TREATMENT OUTCOMES FOR PROFESSIONAL VOICE USERS

By

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by

Judith Maige Wingate
This document is dedicated to my daughters, Lauren and Jennifer. Always remember to follow your dreams.
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Professional voice users comprise 25 to 35% of the United States working population. Voice problems in this population can lead to voice quality change, lost work days due to inability to speak, and workers’ compensation claims. The estimated cost of voice problems for teachers per year, a subset of this group, is estimated at two billion dollars. 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 of the participants received five weeks of expiratory muscle strength training followed by six sessions of traditional voice therapy. Half of the participants were diagnosed with benign vocal fold lesions while half had complaints of throat pain or fatigue when speaking. The treatment order was reversed for the remaining half of the group. The study was designed as a repeated measures study. The independent variables were treatment order, laryngeal
diagnosis (lesion vs. non-lesion), gender, and time. Dependent variables were maximum expiratory pressure (MEP), Voice Handicap Index (VHI) score, Vocal Rating Scale (VRS) score, Voice Effort Scale score, measures of fundamental frequency and intensity from the phonetogram, measures of irregularity and noise from the Hoarseness diagram, phonation threshold pressure, subglottal pressure, and perceptual rankings of voice.

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 seen in treatment order. It was concluded that the combined treatment was responsible for the improvement seen in the dependent variables. The results indicate that a combined modality treatment may be successful in the remediation of vocal problems for professional voice users.
CHAPTER 1
INTRODUCTION AND REVIEW OF THE LITERATURE

Speech and voice are the primary tools of trade for many occupations. Based on conservative estimates, professional voice users comprise between 25 and 35 percent of the working population in the United States (Titze, Lemke, & Montequin, 1997) and at least a third of the work force in other industrialized societies (Vilkman, 2000). This number is likely to increase with the escalating use of voice recognition systems for data entry, word processing, and general computer control. Therefore, prevention and treatment of voice problems in workers have social and economic significance, not only for the professional voice user but for employers as well.

Professional voice users are individuals whose livelihoods depend partially or wholly upon the ability to produce voice. Professional voice users may include, but are not limited to, teachers, ministers, salesmen, telemarketers and telephone operators, actors, singers, radio and TV announcers, and attorneys. Although the range of vocal sophistication and quality needed may vary greatly across the range of occupations, professional voice users share a dependence on vocal endurance (Benninger, Jacobsen, & Johnson, 1994; Sataloff, 1997). Those professionals with persistent voice disorders may experience deleterious effects on job performance, income and career longevity, particularly if unable to speak.

Constant voice use by professional voice users may lead to vocal difficulties. With sufficient recovery time, these vocal difficulties may improve but the professional voice user typically has to return to work the next day and the cycle of repair and injury is
repeated. Other factors in the work environment may also contribute to vocal difficulties, including high levels of background noise, poor environmental acoustics, and poor atmospheric humidity (Carding & Wade, 2000; Ohlsson, Jarvholm, Lofqvist, Naslund, & Stenborg, 1987; Vintturi et al., 2001).

Within the group of professional voice users, there are different levels of vocal demand and usage as well as a wide variation in the quality of voice needed. Vilkman (2000) has classified voice and speech professions by vocal quality and load. Vocal loading is defined as prolonged use of the voice combined with factors such as acoustic conditions at work and the type of communication required. Cumulative talking time is a major factor in vocal load. Persons with high voice quality demands as well as high vocal load may be more aware of changes in their voice production because of the constant demand for consistent, high quality voice output. Actors and singers would be examples of persons with high quality and high vocal load demands. These persons are more likely to seek assistance for their voices than persons with lower quality demands such as nurses or secretarial personnel.

The majority of professional voice users receive little, if any, instruction in voice production. The exceptions to this are singers, actors, and broadcasters who may receive some formal training. Those individuals who do not receive training may speak by imitating what they hear or by trial and error (Benninger et al., 1994). However, these methods are likely inadequate, leaving these individuals at greater risk for vocal problems.

