Treatment Outcomes for Professional Voice Users

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Treatment Outcomes for Professional Voice Users

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Summary: Professional voice users comprise 25% to 35% of the U.S. working population. Their voice problems may interfere with job performance and impact costs for both employers and employees. The purpose of this study was to examine treatment outcomes of two specific rehabilitation programs for a group of professional voice users. Eighteen professional voice users participated in this study; half had complaints of throat pain or vocal fatigue (Dysphonia Group), and half were found to have benign vocal fold lesions (Lesion Group). One group received 5 weeks of expiratory muscle strength training followed by six sessions of traditional voice therapy. Treatment order was reversed for the second group. The study was designed as a repeated measures study with independent variables of treatment order, laryngeal diagnosis (lesion vs non-lesion), gender, and time. Dependent variables included maximum expiratory pressure (MEP), Voice Handicap Index (VHI) score, Vocal Rating Scale (VRS) score, Voice Effort Scale score, phonetogram measures, subglottal pressures, and acoustic and perceptual measures. Results showed significant improvements in MEP, VHI scores, and VRS scores, subglottal pressure for loud intensity, phonetogram area, and dynamic range. No significant difference was found between laryngeal diagnosis groups. A significant difference was not observed for treatment order. It was concluded that the combined treatment was responsible for the improvements observed. The results indicate that a combined modality treatment may be successful in the remediation of vocal problems for professional voice users.

Key Words: Professional voice—Voice therapy—Treatment outcomes.

INTRODUCTION

Professional voice users comprise between 25% and 35% of the working population in the United States[1] and other industrialized societies.[2] Professional voice users' livelihoods depend partially or wholly on the ability to produce voice and include,

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but they are not limited to, teachers, ministers, salesmen, telemarketers, telephone operators, actors, singers, radio/TV announcers, and attorneys. Although vocal sophistication, voice quality, and vocal load may vary, professional voice users share a dependence on vocal endurance.[3,4] Their constant voice use, or vocal load, required occupationally may lead to voice difficulties. Factors in the work environment may contribute to vocal difficulty, including high levels of background noise, poor environmental acoustics, and poor atmospheric humidity.[5–7] Those persons with high vocal quality demands, such as radio announcers and singers, are more likely to recognize changes in their voices and to seek assistance for voice problems than those persons in occupations with lower voice quality demands.

Problems reported by professional voice users are varied and may include hoarseness,[8–12] voice breaks or cracks,[8,9] voice loss,[8] weak voice,[10,11] and vocal fatigue.[9,11–13] Related physical complaints include shortness of breath[9,11,12]; dry throat[8,10,12]; scratchy sensation in the throat[8,10]; throat discomfort, tightness, or pain[8,9,11]; and effortful speaking.[9–11] Chronic voice problems may result in laryngeal irritation and edema[14] or in benign vocal fold lesions, including vocal fold nodules, polyps, hemorrhages, and cysts.[1,15–19]

Incidence figures for voice problems are most prevalent for teachers and range from 38%[10] to 80%.[9] Other incidence figures for voice problems include 68% for telemarketers,[8] 44% for aerobics instructors,[20] and approximately 4% for salespersons.[21] The voice problems experienced by professional voice users may lead to problems for both the employee and the employer. Employees may exhibit reduced productivity,[8,11] reduced work quality, restriction of daily activities and social function,[22] with subsequent reduction in quality of life.[23] Employees may miss work as a result of the voice problem[12] and may consider switching careers.[11] Employers may see increased absenteeism, increased employee turnover, and increased costs for substitute workers, medical treatment,[14] and workers' compensation claims.

Behavioral therapy is the treatment of choice for most voice problems incurred by professional voice users.[24] Currently, only a few experimental studies exist that examine outcomes of voice therapy.[25–29] None of these studies have been aimed at professional voice users. Furthermore, no behavioral therapy programs specifically target the professional voice user. The use of expiratory muscle strength training (EMST) holds promise for helping professional voice users to meet the increased physical demands for loudness and sustained phonation by increasing maximum expiratory pressures for voice production.

The use of EMST has been studied in several groups, including healthy subjects,[30-32] subjects with disease,[33,34] and professional voice users.[35] The purpose of the current study was to ascertain whether the combination of EMST and voice therapy would be useful in meeting the voice demands of this group. Specifically, the study sought to determine whether EMST, combined with ''traditional'' voice therapy, would result in improvements in voice production and voice-related quality-of-life ratings for professional voice users as compared with either of the treatments alone in a pilot group. It was hypothesized that expiratory muscle strength training combined with voice therapy will produce greater improvements in voice production than will voice therapy alone.

METHODS

The study was a prospective, complete, repeated measures design. After obtaining approval from the University of Florida Institutional Review Board, a total of 18 participants were recruited for the study. All participants reported at least 4 hours of daily speaking time in their work setting. All had complaints of vocal problems. Participants were excluded from the study if they had a history of cardiac, neuromuscular, or pulmonary disease or history of tobacco use within the last 5 years. All participants underwent rigid or transnasal laryngoscopy with videostroboscopy before enrollment. Based on the laryngeal examination, they were placed in one of two groups. Group 1, named the Dysphonia Group, consisted of 9 participants with laryngeal irritation or edema without vocal fold lesions. Group 2, named the Lesion group, consisted of 9 participants with benign vocal fold lesions. A total of 10 women and 8 men participated in the study. The average age for men was 46 years (range: 27–59), and the average age for women was 39 years (range: 25–59). The average length of time on the job before study completion was 13.4 years for men and for women 11.5 years. All patients reported symptomatic complaints about their voice for at least 6 months before enrollment in the study. The Dysphonia Group and the Lesion Group received both voice therapy and EMST training. Half of the participants from each group received voice therapy first, followed by EMST, and the other half received EMST followed by voice therapy.

