Influence of traction therapy of the cervical spine on the distribution of harmonics in the voice as well as the intensity and length of phonation

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Abstract

Background: Contemporary physiotherapeutic techniques and methods could be useful in changing the approach to teaching correct phonation in people with different vocal experience. A physiotherapist can use stimulating techniques, improving the lower rib breathing in a vocalist, using thoracic expansion techniques, diaphragm decompression or manual massage, as well as spinal and rib mobilization. Moreover, many modalities for temporomandibular joint (TMJ) therapy can be useful for working with vocalists.

Aims: The aim of the study was to find the relationship between the distribution of harmonics, sound intensity, and phonation length and the use of the cervical spine traction technique in people with different vocal experience.

Material and methods: The study in a group of 35 people was carried out at the Physioteam clinic in Wroclaw (Poland). First, the respondent was asked to complete a questionnaire regarding his experience and aspects of vocal education. Then the measure was conducted from the distance of 30 cm from the mouth to the membrane and took a sound sample on C-sound (130 Hz) for men and (260 Hz) for women. After recording the sample, we moved on to traction. Traction was performed on a massage table, in the supine position, by one physiotherapist for all persons from the study. The technique was performed for 2 minutes in each of the 3 positions: the head is slightly extended and the neck is flexed, the head and neck in right-sided rotation, and the head and neck in left-sided rotation.

Key words

singing, harmonics, phonation, traction, cervical spine, temporomandibular joint, physiotherapy.

Results: The study showed that for the entire study group of singers, the average length of the sample was longer at measurement 2, i.e., after applying the cervical spine traction technique, than before performing the technique. This is a significant change that can be noticed in the study group after performing the technique. The Root Mean Square (RMS) parameter did not change significantly, while the spectrum centroid decreased at measurement 2.

Conclusions: Based on the results, the following conclusions were drawn: the technique of traction of the cervical spine significantly influences the phonation length in a group of experienced singers, the technique of traction of the cervical spine decreased the spectrum centroid in the whole study group, this technique is most applicable to an experienced group of singers, physiotherapy is a field which, with the help of its tools, can change the approach to teaching correct phonation.

Introduction

All of the new vocal schools strive to objectify the sensation of correct phonation according to their assumptions. Each of the vocal schools carries a good dose of sound knowledge backed by experience, but unfortunately, many of them perpetuate the myths that have accrued in the vocal community by the previous inability to measure objective parameters during the vocalist's education. Almost the only determinant of vocal technique was the vocal teacher's verification, which in turn is dependent on his experience, education, and knowledge of the many disciplines that go into such a vast field as vocal performance. Today, thanks to technical developments, special equipment, much greater expertise of specialists, and accessibility to knowledge for those interested in this art, we can increasingly develop conscious vocal emission. We have access to such devices as posturographic platforms, with which we can pre-diagnose the problem of center of gravity distribution, so indirectly also postural dynamic defects giving direct biofeedback, digital analyzers that allow accurate analysis of a sound sample and interpretation of its many parameters, magnetic resonance imaging, and videostroboscopy, which allow analyzing the dynamic work of the soft structures of the vocal apparatus [1,2].

In addition, physiotherapy has developed itself, its schools, and its scope of work. As therapists, we are also in a position to have a real impact on the quality of voice emission since the process has many components that add up to the expected effect. The primary influence that a physiotherapist can have on the effectiveness of emission is to improve posture. Abnormal posture can project into phonation forcing, increased subglottal pressure, or abnormal breathing [3]. The physiotherapist can also work with correct breathing and teach the singer the optimal work of the diaphragm, abdominal muscles, and respiratory proportions. In addition, the singer can be made aware of the mechanism of forced expiration and the Valsalva maneuver, which, without complete glottal closure, will be physiologically similar to vocal emission with the addition of appropriate vocal cord constriction, which can help provide an indirect sense of what glottal closure is and the relationship between the intense exhalation and the subglottal and supraglottal pressures [4].

A physiotherapist can also use their hands to stimulate the lower rib breathing in a vocalist, using thoracic expansion techniques, diaphragm decompression or manual massage, rib mobilization, and spinal and thoracic rotational mobilization [5]. Many temporomandibular joint (TMJ) therapy techniques will be useful for working with vocalists. Beginning with facial massage, relaxing the masseter externally and intraorally,

working on the superficial and deep muscles of the neck, using TMJ traction and mobilization for lowering and rotation [6–9].