Professional voice users report a variety of vocal problems. These may include changes in vocal quality as well as physical complaints. Vocal quality changes include
hoarseness (Jones et al., 2002; Sapir, Keidar, & Mathers-Schmidt, 1993; Smith, Lemke, Taylor, Kirchner, & Hoffman, 1998; Smith, Gray, Dove, Kirchner, & Heras, 1997; Yiu, 2002), voice breaks or cracks (Jones et al., 2002; Sapir et al., 1993), voice loss (Jones et al., 2002), and weak voice (Smith et al., 1998; Smith et al., 1997). Related physical complaints include shortness of breath (Sapir et al., 1993; Yiu, 2002); dry throat (Jones et al., 2002; Sapir et al., 1993; Yiu, 2002); scratchy sensation in the throat (Jones et al., 2002; Smith et al., 1998); throat discomfort, tightness, or pain (Sapir et al., 1993; Smith et al., 1997; Jones et al., 2002); and effortful speaking (Sapir et al., 1993; Smith et al., 1997, Smith et al., 1998). Another common complaint is vocal fatigue (Kostyk & Rochet, 1998; Sapir et al., 1993; Smith et al., 1997; Yiu, 2002). Vocal fatigue may be defined as negative vocal adaptation that occurs as a consequence of prolonged voice use (Welham & Maclagan, 2003). Vocal fatigue may be manifested as changes in vocal quality, loudness, pitch or effort that begin to occur as the speaking day progresses. These changes are most apparent by the end of the day and usually disappear by the following morning (Gotaas & Starr, 1993). Further, fatigue may manifest itself as tightness in the throat and chest, difficulty in loud talking, talking in a monopitch, and weakening and straining of the vocal muscles (Zeine & Waltar, 2002).

Kaufman and Blalock (1988) described laryngeal tension-fatigue syndrome in a group of professional voice users. They described a triad of typical complaints consisting of dysphonia, vocal fatigue, and odynophonia. They further defined the tension-fatigue syndrome as being characterized by a fluctuating voice quality, which is worse after strain and during times of stress. They found this syndrome to be associated with a low speaking fundamental frequency and poor breath support.
Incidence of Voice Problems

The incidence of voice problems in the general population of the United States is estimated between 3% and 9% (Verdolini & Ramig, 2001). About 2% of that number may be viewed as having clearly abnormal voice quality (Brindle & Morris, 1979). The incidence of voice problems in professional voice users is higher than for the general population.

Much of the available data regarding voice problems in professional voice users pertain to teachers. According to the United States Bureau of Labor Statistics (2002), teachers held 7.65 million jobs in 2001, about 6 percent of the U.S. workforce. The cited percentage of teachers with vocal difficulties ranges from 38% (Smith et al., 1998) to as high as 80% (Gotaas & Starr, 1993). Teachers, especially in the primary grades, may spend 90 minutes or more a day talking, with about half of the total talking time at greater than 80 decibels (Masuda, Ikeda, Manako, & Komiyama, 1993). Teachers of singing are also at-risk for vocal problems, with 64% of 125 voice teachers surveyed indicating past vocal problems compared to 33% of a control group (Miller & Verdolini, 1995). Daycare workers are also at risk for voice problems. In a study comparing Finnish daycare workers to nurses, daycare workers demonstrated significantly more voice problems with 54% of the daycare workers reporting at least one voice symptom (Sala, Laine, Simberg, Pentti, & Suonpaa, 2001).

There are limited data available regarding the incidence of voice problems in other occupational groups of professional voice users. In a sample of 304 telemarketers, Jones and colleagues (2002) found that 68% of this group had vocal complaints and were twice as likely to have vocal problems when compared to an age-matched control group. Similarly, aerobics instructors are at high-risk for voice problems. In one study, 44%
percent of a sample of 54 aerobics instructors experienced voice loss associated with class instruction (Long, Williford, Olson, & Wolfe, 1998).

Persons using voice recognition software to complete their jobs may also be at risk for vocal problems. At least one case of vocal fatigue and strain has been documented in a graduate student lecturer following the introduction of voice recognition software. In this particular case, the individual developed tendonitis and synovitis in the hands, wrists, arms, and shoulders as a result of repetitive stress and turned to voice recognition software for her writing. Subsequently, she experienced vocal fatigue, strain, and difficulty projecting her voice in the classroom. Prior to this, the individual had experienced no vocal problems (Haxer, Guinn, & Hogikyan, 2001). The Voice and Speech Laboratory of the Massachusetts Eye and Ear infirmary also reported four cases of voice recognition product users who developed vocal problems. In each case, the individuals complained of vocal fatigue, changes in vocal quality, and throat tightness. Endoscopy confirmed edema and/or vocal hyperfunction in all four cases (Williams, 2003).

