Volume: 4 **Issue: 3**
Year: 2023
DOI: 10.53811/ijtcmr.1345954

International Journal of Traditional and Complementary Medicine Research

Publisher
Duzce University

ORIGINAL RESEARCH

Immediate Effects of Cervical Mobilization on Acoustic Properties and Performance in Voice Training Students

Ismail Ceylan[1*] Sati Doganyigit Yildiz[2] Anil Ozudogru[1]

[1] School of Physiotherapy and Rehabilitation, Kırşehir Ahi Evran University, Kırşehir, Türkiye
[2] Neset Ertas Faculty of Fine Arts, Department of Music, Kırşehir Ahi Evran University, Kırşehir, Türkiye

* Corresponding Author: İsmail Ceylan, e-mail: fztceylan@mail.com

Received: 18.08.2023 Accepted: 16.10.2023

Abstract
Objective: This study aimed to investigate the immediate effects of cervical mobilization on acoustic properties and performance in female voice training students.
Material-Method: Fifteen female volunteer students participated in the research. The study evaluated the acoustic properties of the voice, performance, and cervical mobility. A single session of cervical mobilization was administered by an experienced physiotherapist, after which assessments were repeated.
Results: There was a significant increase in cervical flexion-extension (p=0.002), rotation (p=0.001), and lateral flexion (p=0.006) range of motion measurements after treatment compared to pre-treatment measurements. Head register analysis revealed a significant increase in mean pitch frequency measurements after treatment compared to pre-treatment measurements (p=0.036). Expert opinions obtained through interviews indicated a significant improvement in acoustic performance in the post-treatment status compared to the pre-treatment status (p=0.001).
Conclusion: This study observed that a single session of cervical mobilization positively affected both acoustic performance and cervical mobility.
Keywords: Manual Therapy, Voice Training, Cervical Mobility

INTRODUCTION

The most basic tool of communication is sound. However, our vocal cords are located in the larynx, a region of our body that we cannot see, and are surrounded by bone, muscle and cartilage tissue around it.[1] Training the voice is a very difficult process, both because we cannot see it and because it is directly affected by many changes in the body. In addition to overcoming technical difficulties, a relaxed mind and body are required for the correct and effective use of voice, especially for those who use their voice professionally.[2]

The practical use and improvement of the current professional competencies of voice training students are significantly related to their practice habits, self-regulation skills, and attitudes in their fields of study.[3] Voice training, as an important dimension of music education, consists of a process for achieving certain technical gains such as imagination.[4] Individuals who sing produce sound using their whole body, not just their vocal muscles. Therefore, it is necessary to learn to sing with the whole body, to use the breath correctly, to be aware of the body and to know the body well. More controlled singing is directly proportional to greater body awareness and control. Singers who are aware of their bodies and know how to relax their muscles and joints will be more successful.[5]

During vocal training exercises, internal and external softening of the body should be ensured. The beauty that will appear in the expressions during singing is directly proportional to the right presentation, the comfort of the body and the attention. The mind must be active, the sound producing organs must be ready to make the necessary expansions. It is particularly important to relax the neck, where the vocal chords are located.[6]

Excessive use of the muscles around the neck, one of the organs we use constantly, prevents the maintenance of a comfortable posture and a balanced head position. Since a balanced posture directly affects sound production, tense neck muscles can force the sound and lead to incorrect phonation. For this reason, harmony between the muscles surrounding the neck and a balanced head position are very important in phonation.[5] Especially for singers, tension in the neck, shoulder and larynx

muscles directly affects sound production and prevents the correct and desired sound formation. The fact that the body is comfortable and the muscles are free of tension has a positive effect on the tone quality of the voice.[8]

The cervical suboccipital muscles have been shown to have 36 muscle spindles per gram of muscle tissue, compared to 0.7 spindles per gram in the gluteus maximus.[9] The high number of stretch receptors in these tissues and their essential link from eye movements to coordination of the rest of the back muscles ensures their central role in cognitive performance.[10] A randomised controlled trial concluded that cervical mobilisation had a significant benefit on attention and anxiety in patients with cervical postural disorders.[11] Neck disorders (ND) are recognised as a common public health problem in the modern world, and although their lifetime prevalence is approaching 50%, they are often seen in young populations. Neck disorders are defined as severe discomfort in the lateral and posterior regions of the neck lasting more than 3 months, resulting from poor posture, degenerative and mechanical changes. ND causes disability, limitation of activities of daily living, job dissatisfaction and increased economic and social costs.[12]