The phonation professional should also ensure that the neck, upper chest, and back muscles are balanced; otherwise, the larynx may become compressed. Direct compression of the larynx will limit its mobility, resulting in less mobility of the vocal cords as well, so the singer's skills will be limited relative to his physiological capabilities. Phonation will cause effort, which may have consequences in terms of faster wear and tear on the vocal apparatus.

Aims

The aim of the study is to identify the relationship between the distribution of harmonic components, sound intensity, and phonation length, and the application of cervical spine traction technique in people with different vocal experience. In addition, an attempt was made to prove that physiotherapy is a field that can change the approach to the study of phonation by updating the knowledge in the vocal world with professional, reliable, and recent knowledge and publications, and can change the comfort and quality of singing in singers. To detail the problem, the following questions were formulated: Did the length, loudness of sound, and quality of phonation improve after using the cervical traction technique? Is the possible effect of the cervical spine traction technique dependent on the singer's experience? In which part of the study group does the cervical spine traction technique show the greatest potential utility?

Material and methods

The study was conducted between May and November 2021 at the Physioteam Clinic in Wroclaw, Poland. The study included 35 participants, including 26 women and nine men. The group of 18-25 years old was the youngest, with the largest number of subjects - 15 people, while the age group of 26-35 years old included 14 people, the next range of 36-55 years old accounted for five people, and in the last range, over 55 years old, there was only one subject. Among the study group, the participants had different vocal seniority. In the group that has been singing the longest, i.e. over ten years, there were ten people; the range from 6 to 10 years was, on the other hand, the most numerous because it included 15 surveyed people in the group whose experience ranged from 3 to 5 years there were 10 participants, while in the least experienced group, i.e. less than two years of singing, there were only four people.

The testing of all participants took place in the same room to maintain acoustic repeatability for each participant; they stood in the same place, and we measured the same distance of the mouth from the microphone membrane, which was 30 cm. For sampling, we used a Sontronics STC - 20 condenser microphone, which was connected to an external sound card Focusrite Scarlett 2i2 2nd gen. The samples were recorded in the DAW program Ableton Live 9. The sample was exported and subjected to the reading of parameters such as length, Root Mean Square (RMS) intensity and the centroid of the spectrum in a program written in Python language by Eng. Andrzej Józefczyk.

First, the subject was given a questionnaire to complete regarding his experience and aspects of vocal education. The survey consisted of 12 questions. The first part was a metric - gender and age; in addition, we asked about the city where most of the vocal education took place. The next questions dealt directly with vocal experience, the number of vocal teachers in the training process to date, and music education. Next, a distance of 30 cm of the mouth from the microphone membrane was measured, and a sound sample was taken on the C(130Hz) sound for men and (260Hz) for women. After the sample was taken, traction was realized. In the supine position, the same physiotherapist performed the traction technique on a massage table for all study subjects. The technique was performed in 3 positions: head in slight upright and neck in flex-

ion, head and neck in right rotation, and head and neck in left rotation. Traction in each position was performed for 2 minutes, and, in addition, when exhaling, the therapist pushed the sternum in a caudal direction. There was a 30-second break between positions. After the therapy, we again measured the distance of 30 cm of the mouth from the diaphragm and once again took a sound sample. The sound sample was recorded using a condenser microphone, and the degree of correlation between cervical spine traction therapy and the distribution of the harmonic components of the voice will be determined using a frequency spectrum analyzer.

Statistical analyses were performed using the IBM SPSS Statistics 26 package to answer the research questions posed and to test the hypotheses. With its help, an analysis of basic descriptive statistics was carried out along with Shapiro-Wilk tests, a series of analyses by Student's t-test for dependent and independent samples, and their non-parametric counterparts in the form of Wilcoxon test and Mann-Whitney U test. The classical threshold of $\alpha = 0.05$ was considered the significance level; however, due to the relatively small sample size, a significance result between 0.051 and 0.1 was considered to indicate significant differences at the statistical trend level.

