CLINICAL STUDY

THE EFFECT OF ABDOMINAL (DIAPHRAGM) RESPIRATORY TRAINING ON AERODYNAMIC PARAMETERS IN PATIENTS WITH MUSCLE TENSION DYSPHONIA

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SUMMARY

Objective: In this study, the effectiveness of abdominal (diaphragm) respiratory training on muscle tension dysphonia was investigated using aerodynamic parameters.

Material-Method: 60 patients between the ages of 18-65 who were diagnosed with muscle tension dysphonia were included in the study. 60 healthy individuals were included in the control group. Maximum phonation time (/ a /), maximum (/ s /)duration, maximum (/ z /) duration, s / z ratio, vital capacity and phonification quotient were measured before respiratory training for all participants. Abdominal (diaphragm) respiratory training was given to the group with muscle tension dysphonia, and aerodynamic parameters were measured again after 4 weeks of respiratory training. The data of the control group were compared with the data of the patient group before abdominal (diaphragm) respiratory training. Then, the patient group"s aerodynamic parameters before the abdominal respiratory training were compared with the patient group"s aerodynamic parameters after the training.

Results: The aerodynamic parameters of patients before abdominal (diaphragm) respiratory training; maximum phonation time, vital capacity, s / z ratio and phonation quotient were found to differ statistically significantly from the control group ($p < 0.05$). When the patient data after four weeks of respiratory training were compared with the patient data before respiratory training, no significant change was observed in the other parameters ($p < 0.05$), except for the s / z ratio ($p < 0.05$).

Conclusion: The main source of sound is air in the lungs. Therefore, correct and effective breathing is necessary for the effectiveness and continuity of phonation. Although, in our study, no statistically significant change was observed in relation to aerodynamic parameters, vital capacity, maximum phonation time and phonification quotient after 4 weeks, positive changes were observed in all the parameters mentioned. While it was thought that the four-week period might be short, it was observed that abdominal (diaphragm) respiratory training was effective on the s / z ratio of aerodynamic parameters.

Keywords: Muscle tension dysphonia, s / z ratio, aerodynamic parameters, maximum phonation time, phonation quotient

KAS GERİLİM DİSFONİLİ HASTALARDA ABDOMİNAL (DİYAFRAM) SOLUNUM EĞİTİMİNİN AERODİNAMİK PARAMETRELER ÜZERİNE ETKİSİ

ÖZET

Amaç: Bu çalışmada abdominal (diyafram) solunum eğitiminin, kas gerilim disfonisi üzerindeki etkinliği aerodinamik parametreler kullanılarak incelenmiştir.

Materyal- Metod: Kas gerilim disfonisi tanısı almış 18-65 yaş arası 60 hasta çalışmaya alındı. Kontrol grubuna ise 60 sağlıklı birey dahil edildi. Tüm katılımcıların solunum eğitimi öncesi maksimum fonasyon zamanı (/a/), maksimum /s/ süresi, maksimum /z/ süresi, s/z oranı, vital kapasite ve fonasyon katsayısı ölçüldü. Kas gerilim disfonisi olan gruba abdominal (diyafram) solunum eğitimi verildi. 4 haftalık solunum eğitimi sonrası aerodinamik parametreler tekrar ölçüldü. Kontrol grubuna ait veriler, abdominal (diyafram) solunum eğitimi öncesi hasta grubuna ait verilerle karşılaştırıldı. Daha sonra abdominal solunum eğitimi öncesi hasta grubu aerodinamik parametreleri ile eğitim sonrası hasta gurubu aerodinamik parametreleri birbirileri ile karşılaştırıldı.

Bulgular: Abdominal (diyafram) solunum eğitimi öncesi hastalara ait aerodinamik parametrelerin; maksimum fonasyon zamanı, vital kapasite, s/z oranı ve fonasyon katsayısının kontrol grubundan istatistiksel olarak anlamlı farklılık gösterdiği bulundu ($p<0,05$). Dört haftalık solunum eğitimi sonrası hasta verileri, solunum eğitimi öncesi hasta verileri ile karşılaştırıldığında s/z oranı hariç ($p<0,05$) diğer parametrelerde anlamlı değişiklik olmadığı görüldü ($p>0,05$).