Various modalities such as physiotherapy, exercise, massage, chiropractic, spinal mobilisation and manipulation are used in the treatment of musculoskeletal disorders.13 Manual therapy (MT) is an increasingly popular treatment for people with ND.[14] MT includes both passive and active techniques. Palmgren et al concluded that manual therapy had a positive effect on proprioception and pain in patients with neck disorders.[15] In another randomised controlled trial, Zaproudina et al showed that mobilisation techniques reduced disability in patients with chronic neck disorders.[16] Cleland et al also reported that thoracic spinal manipulation had analgesic effects in people with mechanical neck disorders.[17] Sound is produced by the coordinated work of the inspiratory and expiratory muscles. As the expiratory muscles originate from the cervical region, mobilisation of this region in non-symptomatic individuals will affect acoustic performance. As there are more sensory receptors in the cervical region than in other regions of the body, even a single session of mobilisation of this region has a direct effect on acoustic performance.[11]

It has also been shown that cervical mobilisation can have concomitant effects on motor function and autonomic nervous system function in subjects with musculoskeletal disorders.[11]

Based on the studies in the literature, the aim of this study was to investigate the immediate effects of cervical mobilisation on the acoustic properties and performance of voice training students.

MATERIALS AND METHODS

Materials

The participants' sex, age, height, weight and body mass index were recorded. The acoustic properties of the voice, performance and cervical spine mobility were then assessed.

Acoustic measurements

Participants' voices were recorded using a Shure PG57 microphone and Audacity software. Prior to voice recording and cervical mobilisation, the participants were given voice exercises. The recordings were made in a quiet room. During the recording, the distance between the mouth and the microphone was set at 15 cm and the microphone was placed under the mouth at an angle of 45°. Participants were asked to produce the sound /a/ at a sampling rate of 44,100 Hz in four voices: chest, middle, head and speech. The measurement was repeated three times for each register. Each recording was repeated three times and the best recordings were analysed. The recordings were made by a music education researcher. Mean pitch, jitter, shimmer and harmonics to noise ratio (HNR) were analysed. Mean pitch is the lowest rate of vibration produced by the vocal folds during phonation and is expressed in Hz. Hz is the number of vibrations per second. As the fundamental frequency increases, the pitch becomes thinner, and as the fundamental frequency decreases, the pitch becomes thicker. Jitter is the irregularity in the vibration of the vocal cord. It is generally found to be increased in patients with voice disorders. Flicker refers to the change in sound intensity from glottal cycle to cycle. It is usually found to be increased in voice patients. HNR is the ratio of harmonics to noise. Harmonics are frequencies that are integral multiples of the fundamental frequencies.18 The audio recordings obtained were analysed using the Praat program. The sounds marked in Figure 1 were identified and recorded in the chest, middle and head registers.

Volume: 4 **Issue: 3**
Year: 2023
DOI: 10.53811/ijtcmr.1345954

International Journal of Traditional and Complementary Medicine Research

Publisher
Duzce University

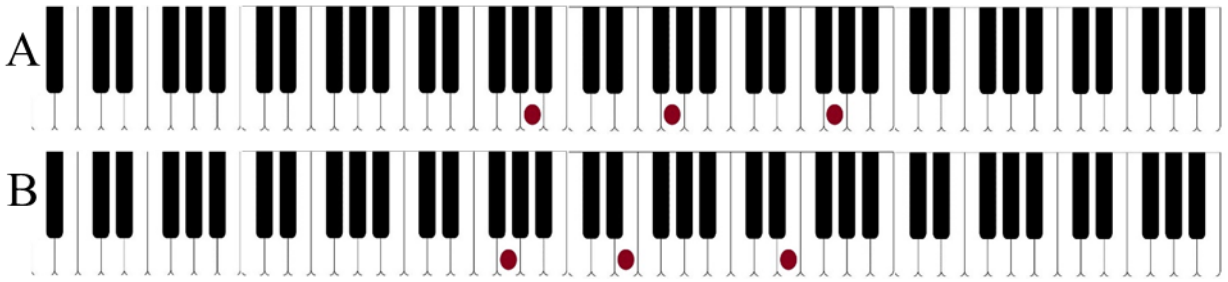

Figure 1. A: Sounds recorded from the chest, middle and head registers for soprano voices, B: Sounds recorded from the chest, middle and head registers for alto voices

Performance evaluation

The participants performed their most recent works, appropriate to their level, in a quiet room. During the recording, they performed by listening to the piano accompaniment of the piece through headphones in one ear and video recordings were made. The video recordings were evaluated by two experts in the field of vocal training; musicality, technique, correct use of breath, correct use of body, legato singing, style and interpretation, and their opinions were obtained by interview.

