Turkish Journal of Thoracic and Cardiovascular Surgery 2019;27(1):101-106
http://dx.doi.org/doi: 10.5606/tgkdc.dergisi.2019.17375

Original Article / *Özgün Makale*

Acute effects of manual therapy on respiratory parameters in thoracic outlet syndrome

Torasik çıkış sendromunda manuel tedavinin solunum değişkenleri üzerine akut etkileri

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ABSTRACT

Background: This study aims to investigate the acute effects of manual therapy on pain perception and respiratory parameters in patients with thoracic outlet syndrome.

Methods: The study included 10 patients with thoracic outlet syndrome (1 male, 9 females; mean age 31.3±9.0 years; range, 20 to 43 years). Patients were accepted in a single session of manual therapy involving the cervical spine and thorax. Stretching of scalene, upper trapezius, sternocleidomastoid, rectus abdominis, hip flexor muscles; and mobilization of first rib, cervical and thoracic spine, sacroiliac joints and thorax were applied as manual therapy program. Pain perceptions of upper arm and neck were assessed with visual analog scale. Measurements were performed before and immediately after of a 30-minute session of manual therapy. Pulmonary function testing was performed with a spirometer. Respiratory muscle strength (inspiratory and expiratory muscle strength, maximal inspiratory pressure and maximal expiratory pressure, respectively) was measured. Respiratory muscle endurance was recorded using sustained threshold loading of 35% maximal inspiratory pressure.

Results: There were no significant changes in any pulmonary function parameters or maximal expiratory pressure following manual therapy intervention ($p>0.05$). However, maximal inspiratory pressure and respiratory muscle endurance improved ($p<0.05$). Pain perceptions of upper arm and neck reduced after treatment ($p<0.05$).

Conclusion: A 30-minute single manual therapy session improved inspiratory muscle strength and respiratory muscle endurance but not pulmonary function and expiratory muscle strength in patients with thoracic outlet syndrome. Manual therapy may facilitate functional breathing and support use of primary respiratory muscles more effectively together with rapid pain reduction. The long-term effects of regular manual therapy on respiratory parameters should be investigated after surgical procedures.

Keywords: Inspiratory muscle strength; manual therapy; thoracic outlet syndrome.

ÖZ

Amaç: Bu çalışmada torasik çıkış sendromlu hastalarda manuel tedavinin ağrı algısı ve solunum değişkenleri üzerine akut etkileri araştırıldı.

Çalışma planı: Çalışmaya torasik çıkış sendromlu 10 hasta (1 erkek, 9 kadın; ort. yaş 31.3±9.0 yıl; dağılım, 20-43 yıl) dahil edildi. Hastalar servikal omurga ve toraksı kapsayan tek bir manuel tedavi seansına alındı. Manuel tedavi programı olarak skalen, üst trapez, sternokleidomastoid, rektus abdominis, kalça fleksör kaslarına germe; birinci kaburga, servikal ve torakal omurga, sakroiliyak eklem ve toraks mobilizasyonu uygulandı. Üst kol ve boynun ağrı algısı görsel analog ölçeği ile değerlendirildi. Ölçümler 30 dakikalık manuel tedavi seansının öncesinde ve hemen sonrasında gerçekleştirildi. Pulmoner fonksiyon testi spirometre ile yapıldı. Solunum kas kuvveti (inspiratuar ve ekspiratuar kas kuvveti; sırasıyla maksimum inspiratuar basınç ve maksimum ekspiratuar basınç) ölçüldü. Solunum kas enduransı, maksimal inspiratuar basıncın %35'inde, sabit eşik yükü kullanılarak kaydedildi.

Bulgular: Manuel tedavi girişimi sonrasında pulmoner fonksiyon değişkenleri ve maksimum ekspiratuar basınçta anlamlı değişim yoktu ($p>0.05$). Buna karşın, maksimum inspiratuar basınç ve solunum kas enduransı arttı ($p<0.05$). Üst kol ve boyundaki ağrı algıları tedavi sonrasında azaldı ($p<0.05$).

Sonuç: Torasik çıkış sendromlu hastalarda 30 dakikalık tek bir manuel tedavi seansı inspiratuar kas kuvvetini ve solunum kas enduransını artırırken pulmoner fonksiyon ve ekspiratuar kas kuvvetini artırmadı. Manuel tedavi hızlı ağrı azalması ile birlikte fonksiyonel solunumu ve primer solunum kaslarının daha etkili kullanımını kolaylaştırabilir. Cerrahi işlemlerden sonra düzenli manuel tedavinin solunum değişkenleri üzerine uzun dönem etkileri araştırılmalıdır.