While persons in other occupations are also at-risk for voice problems, specific data regarding the incidence of persons in these occupations that experience vocal complaints are minimal. The information that is available is based on surveys from voice clinics indicating the percentage of professional voice users seeking medical treatment; therefore, this is not a true representation of all the professional voice users experiencing vocal difficulty. In an examination of over 8,000 patient records from two clinics over a two-year period, the most frequently represented occupations were executive manager (7.8%), teacher (5.2%), clerical worker (4.6%), factory worker (4.4%), sales (2.3%),
retail (2.2%), and singer (1.5%) (Coyle, Weinrich, & Stemple, 2001). Other occupations that are frequently identified as being at-risk for voice problems include ministers, telephone operators, public relations specialists, speech pathologists, and broadcasters (Titze, Lemke, & Montequin, 1997).

**Consequences of Voice Problems**

**Professional voice users.** Professional voice users may experience a number of work-related problems due to vocal complaints. Reduced productivity may result from physical discomfort associated with speaking or from vocal fatigue (Jones et al., 2002; Smith et al., 1997). Chronic hoarseness, roughness, or other vocal quality changes may result in reduced quality of work, especially for persons in jobs requiring moderate to high vocal quality. This, in turn, may lead to problems with low self-esteem. The voice problems may adversely impact daily activities and social function. The limitation of, or restricted participation in, daily activities may result in deterioration of the quality of an individual's life (Ma & Yiu, 2001). Individuals with vocal problems have significantly lower scores on quality of life scales than do matched controls (Wilson, Deary, Millar, & Mackenzie, 2002).

Voice problems in professional voice users may be considered a form of repetitive strain injury (Verdolini & Ramig, 2001) caused by the repeated contact of the vocal folds during voice production. The repeated movement and resulting collision of the vocal folds during speaking may occur over a million times per day on the job (Vilkman, 2000). Over time, chronic voice problems and laryngeal pathology may result. In a study that followed education majors through the first years of professional teaching, 50% of the subjects reported voice problems after two years of professional activity (Debdot, Wuyts, Van de Heyning, Lambrechts, & Abeele, 1998).
Voice loss, even if temporary, is likely to result in missed workdays (Yiu, 2002). For those persons not in permanent employment situations, such as actors and singers, this can have a negative impact on earning potential. Frequent cancellation or postponement of jobs may result in fewer job offers and could eventually lead to dismissal from a particular performance venue.

Career decisions may also be impacted by voice problems. Smith and colleagues (1997) found that 40% of teachers reported that their voice problems made them reconsider future career plans. Four percent of teachers in their survey considered a job change. Data regarding career changes related to voice problems are not available for other occupations.

**Employers.** Employers may see the impact of voice problems on their employees in several ways. Occasional voice loss or throat pain may result in absenteeism. Employer job satisfaction may drop, leading to strained relations between management and employees. When voice problems become chronic, employee turnover may increase. Verdolini and Ramig (2001) estimate the annual treatment costs for teachers with voice problems to be over 14 billion dollars. Further, they speculate that if each teacher with vocal difficulty missed three workdays annually requiring the hiring of a substitute teacher at approximately $60 per day, the cost in the United States would be over 372 million dollars. The total cost for teachers annually would amount to nearly 2 billion dollars with most of this cost being absorbed by the employer.

For those occupational voice users who are unable to perform their job duties, workers compensation claims may be filed. For 2001, the total cost to American businesses for disabling injuries and lost workdays was 132 billion dollars (Chubb
Group, 2004). The National Safety Council estimates the average per case cost of wage and productivity losses, medical expense, and administrative expense of workers' compensation claims to be $33,000 (2002). Specific figures for voice-related disability complaints are not available.

**Types of Vocal Pathologies Found in Professional Voice Users**

Professional voice users are susceptible to the same vocal pathologies as other voice users. Pathologies may occur as a result of repeated trauma to the vocal folds or in response to environmental triggers, such as toxins, molds, and dust. The most common disorder of the vocal folds in an occupational setting is laryngitis, although the development of vocal fold nodules, vocal fold polyps, and contact ulcers may also be seen (Williams, 2002; Sala et al., 2001).