MEASURES

Measures were taken from all participants before beginning the first treatment phase. A second set of measures was taken after the first therapy phase (either EMST or voice therapy). The measures taken at this point represented the results of the single treatment condition. The third set of measures, taken after completion of both therapy phases, represented the combined effect of treatment. Participants were screened before the study to ensure that they had no underlying pulmonary problems. Screening measures of forced expiratory volume at one second (FEV_1) and forced vital capacity (FVC) were taken for each participant using a computerized spirometer (Spirovision 3+, Futuremed of America). The values of FEV_1 and FVC had to be at 75% or greater of expected values for participants to be eligible for the study.

Perceptual measures

Self-rating scales

Each participant completed three self-evaluation scales at each of the three measurement points. The first was the *Voice Handicap Index (VHI)*[36] designed to measure the impact of voice problems on a person's quality of life. The second scale, the *Voice Rating Scale* (VRS), was developed by the first author and asked participants to rate their responses to 10 work-related voice items using a 100-mm visual analog scale (Appendix 1). The third scale, the *Vocal Effort Scale* (VES), was a two-item scale, also developed by the investigator that asked participants to rate their effort to speak at work and in social situations in the prior week (Appendix 2).

Voice measures

Listener ratings

Voice recordings were collected for each participant at each of the three measurement points. Participants produced the vowel and sentence stimuli from the *Consensus Auditory Perceptual Evaluation of Voice* (CAPE-V) developed by a consensus committee sponsored by the American Speech-Language-Hearing Association's Special Interest Division 3: Voice and Voice Disorders in 2002. The voice samples were collected in a sound-treated room using a Shure SM48 cardioid microphone (Shure, Inc.) with a frequency response of 55 Hz to 14 kHz and digitized directly in the Computerized Speech Lab Model 4300B (Kay Elemetrics Corporation, Lincoln Park, NJ) at a sampling rate of 44.1 kHz. One sentence (''We were away a year ago'') from each measurement point for each speaker (total = 54) was selected for perceptual testing. A group of 10 listeners, all speech pathologists with a minimum of 3 years of clinical experience in voice disorders, were recruited to rate the voice quality and were blinded to participant group and treatment condition. The ratings for each listener were averaged together for analysis.

The perceptual experiment was carried out using the *EcosWin* software (Avaaz Innovations, Inc.) The 54 sentences were used to form 10 blocks of stimuli. Each block consisted of one occurrence of each sentence in random order yielding a total of 540 stimuli. The listening tests were carried out in a single-walled sound-treated booth. Stimuli were presented through a RP2 processor (Tucker-Davis Technologies, Inc.) over TDH-39 headphones at a comfortable loudness level. Listeners made their response using a computer monitor and keyboard. Each listener heard all 10 blocks of stimuli once, but the order of the blocks was randomized across listeners. The listeners were asked to indicate the severity of voice quality for each sentence using a 5-point rating scale (1 = normal quality; 5 = severe quality). To minimize the variability within and across listeners, data from the multiple observations were averaged to obtain a single judgment for each stimulus.[37]

Videostroboscopic ratings

A group of seven speech pathologists and one otolaryngologist rated the pre- and posttreatment stroboscopic examinations for the participants in the lesion group only. Stroboscopic assessments were completed using a 7-point scale adapted from a University of Wisconsin rating scale[16] to rate vocal fold edge, mucosal wave, amplitude of mucosal wave, glottic closure, and phase closure. The examinations were randomized on videotape, and raters were not provided with information regarding treatment condition. Data for the multiple observations of each of the parameters were averaged across raters for analysis.

Pulmonary measures

Maximum expiratory pressure (MEP) measured at the mouth was used as the indirect measure of expiratory muscle strength. The measurement apparatus consisted of a mouthpiece connected to a Smart 350 series pressure manometer (Meriam Instruments) by 46 cm of 6-mm inner diameter tubing with a 14-gauge needle air-leak. MEP was measured with the participant standing, and their nose was occluded with a nose clip. After inhaling to total lung capacity, the participants placed their lips around the mouthpiece and blew out as forcefully as possible. Repeated measures were taken with a 1- to 2-minute rest between trials, until three measurements within 5% of each other were obtained. The average of these three values was recorded. The percentage of change in MEP from baseline to the end of respiratory training served as the primary index for documenting changes in expiratory muscle strength as used in other studies.[30,33,34]

Aerodynamic measures

Subglottal pressure, the minimum lung pressure necessary for the initiation and maintenance of vocal fold vibration for voice production, was estimated from measures of intraoral pressure as described by Smitheran and Hixon.[38] Specifically, the pressure was measured from the middle four /pɑ/ syllables produced during a syllable train at both "comfortable" and "loud" intensity levels, as determined by the participants. Recordings were made of three trials from each participant. Intraoral pressure was collected by inserting a small pitot tube (2 mm diameter) into the oral cavity between the lips and behind the front teeth. A pressure transducer (Glottal Enterprises, PTL-1) recorded the air pressure. The pressure transducer was calibrated at 5 cm H_20 for each participant with a dedicated calibration unit (Glottal Enterprises MCU-4). The recordings for pressure were made in a quiet room.

Estimates of phonation threshold pressure were made in a similar manner. Phonation threshold pressure was defined as the minimal pressure required for initiating vocal fold vibration.[39] The same syllable train used for measuring intraoral pressure was used for estimating phonation threshold pressure. Participants were instructed to initiate voice at the lowest possible intensity level without whispering, and they were allowed to practice until they were successful with the task. Three successful attempts were recorded for each participant. All pressure measures were recorded using *PowerLab 8SP* with Chart 4 for Windows software (AD Instruments). The sampling rate was set at 10-kHz samples per second for all pressure measures.