Cervical mobility

Cervical mobility was measured by a physiotherapist using a universal goniometer. In the sitting position, flexion-extension, right-left lateral flexion, right-left rotation and active range of motion were measured (Figure 2).

Intervention

Cervical mobilisation was performed by an experienced physiotherapist after the initial assessment of the participants. As the expiratory muscles originate from the cervical region, mobilisation of this region in non-symptomatic individuals affects acoustic performance. As there are more sensory receptors in the cervical region than in other regions of the body, even a single session of mobilisation of this region has a direct effect on acoustic performance. The Cyriax technique is a low-risk form of physiotherapy that can be used to quickly and effectively reduce pain caused by injury or illness.[11] The Cyriax manipulation protocol is used in conjunction with cervical isometrics and muscle stretching. This technique is performed in a comfortable lying position with the head slightly off the bed. Initial pre-manipulative massage is applied to the mid-cervical region with the fingers on the contralateral side and the thumb on the ipsilateral side. The massage is performed by simultaneously flexing and extending the wrist in the skin.

Cervical mobilisation consists of flexion-extension, right-left lateral flexion, right-left rotation, antero-posterior gliding, medio-lateral gliding and spinal traction with the patient in the supine position. Each mobilisation is performed 5 times and traction for 20 seconds. The physiotherapist controls the speed of the movement, the smoothness of the angle and helps to perform the movement correctly (Figure 3).

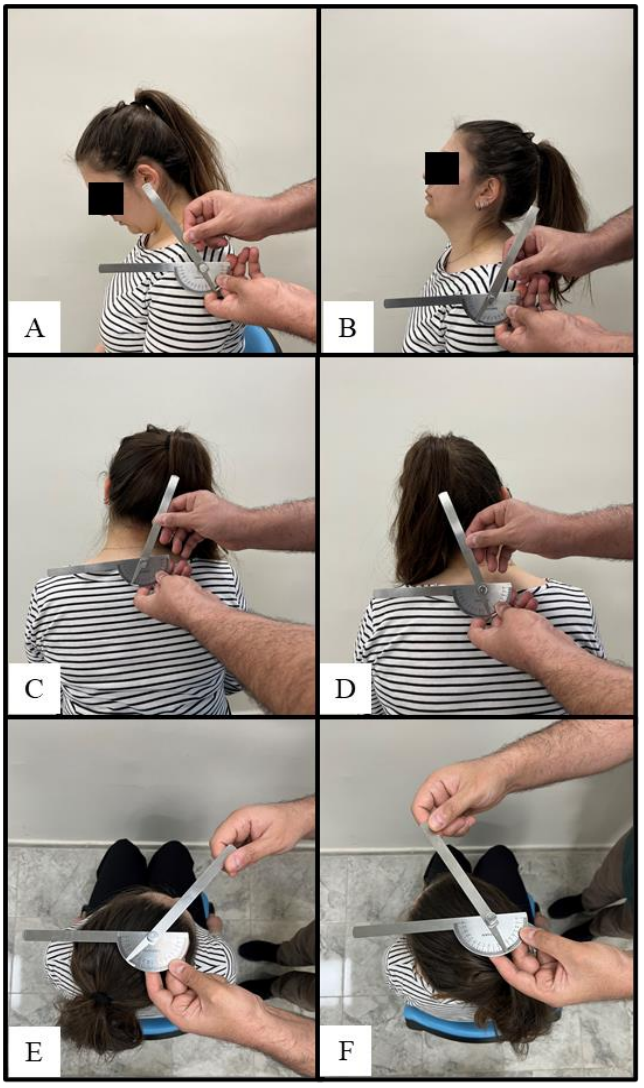

Figure 2. Cervical mobility measurements: A) Flexion, B) Extension, C) Lateral flexion-right, D) Lateral flexion-left, E) Rotation-right, F) Rotation-left

Volume: 4 **Issue: 3**
Year: 2023
DOI: 10.53811/ijtcmr.1345954

International Journal of Traditional and Complementary Medicine Research

Publisher
Duzce University

.