Sonuç: Sesin ana kaynağı akciğerlerdeki havadır. Bu nedenle doğru ve etkili bir solunum, fonasyonun etkinliği ve devamlılığı için gereklidir. Her ne kadar bizim yaptığımız çalışmada aerodinamik parametrelerden vital kapasite, maksimum fonasyon zamanı ve fonasyon katsayısı üzerinde 4 hafta sonunda istatistiki bir anlamlı değişiklik izlenmese de adı geçen tüm parametrelerde olumlu değişiklikler izlendi. Dört haftalık sürenin kısa olabileceği düşünüldü. Aerodinaimk parametrelerden s/z oranı üzerinde ise abdominal (diyafram) solunum eğitiminin etkili olduğu görüldü.

Anahtar Sözcükler: Kas gerilim disfonisi, s/z oranı, aerodinamik parametreler, maksimum fonasyon zamanı, fonasyon katsayısı

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INTRODUCTION

Despite the anatomy being normal, changing laryngeal muscle tension is thought to change the functionality of the larynx. Therefore,

the term muscle tension dysphonia (MTD) is now preferred to functional dysphonia [1,2].

Muscle tension dysphonia is a condition mostly seen in women, in which no neurological, anatomical or organic pathology of the larynx is observed. Although its incidence and prevalence have not been determined yet, it is thought that it constitutes 10-40% of the cases seen in voice polyclinics and its response to treatment methods varies [3-6].

Muscle tension dysphonia appears as a sound quality disorder. In the evaluation of patients who apply to voice polyclinics with dysphonia, subjective methods are used to evaluate the perceptual characteristics of the sound and the quality of life of the patient, while objective methods also evaluate the acoustic and aerodynamic parameters of the sound. In addition, video-laryngostroboscopy is used in the follow-up and evaluation of patients [6,7].

The average value of the airflow rate in the glottis during phonation is called the mean flow/airflow rate (MFR) and is measured by pneumotachograph. If there is no suitable instrument to measure the MFR, (Hirano et al.), the phonation quotient (PQ) can be used instead, because of its positive relationship with the MFR. The PQ is calculated via the ratio of vital capacity to maximum phonation time (MPT). Vital capacity (VC) is usually larger than the phonation capacity, so the PQ is usually larger than MFR [8,9].

By calculating the maximum / s / and maximum / z / times measured after maximum inspiration, the s / z ratio is calculated. If there is no pathology affecting the degree of glottic closure, the / s / and / z / times are approximately equal. However, when decreased glottic activity or vocal cord pathologies are observed, the duration of / z / is shortened more than / s / since / z / sound requires phonation different from that of / s /. Therefore, the s / z ratio takes a value greater than 1 [10,11].

Although many methods are used in treatment, the main source of the sound is air in the lungs, and for a quality sound, the breathing technique should be appropriate and effective, because an adjustment disorder between phonation and respiration may cause problems in the voice formation. Therefore, patients are given abdominal (diaphragm) respiratory training (DRT) for improved phonation [6,12]. With abdominal (diaphragm) breathing, the diaphragm contracts downward and the anterior abdominal wall comes forward. In this way, more air fills the lungs for sound production.This results in increased lung volume and softer expiration for sound production at a given subglottic pressure value [13,14]. In order to observe the effectiveness of this study, DRT was given to patients diagnosed with MTD and its effect on aerodynamic parameters was examined.

MATERIAL and METHODS

Between December 2018 - May 2019, of those who came to the Dicle University Ear, Noise Throat and Voice Polyclinic, and who were diagnosed with MTD following evaluation, 60 patients between the ages of 18-65, who had no chrionic lung or neurological disease etc, or symptoms for at least one month and more were included in the study.

All participants were selected from non-smokers. Those who presented with symptoms of infection or allergy during the evaluations were excluded from the study. Patients who had previously received diaphragm respiratory training etc.were also excluded from this study. Informed consent of the patients was obtained. To determine whether patients diagnosed with MTD were different from healthy individuals in terms of aerodynamic parameters; 60 individuals without complaints about larynx, lung, neurological and voice disorders were included in the study as a control group (CG) and informed consent forms were obtained from them. Ethics committee approval was received from the Dicle University Ethics Committee (No: 19, date: 22/11/2018) for the study.

Patients and healthy individuals in the control group were asked to provide their maximum extended / a /, / s /, / z / sounds after a maximum inhalation in the correct posture, with appropriate pitch and sound intensity (approx. 50 - 60 dB SPL) in the sound laboratory. A 1 minute rest period was given between trials. The value with the longest duration was recorded for the study. A microphone (Audio-Technica AT2005USB) connected to a computer with an

audio recorder (Audacity) was positioned 15 cm from the mouth for the measurements. In addition, all patients included in the study were evaluated by video-laryngostroboscopy (VLS) (Karl Storz, Totalinken).