Results

In order to check whether the assumption that the distributions of the measured quantitative variables follow a normal distribution was met, an analysis of basic descriptive statistics was conducted first, along with the Shapiro-Wilk test. As it turned out, the test result was statistically significant for most of the measured variables. This means that their distribution deviates statistically significantly from the Gauss curve. In addition, however, it should be noted that for these variables, the result of the skewness parameter exceeds the conventional absolute value of 1.0, which means that these distributions are significantly asymmetric with respect to the normal curve, which confirms the result of the Shapiro-Wilk test (George, Mallery, 2016). Therefore, in the case of the centroid of the frequency spectrum in the first and second measurements and the ratio for the centroid and RMS, parametric tests were used, while in other cases, non-parametric tests were used. The basic descriptive statistics, along with the result of the Shapiro-Wilk test, are presented in **Table 1** while **Figs. 1** and **2** provide a graphical illustration of the distribution of quantitative variables.

In order to test the hypothesis that the use of traction has an effect on the value of centroid, length, and average sound intensity, a Student's t-test for dependent samples (in the case of centroid) and two Wilcoxon rank-sum sign tests (for RMS and length) were performed. The analysis showed that there were no statistically significant differences for the centroid measurement between the first and second measurements. The results obtained are presented in **Table 2**, with **Fig. 3** illustrating both compared averages.

Table 1. Basic descriptive statistics of variables measured on quantitative scales with the Shapiro-Wilk test.

	M	Me	SD	Sk.	Kurt.	Min	Max	W	p
Centroid – Measurement 1	1894.80	1887.11	258.92	0.13	-0.41	1394.68	2471.42	0.99	0.964
Centroid – Measurement 2	1877.44	1884.16	286.68	0.22	-0.36	1348.80	2585.01	0.98	0.748

Length – Measurement 1	9.06	8.52	2.25	2.03	5.89	6.00	17.85	0.83	<0.001
Length – Measurement 2	9.86	9.25	2.86	2.49	7.40	7.00	21.34	0.73	<0.001
RMS – Measurement 1	0.01	0.00	0.01	2.33	6.17	0.00	0.02	0.74	<0.001
RMS – Measurement 2	0.01	0.00	0.01	2.14	5.15	0.00	0.02	0.77	<0.001
Centroid – ratio	1.02	1.02	0.09	0.52	1.40	0.81	1.26	0.96	0.259
Length - ratio	0.95	0.92	0.21	1.85	9.05	0.51	1.84	0.81	<0.001
RMS – ratio	1.05	1.05	0.27	-0.06	-0.12	0.55	1.66	0.97	0.433

Abbreviations: *RMS – Root Mean Square, M – mean, Me – median, SD – standard deviation, Sk. – skewness, Kurt. – kurtosis, Min – minimum, Max – maximum, W – Shapiro-Wilk distribution normality test statistic, p – statistical significance of the Shapiro--Wilk test.*