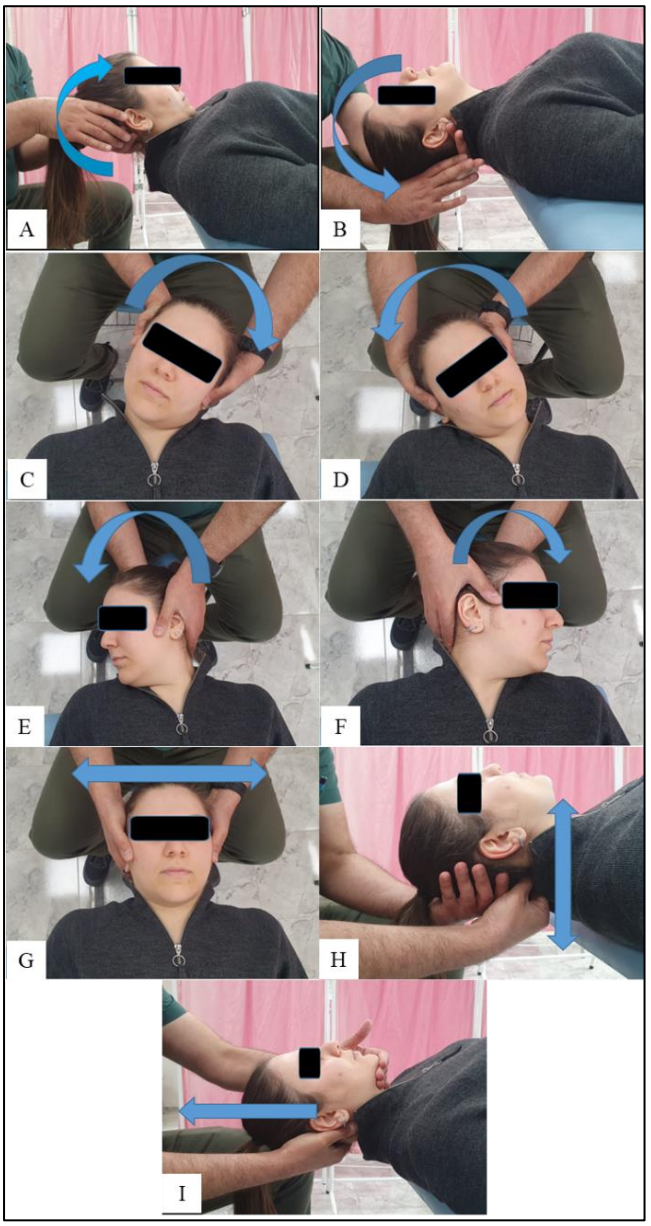

Figure 3. Cervical mobilization intervention: A) Flexion, B) Extension, C) Lateral flexion-left, D) Lateral flexion-right, E) Rotation-right, F) Rotation-left, G) Medio-lateral gliding, H) Antero-posterior gliding, I) Traction.

Statistical analysis

Version 3.1.9.4 of the G*Power programme (Heinrich-Heine-Universita¨t Dusseldorf, Germany) was used to determine the sample of the study. To achieve 80% power (1 - β error probability) with an α error level probability of 0.05, IBM SPSS Statistics 22.0 was used to analyse the results. Descriptive analyses were presented using median, minimum and maximum values for the non-normally distributed variables. Wilcoxon tests were used to compare measurements of acoustic measures, performance and cervical mobility before and after cervical mobilisation.

RESULTS

The demographic characteristics of the participants are shown in Table 1. Comparison of cervical mobility, performance and acoustic properties of the voice before and after cervical mobilisation are shown in Table 2.

Table 1. Demographic properties of the participants.

Variables	Median (Min.-Max.)
Age (years)	24 (19-40)
Height (m)	1.65 (1.58-1.72)
Weight (kg)	61 (47-98)
Voice Type (n)	12 soprano, 3 alto

n: number of participants, m: meter, kg: kilogram.

There was a significant increase in cervical flexion-extension, rotation and lateral flexion range of motion measurements after treatment compared to pre-treatment measurements. While the highest significance was for rotation (P = 0.001), the lowest significance was for lateral flexion (P = 0.006), (Table 2).

According to the chest register analysis, there were reductions in jitter, shimmer and mean HNR measurements after treatment based on pre-treatment measurements. However, there was no significant difference in any of the breast register parameters (Table 2).

According to the head register analysis, there were no reductions except for jitter and shimmer. However, there was a significant increase in mean pitch frequency measurements after treatment compared to pre-treatment measurements (P=0.036) (Table 2).

