms of myotonometric measurements may be due to passive measurements when the individuals were inactive because there are studies indicating that there is a difference between FHP and NFHP individuals in measurements during movement, but no difference in passive measurements in which the individuals are inactive [25].

In addition, studies indicating age-related myotonometric changes were also encountered. They report age-related changes in terms of muscle elasticity, stiffness, and tonus, but these changes are not clearly understood [26, 27]. Considering that there may exist age-related myotonometric changes, one can suppose that there was no difference between our FHP and NFHP groups regarding the viscoelastic properties of the muscles owing to the low average age of the subjects.

On the other hand, myotonometric measurements were similar for both genders in our study. The only difference in the myotonometric measurements of the pectoralis major muscle between the genders may be due to the breast fat tissue in females. However, we determined differences between the FHP and NFHP individuals in terms of respiratory capacities.

It is generally known that breathing is an activity affected by complex biomechanical factors. The stability of the cervical and thoracic regions of the spine has a great importance for respiratory function [28]. FHP, which is a postural disorder of the cervical region, may cause a decrease in FEV_1 and FVC values because of the shortening and weakening of the accessory respiratory muscles [29]. Lee et al. [30] reported that an increase in FHP might result as respiratory dysfunction. FHP also increases the muscle tension around the thoracic spine, thereby limiting the range of motion in the upper thoracic spine. Wirth et al. [31] demonstrated that the weakness of the neck muscles and accessory respiratory muscles caused a decrease in thoracic mobility in patients with neck pain. Thus, they stated that maximal voluntary ventilation, maximal inspiratory pressure, and maximal expiratory pressure could be closely related to FHP. However, some studies have reported that an increase in FHP results in an increase in maximal expiratory pressure [31, 32]. The literature implies that FHP is a postural disorder that may affect the respiratory capacities. Also in our study, some parameters indicate that an increase in FHP decreased respiratory capacities. On the basis of the correlation observed in our study between the myotonometric measurements and pulmonary function values, we suppose that the PM and SSC muscles may play an especially important role in chest expansion by affecting thoracic mobility and thus VC changes. It can also be concluded that the other measured muscles are of a lesser importance for thoracic mobility and therefore VC was not reduced in FHP individuals.

Limitations

Although 63.6% of the participants were cigarette users, this situation was ignored because the pack-years were below 10. In the literature, this group is called 'light smokers'. There are studies determining that the respiratory capacities of light smokers are similar to those of healthy individuals [33]. In the future studies, more objective results can be obtained by creating a non-smoking group. Stress and anxiety levels of the participants can also be evaluated.

Conclusions

On the basis of the pulmonary capacity differences between FHP and NFHP individuals, it can be stated that FHP affects pulmonary capacity. Also, it can be suggested that the PM and SSC muscles play an important role in thoracic expansion and therefore they influence VC.

Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

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