For the VC value, measurements were made using a spirometer in the Dicle University Faculty of Medicine, Pulmonary Function Tests unit. These values were recorded for each patient before diaphragm respiratory training. The patients were first told about the correct method of breathing by the clinician in the voice clinic. The correct breathing was then shown. Common mistakes were also shown. Then, training began with the patient. Exercises continued until the patient's abdominal (diaphragm) breathing was found to be correct. After respiratory training, patients were required to perform daily (50-100 times) breathing exercises for 4 weeks. Voice recordings were obtained again from the patients who had completed the four-week period and VC values were calculated.

For maximum phonation time, the duration of the / a / vowel at maximum phonation was taken. The s / z ratio was calculated by deriving the proportion of the maximum phonation times of the / s / and / z / sounds.The PQ was calculated as the ratio of VC to MPT (ml / sec). These values were recorded separately before and after DRT. The age, occupation and gender of the individuals participating in the study were taken into consideration.

IBM SPSS 21.0 for Windows statistical package program was used in the statistical evaluation of our research data. Measurable variables were presented with mean ± standard deviation (SD), categorical variables were presented with numbers and percentages (%). A check was also made to determine wheher the data were normally distributed; the Dependent t-test was used for comparison of the two dependent groups, while the Independent t-test was used for comparison of the two independent groups. Two-tailed hypotheses were taken and $p \leq 0.05$ was considered statistically significant.

RESULTS

Demographic data consisted of gender, age, education, and professional status variables for each individual. When the gender distribution of the patients was examined, 28 of the 60 patients (46.67%) were male and 32 (53.33%) were female. In the CG, there were 30 (50%) females and 30 (50%) males. The mean age of the patients was determined to be 33.13 ± 10.60 years. The average age of those in the CG was 37.75 ± 13.51. The educational status of the patients was examined under 5 categories: primary, secondary, high school, associate degree and graduate. Graduates (n: 32, 53.34%) made up more than half of the patients. Primary school graduates (n: 3, 5%) were the smallest patient group. When the educational status of individuals in the CG was analyzed, graduates (n: 28, 46.7%) and high school graduates (n: 21, 35%) were in the majority (Table 1).

When the patients were examined in terms of profession, it was found that the number of teachers (n: 18, 30%), housewives (n: 15, 25%) and secretaries (n: 13, 21.66%) was more numerous. It was found that housewives (n: 27, 45%) and teachers (n: 21, 35%) were the largest occupational groups in the CG. (Table 1)

The aerodynamic parameters of the 60 patients in the study group were measured before and after DRT. The aerodynamic parameters of individuals in the control group were also measured and these measurements were compared with each other. The effects of DRT on these measurements were investigated.

When the aerodynamic parameters were analyzed according to gender; MPT, VC and PQ values were found to be higher in males and the s / z values were seen to be lower in males than females in all groups. (Table 2)

It was found that the MPT of the CG was statistically significantly longer than PG's MPT before DRT ($p = 0{,}000$). There was no significant difference between MPT (14.56 ± 4.50) evaluated after 4 weeks of DRTwhen applied to the PG and the MPT (13.13 ± 4.25) before DRT ($p = 0.086$). (Table 3 and Table 4)

A significant difference was found between the maximum / s / sound time (15.25 ± 3.79) of the CG and the maximum / s / sound (15.27 ± 3.61) of the PG before DRT ($p < 0.05$) There was no significant difference between the maximum / s / sound time (15,60 ± 4,60) of the

PG after four weeks of DRT and the maximum / s / sound time (15.27 ± 3.61) before DRT (p> 0.05). No significant difference was found between the maximum / z / sound duration (13.67 ± 3.12) of the CG and the maximum / z / sound duration (12.27 ± 2.94) of the PG before DRT (p> 0.05). A significant difference was observed when the maximum / z / sound duration (15.20 ± 4.15) of the PG and the maximum / s / sound duration before DRT (12.27 ± 2.94) were compared after four weeks of DRT (p <0.05).