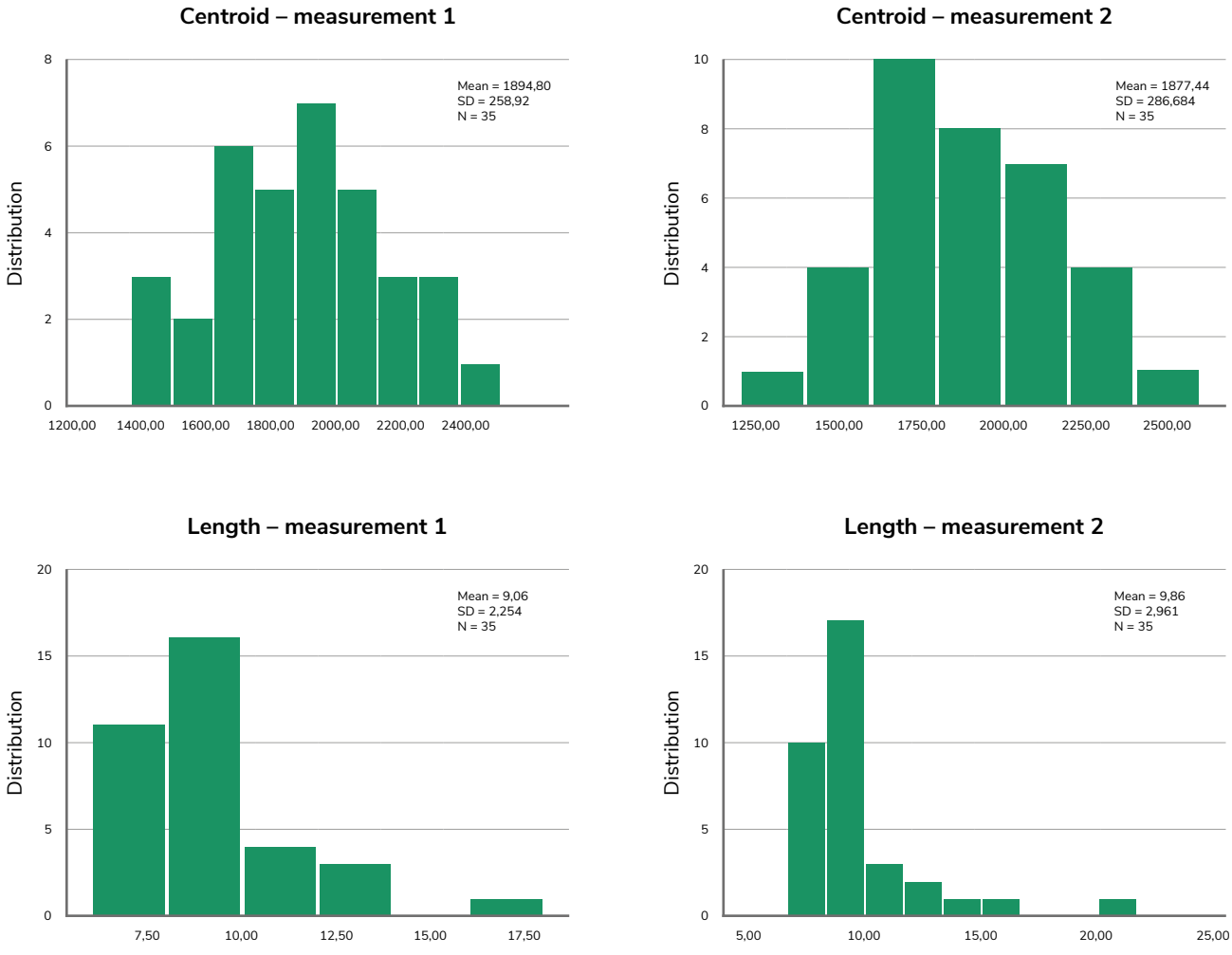
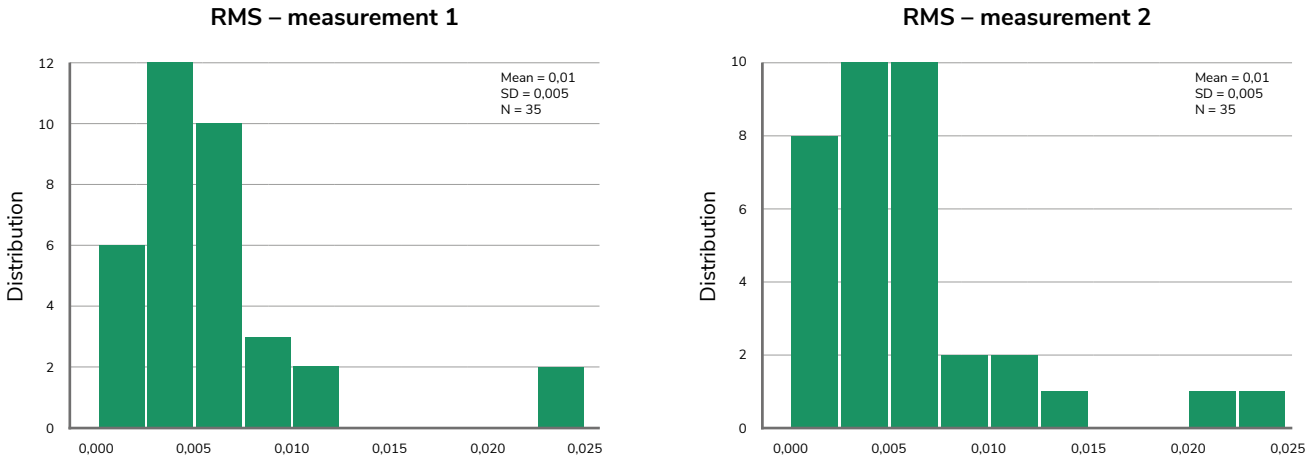


Figure 1. Histograms illustrating the distribution of centroid, length, and RMS in the first and second measurements.