In a study with high-risk vocal performers, laryngoscopic and stroboscopic examination showed performers to have vocal fold edema, increased vascularity of the vocal folds, and irregular vocal fold edges (Hoffman, Lehman, Crandell, Ingram & Sapienza, 2001). In another study of 20 singing teachers who volunteered at a national conference for laryngoscopic examination, 61% were found to have subepithelial vocal fold cysts. The cysts were accompanied by varicosities at their bases, suggesting traumatic etiology. Another 8% of the teachers in the sample had vocal fold polyps (Heman-Ackah, Dean, & Sataloff, 2002).

Another common pathology of professional voice users is vocal fold nodules. Vocal fold nodules typically form on the edges of the vocal folds resulting in hoarseness, breathiness, loss of vocal range and reduction in vocal flexibility (Benninger et al., 1994; Colton & Casper, 1990). Nodules typically occur from misuse or abuse of the voice resulting in vocal fold trauma (Sataloff, 1991). Other lesions of the vocal fold, such as
hemorrhage or cysts, may occur with forceful voice use and are often seen in professional voice users (Benninger et al., 1994; Lin, Stern, & Gould, 1991).

Extra-esophageal reflux may also lead to voice difficulties for professional voice users. The recurring irritation to the laryngeal tissues may cause vocal fold edema and/or compensatory muscle tension dysphonia (Ross, Noordzji, & Woo, 1998; Sataloff, 1997). Professional voice users, particularly those who travel frequently or eat late at night, may be especially prone to reflux (Benninger et al., 1994). In fact, Sataloff (1997) found reflux laryngitis in 45% of consecutive professional voice users seen in a voice clinic.

**Compensations for Vocal Pathologies**

Professional voice users perform under a number of adverse conditions that may lead to vocal compensations. A common condition is increased background noise, such as that occurring in a classroom, factory, day care center, or busy office. A study done with welders in Sweden showed a mean workplace noise level of 95 dBA (Ohlsson et al., 1987). Background noise levels in day care centers were found to be 76 dB on average (Sodersten, Granqvist, Hammarberg, & Szabo, 2002). Speakers may increase their vocal intensity two to five decibels for every ten-decibel increase in noise level (Garber, Siegel, & Pick, 1981). If the increased vocal loudness is sustained for long periods of time, speakers may increase vocal fold adduction and this may lead to irritation or inflammation of the vocal folds (Ohlsson et al., 1987; Sapienza, Crandell, & Curtis, 1999). A related issue is poor room acoustics that may lead to poor acoustic feedback for the speaker. This situation may also lead to increased vocal strain (Caldwell et al., 2001).

Anxiety, stress, and stage fright may lead to increased musculoskeletal tension and altered breathing patterns. Stress may also be manifested as dry mouth, fatigue, headaches, insomnia, and heartburn (Sataloff, 1991). In turn, this may lead to increased
strain of the laryngeal muscles to produce an acceptable vocal quality. Similar compensatory muscle tension may occur in response to the quality changes created by throat infection as the speaker attempts to maintain a normal tone (Caldwell et al., 2001). Heavy costumes and makeup may create special problems for singers and actors. Costumes may alter respiratory function and posture. Makeup, especially the use of prosthetics or masks, may alter face and jaw movement and make projection and articulation more difficult (Raphael, 1991; Hoffman-Ruddy et al., 2001). The performer may compensate for these altered movements by changing laryngeal dynamics.

Frequent travel may lead to alterations in diet and sleep patterns for professional voice users. These changes may lead to dehydration, fatigue, and digestive problems (Caldwell et al., 2001). The professional voice user's response to each of these problems may lead to compensatory behaviors that adversely affect vocal production.

As compensatory behaviors lead to increases in musculoskeletal tension, reduced respiratory function, and altered laryngeal dynamics, the professional voice user may find it increasingly difficult to produce voice consistently with the desired quality. When this occurs, the professional voice user is likely to seek medical treatment for the vocal problem in order to regain and maintain desirable vocal quality.