When evaluated in terms of the s / z ratio, which is another parameter in aerodynamic evaluation, the statistical significance of the PG's pre- DRT s / z (1.30 ± 3.35) ratio compared to CG's s / z (1.10 ± 0.13) ratio was found to be significantly larger (p = 0.003). It was observed that the ratio of s / z (1.09 ± 0.30) as applied to the PG after 4 weeks of DRT decreased significantly compared to the value of s / z (1.30 ± 3.35) before DRT (p = 0.001). (Table 3 and Table 4)

When the data were examined in terms of the VC value, it was found that the VC (3870 ± 540) value of the CG was significantly higher than the VC (3460 ± 690) value of the PG before respiratory training (p = 0.041). However, there was no significant difference between the VC (3460 ± 690) values before 4 weeks of DRT and the VC (3620 ± 730) values after DRT (p = 0.336). (Table 3 and Table 4)

When evaluating in terms of PQ, obtained via the ratio of MPT to VC, while there was a significant difference (p = 0.006) between the PQ's pre-DRT value for the PG (270 ± 80) and CG's PQ (230 ± 60), there was no significant difference between PQ (270 ± 80) before DRT and PQ (260 ± 80) after DRT (p = 0.252) as applied to the PG.. (Table 3, Table 4)

Tablo 1: Demographic data of the patient and control groups

	Patient Group N (%)	**Control Group N(%)**
Gender		
1.Woman	32 (53.33%)	30 (50%)
2.Man	28 (46.67%)	30 (50%)
Total	60 (100%)	60 (100%)
Age (mean ± SD)	33.18±10,60	37.75±13,51
Education Level		
1. Primary School	3 (5%)	0
2. Middle School	7 (11,66%)	6 (10%)
3. High School	15 (25%)	21(35%)
4. Associate	3 (5%)	5 (8,3%)
5. License/Graduate	32 (53.34%)	28 (46,7%)
Profession		
1. Housewife	15 (25%)	27 (45%)
2. Secretary	13 (21.66%)	3 (5%)
3. Lawyer	5 (8.33%)	6 (10%)
4. Teacher	18 (30%)	21 (35%)
5. Singer	9 (15%)	0
6. Other	0	3 (5%)

Tablo 2: Averages of aerodynamic parameters by gender,CG: Control group, DRTB-PG: Patient group before abdominal respiratory training, DRTA-PG: Patient group after abdominal respiratory raining, mean: mean, MPT: maximum phonation time

	WOMAN			**MAN**		
	CG	DRTB-PG	DRTS-PG	CG	DRTB-PG	DRTA-PG
MPT (/a/) (sec) (mean.)	16.02	12.20	13.88	19.06	14.18	15.33
s/z (mean.)	1.07	1.27	1.14	1.06	1.24	1.03
VC (ml) (mean)	3400	2970	3180	4330	4000	4100
PQ (ml/ sec) (mean)	200	260	240	220	280	260

Tablo 3: Comparison of the averages of aerodynamic parameters before the abdominal (diaphragm) respiratory training of the control group and patient group,CG: Control group, DRTB-PG: Patient group before abdominal respiratory training, mean: mean, SS: Standard deviation, MPT: maximum phonation time

	CG	**DRTB-PG**	**p**
MPT (/a/)(sec): mean±SD	17.36±2.75	13.13±4.25	0.002
s/z : mean±SD	1.10±0.13	1,30±3,35	0.003
VC (ml): mean±SD	3870±540	3460±690	0.041
PQ (ml/sec): mean±SD	230±60	270±80	0.006

Tablo 4: Comparison of the average of aerodynamic parameters of the patient group before and after abdominal (diaphragm) respiratory training,DRTB-PG: Patient group before abdominal respiratory training, DRTA-PG: Patient group after abdominal respiratory training, mean: mean, SD: standard deviation, MPT: maximum phonation time

	DRTB-PG	**DRTA-PG**	**p**
MPT (/a/) (sec): mean±SD	13.13±4.25	14,56±4,50	0.086
s/z : mean±SD	1.30±3.35	1.09±0.30	0.001
VC (ml): mean±SD	3460±690	3620±730	0.336
PQ (ml/sec): mean±SD	270±80	260±80	0.252

DISCUSSION

Aerodynamic analysis can be used to evaluate the effectiveness of the technique applied before and after therapy in therapies applied in patients diagnosed with MTD [15]. Many voice therapies and techniques can be applied in MTD [16]. A correct and effective breathing technique provides good phonation, and in this sense, the abdominal (diaphragm) respiartory technique can deliver better phonation [6]. In this study, DRT was given to patients with MTD, whose aerodynamic parameters differed significantly from those of normal healthy individuals, and the effects of DRT on MPT, s / z, PQ and VC were examined.