Acoustic measures

Phonetogram

An individual phonetogram, or voice range profile, a display of vocal intensity range versus fundamental frequency,[39] was obtained at each of the three measurement points for each participant. The phonetogram was collected using the *Voice Range Profile* (*VRP*) software (Kay Elemetrics, Model 4326, Version 2.3). A Shure SM 48 cardioid microphone, mounted on a microphone stand, was used at a constant 6-inch mouth-to-microphone distance to record the acoustic signal. Participants were asked to produce maximum variations in fundamental frequency at minimum and maximum intensity levels while producing an /ɑ/ vowel in ascending and descending pitch glides. Intensity range was plotted vertically on a graph, and frequency was plotted horizontally in linear units. The participant's productions were plotted in real time and served as visual feedback for the participant. Participants were instructed to repeat the maneuver multiple times until they felt that they had produced a maximum plot of intensity and frequency. The total area of the phonetogram was calculated using *Matlab* Version 6.5.1. Minimum and maximum intensity and minimum and maximum fundamental frequency produced by each participant were also recorded.

Hoarseness diagram

Measures were made to calculate the coordinates of the vowel /ɑ/ produced by all speakers on the hoarseness diagram. The hoarseness diagram consists of four acoustic measures that are plotted together.[40] The measures, jitter, shimmer, and mean period correlation, form the horizontal axis of the diagram, labeled as the irregularity component, and the fourth measure, glottal-to-noise excitation ratio, is plotted on the vertical axis, labeled as the noise component. This glottal-to-noise excitation ratio indicates the extent to which the voice excitation is due to a pulse train or due to noise.

Samples analyzed for the hoarseness diagram were obtained from the middle one second of sustained /ɑ/ productions. Freeware available from the developer's website, www.physik3.gwdg.de/micha/english/hd.html, was used for determining the irregularity and noise components.

Training protocol

As stated, each participant was assigned to one of two groups based on laryngeal diagnosis: the Dysphonia Group or the Lesion Group. Both groups received twice weekly sessions of voice therapy for a period of 3 weeks for a total of six sessions. Both groups also received 5 weeks of EMST. Five participants from the Dysphonia Group and 4 from the Lesion Group completed the EMST followed by voice therapy. Four participants from the Dysphonia Group and 5 from the Lesion Group completed voice therapy followed by EMST.

The voice therapy sessions lasted approximately 45 minutes each and were conducted by a certified speech-language pathologist with specialized training in voice therapy. A 16-page script was followed for each session to minimize variability between participants. Topics covered included review of vocal and respiratory anatomy and physiology, implementation of a vocal hygiene program to help reduce hyperfunctional voice use and address environmental modifications and nutrition issues such as not including acidic food groups, increasing hydration, minimizing speaking in noisy situations, and other standard vocal health suggestions. Additionally, the script taught the person how to be aware of abdominal breathing movements during voice production through imagery and tactile feedback. Particular attention was given to easy voice onset, and care was taken to minimize excess strain on the vocal folds using techniques discussed by Boone[40] and others.[41,42] Participants were also given instruction in using increased resonance during therapy sessions. Daily homework activities, which lasted approximately 15 to 20 minutes, were required to be completed by the participant 5 days a week. Compliance with homework was measured using a diary that was turned in to the clinician weekly.

Expiratory pressure threshold trainer

The expiratory pressure threshold trainer used to complete the expiratory muscle-training program was a cylindrical device that consisted of a mouthpiece and a one-way spring-loaded valve. The valve blocked expiratory airflow until a sufficient threshold pressure was reached to overcome the spring force. To achieve this threshold pressure, the participant breathed out with an increased expiratory effort. As long as the threshold pressure was maintained, air flowed through the device. The device contains an adjustable spring, which allows the required threshold pressure to be increased. The threshold pressure was set at 75% of the participant's MEP at the time of measurement (pretraining and at the beginning of weeks 1–5). Each training breath lasted 3 to 4 seconds. Participants performed the exercise five times per set and completed five sets for five days of the week as reported by other investigators.[32,35,43] Both groups received 5 weeks of expiratory muscle strength training. To ensure compliance, participants kept a training log as well as a log of daily exercise during the voice therapy component. Participants were provided with written and verbal instructions for the completion of EMST and voice therapy.

Statistical method

The primary statistical method that was used to examine treatment differences with respect to the change from baseline scores across the two treatment groups for subglottal and phonation threshold pressures, voice ratings, and acoustic measures, was the analysis of variance for repeated measures (ANOVA). The between-subject factors tested were lesion group, gender, and treatment group. The within-subject factor was the number of weeks of treatment. Paired sample *t* tests were used to analyze MEP because only pre- and posttreatment measures were taken. The Wilcoxon Signed Ranks test was used to analyze rater evaluations of the videostroboscopic examinations. All analyses were carried out using *SPSS* software version 11.5 (SPSS Inc., Chicago, IL). Significance level was set at $P = 0.05$.

The independent variables for the study were treatment order, laryngeal diagnosis, and gender. The dependent variables were the scores on the *VHI*, the *VRS*, the Voice Effort Scale, measures from the hoarseness diagram, measures made from the phonetogram, respiratory pressures, and perceptual ratings of voice. Main effects were found for the *VHI*, *VRS*, MEPs, subglottal pressure produced at loud intensity, phonetogram area, and dynamic range.

Inter- and intrarater reliability was carried out on 10% of the data that were measured by hand. To test the interjudge reliability of the dependent variables, a different examiner, a student trained in scoring the various measures, reanalyzed the data. The student was blinded to the purpose of the study. Pearson *r* correlations were used to compare the results between examiners. To test intrarater reliability, the author reanalyzed 10% of the data and compared the first set of measures against the second using Pearson *r* correlations.