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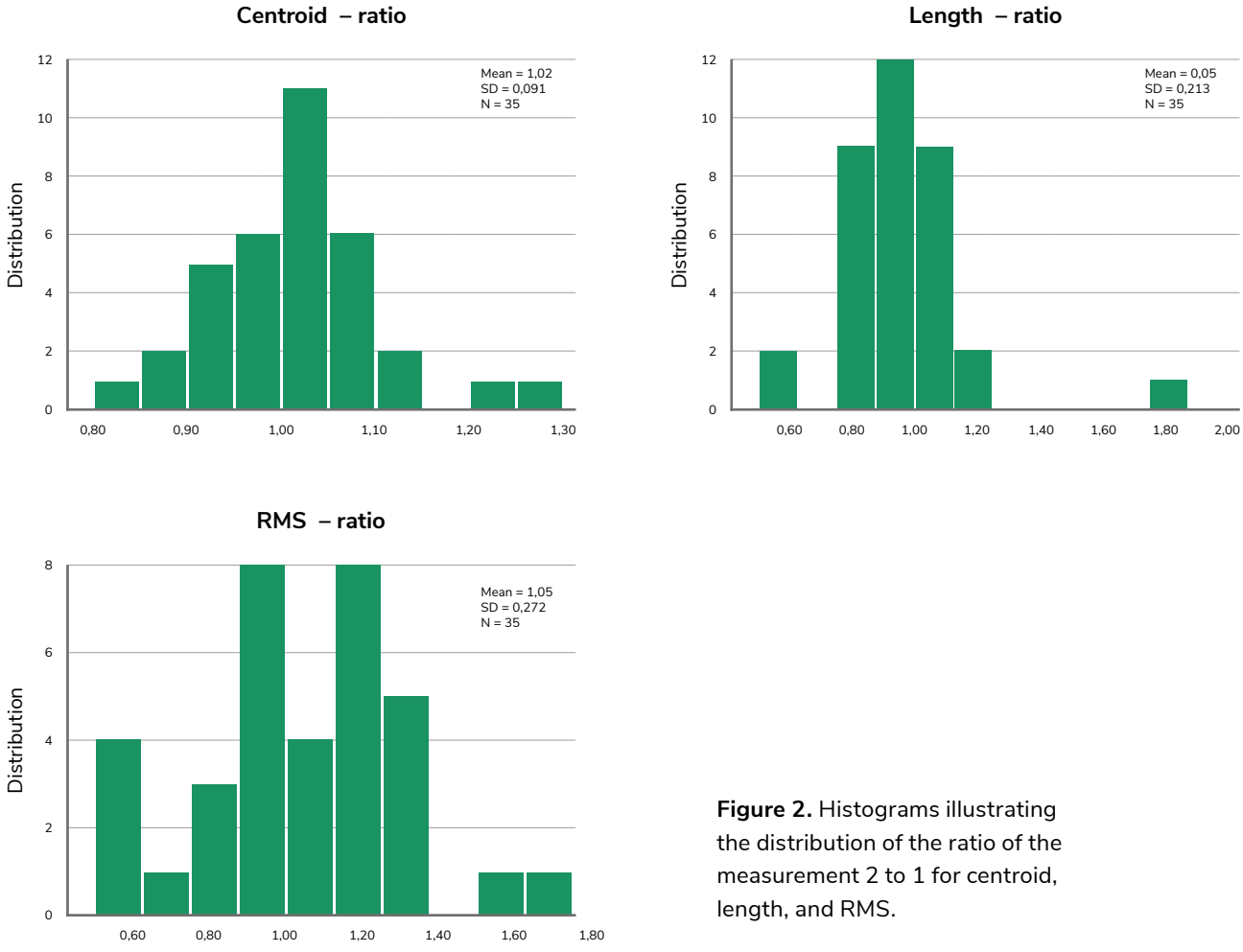

Figure 2. Histograms illustrating the distribution of the ratio of the measurement 2 to 1 for centroid, length, and RMS.