**Assessment for Voice Problems**

Assessment of voice production may be accomplished in a variety of ways. A medical examination of the larynx is typically accomplished using visualization via an endoscope. This allows for assessment of laryngeal structures and mobility. With the addition of stroboscopy, a more detailed look at vocal fold movement can be obtained. Self-perception of vocal quality and its impact on a person's quality of life may be assessed using any number of self-assessment scales. The Voice Handicap Index
(Jacobson et al., 1997) was developed for this purpose and was chosen for use in this study. It consists of thirty items that are ranked by the subject on a five-point ordinal scale with a maximum score of 120. Higher scores indicate a higher degree of vocal disability. The developers of the VHI indicate that an 18-point difference is necessary to determine meaningful change between administrations of the test that is not due to inherent variability.

The voice may also be assessed using perceptual measures. Perceptual assessment typically involves the use of a rating scale that may be completed by an individual regarding their voice or by another listener. Several types of scales have been used for this purpose including equal-appearing interval scales and direct magnitude estimation. For this study, a visual analog scale was used. The visual analog scale has been shown to be a reliable, valid, and sensitive method for self-report of subjective experiences (Gift, 1989). The visual analog scale uses a line, usually 100 millimeters long, with descriptors at each end. The subject is asked to make a mark along the line that measures his/her perception of the parameter at the present moment. The data yielded are of a ratio level and are useful for parametric statistical analysis (Cannito et al., 1997).

The physical characteristics of the voice may be assessed using various measures. The phonetogram, or voice range profile, is one such measure that has been used to track changes in both frequency and intensity over time. The phonetogram is a display of vocal intensity range plotted with fundamental frequency (Titze, 1994). Coleman (1993) describes the phonetogram as a descriptor of total vocal tract output. He also states that the covariance of pitch and loudness may be used to track changes in the pathological conditions of the vocal system.
Akerlund (1993) used the phonetogram to determine if treatment affected mean sound levels and frequencies in a group of subjects with non-organic dysphonia. Results showed that both sexes extended their vocal range an average of 1.5 to 2.1 semitones. Frequency has been shown to have little variation, of about 1 semitone, between trials with normal subjects (Coleman, Mabis, and Hinson, 1977). Intensity has a short-term mean variation of 2-3 dB between administrations of the phonetogram (Gramming, Sundberg, and Akerlund, 1991).

Another method for describing physical characteristics of the voice is the hoarseness diagram. Typically, analysis of the dysphonic voice has been difficult to accomplish because of the aperiodicity of the signal. The hoarseness diagram seeks to minimize this difficulty. The method, devised by Frolich, Michaelis, Strube, and Kruse (1997, 2000), is based on four acoustic measures that allow a quantification of voice quality with regard to roughness and breathiness. The roughness, or irregularity component, is calculated using jitter, shimmer, and the mean correlation coefficient between consecutive glottal cycles. The breathiness, or noise, component is based on the glottal-to-noise excitation ratio (GNE). The GNE is applicable even for highly irregular glottal oscillation. Any narrow-band noise generated by turbulence does not influence the degree of turbulence measured (Michaelis, Gramms, & Strube, 1997). The GNE is based on correlations between Hilbert envelopes calculated for different frequency channels of an inverse-filtered speech wave. Values close to one reflect a pulse-like excitation. Conversely, values close to 0 result from a noise-like excitation (Frolich et al, 2000). The values obtained from the hoarseness diagram may be plotted on a graph with the irregularity component on the x-axis and the breathiness, or noise component, plotted
on the y-axis. Voices that are normal cluster in the lower left region of the graph and voices that are more pathologic are undifferentiated in their placement (Michaelis, Frolich, & Strube, 1998).

Physiologic measures may also be useful in voice analysis. These may include aerodynamic measures, electromyography, and electroglottography. For this study, aerodynamic measures of subglottal and intraoral pressure were obtained.