RESULTS

The central hypothesis stated that EMST combined with voice therapy would produce greater improvements in voice production than would voice therapy alone. To test this hypothesis, a repeated measures analysis was used. Main effects were tested, and comparisons of the pretreatment, mid-treatment, and posttreatment conditions were completed. The mid-treatment condition indicated the time when each of the independent intervention methods was examined. At the mid-treatment condition, the effects of EMST or voice therapy were interpreted. The posttreatment condition reflected the effect of the combined modality treatment.

Reliability

High correlations were found between the two sets of measurements made by the experimenter, which suggests high intra-judge reliability. High correlations were also found between ratings across multiple judges suggesting high interjudge reliability. The Pearson *r* between the first and second sets of measurement (intrajudge reliability) ranged from 0.81 to 1.00. Likewise, for interjudge measures, there was a strong positive correlation between the two measurers for the dependent variables listed with a range of 0.41 to 1.00. Given these data, the reliability of the dependent variables was considered adequate for the purpose of the current experiment.

Perceptual measures of effort and handicap

The results of the repeated measures ANOVA showed a significant main effect for the *VHI*, $F\ (2, 20) = 5.593$, $P = 0.012$ and the *VRS*, $F\ (2, 20) = 3.703$, $P = 0.043$. The mean *VHI* scores were found to be significantly reduced by 9 points between pre- and mid-treatment, $F\ (1, 10) = 8.416$, $P = 0.016$. The 4-point difference between the mid and posttreatments was not significantly different, $F\ (1, 10) = 3.68$, $P = 0.084$. Similarly, the *VRS* scores were found to significantly reduce by 83 points between pre- and mid-treatment, $F\ (1, 10) = 2.48$, $P = 0.146$ and significantly reduce by 43 points between the mid- and posttreatments, $F\ (1, 10) = 5.493$, $P = 0.041$. Results for the group averages for the *VHI* are illustrated in Figure 1.

After a single treatment, either EMST training or voice therapy, 83% of the participants had an improved *VHI* score with the range of score decreasing from 1 to 32 points. After the combined modality treatment, 39% of the participants either had no change in *VHI* score or an increase of 1 to 14 points. Average *VRS* scores are in Figure 2. After a single treatment at the mid-point of the study, 77% of the participants demonstrated a decrease in *VRS* scores (range = 3–304 points), whereas 23% had an increase in their scores (range = 28–358

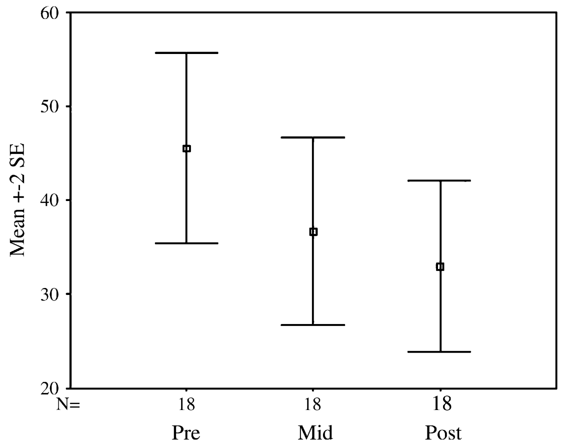

FIGURE 1. Mean Voice Handicap Index scores before treatment, at the midpoint, and following treatment.

points). After the combined modality treatment, 61% of the participants indicated a decreased in *VRS* scores (range = 7–235 points), whereas 39% of the participants had an increase in their *VRS* scores (range = 14–136 points).

The *VHI* and *VRS* were highly correlated across treatment conditions across different speakers with correlations ranging from 0.751 to 0.894. Correlations for the functional and emotional subscales of the *VHI* to the *VRS* were also calculated. The only significant correlation was found between the functional subscale of the *VHI* and the *VRS* before the initiation of treatment (r = 0.668, P = 0.002). No significant main effect was found for the vocal effort scales, F (1, 30) = 0.930, P = 0.343.

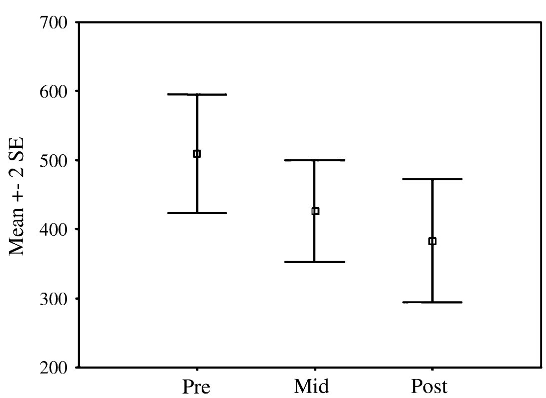

FIGURE 2. Vocal Rating Scale scores before treatment, at the mid-point and following treatment.

Voice measures

Listener ratings

The voice measures did not support the central hypothesis. The listener ratings for voice quality showed no significant main effect in the severity of voice quality ratings F (1.544, 24.712) = 3.233, P = 0.068. No significant differences were indicated between the pre- to mid-treatment, F (1.544, 24.712) = 3.777, P = 0.07) and the mid- to posttreatment conditions, F (1.544, 24.712) = 3.603, P = 0.076). The listener ratings of voice quality used a 5-point rating scale, with a range from 1 (normal voice quality) to 5 (severe voice quality). After the single therapy was received, 78% of the participants were judged to have increased severity of voice quality rating (range = 0.1–2.48 points), whereas 11% had no change and 11% had an improvement in voice quality (range = 0.1–0.74 points). After the combined modality treatment, 72% of the participants had an improvement in voice quality rating (range = 0.12–2.61 points) with 11% of the participants' ratings remaining the same and an additional 17% of the participants showing increased severity of voice quality ratings posttreatments (range = 0.07–0.1 points).