When analysing the speech data, although there was an increase in post-treatment measurements compared to pre-treatment measurements for mean pitch and mean HNR, no significant difference was found (Table 2).

As a result of the analysis of the middle register data, no significant difference was found for any of the parameters (Table 2).

Table 2. Comparison of cervical mobility and acoustic properties of voice before and after cervical mobilization.

Variable	Pre Median (IQR)	Post Median (IQR)	p
Cervical Mobility			
Flexion-Extension (˚)	90 (80-95)	100 (90-105)	**0.002***
Rotation (˚)	115 (90-120)	120 (110-135)	**0.001***
Lateral Flexion (˚)	70 (60-80)	80 (70-90)	**0.006***
Chest Register			
Mean pitch (Hz)	219.25 (215.24-223.55)	220.27 (216.15-222.90)	0.191
Jitter (%)	0.17 (0.11-0.20)	0.16 (0.12-0.29)	0.609
Shimmer (%)	4.70 (3.97-7.14)	5.67 (4.42-7.59)	0.570
Mean HNR (dB)	22.44 (19.07-25.56)	22.35 (19.26-24.25)	0.609
Head Register			
Mean pitch (Hz)	394.27 (371.06-396.69)	395.07 (379.85-399.39)	**0.036***
Jitter (%)	0.19 (0.12-0.33)	0.12 (0.06-0.25)	0.379
Shimmer (%)	4.94 (3.58-6.78)	3.56 (2.15-6.80)	0.088
Mean HNR (dB)	26.72 (21.66-29.16)	28.99 (23.48-33.41)	0.078
Speaking			
Mean pitch (Hz)	211.45 (198.79-230.44)	214.93 (199.49-223.48)	0.776
Jitter (%)	0.16 (0.15-0.23)	0.16 (0.13-0.27)	0.307
Shimmer (%)	6.38 (4.73-6.92)	5.45 (4.20-8.33)	0.470
Mean HNR (dB)	20.98 (19.47-22.23)	21.27 (19.86-22.42)	0.255
Middle Register			
Mean pitch (Hz)	391.01 (385.41-396.03)	391.29 (388.83-397.12)	0.570
Jitter (%)	0.21 (0.19-0.48)	0.23 (0.18-0.38)	0.514
Shimmer (%)	4.87 (3.64-6.34)	3.50 (2.97-5.70)	0.156
Mean HNR (dB)	23.16 (21.14-26.27)	25.65 (22.47-27.15)	0.427
Performance (%)	65.00 (62.49-78.33)	79.58 (73.74-89.58)	**0.001***

*: p<0.05, IQR: Interquartile range, HNR: Harmonics to Noise Ratio

Voice Training Expert 1

It is noticeable that after the application all the students had a relaxed appearance, especially in the neck and face, their resonance areas were more open and their breathing support was much better, they could sing more legato, there was a controlled increase in their vocal intensity and they were more physically comfortable. Whilst it can be seen that their breath control is weaker before the application, especially when they try to get support from their necks, the voice is heard to be breathy. Before the application it is seen that they could not maintain their position in low voices because their breathing support was weak and uncontrolled, and the voice dropped frequently, had difficulty in high voices and maintaining tone. As the breathing support is better after the application, it is seen that the dropping of the voice is much less, and they are more comfortable and controlled when making a high pitched sound, and they maintain the position of the sound.

Voice Training Expert 2

Before the application some of the students could hear detonations and after the application it was observed that they were able to stay in tune as the student provided better breathing support. Before the application, the students' concentration on the work was weaker and it was observed that their mastery of the work increased after the application. Before the application, most of the students were weaker in providing body posture and singing position with breathing support, but after the application it was observed that the body posture and singing positions were more accurate because they could provide better breathing support. They were also observed to be more successful in performing legato. After the application, it was observed that the more correct behaviour of the students increased their musicality, but it was also seen that they could better reflect the stylistic features of the works.

According to the experts' opinions, based on the interview results, there was a significant increase in performance in the post-treatment status compared to the pre-treatment status (P = 0.001), (Table 2).

DISCUSSION

In this study, acoustic analysis of speech, chest, middle and head registers was performed before and after cervical mobilisation. According to the analysis results, no significant difference was observed in the parameters jitter, shimmer and HNR. On the other hand, a significant difference was observed in the mean pitch (fundamental frequency - F0) parameter

of the voices recorded as the head register.