Table 2. The result of the Student's t-test compares the mean centroid value between the first and second measurements.

	Measurement 1 (n = 35)		Measurement 2 (n = 35)				95% CI		
	M	SD	M	SD	t	p	LL	UL	dCohen
Centroid	1894.80	258.92	1877.44	286.68	0.61	0.545	-40.41	75.12	0.10

Abbreviations: *M – mean, Me – median, SD – standard deviation, t – Student's t-test statistic, CI – confidence interval, p – statistical significance of Student's t-test.*

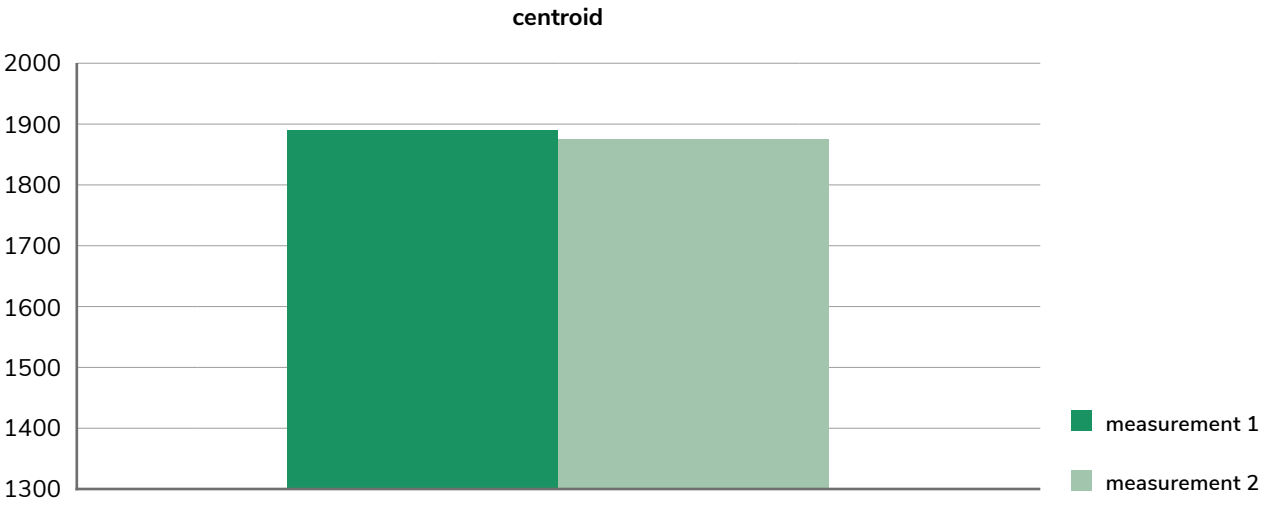

Figure 3. Mean centroid value in measurement 1 and 2.

Another of the analyses conducted showed that the previously observed significant difference in sound length change was seen only in experienced vocalists. Only in them, a higher sound length score was observed more often in the second measurement than in the measurement 1. The observed treatment effect is very strong in this case. The remaining differences are statistically insignificant. Collectively, the results obtained are presented in **Table 3**.

Discussion

The study showed that for the entire study group of vocalists, the average sample length was longer at measurement 2 – after applying the cervical spine traction technique. This is a significant change seen in the study group after performing the traction technique. The RMS parameter did not change significantly, while the centroid of the spectrum decreased at measurement 2. These results may indicate the relevance of the cervical spine traction technique in working with vocalists who have problems with properly matching breath to phrase or with prolonged exhalation. In addition, the study showed a shift of the spectral centroid toward a lower value, indicating a tendency to perceive the sound as "darker" after therapy, which may lead one to think that patients felt more comfortable because for singing low notes, the singer must relax the laryngeal structures more, the larynx must be more mobile.

Table 3. Results of the Wilcoxon test examine the effect of traction use on the length and average intensity of sound in a group of experienced and inexperienced subjects.