**Treatments for Voice Problems**

Treatments for voice problems may be surgical, medical, or behavioral. Surgical treatment is indicated for problems that are not amenable to therapy alone. These problems would include, but are not limited to, vascular lesions, structural abnormalities, hemorrhagic polyps, and vocal fold cysts (Benninger et al., 1994; Davies & Jahn, 1998). Management with medications may be indicated for cases of allergy, edema, and gastroesophageal reflux. Behavioral therapy is often the treatment of choice for voice disorders as surgical management may result in vocal fold scarring, resulting in an adynamic segment along the vibratory margin of the vocal fold (Sataloff, 1991). There are four primary approaches to behavioral voice therapy in common use at the present time: hygienic, symptomatic, psychogenic, and physiologic. Physiologic therapy is the type used for this study.

**Physiologic voice therapy.** Physiologic voice therapy is based on improving the balance between the vocal subsystems of respiratory support, laryngeal muscle strength, and resonance. The objective of this type of therapy is to promote a healthy vocal fold cover (Stemple, Glaze, & Gerdeman, 1993). The physiologic condition of the vocal folds is considered in developing direct exercise or manipulation to improve the patient's vocal condition. Several approaches fit under the physiologic voice therapy heading. These
include vocal function exercises (Stemple, Lee D’Amico & Pickup, 1994; Sabol, Lee & Stemple, 1995), resonant voice therapy (Verdolini, Druker, Palmer, & Samawi, 1998), and the accent method of voice therapy (Kotby, El-Sady, Basiouny, Abou-Rass, & Hegazi, 1991).

There are few experimental studies utilizing prospective, randomized designs that have addressed the issue of outcomes for voice therapy. One study compared the effect of intensive hydration therapy to a control period for six subjects with vocal fold nodules (Verdolini-Marston, Sandage, & Titze, 1994). A reduction in perceived vocal effort, improvement in laryngeal appearance, and reduced phonation threshold pressure were found under the hydration condition. In another study examining subjects with vocal fold nodules, the effect of confidential voice therapy was compared to resonant voice therapy over a 12-day period. Findings suggested improvements in voice quality with both therapy methods as long as subjects were compliant with treatment (Verdolini-Marston, Burke, Lessac, Glaze, & Caldwell, 1995). Basiouny (1998) compared use of the accent method to instruction in vocal hygiene. Significant improvements were found for vocal function and aerodynamic measures as well as improvement in laryngeal appearance for the group receiving the accent method of treatment.

A study of voice therapy outcomes for women with vocal fold nodules was undertaken at the Massachusetts Eye and Ear Infirmary in Boston. The treatment protocol consisted of five basic behaviorally based phases: vocal hygiene, direct facilitation, respiration, relaxation, and carry-over (Holmberg, Doyle, Perkell, Hammarberg, & Hillman, 2003). They found that significant changes in perceptual parameters occurred after completion of the direct facilitation and/or respiration treatment
approaches. For 9 of the 10 subjects, the nodules decreased in size post treatment and accompanying edema was reduced.

In a study by Carding, Horsley, and Docherty (1999) direct and indirect treatment groups were compared to a control group. The direct treatment group received individual therapy personalized to meet their specific needs. The indirect treatment group received lifestyle management and vocal hygiene suggestions only. After an eight-week therapy trial, the direct treatment group showed significant improvement in voice severity. When results for both treatment groups were combined, 92% of the subjects showed improvement.

In the largest comparative treatment study utilizing 204 patients with functional dysphonia, subjects received six sessions of direct voice treatment compared to a non-treatment group. Significant improvements were found in ratings of voice quality, both self-rated by the subjects and by a group of expert listeners. Improvement was also found in shimmer values (MacKenzie, Millar, Wilson, Sellars, & Deary, 2001). None of the studies examined were specific to professional voice users. In fact, this population was excluded from most of the studies reviewed.

While no existing therapy programs specifically target the professional voice user, any of the behavioral therapy programs may be utilized as appropriate for an individual's particular problems and complaints with some degree of success. However, as previously discussed, professional voice users may have significant difficulty with vocal endurance and may have demands for sustained loudness due to working conditions. No existing therapy programs target these requirements. Two of the physiologic types of therapy, Vocal Function Exercises and the Accent Method, specifically target the respiratory
component of voice production. However, there is no program that focuses on strengthening the respiratory muscles used for voice production. It is believed that strengthening the respiratory drive used for voice production will assist professional voice users in meeting loudness and endurance demands by increasing the respiratory system's ability to generate respiratory pressures.