Videostroboscopic ratings

Evaluations of videostroboscopic examinations were completed only for the lesion group because these participants were the only ones expected to have any change in their physical laryngeal examination posttreatment. One participant did not have a follow-up stroboscopic examination due to medical problems precluding the use of the nasal endoscope as well as difficulty tolerating the oral endoscope. Therefore, subjective ratings of the stroboscopic examinations were obtained for only 8 of the 9 participants. Four of the 8 participants showed partial resolution of the pathology on postexamination as evidenced by visual examination. The Wilcoxon signed ranks test was used to analyze the stroboscopy ratings. A significant improvement was found for the left vocal fold edge from pre- to posttreatment. The change in other ratings obtained was not statistically significant.

Pulmonary and aerodynamic measures

The pulmonary and aerodynamic measures supported the hypothesis. Maximum expiratory pressures showed a significant main effect from pre- to posttreatment t (17) = –8.063, P = <0.001. Mean MEP pretreatment was 85.92 cm H_20 (SD = 26.14), and mean MEP posttreatment was 147.87 cm H_20 (SD = 42.27). Increases in MEP posttreatment ranged from 17.88% to 130%, with an average increase of 76.94%. Results for MEP are shown in Figure 3.

A significant main effect in estimated subglottal pressure for loud phonation was observed increasing with treatment, F (2, 20) = 5.234, P = 0.015. The greatest increase occurred after the first treatment, F (1, 10) = 5.847, P = 0.036. No main effects were obtained for estimated subglottal pressures at comfortable loudness, F (2, 20) = 0.406, P = 0.672 or for phonation threshold pressures, F (2, 20) = 0.297, P = 0.746. No statistically significant differences were indicated from pre- to mid- or mid- to posttreatment for subglottal pressure at comfortable loudness or for phonation threshold pressure.

Acoustic measures

The results for the phonetogram supported the hypothesis. The area of the phonetogram increased significantly from pre- to posttreatment, F (2, 20) = 21.667, P = <0.001 (Figure 4). After the first treatment condition, the increase was not statistically significant, F (1, 10) = 0.859, P = 0.376. Between mid- and posttreatment, the area increased significantly, F (1, 10) = 48.74, P = <0.001. After the first treatment condition, 14 of 18 subjects (77%) had an increase in phonetogram area (range = 60–435 units). The remaining 4 subjects (23%) had a decrease in area (range = 157–293 units). After the combined modality treatment, 16 of 18 subjects (89%) showed an increase in phonetogram area (range = 8–596 units), whereas the area for 2 of the 18 (11%) remained the same or decreased (range = 0–84 units).

Dynamic range increased significantly pre- to posttreatment F (2, 20) = 7.153, P = 0.007 (Figure 5), with the greatest change occurring between the mid- and posttreatment conditions, F (1, 10) = 20.793, P = 0.001. No significant increase occurred between the pre- and mid-treatment conditions, F (1, 10) = 0.443, P = 0.521. After either EMST or voice therapy, 10 of the 18 participants (56%) demonstrated an increased dynamic range (range 1–19 dB). For 8 of the 18 participants (44%), dynamic range did not change or decreased (range = 0–18 dB). After the combined modality treatment, 13 of the 18 participants (72%) demonstrated an increase in dynamic range (range = 3–22 dB), whereas 5 of the 18 (28%) stayed the same or had a decrease in range (range = 0–6 dB). Frequency range did not demonstrate a significant main effect, F (2, 20) = 1.830, P = 0.186. A significant increase did not occur between the mid- and posttreatment conditions, F = (1, 10) 4.344, P = 0.064. There was a significant difference noted for frequency range between men and women.

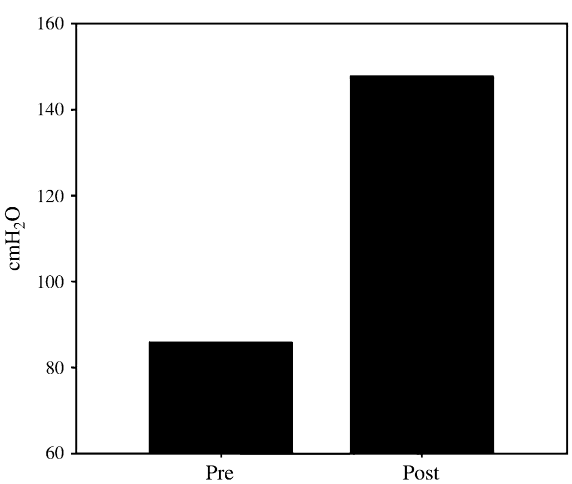

FIGURE 3. Maximum expiratory pressure changes before and after treatment.

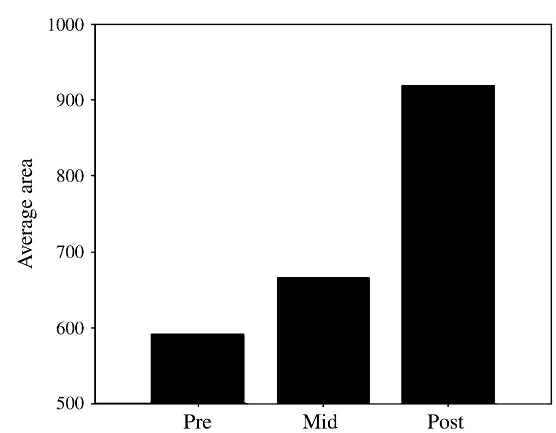

FIGURE 4. Change in phonetogram area following treatment.