In two studies conducted on 20 men and 45 women at different times, the Digital Spirometer, Phonatory Aerodynamic System (PAS) and Baseline Windmill Spirometer were evaluated for VC and PQ measurements A strong correlation was determined between these three devices in terms of good measurement reliability. Although pneumotachograph-based systems are more comprehensive, it has been noted that spirometers can be used to obtain aerodynamic parameters, as pneumotachograph-based systems are not always feasible and are expensive [17,18]. Hirano et al stated that there is a positive relationship between the MFR value calculated with the pneumotachograph and the PQ [9]. In our study, the Digital Spirometer was used to determine VC and derived PQ.

Air in the lungs is the main factor in the realization of phonation. MPT is a good indicator of this. Due to the breathing exercises, the width of the diaphragm increases and indirectly this is reflected in the MPT. When the patients were evaluated from a professional standpoint, it was found that from within the professions within the group, teachers were those who made the most extensive use of their voices. From this perspecitve, teachers are at a great risk of voice diseases [19,20]. In this study, the majority of the patient group (PG) (n = 18, 30%) was composed of teachers. In a study conducted with 34 teachers in Thailand, the relationship between DRT and MPT was examined [4,7,10,13]. MPTs of the teachers were measured for several weeks. When compared to MPTs before respiratory training, MPTs had increased statistically significantly at the end of 13th week and stood at 17.36 ± 4.17 [20].

In our study, when the CG and the MTD group were compared in terms of MPT; the CG's mean MPT (17.36 ± 2.75) was statistically significantly longer than the PG's MPT (13.13 ± 4.25). Although the MPT (14.56 ± 4.50) value of the MTD was extended after four weeks of DRT, there was no statistical difference between MPTs before and after respiratory training. This would have changed if DRT had been applied for a longer period of time.

MPT was longer in men than in women. When MPT values were examined by Zheng et al. in terms of gender in their study with 26 MTD and 27 normal individuals; it was found that MPT (12.3 sec.) was shorter in female patients than MPT (15.5 sec.) in male patients, and in the control group of healthy individuals, MPT was longer in males [21]. In our study, similar to the women in the MPT group, MPT was 12.2 sec, for men in the MTD patient group, MPT was 14.18 sec.

Vital capacity was an average of 3235 ml for women, while 4662 ml for men. Individual's age, gender, whether they smoke, their physical size, health, etc. affect VC [6,22]. In our study, it was found that women had low VC values in both the PG and CG compared to men in keeping with the literature.

In a study comparing MTD and normal healthy individuals, no significant difference was observed in terms of basic lung volumes. However, after a provocation (hypertonic saline) test, the narrowing of the glottis level in the MTD group was found to be significantly higher

than in normal individuals [23]. In another study examining respiratory and laryngeal functions, it was found that individuals with functional dysphonia spoke at lower lung volumes when compared to healthy individuals. It was also emphasized that those with voice disorders use different speech and breathing strategies to those of healthy individuals [24].

When respiratory training is started, the aim is to increase lung volume for softer expiration and phonation [13]. In this study, it was found that individuals with MTD had statistically significantly lower lung volumes compared to those in the CG. Although there was an increase in the vital capacity of patients with MTD following DRT for four weeks, there was no statistically significant increase in vital capacity before and after respiratory training. This situation was attributed to the fact that 4 weeks of training might be a short period of time for a significant difference.

The phonation quotient was determined by Hirano et al. to be the ratio of VC to MTD. In the absence of pneumotachograph-based systems, it was stated that the PQ can be used in the clinic since it correlates with MFR. It has been stated that abnormal values for women are outside the range of 78 ml / sec-241 ml / sec., while values outside the range of 69ml / sec-307 ml / sec for males are emphasized as being abnormal for the PQ. [9] High airflow values may not always be indicative of poor aerodynamic function as air flow rates fall within a wide range for healthy individuals [25,26]. Likewise, in a study to determine normative PQ values for healthy adults, PQ values calculated using a digital spirometer were 124.81 mL / sec, for women, while they were found to be 183.76 mL / sec in men [17,18]. In a study conducted by Aghajanzadeh et al. it was found that the PQ, one of the aerodynamic parameters of patients with MTD, was significantly higher than that of normal healthy individuals [27].