Anahtar sözcükler: İnspiratuar kas kuvveti; manuel tedavi; torasik çıkış sendromu.

Received: October 15, 2018 *Accepted*: October 30, 2018

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Cite this article as:
Fırat T, Sağlam M, Vardar Yağlı N, Tunç Y, Çalık Kütükçü E, Delioğlu K, et al. Acute effects of manual therapy on respiratory parameters in thoracic outlet syndrome. Turk Gogus Kalp Dama 2019;27(1):101-106

Thoracic outlet syndrome (TOS) is a complex symptom group that includes the upper limb neural, arterial and venous disorders.[1,2] It is defined as the compression of nerves or blood vessels in at least one anatomical area around thoracic outlet.[3,4] Compression of the subclavian artery or vein is classified as vascular TOS.[5] Neurogenic TOS is characterized by compression of the brachial plexus nerve roots (C5 to T1) within the scalene triangle and/or subpectoral space. Neurogenic thoracic outlet syndrome is the most common manifestation, presenting with pain, numbness, tingling, weakness, and vasomotor changes of the upper extremity.[6] Besides, it also affects the neck and upper back and intervenes in many lesions including cervical disc problems, fibromyalgia, and shoulder tendinopathies.[7]

Several factors have been suggested for the etiology of thoracic outlet syndrome. The trauma of the neck and shoulder, postural problems, work related injuries, repetitive overhead activities and altered breathing pattern have been attributed as causative factors for TOS.[1,8] Diagnostic criteria, objective assessment tools, treatment algorithms and treatment methods, either conservative or surgical, are controversial in TOS.[9] Surgical approaches including first rib resection, decompression using supraclavicular approach and retropectoral release are the most recognized techniques whereas exercises, postural adjustments, manual therapy and electrophysical agents are common physiotherapy approaches.[9]

Conservative or surgical treatment methods generally focus on two important muscles: scalene muscles and pectoralis minor.[10] Due to their task in respiration, an accessory and altered breathing pattern instead of diaphragmatic breathing was observed in TOS. The overload of these accessory muscles increases the mobility in upper rib cage during inspiration and makes the respiration superficial that needs enhancing in respiratory rate and minute volume.[11] Moreover, chronic neck pain has been responsible for respiratory dysfunction in several research studies.[12,13] Manual therapy can reduce exaggerated muscle tone around soft tissue and joints, thus improve muscle length and joint mobility which may relieve respiratory dysfunction.[14]

To our knowledge, no study has been conducted that investigate the respiratory dysfunction in patients with TOS. Therefore, in this study, we aimed to investigate the acute effects of manual therapy on pain perception and respiratory parameters in patients with TOS.

PATIENTS AND METHODS

This study was conducted at Hacettepe University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation between June 2018 and September 2018. Inclusion criteria were having a diagnosis of TOS, having pain for at least six months and being aged between 18 and 65 years. Patients with surgery plan for TOS, those who underwent TOS surgeries, those with smoking history, traumatic cervical injuries, cervical disc disorders, upper extremity nerve entrapment syndromes, clinical abnormalities of the thoracic cage or vertebral column, known systemic comorbidities (neurological, cardiorespiratory, psychiatric and musculoskeletal disorders), diabetes mellitus and/or malignancies were excluded. Of the 18 patients assessed as being eligible, eight were excluded due to respiratory disorders (bronchial asthma, bronchiectasis), history of TOS surgery, and smoking history. Finally, 10 patients with neurogenic TOS (1 male, 9 females; mean age 31.3±9.0 years; range, 20 to 41 years) were included in this study. The study protocol was approved by the Hacettepe University Ethics Committee (number GO 18/447). A written informed consent was obtained from each patient. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Age, gender, height, and weight were all recorded. Body mass index was calculated as kg/m^2. Each participant was asked to rate their pain perceptions of upper arm and neck on a visual analog scale (VAS) from 0 cm (none) to 10 cm (worst or highest level).[15]

Pulmonary function test was performed in sitting position using a Spirolab III spirometer (Spirolab, Medical International Research, Rome, Italy) according to the American Thoracic Society/European Respiratory Society criteria. Forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), FEV_1/FVC rate, peak expiratory flow (PEF), and forced expiratory flow between 25% and 75% of FVC ($FEF_{25-75\%}$) were recorded. Respiratory function test parameters were expressed as percentage of the expected value for age, height, body weight, and gender.[16,17]