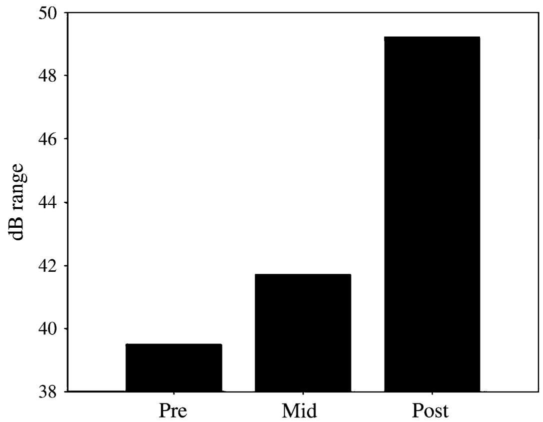

FIGURE 5. Average dynamic range pre-treatment, at the mid-treatment point, and following treatment.

The measures of irregularity, F (2, 20) = 0.637, P = 0.539 and noise, F (2, 20) = 1.883, P = 0.178, in the voice, taken from the hoarseness diagram did not show a significant main effect for either treatment group.

Differences between lesion and non-lesion groups

Only one dependent variable, estimated subglottal pressure at loud intensity levels, showed a statistically significant difference between the lesion and non-lesion groups F (1,30) = 26.543, P = $<$0.001). This result is highlighted in Figure 6.

DISCUSSION

The central hypothesis for this study was that EMST combined with voice therapy would produce greater improvements in specific aspects of voice production than would voice therapy alone. In general, this result was the case. Statistically significant main effects were found for more than half of the dependent variables examined. Thus, it seems that the combination of EMST training and voice therapy is a beneficial treatment paradigm for professional voice users.

For example, both treatment groups reported greater reduction in vocal symptoms after the combined treatment as compared with voice therapy alone as evidenced by the significant improvement on the VRS. The statements on the VRS were pertinent to the problems of professional voice users at work with the content focused on specific situations and needs in the workplace. The change between the pre- and mid-treatment conditions was not significant, which suggests the combined modality treatment served to decrease the participants' perception of how their voice difficulty was impacting functional activities.

The significant main effects observed for MEP and subglottal pressure produced at loud intensity level further supported the central hypothesis. The average increase in MEP of nearly 77% was consistent with increases in MEP found in previous studies with healthy persons, performers, and high-school band students.[31,32,43] All participants increased MEP from pre- to posttreatment.

It is reasonable to conclude that the increased MEP could aid in improving the overall voice quality produced by the participants. A greater demand for increased respiratory drive exists during long speaking tasks.[44] This demand necessitates the active use of expiratory muscles to increase the drive for phonation, as passive lung recoil cannot meet the pressure demands. The increased strength of the respiratory muscles may enhance the person's ability to generate and maintain the required pressure because the driving force of the respiratory system is increased,[32] thereby improving the physiological function of the vocal folds. The goal of the EMST program is not to raise the subglottal pressure for the task but rather to provide the capacity for producing the subglottal pressure and more specifically to reduce the ratio between the needed subglottal pressure and the maximum expiratory pressure capability of the person. This process

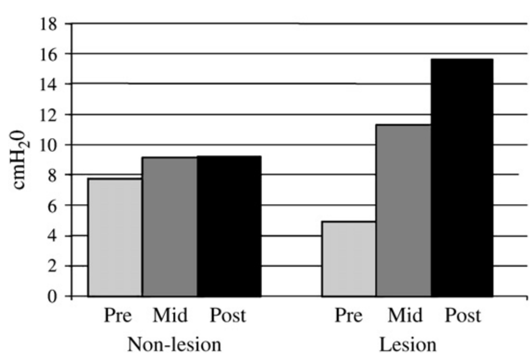

FIGURE 6. Estimated subglottal pressure at loud intensity for non-lesion groups.

reduces the perception of physiologic work produced during the task, which is referred to conceptually as increasing the functional reserve of a physiological system.[45]

Subglottal pressure for normal conversation typically ranges from 4 to 6 cm H_20.[46] Subglottal pressures for participants without lesions were within the normative range pre- (3.6–8.7 cm H_20) and posttreatment (5.3–8.6 cm H_20). The participants identified as having vocal fold lesions demonstrated an average higher subglottal pressure both pre- (5.1–16.4 cm H_20) and posttreatment (4.3–14.8 cm H_20), which is consistent with reports of higher transglottal air pressure in patients with benign lesions. In a study by Holmberg et al,[47] transglottal pressures were 2 to 6 standard deviations higher for participants with lesions as compared with normal subjects. This result may reflect the increased mass and stiffness of the vocal fold and/or hyperfunctional voice production. No significant main effect was observed in subglottal pressure produced at comfortable intensity posttreatment, which makes sense for the non-lesion group because their subglottal pressures were already within normal limits. The lack of change in subglottal pressure for the lesion group was disappointing, although there was a drop of approximately 1.5 cm H_20 after the combined treatment.

Subglottal pressures associated with increased vocal intensity typically range from 8 to 20 cm H_20.[44,46] The non-lesion group showed a range of 5.2–11 cm H_20 pretreatment, which is within normal limits but on the lower end of the normal range. After the combined modality treatment, the range increased from 6.5–14, a 1- to 3-cm H_20 increase. As a group, the pressures moved closer toward the normal range. The ability to increase pressure for loud talking is likely an important contributing element to the decreased *VRS* scores discussed. The capability to increase the subglottal pressures used to produce a louder voice certainly would impact the professional voice users function in the workplace, particularly the teachers, ministers, and attorney involved in this study. Additionally, the ability to increase pressure may be important when talking in conditions of increased noise, a situation often encountered by professional voice users. In increased noise, people may have difficulty monitoring their intensity levels and, as a result, may increase their effort by increasing vocal fold tension and medial vocal fold compression.[39,48] By increasing subglottal pressure with the increased expiratory muscle strength, the need for increased medial compression should be reduced and laryngeal tissue trauma from excess compression is minimized.[39]

The main effects found for phonetogram area and the dynamic range supported the central hypothesis. Phonetograms are representative of the output of the entire phonatory mechanism[49] and have been considered as a measure of voice coordination.[50] The increased area shown after the combined treatments is considered a positive outcome of the combined modality treatment.[51] Eighty-nine percent of the individual participants increased phonetogram area with the combined treatment as opposed to 77% with the individual treatments. So, there was some slight benefit, on the order of 10% improvement by combining the treatment techniques. Increased respiratory drive, coupled with the participants' ability to efficiently control airflow as learned from the voice therapy exercises, likely contributed to the increased dynamic range that, in turn, contributed to the increased phonetogram area.