In contrast to our findings, Fachinatto reported that no difference in sound quality was observed in perceptual auditory assessment or acoustic assessment after a single spinal manipulative intervention applied to the thoracic and cervical spine in their study of 29 male participants performing similar singing activities.[20] Kar analysed the effects of body awareness and kinetic exercises on sound production in voice training and, similar to this study, analysed voice recordings from the speech, chest, middle and head registers with the Praat analysis program. The analysis evaluated mean pitch (fundamental frequency), jitter, shimmer and HNR parameters, but no significant difference was found in mean pitch and jitter parameters. On the other hand, a significant difference was found for shimmer and HNR values, and an increase was observed for the shimmer parameter, while a decrease was observed for the HNR parameter.[21] Although these studies have reported conflicting results as to whether manual therapy or exercise is effective in improving acoustic properties, according to the results of the current study, a statistically significant improvement was found for all cervical range of motion scores. However, only the mean pitch parameter of acoustic properties showed a statistically significant improvement.The effectiveness of mobilisation applications becomes apparent after a minimum of 6 sessions. This may be one reason why no differences were found in the acoustic parameters.

In one study, the mean scores of the study group were examined in terms of performance parameters for action research and post-singing; it was found that the mean scores for the parameters 'musicality', 'technique', 'correct use of breath', 'correct use of body', 'legato singing' and 'style interpretation' increased from 63.62 points to 75.3 points.[21] In our study, it was found that the mean score increased from 65.00 points to 79.58 points. It was therefore concluded that performance rates increased in a similar manner in both studies.

The autonomic nervous system (ANS) regulates certain bodily processes, such as blood pressure and breathing rate, which are controlled by centres in the spinal cord, brain stem and hypothalamus. The autonomic nervous system consists of sympathetic, parasympathetic and enteric divisions. The parasympathetic division is normally associated with the basal autonomic functions of heart rate and respiration. Rhythmic mobilisation of the joints activates the parasympathetic part of the ANS, resulting in both increased joint movement and relaxation of peripheral muscles.[11]

The singer's instrument is inside her body, and she produces sound with her whole body, not just her vocal chords. For this reason, singers should know their bodies well. In addition, since physical and mental tensions create tension in the joints, spine and muscles, they should act with an understanding of the importance and necessity of relaxation.[22]

The term "mobilisation" refers to low-velocity manual therapy techniques that involve continuous passive movement of joints and/or associated soft tissues.[23] Due to the physiological lordosis of the spine, the cervical and lumbar regions carry a greater load than the thoracic and sacral regions.[24] Cervical mobilisation is one of the most common techniques used to treat head and neck disorders.[25] In particular, mobilisation of the neck facilitates control of the respiratory muscles and thus more controlled voice management can be achieved. In this study, the video recordings of the students who underwent cervical mobilisation before and after the application were interpreted by two experts. Both experts reported that the students' vocal and respiratory control increased after the application, that they were more successful in performing legato, and that their postures were more accurate.

It has been shown that the electromyographic activity of the superficial neck flexors decreased and the function of the deep neck flexors increased after cervical mobilisation.[26] The source for the electromyographic activity is muscle afferent input, particularly from the muscle spindle.[27] The presence of many muscle spindles and mechanoreceptors that provide proprioception in the suboccipital region where the cervical vertebrae are located makes the cervical region important between the spinal segments.[28] As a result of the cervical mobilisation used in this study, it was found that the participants' attention level and postural stabilisation increased. An increase in musicality was also measured. Receptors in the cervical region not only connect to the visual and vestibular systems, but also to the sympathetic nervous system. Receptors involved in the cervico-colic reflex, cervico-ocular reflex and tonic neck reflex are important in regulating head, eye and postural stability. The cervico-colic reflex helps to maintain the position of the head in space, the cervico-ocular reflex helps the eye to see clearly during head movements by activating the extra-ocular muscles, and the tonic neck reflex helps to maintain postural stability.[29] The people in this study received a single session of cervical mobilisation. Although the average age of the participants in this

study was 24 years, the cervical range of motion limitations were severe. However, as a result of a single session of mobilisation, a significant increase in joint movement in all directions was measured. In addition, according to the expert reports analysing the vocal performance of the students participating in the study, it was reported that the students' attention increased, their postural control improved and their musicality increased. Therefore, it can be said that the single session of cervical mobilisation we used had a small benefit on acoustic performance.

Voice quality can be influenced by several postural aspects.[30] The position of the head relative to the torso can alter the diameter of the pharyngeal cavity.[31] The position of the head and cervical spine has been associated with certain types of voice.