**Role of Respiratory System in Voice Production**

The respiratory system provides the power for vocal fold vibration. Ample air must be moved in an outward direction through the glottis in order for voice to be established and maintained (Titze, 1994). This occurs through a combination of thoracic and abdominal muscle function coupled with adjustments to the closure of the vocal folds themselves. As demands for loudness and/or duration increase, the abdominal muscles are responsible for increasing expiratory force.

At rest, air exchange occurs as the thorax is enlarged. During inspiration, the diaphragm descends, increasing the vertical dimension of the chest, allowing the lungs to expand and fill with air. At the same time, the external intercostal muscles pull the ribs up and forward to further increase the dimensions of the chest cavity. The system then recoils to its resting state during passive exhalation. Speech is typically produced in the midrange of vital capacity, near the resting expiratory level, or at 50% to 65% of vital capacity (Mitchell, Hoit, & Watson, 1996).

During more active breathing for exercise or for the demands of singing or public speaking, the muscles of exhalation become more active. These muscles include the internal and external obliques, rectus abdominis, transverse abdominis, and the quadratus lumborum (Zemlin, 1998). They serve to drive the abdominal contents inward and create a piston-like effect on the diaphragm. The contraction of the internal intercostals and the
serratus posterior inferiors assists in depressing the rib cage. These muscle contractions decrease lung volume, increase lung pressure, and increase the velocity of airflow out of the lungs (West, 2000).

**Mechanisms for Variation of Vocal Intensity**

Lung pressures generated during the expiratory phase vary with the amount of muscular force applied to the lung and chest wall unit. An increase in expiratory muscle force will increase lung pressure and, in turn, increase the pressure below the vocal folds (subglottal pressure). This is the primary mechanism for increasing vocal intensity (Isshiki, 1964). The required subglottal pressure for generating normal conversational speech is 4 to 6 cmH₂O. The elastic recoil forces of the lung and chest wall usually produce this pressure level at lung volume initiations between 40 and 60% lung volume. Men have higher static recoil pressures than females which suggests that women need to initiate speech at higher lung volumes than men to achieve the same static recoil pressures (Stathopoulous & Sapienza, 1993). When greater pressures are required for loud speech or singing, expiratory muscle force plays a critical role in sustaining appropriate subglottal pressure (Sundberg, 1987). Subglottal pressure may increase to 10 to 15 cmH₂O for loud conversation and has been measured as high as 20 to 30 cmH₂O for shouting (Hixon, 1987). In singing, subglottal pressures for loud singing also fall in the 20 to 30 cmH₂O range (Sundberg, 1987).

Sound intensity may be influenced by other factors as well. Physiologically, there is a strong relationship between the shut-off of glottal airflow and the sound pressure level of the voice. The sound pressure level, or intensity, increases as the rate of glottal shut-off of airflow increases (Scherer, 1991). Degree of glottal adduction is also linked to sound intensity. Increased vocal fold adduction decreases the ratio of the intensity of
the fundamental frequency to the overall intensity. The greatest increase in intensity appears to occur when the vocal processes are almost touching during the closed phase of vibration (Scherer, 1991). Acoustic properties of vocal production may also increase intensity. As fundamental frequency increases, there is a 6 dB increase for every octave change that occurs (Titze, 1994).

Professional voice users frequently have high demand for increased loudness due to increased background noise or poor environmental acoustics in the workplace. As previously discussed, background noise in some work settings may range from 76 to 95 dBA (Ohlsson et al., 1987; Sodersten et al., 2002). Therefore, the demands on the respiratory system must be increased to accommodate the increased background noise. Without an adequate increase in subglottal pressure for loudness demands, the professional voice user may increase laryngeal hyperfunction which may lead to vocal fatigue and increased risk of tissue trauma (Sataloff, 1997; Titze, 1994). Therefore, strengthening the expiratory muscle system should prove beneficial to professional voice users, both in fulfilling the demands for higher respiratory drive and in minimizing potential vocal fold damage from trauma.