Wang et al. used hyaluronic acid injection in patients with unilateral vocal chord paralysis and used the PQ in patient follow-ups after injection [28]. In our study, it was observed that the PQ value of patients diagnosed with MTD was statistically significantly higher than that of normal healthy individuals. The patients were given DRT for 4 weeks and the effect of DRT on PQ was investigated. There was no statistically significant change in the pre- and post-training PQ values at the end of 4 weeks. There was a decrease in PQ values after training. If DRT had continued for longer and had been more effective, different PQ values could have been seen. However, when previous studies are examined, since the PQ value falls within a wide range, perhaps every clinic should determine their own normative values via their own instruments and use these parameters in patient follow-up.

As a measure of the laryngeal valve, the ratio of the maximum / s / sound time to the maximum / z / sound time was found to be 1.09 for women and 1.07 for men in a study for the normative values of the s / z ratio as first defined by Boone [29]. In the same study, it was stated that there was no significant difference between women and men in terms of the s / z ratio [30]. In another study where women and men were compared in terms of the s / z ratio, it was stated that gender did not make a significant difference with respect to the s / z ratio [31]. Watts et al. in their study of 20 patients with MTD, divided the patients into two groups of 10. The s / z ratios of the patients, who received the MTD diagnosis before vocal hygiene and voice therapy, were between 1,40-1,50. Only vocal hygiene training was given to the control group. In the experimental group, voice therapy was given along with vocal hygiene training, and the s / z ratio and MPT were used in patient follow-up [32].

In our study, the s / z ratio was calculated before and after DRT as applied to MTD patients. The ratio of s / z (1.30) before training

in the PG was significantly greater than the ratio of the CG s / z. It was observed that the ratio of s / z (1.09) decreased significantly after training. This may be due to the fact that abdominal respiration may have taught the patient to use the air in their lungs more efficiently during controlled expiration and phonation, because while there was no significant change in the maximum / s / sound duration before and after training, in contrast, the maximum duration of the / z / sound requiring phonation was observed to be significantly longer after training. When the literature is considered, it was concluded that the s / z ratio can be used in treatment follow-ups.

CONCLUSION

As the main source of sound is air in the lungs, correct and effective breathing is necessary for the effectiveness and continuity of phonation. Although there was no statistically significant change in the aerodynamic parameters, VC, MPT, and PQ after 4 weeks in our study, positive changes were observed in all recorded parameters. It was thought that the four-week period might have been short. In addition, studies applied in conjunction with other voice therapy techniques of DRT should result in much earlier treatment in this group of patients. It is concluded that abdominal (diaphragm) respiration is effective with respect to the s / z ratio, one of the aerodynamic parameters.