Therefore, manoeuvres that facilitate these postures may improve sound emission. A study investigating the effect of spinal manipulative therapy on the singing voice of male individuals reported that no differences in the quality of the singing voice of asymptomatic male singers were observed after a single spinal manipulative intervention on either perceptual audio evaluation or acoustic evaluation.[20] A retrospective cohort study investigating the role of a specialised physiotherapy programme for patients with muscle tension dysphonia as an adjunct to standard voice therapy found improvement, but no significant results in favour of manual therapy.[32] According to literature reports, the superiority of this study is that we found a statistically significant improvement in cervical range of motion.

Our study has the limitations of being a small single centre study and the intervention time was relatively short. This study lacked the participation of male students because there was no vocal training for male students in this semester. In the current study group, the positive effect was obtained mainly in terms of interwiev reports. However, these reports are subjective measures based on expert opinion. Therefore, the use of objective measurement methods such as artificial intelligence and digitalised voice-body analysis, which can simultaneously measure the vacal effect of the cervical mobilisation technique, in future studies will strengthen the level of evidence.

CONCLUSION

This study found that a single session of cervical mobilisation had a positive effect on performance and cervical mobility. In light of these findings, it could be said that regular mobilisation of the cervical region would improve vocal performance in music students and professional musicians.

ACKNOWLEDGEMENTS

The authors thank Seher Dursun and Büşra Kürtüncüoğlu for their technical support.

Disclosure Statement: The authors have no conflicts of interest to declare.

Author contributions: Conceptualization: [İC, AÖ, SDY]; Design: [SDY, İC]; Writing: [İC, AÖ, SDY]; Investigation/Data collection: [SDY, AÖ].

Conflict of Interest: There is no potential conflict of interest relevant to this article.

REFERENCES

1. Shaabdurakhimova SS. Voice formation mechanism and causes of voice impairment. *ACADEMICIA*. 2021;11(3):2259-2265.
2. Nusseck M, Immerz A, Spahn C, Echternach M, Richter B. Long-term effects of a voice training program for teachers on vocal and mental health. *J VOICE*. 2021;35(3):438-446.
3. Gurel, S. Comparison of piano practicing habits and attitude levels of vocal students. *Int. Online J. Educ. Sci.* 2022;14(2), 359-373.
4. Doğanyiğit S, Yiğit N. The perspective of trainers on the use of imagination in singing training. *Arhiv za Farmaciju*, 2023: 7.1.
5. Tsaknaki V, Cotton K, Karpashevich P, Sanches P. "Feeling the Sensor Feeling you": A Soma Design Exploration on Sensing Non-habitual Breathing. *Conference on Human Factors in Computing Systems* 2021:1-16.
6. Fancello V, Natale E, Guerzoni A, et al. Laryngeal Taping as a supportive tool to relieve phonasthenia in singers: a preliminary report. *J VOICE* . 2021;
7. Cirilo TAS, Oliveira VGd, Ceniz AA, Tanigute CC, Fernandes ACN, Silva EMd. Singers' postural alignment and vocal quality. *Audiol. Commun. Res.* 2021;26
8. 8 Lopez E, Lee S-H, Bahr R, et al. Breathing Techniques in Collegiate Vocalists: The Effects of the Mind-Body Integrated Exercise Program on Singers' Posture, Tension, Efficacy, and Respiratory Function. *Perspectives in Performing Arts Medicine Practice: A Multidisciplinary Approach*. 2020:111-125.
9. Williamson A, James MB, Tucker V, et al. Bio-somatic dance movement naturotherapy: The occiput, scapulae and sacrum–Fulcrums of support and reorganization. *Dance, Movement & Spiritualities*. 2020;6(1-2):49-85.
10. Uysal SA, Düger T. Motor control and sensory-motor integration of human movement. *Comparative Kinesiology of the Human Body*. Elsevier; 2020:443-452.