Respiratory muscle strength (maximal inspiratory pressure [MIP] and maximal expiratory pressure [MEP]) was assessed using a portable mouth pressure device (MicroRPM, Micromedical, Kent, United Kingdom) with a rigid flanged mouthpiece. The MIP was measured near a residual volume after a maximal expiration, and the MEP was measured near total lung capacity after a maximal inspiration. The MIP and MEP values were calculated from the maximum

Table 1. Descriptive characteristics of patients

Variables	Mean±SD
Age (year)	31.25±9.00
Height (cm)	165.86±5.73
Weight (kg)	67.43±24.14
Body Mass Index (kg/m^2)	24.52±8.54

SD: Standard deviation.

effort sustained for one second. Tests were repeated until no further improvements were obtained, and there was less than a 10% difference between the two best values.[18,19]

Respiratory muscle endurance test was measured with a threshold loading inspiratory muscle trainer device (Threshold® IMT (Philips. Respironics, Andover, MA, USA). A threshold inspiratory load equivalent to 35% of the maximal inspiratory pressure was placed on the inspiratory port of the mouthpiece. Subjects were instructed to maintain the established breathing pattern during loaded breathing. The test ended when the subject could not open the threshold valve for three consecutive breaths, or when the subject could no longer subjectively tolerate the test and had to remove the mouthpiece.[19] Loaded breathing typically lasts between 2-10 minutes.

Patients were positioned in a supine position. After a five-minute resting period, the treatment was applied. Manual therapy technique consisted of soft tissue mobilization of cervical paraspinal muscles, mobilization of cervical facet joints, stretching of scalene anterior, scalene medius, upper trapezius, levator scapula, pectoralis major and minor, rectus abdominis, iliopsoas and quadratus lumborum muscles.[20] Subsequently, costovertebral and costotransverse joint mobilizations were applied using rib elevation. Then, sacroiliac joint was mobilized by shifting ilium to the posterior while shifting sacrum anterior direction in side-lying position. Then, manipulation of the vertebrae the levels between T_5 and T_9 were applied using thrust mobilization technique.[21] Afterwards, mobilization of the first rib was applied.[22] Finally, mobilization of the upper cervical spine was performed using the Mulligan technique while patient was sitting. The same physiotherapist evaluated the patients before and immediately after the treatment.

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 23.0 software (IBM Corp., Armonk, New York, USA). All data are reported as the mean ± standard deviation. Prior to intervention, the normality of data was assessed with the Shapiro-Wilk test.

Table 2. Results of acute effects of manual therapy on pulmonary function, respiratory muscle strength and endurance, and pain perception

Variables	Pre-MT	Post-MT	
	Mean±SD	Mean±SD	*p*
Forced expiratory volume in the one second (L)	2.9±0.5	2.8±0.3	0.677
Forced expiratory volume in the one second (%)	94.5±16.0	94.7±13.0	1.000
Forced vital capacity (L)	3.4±0.5	3.5±0.3	0.767
Forced vital capacity (%)	97.6±13.8	99.7±13.3	0.726
Forced expiratory volume in the one second/Forced vital capacity	82.9±6.8	82.2±3.1	0.327
Peak expiratory flow (L)	6.1±1.4	5.9±1.3	0.953
Peak expiratory flow (%)	88.0±25.3	86.8±22.3	0.595
Forced expiratory flow between 25% and 75% (L)	3.2±0.7	2.9±0.5	0.114
Forced expiratory flow between 25% and 75% (%)	80.3±15.7	77.4±13.0	0.528
Maximal inspiratory pressure (cmH_2O)	81.5±27.2	91.3±26.9	0.047*
Maximal expiratory pressure (cmH_2O)	102.5±13.1	110.0±21.8	0.262
Respiratory muscle endurance duration (minute)	1.0±0.8	1.9±0.9	0.008*
Upper arm pain (VAS)	6.1±1.2	4.1±1.1	0.04*
Neck pain (VAS)	7.0±0.5	3.7±0.7	0.04*

MT: Manual therapy; SD: Standard deviation; cmH_2O: Centimeter of water; VAS: Visual Analog Scale; * $p<0.05$.

The Wilcoxon test was used to compare pain perception scores, pulmonary function, respiratory muscle strength and endurance before and after the intervention. Statistical significance was defined as a value of $p<0.05$.

RESULTS

Data regarding the characteristics of the participants are shown in Table 1. Table 2 shows the mean and standard deviation of pre- and posttreatment results of pain perception, pulmonary function test (FVC, FEV_1, the ratio of FEV_1 to FVC, PEF, and $FEF_{25-75\%}$), MIP, MEP, and respiratory muscle endurance duration scores used in the study.