REFERENCES

1. Morrison MD, Rammage LA. Muscle misuse voice disorders: description and classification. Acta Otolaryngol. 1993;113(3):428-34.
2. Chedda N, Werning J. Functional voice disorders. Revisado en junio. 2018.
3. Bridger MWM, Epstein R. Functional voice disorders: A review of 109 patients. J Laryngol Otol. 1983;97(12):1145-8.
4. Koufman JA, Blalock PD. Functional voice disorders. Otolaryngol Clin North Am. 1991;24(5):1059 1073.
5. Roy N, Bless DM, Heisey D, Ford CN. Manual circumlaryngeal therapy for functionaldysphonia: An evaluation of short-and long-term treatment outcomes. J Voice. 1997;11(3):321-331.
6. Öğüt MF, ŞahinFF, Sezgin B. Fonksiyonel Ses Bozuklukları. Türkiye Klinikleri Kulak Burun Boğaz-Özel Konular. 2019;12(3):48-51.
7. Kılıç MA. Ses problemi olan hastanın objektif ve subjektif yöntemlerle değerlendirilmesi. Curr PracrORL. 2010;6(2):257-265.
8. Yumoto E. Aerodynamics, voice quality, and laryngeal image analysis of normal and pathologic voices. Curr Opin Otolaryngol Head Neck Surg. 2004;12(3):166-173.
9. Hirano M, Koike Y, Von Leden H. Maximum phonation time and air usage during phonation. Folia Phoniatr Logop. 1968;20(4):185-201.
10. Van der Meer G, Ferreira Y, Loock JW. The S/Z ratio: A simple and reliable clinical method of evaluating laryngeal function in patients after intubation. Journal of critical care. 2010;25(3):489-492.
11. Eckel FC, Boone DR. The s/z ratio as an indicator of laryngeal pathology. J Speech Hear Disord. 1981;46(2):147-149.
12. Huttunen K, Rantala L. Effects of Humidification of the Vocal Tract and Respiratory Muscle Training in Women With Voice Symptoms?A Pilot Study. Journal of Voice. 2019.
13. Aronson AE, Bless DM. Voice disorders of structural origin. Clinical Voice Disorders. 4th ed. New York: Thieme Med Pub. 2009:24-38.
14. Stemple JC, Roy N, Klaben BK. Clinical voice pathology: Theory and management: Plural Publishing; 2018.
15. Liang F-Y, Yang J-S, Mei X-S, et al. The vocal aerodynamic change in female patients with muscular tension dysphonia after voice training. Journal of Voice. 2014;28(3):393-e397.
16. da Cunha Pereira G, de Oliveira Lemos I, Gadenz CD, Cassol M. Effects of voice therapy on muscle tension dysphonia: a systematic literature review. Journal of Voice. 2018;32(5):546-55.
17. Joshi A, Watts CR. Phonation quotient in women: a measure of vocal efficiency using three aerodynamic instruments. Journal of Voice. 2017;31(2):161-167.
18. Joshi A, Watts CR. Measurement reliability of phonation quotient derived from three aerodynamic instruments. Journal of Voice. 2016;30(6):773-e713.
19. Morrow SL, Connor NP. Comparison of voice-use profiles between elementary classroom and music teachers. Journal of Voice. 2011;25(3):367-372.
20. Patorn Piromchai MD. Effects of the Self-Training Breathing Exercise on Maximum Phonation Time in Teachers. J Med Assoc Thai. 2017;100(6):S153-S159.
21. Zheng Y-Q, Zhang B-R, Su W-Y, et al. Laryngeal aerodynamic analysis in assisting with the diagnosis of muscle tension dysphonia. Journal of voice. 2012;26(2):177-181.
22. Leite AC, Christmann MK, Hoffmann CF, Cielo CA. Maximum phonation times and vital capacity in dysphonic women. Revista CEFAC. 2018;20(5):632-639.
23. Vertigan AE, Gibson PG, Theodoros DG, Winkworth AL, Borgas T, Reid C. Involuntary glottal closure during inspiration in muscle tension dysphonia. The Laryngoscope. 2006;116(4):643-649.
24. Lowell SY, Barkmeier-Kraemer JM, Hoit JD, Story BH. Respiratory and laryngeal function during spontaneous speaking in teachers with voice disorders. Journal of Speech, Language, and Hearing Research. 2008;51(2):333-349.

25. Joshi A, Watts CR, Hathway J. Phonation Quotient Using Three Aerodynamic Instruments in the Disordered Voice. Journal of Voice. 2020;34(1):20-24.

26. Baken RJ, Orlikoff RF. Clinical measurement of speech and voice: Cengage Learning; 2000.

27. Darouie A, Aghajanzadeh M, Dabirmoghaddam P, Salehi A, Rahgozar M. Comparison of Voice Aerodynamics Characteristics in Spasmodic Dysphonia and Muscle Tension Dysphonia. Journal of Paramedical Sciences & Rehabilitation. 2017;6(4):15-21.

28. Wang CC, Chang MH, Wang CP, Liu SL,Kai LW,Shang HJ,Rong SH,Hui TL, Hsiu C. Laryngeal electromyography-guided hyaluronic acid vocal fold injection for unilateral vocal fold paralysis: a prospective long-term follow-up outcome report. JAMA Otolaryngology-Head & Neck Surgery. 2015;141(3):264-271.

29. Boone DR, McFarlane SC, Von Berg SL, Zraick RI. 2014.The voice and voice therapy.

30. Joshi A. A comparison of the s/z ratio to instrumental aerodynamic measures of phonation. Journal of Voice. 2020;34(4):533-538.

31. Gelfer MP, Pazera JF. Maximum duration of sustained/s/and/z/and the s/z ratio with controlled intensity. Journal of Voice. 2006;20(3):369-379.

32. Watts CR, Hamilton A, Toles L, Childs L, Mau T. A randomized controlled trial of stretch-and-flow voice therapy for muscle tension dysphonia. The Laryngoscope. 2015;125(6):1420-1425.