11. Ceylan İ, Canlı M, Kuzu Ş, Ayhan DT, Gürses ÖA, Oyman BE, Alkan H, Doğan E. The effectiveness of two different treatment approaches in individuals with chronic non-specific neck pain: a randomized control trial. Turk J Health S. 2023;4:2:56-62. Doi: http://dx.doi.org/10.29228/tjhealthsport.69835
12. Myrtveit SM, Sivertsen B, Skogen JC, Frostholm L, Stormark KM, Hysing M. Adolescent neck and shoulder pain—the association with depression, physical activity, screen-based activities, and use of health care services. *J Adolesc Health*. 2014;55(3):366-372.
13. Binder AI. Cervical spondylosis and neck pain. *Bmj*. 2007;334(7592):527-531.
14. Gallego-Sendarrubias GM, Rodríguez-Sanz D, Calvo-Lobo C, Martín JL. Efficacy of dry needling as an adjunct to manual therapy for patients with chronic mechanical neck pain: A randomised clinical trial. *Acupunct Med*. 2020;38(4):244-254.
15. Palmgren PJ, Sandström PJ, Lundqvist FJ, Heikkilä H. Improvement after chiropractic care in cervicocephalic kinesthetic sensibility and subjective pain intensity in patients with nontraumatic chronic neck pain. *J Manipulative Physiol Ther*. 2006;29(2):100-106.
16. Zaproudina N, Hänninen OO, Airaksinen O. Effectiveness of traditional bone setting in chronic neck pain: randomized clinical trial. *J Manipulative Physiol Ther*. 2007;30(6):432-437.
17. Cleland JA, Childs MJD, McRae M, Palmer JA, Stowell T. Immediate effects of thoracic manipulation in patients with neck pain: a randomized clinical trial. *Man. Ther*. 2005;10(2):127-135.
18. Teixeira JP, Oliveira C, Lopes C. Vocal acoustic analysis–jitter, shimmer and hnr parameters. *Proc. Technol*. 2013;9:1112-1122.
19. RAzzaq, Aisha, et al. Comparison of Cyriax manipulation with traditional physical therapy for the management of cervical discogenic problems. A randomized control trial. *J Pak Med Assoc*, 2020, 70.8.
20. Fachinatto APA, de Campos Duprat A, e Silva MA, et al. Effect of spinal manipulative therapy on the singing voice. *J VOICE*. 2015;29(5):645. e33-645. e39.
21. Kar T. *Ses eğitiminde bedensel farkındalık ve devinimsel ses egzersizlerinin kullanımı: Eylem araştırması*. Doktora Tezi. Marmara Universitesi (Turkey); 2020.
22. Tülay U. Alexander tekniğinin şan tekniğindeki önemi. *Asya Studies*. 2017;1(1):51-58.
23. Gross A, Kay T, Kennedy C, et al. Clinical practice guideline on the use of manipulation or mobilization in the treatment of adults with mechanical neck disorders. *Man. Ther*. 2002;7(4):193-205.
24. Özüdoğru A, Canlı M, Ceylan İ, Kuzu Ş, Alkan H, Karaçay BÇ. Five Times Sit-to-Stand Test in people with non-specific chronic low back pain—a cross-sectional test–retest reliability study. *Ir. J. Med. Sci*. 2022:1-6.
25. Celenay ST, Akbayrak T, Kaya DO. A comparison of the effects of stabilization exercises plus manual therapy to those of stabilization exercises alone in patients with nonspecific mechanical neck pain: a randomized clinical trial. *J Orthop Sports Phys Ther*. 2016;46(2):44-55.
26. Sterling M, Jull G, Wright A. Cervical mobilisation: concurrent effects on pain, sympathetic nervous system activity and motor activity. *Man. Ther*. 2001;6(2):72-81.
27. Özüdoğru A, Canlı M, Kuzu Ş, Aslan M, Ceylan İ, Alkan H. Muscle strength, balance and upper extremity function are not predictors of cervical proprioception in healthy young subjects. *Somatosens Mot Res.* 2023:1-5.
28. Sung, Yun-Hee. Suboccipital muscles, forward head posture, and cervicogenic dizziness. *Medicina*, 2022, 58.12: 1791.
29. Abbas A, Hassan Z, ul Hassan AM, Mustansar A, Qamar S, Mustafa M. To Determine The Effect Of Cervical Muscle Fatigue And Its Correlation With Visual Acuity. *JPSP*. 2023:2358-2365.
30. Arboleda, Barbara M. Wilson; Frederick, Arlette L. Considerations for maintenance of postural alignment for voice production. *J VOICE*, 2008, 22.1: 90-99.
31. Muto, Toshitaka, et al. The effect of head posture on the pharyngeal airway space (PAS). *Int.J.Oral Maxillofac. Surg*, 2002, 31.6: 579-583.
32. Craig, Jennifer, et al. Combining voice therapy and physical therapy: a novel approach to treating muscle tension dysphonia. *J. Commun. Disord*. , 2015, 58: 169-178.