There were no significant changes in any of the pulmonary function parameters or MEP following the manual therapy intervention ($p>0.05$). However, MIP and respiratory muscle endurance improved after the manual therapy compared with the pretreatment session ($p<0.05$). Pain perception scores for patients' upper arm and neck region were reduced after manual therapy session ($p<0.05$).

DISCUSSION

This preliminary study examined the effect of a single session of manual therapy applied to the cervical and thoracic spine, and thorax on pulmonary function and respiratory muscle strength and endurance in patients with TOS. The main finding of this study was that manual therapy session immediately improved inspiratory muscle strength and endurance, and pain perception in patients with TOS. However, it did not alter pulmonary function immediately 30 minutes after a manual therapy intervention.

The relationship between neck pain and respiratory function has been investigated in many research studies. Perri and Halford[23] suggested that 83% of patients with neck pain had altered breathing pattern. The close anatomical, musculoskeletal and neural connections of cervical region with the thoracic spine create a base for explaining the biomechanical changes in the thoracic spine and rib cage. Many theories have been suggested to describe the connection between pain and respiration. Kapreli et al.[24] described a few possible mechanisms that might influence respiration: firstly, noxious stimulus modulates ventilatory control system Secondly, pharmacological treatment has depressant effect on respiration. Lastly, anxiety due to chronic pain also has an influence on ventilation leading to hyperventilation and respiratory instability. Furthermore, some structural alterations are seen as a result of chronic pain including kinesiophobia, muscle weaknesses, joint hypomobilities and muscle stiffness. These symptoms cause limitation in cervical range of motion, disturbed rib cage mobility and altered length-tension relationship in respiratory muscles.[24] We planned our extensive manual therapy approach mainly for solving these mechanical restrictions. Besides, we aimed to reduce overactivation of these muscles.[25] Scalene muscle structural alterations were described previously by Sanders et al.[26] Decreased type 2 fibers and increased connective tissue ratio were found in anterior and middle scalene muscles. These changes cause the muscles to become more stiff and short. Also, postural adaptation with chronic pain contributes to the stiffness of these muscles.[26] Stretching of the scalene muscles may provide relief in pain and appropriate length-tension relationship. As Ganesh et al.[27] commented, pain relief in our patients may be explained with Gate Control Theory, relief of sympathetically maintained pain and physiological effects of mobilization. We also think that rapid pain relief after one session of manual therapy may be related with stimulation of descending inhibitory mechanisms.[6]

While manual therapy is a commonly used treatment modality, very limited research has investigated its effect on lung function and respiratory muscle parameters.[14,25,28] To our knowledge, this is the first study to show the immediate effects of manual therapy on respiratory parameters in patients with TOS. Our findings indicate that one session of manual therapy does not result in acute changes in pulmonary function. Similar to our findings, Wall et al.[14] reported no change in lung function parameters after thoracic manipulative treatment in a healthy population. Despite the lack of changes in pulmonary function in our study, there are a few studies that showed improvement in static and dynamic pulmonary functions in patients with chronic obstructive pulmonary disease (COPD)[25,29,30] and stroke.[28] Possible explanations for this may be patients having normal lung function in our study and exclusion of patients with respiratory problems.

Inspiratory muscle strength and endurance improved with a single manual therapy session in our study. Previous studies in healthy populations and COPD patients showed that manual therapy with muscle stretching may improve the muscular mechanical advantage by increasing the flexibility of soft tissues that affects the contractile properties of muscle fibers and viscoelastic changes in the muscle-tendon unit. Manual therapy reduces the effects of muscle overload and decreases muscular tension. This reduction in the muscle tension occurs along with the reduction in myoelectric activity.[31,32] Manual therapy treatment increases thoracic mobility and muscle tone that allow increased inspiratory muscle length, improved muscle efficiency, reduced muscle fatigue level and breathing effort.

Several limitations should be considered when interpreting the study results. Although the results were statistically significant when compared with the pre- and posttreatment outcomes, the main limitations are the lack of a control group and the small sample size. The other limitation of this study is the absence of long-term effects of the treatment. Further studies should investigate the long-term effects of regular manual therapy sessions on respiratory parameters in this population.

In conclusion, a 30-minute single manual therapy session improved inspiratory muscle strength and endurance, and reduced pain perception but not pulmonary function or expiratory muscle strength in individuals with thoracic outlet syndrome. Manual therapy may facilitate functional breathing and support the use of primary respiratory muscles more effectively. Moreover, manual therapy intervention should be included in the physiotherapy process following surgical procedures.

Declaration of conflicting interests

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

Funding

The authors received no financial support for the research and/or authorship of this article.

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