Frequency range and dynamic range were not targeted in the treatment protocol. The treatment focused on coordination of breath stream and phonation, or voice onset, increased resonance, and projection of the voice. The combined modality treatment may have resulted in the improvements observed in both of these parameters. A practice effect could be responsible for the changes but is not likely. Previous research has shown the vocal range to extend only slightly (1.5 to 2.1 semitones) across repeated administrations of the phonetogram.[52,53] On average, the frequency range of participants in the current study increased 6.5 semitones. Exercises targeting the extension of the frequency range were not included in the therapy protocol, so this expansion likely reflects improved phonatory output as a result of the combined treatment modality rather than change as a result of a practice effect. Variability of dynamic range has also been investigated previously, and although it may differ up to 10 dB across administrations, on average, the variation is about 3 dB.[54] The participants in this study demonstrated a significant change after the combined modality treatment with an average increase of 10 dB. This change may also be attributed to the combined treatment modality and reflects increased power.

Finally, a significant difference was observed between the two diagnostic groups for subglottal pressure at loud intensity level. No significant differences were found between the lesion and non-lesion groups for any of the other dependent variables. The original inclusion criterion was to accept all participants with benign lesions. In retrospect, this decision may have been in error. Benign lesions vary in size, type, and position on the vocal fold. The benign lesions involved in this study ranged from those that altered vocal fold mass to those that had little impact on vocal fold vibration (ie, small vocal nodules). Future studies of the impact of therapy on benign lesions need to be more specific by focusing on one type of benign lesion controlling for the most specific details of the lesion such as size, impact on vibration, and impact on glottal closure.

Main effects were not found for some of the dependent variables included in the study. A main effect was not found for the *VHI* after the combined modality treatment. However, a significant difference was found between the pre- and mid-treatment conditions suggesting that the individual treatments (EMST or voice therapy) resulted in a decrease in vocal handicap.

The finding of no significant effect from mid- to posttreatment indicates that combining treatments did not further benefit the participant by decreasing vocal handicap to a greater extent on this measure. It may be that once the participant perceived a change in the status of their voice, they responded immediately to the change. Typically, changes in the physical condition of the vocal folds and/or the voice quality occur relatively quickly when a patient is exposed to treatment. Most therapeutic protocols indicate a positive effect within a short time such as with the Vocal Function Exercises[55] or Lee Silverman Voice Treatment.[56] Furthermore, when a person receives attention from a clinician, one of the more immediate effects can be a change in the patient's perception of how they are responding to the treatment. This early change may have to do with common factors that are present across therapies, with the likely component being the client–therapist relationship.[57] This effect tends to lessen as the treatment continues and the patient habituates to the newfound voice quality. The focus of outcomes research is often placed on the patient's perspective about the impact of a disease or disability and its treatment.[58] Therefore, the patient's perception of improvement after treatment is an important factor to indicate the success of treatment.[58] The reduction in *VHI* scores observed in this study suggests that a treatment of EMST or voice therapy can be successful and is consistent with the decreased scores reported by various researchers using this tool across a variety of populations.[35,59]

The ratings of effort to speak, both at work and in social situations, did not show a statistical main effect. However, 13 of the 18 participants (72%) indicated a decrease in effort to speak at work, and 10 of the 18 (55%) reported decreased effort when speaking socially. Accordingly, the effort scores at work decreased from a mean of 48 to 36 points and the social effort scores decreased from a mean of 43 to 34 points. Although these scores were not statistically significant, the decrease in effort scores seems to have some clinical significance. As discussed, patient perception of a problem and its subsequent improvement has always been an important indicator of clinical improvement. If the patient perceives decreased effort to speak, especially if this was a complaint before treatment, as was the case for the current participants, then decreased effort represents significant clinical change whether or not statistical significance is reached. It is possible that the minority of participants who did not report a reduction in perceived effort might have interpreted the increased awareness of how they produced voice as an *increase* in effort. Participants were required to learn new behaviors in the course of therapy. These new behaviors require time to become habituated, and the 8- to 9-week time period during treatment may have not been adequate in the case of these participants for habituation to take place. Habits seem to develop as positive reinforcement is repeated over time.[59] The exact time frame required for establishment of habit varies among persons but may take 6 months or more to become fully established.[60,61] So, it is reasonable to assume that some participants may have an increased awareness of their previous vocal behaviors but may not have completely mastered the new vocal behaviors, thereby resulting in no significant change in their perception of vocal effort.

The listener ratings did not show a main effect and did not support the central hypothesis. The main reason for this is most likely due to the large number of voice qualities that were in the mildly disordered range. Because so many of the voices, regardless of the presence of lesion, were rated as mild pretreatment, obtaining a change in quality as a function of treatment was difficult.

From the ratings of the stroboscopic parameters, only one parameter, the left vocal fold edge, showed a statistically significant improvement pre- to posttreatment. The authors have no explanation for why one side would respond differentially to the treatment because this finding occurred for each person in the lesion group, but for 5 of the participants in the lesion group, the lesion appeared larger initially on the left side or occurred only on the left side.