Group			N	M_{rang}	Z	p	η^2
Experienced	Length	Negative ranks [a]	6	5.50	-3.34	0.001	0.45
		Positive ranks [b]	18	14.83			
		Ties [c]	1				
	RMS	Negative ranks [a]	15	14.40	-1.44	0.150	0.08
		Positive ranks [b]	10	10.90			
		Ties [c]	0				
Inexperienced	Length	Negative ranks [a]	4	6.25	-0.30	0.767	0.01
		Positive ranks [b]	5	4.00			
		Ties [c]	1				
	RMS	Negative ranks [a]	4	3.50	-1.38	0.169	0.19
		Positive ranks [b]	6	6.83			
		Ties [c]	0[i]				

Notes: *The letters in the superscripts indicate in turn: a – measurement 2 less than measurement 1; b – measurement 2 greater than measurement 1; c – measurement 1 equal to measurement 2.*

Abbreviations: N – *number of subjects in the given subgroups, Mrang. – mean ranks, Z and p – the result of the non-parametric Wilcoxon test, eta2 – eta square or measure of the strength of the effect, p – statistical significance of the non-parametric Wilcoxon test.*

Another possible collaboration between a physiotherapist and a vocalist could be voice rehabilitation. This includes working with people after any kind of dysfunction or disease of the speech apparatus, such as singing nodules, reflux, bruxism, temporomandibular disorders (TMD), or abnormal posture, which involves abnormal distribution of muscle tone. An example of this is working with TMD. A study on TMD among Polish students found that 26.5% of them have TMJ problems [10]. This may be due to the fact that the trigeminal nerve connects stimuli from the face and neck [11], so a TMD patient may also have cervical symptoms, and there may be additional pathologies such as reduced range of motion and weakened neck muscle strength [12] and increased neck muscle tenderness [13,14], which directly affects the quality and comfort of phonation. Joint mobilization has proven to be an effective solution to TMJ problems [6, 7]. Examples of this technique include mandibular traction performed with a slight downward force [8], anterior sliding, lateral sliding, and disc repositioning [9]. Another effective method for combating musculo-fascial tension in the human speech apparatus is a manual massage of muscles such as the masseter. The relevance of this method is described in a 2013 study by Heredia-Rizo et al. [15].

For our study, we chose the cervical traction technique as an effective method of prevention against the above risks and as a method of working with the patient after the effects of prolonged protraction [16]. This is because traction relaxes the soft structures around the joint that is subjected to it. In addition, it introduces proper head alignment so that the patient with forward head posture (FHP) can feel proprioceptively the correct alignment of the head and neck relative to the lower segments of the spine and trunk. This will help lengthen the pharyngeal portion of the vocal tract, which is essential for free, fully qualitative phonation, and reduce the frequency and duration of pain associated with the trapezius muscle, suboccipital muscles, and the presence of trigger points in this area [17,18].

Previous studies also confirm the correlation between migraines and TMD symptoms, which can be a helpful tool in diagnosing a patient's problems, especially since the study specifies symptoms of headaches of cervical origin. The effectiveness of manual therapy in working with patients with cervical problems is illustrated by a study [12]. A non-invasive clinical test that a physiotherapist could introduce in a vocal patient is the neck extensor muscle strength test; there is a statistically significant difference in the time to hold the head in the test position in TMD patients compared to healthy individuals [20].

Techniques that are not obvious but prove to be very effective are intraoral techniques. Examples of application include techniques for releasing tension on the lateral pterygoid, medial pterygoid, and wedge-mandibular muscles, whose anatomical structure conditions access for the therapist to work only intraorally, and the muscles themselves and their pathologies are a common cause of TMD [21,22]. An example would be their asymmetrical contracture, which will cause the jaw to be pulled toward the contracted side, thus causing asymmetrical movement. Such movement replicated repeatedly will cause dysfunction on the more exploited side. A weakness of the study is the undeveloped selection and selection of study groups, it would be worthwhile to analyze more the individual vocal abilities of each participant and select the selection so that the sound they have to sing is equally comfortable for everyone and adequate to their voice scale.

Conclusions

The cervical spine traction technique significantly affects phonation length in a group of experienced singers. The cervical spine traction technique affected the lowering of the spectrum centroid in the entire study group. This technique shows the greatest use among the experienced group of vocalists. Physiotherapy is a field that, with its tools, can change the approach to teaching correct phonation.

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