Half of the participants who experienced vocal fold lesions had some resolution of their benign vocal fold lesions from mid- to posttreatment, which is similar to results obtained by Holmberg et al[28] with a group of women with vocal fold nodules. After voice therapy, 80% of their participants demonstrated a decrease in nodule size and edema. Resolution of the lesion is an important clinical indicator of improvement, reflecting a return to a more normal physiologic status. This further supports the positive outcome from EMST training combined with voice therapy. Certainly it could be argued that the change in physical status of the vocal folds was not related to either of the specific treatments but rather to time in that the lesions, after an 8- to 9-week time course of rehabilitation, would respond better than at a 4-week time frame. Obviously, to address this potential criticism, one would have to study multiple treatment techniques while manipulating duration of treatment.

The mid- to postcondition was not compared with stroboscopic examination because it was a time-consuming process requiring the participant to go off-site. Given the participants' already full work-schedule and large time commitment to the study, only the pre–postcondition was examined. In performing the stroboscopic examinations, three different clinicians were involved using two different stroboscopy systems. This created differences in technique as well as light and color variations between systems that may have affected the ratings. A few of the raters did not rate all of the stroboscopic parameters for each examination as they felt the samples were inadequate for evaluation. Furthermore, in this study, there were eight raters evaluating a total of 16 video samples. It is possible that the smaller number of raters and samples yielded variable results. In contrast, Poburka and Bless[62] found high agreement among raters for ratings of vocal fold edge, mucosal wave, and amplitude with lower agreement for glottal closure and phase symmetry. They had a total of 39 raters with ratings of 45 video samples. More careful control of the quality of the stroboscopic examinations should eliminate such problems in future research. These concerns were evident based on the poor inter-rater reliability ($r = 0.406$, $P = 0.026$) found for the stroboscopic parameters.

The measures of irregularity and noise, taken from the hoarseness diagram, did not demonstrate a significant main effect. The hoarseness diagram, particularly its noise component, is applicable for highly irregular oscillations.[63] Although this is generally a sensitive measure, it may not be sensitive enough to detect differences in moderately or mildly impaired voices. According to Frolich et al,[42] voice disturbances not primarily affecting the degree of glottal closure or the regularity of vocal fold vibration could not be expected to lead to significant differences from those of normal voices. This measure was selected before enrolling participants in the study. It was unexpected that so many voices would be normal or mildly impaired as ranked by listeners. Participants volunteered for the study based on their vocal complaints and symptoms, and voice quality ratings were not a part of the inclusion criteria.

Most research in voice therapy has examined the effect of a single variable, such as hydration or vocal hygiene, on treatment outcomes. Only a few studies have investigated the outcome of combining two or more treatment approaches for patients with voice disorders and have demonstrated a combined treatment effect.[28,64] The current study is the first to combine specific EMST with voice therapy. The problem with studying these two techniques is that there is not a great deal of information about the effects of either EMST or voice therapy with voice-disordered patients when they are exposed to these individual treatments. The lack of data on EMST and how it affects patients with voice disorders makes the current data a bit more difficult to interpret and gives room for one to argue that it is merely time in therapy that resulted in the positive findings for the combined modality treatments. Therefore, following the results of this study, it is necessary to examine the impact of combined modality treatments with a more complicated design. For example, to determine whether it was truly the combination of EMST plus voice therapy as opposed to simply the time spent in therapy, additional arms would have to be added to the design. The four researched arms would include participants enrolled in EMST plus voice therapy, voice therapy plus EMST, EMST only, and voice therapy only across an 8-week period.

CONCLUSIONS

The combined used of EMST and voice therapy seems to be more effective than either single treatment offered for the group of professional voice users, regardless of laryngeal diagnosis. Furthermore, it seems that the phonetogram may be a useful tool for measuring therapy outcome in this population.

The use of EMST seems to contribute to greater physiologic drive for increased loudness. The use of EMST alone has not resulted in increased loudness. When combined with instruction in applying the increased respiratory drive to voice production, it seems to be an effective tool in treatment.

Future studies are needed to determine the effect of time in treatment on the measures used in this study. Additionally, more information is needed about the effects of single treatments to adequately compare them to combined treatments. Finally, grouping lesions according to type might be an interesting way to study treatment effects in case there is any differential response to the EMST program of the voice therapy program. Although this is not expected, paying more particular attention to group characteristics may be a factor to statistically consider in the future.

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APPENDIX 1. VOICE RATING SCALE

Name______________________________Date_____________________

Please rank the severity of each statement by marking an "x" anywhere on the line provided.

1. I have problems with my voice.

mild moderate severe

2. The degree to which my job performance is affected by my voice problem is:

mild moderate severe

3. The degree to which I have thought about changing my job because of my voice problem is:

mild moderate severe

4. The degree to which people have difficulty understanding me on the phone is:

mild moderate severe

5. The degree to which I have difficulty being understood in noisy environments is:

mild moderate severe

6. The degree to which I have difficulty projecting my voice is:

mild moderate severe

7. The degree to which my throat feels sore after prolonged talking is:

mild moderate severe

8. The degree to which my voice quality changes after prolonged talking is:

mild moderate severe

9. The degree to which my voice tires after prolonged talking is:

mild moderate severe

10. The degree to which I lose my voice after prolonged talking is:

mild moderate severe

APPENDIX 2. VOCAL EFFORT SCALE

Please rank the severity of each statement by marking an “x” anywhere on the line provided.

The degree of effort I have needed to speak at work this week has been:

____

mild	moderate	severe

The degree of effort I have needed to speak socially this week has been:

____

mild	moderate	severe