**Respiratory Muscle Training**

The training of respiratory muscle is a concept that has been applied to both normal and diseased populations. The training is designed to strengthen either inspiratory or expiratory muscles to increase the ability to generate increased muscle pressure. The underlying rationale for expiratory muscle training is that respiratory muscle, like other skeletal muscle, responds to strengthening and conditioning (Leith & Bradley, 1976; Powers, Coombes, & Demeril, 1997). Muscle strength can be increased through weight or resistance training. Resistance training can be accomplished through isometric
training (resistance without movement), isotonic training (resistance with movement) or isokinetic training (resistance at a constant speed) (Saxon & Schneider, 1995). The goal of strength training is to increase the maximum amount of force that can be generated by a muscle or muscle group. High intensity training is required in order to increase muscle strength (Powers & Howley, 2001). Resistance training has been demonstrated to increase both muscle size and muscle strength, and to increase both Type I and Type II fibers (Powers & Howley, 2001).

The overload principle states that muscle must be exercised beyond a level that it is accustomed to in order to achieve a training, or strength, effect (Powers & Howley, 2001). Since the muscle, or muscle system, gradually adapts to this overload through adaptation, increased load must be incorporated into the training program (Saxon & Schneider, 1995). This increased load must be progressive to prevent musculoskeletal injury (Powers & Howley, 2001; Saxon & Schneider, 1995). Further, training must be specific to the muscle fibers involved in the activity and to the metabolic energy system used for the activity (Powers & Howley, 2001). The training program must train the muscles actually used for a specific skill. For example, a runner must practice running in order to strengthen the energy and muscle systems used for running.

Muscle strength can be increased through weight or resistance training. The most common devices used for respiratory muscle strength training are resistance-based trainers or pressure threshold trainers. Resistance training requires that a subject inspire or expire through a mouthpiece that provides resistance to the flow of air. With pressure threshold training devices, the subject must produce a specific amount of mouth pressure to open a one-way valve and allow air to pass through the mouthpiece. Pressure
threshold training is not dependent on airflow and allows training to occur only when the respiratory muscles produce a sufficient lung pressure. The respiratory muscles are known to compensate during resistance-based training by decreasing flow, thereby reducing the amount of muscle contraction needed to complete the task (Powers et al., 1997). Pressure threshold training requires higher levels of muscle force and therefore, most often produces a greater training effect.

**Pressure Threshold Device**

Pressure threshold devices have a spring that presses a cover (valve) over a tube opening. The subject must produce a respiratory pressure sufficient to overcome the spring compression strength to open the valve. Airflow through the device occurs only when the valve is open. Since lung volume changes simultaneously with airflow, the expiratory muscles must produce a constant minimum force throughout the breath. The muscle activation increases as lung volume decreases so the training effect increases late in the expiratory cycle. This results in greater force stress on the expiratory muscles and a greater strengthening effect, thus allowing more specific training for the expiratory muscles (Kellerman, Martin, & Davenport, 2000).

A pressure threshold trainer, designed by University of Florida investigators (Paul Davenport, Daniel Martin, and Christine Sapienza) is available for experimental use. This device allows an individual to train the expiratory muscles at near maximum level. Most commercially available trainers have threshold settings from 4 to 20 cmH₂O that do not provide enough overload to the muscle to increase strength. The current experimental trainer used in this study allows the pressure threshold to be set at levels of up to 155 cmH₂O, much higher than previously available on commercial pressure threshold trainers, thus meeting the required overload principle. This trainer can be calibrated to
allow for quantifiable increases in the pressure threshold level over time, a feature not available on some commercially available trainers.

**Expiratory Training Studies**

Several studies have explored the use of expiratory muscle training. The results of these studies are summarized in Table 1-1. In a study of six healthy subjects who performed expiratory muscle training over a four-week period, twice daily for 15 minutes, a significant increase in the strength of expiratory muscle as well as a reduced sensation of respiratory effort during exercise was noted. All subjects showed an increase in maximum expiratory pressure following training with the group showing a 25% increase in pressure overall (Suzuki, Sato, & Okubo, 1995).

<table>
<thead>
<tr>
<th>Authors</th>
<th>Subject Group</th>
<th># subjects</th>
<th>Training Duration</th>
<th># sets</th>
<th>Training threshold</th>
<th>% increase MEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suzuki et al.</td>
<td>Healthy men</td>
<td>10</td>
<td>4 weeks</td>
<td>15 min/twice a day</td>
<td>30% of MEP</td>
<td>25%</td>
</tr>
<tr>
<td>Smeltzer et al.</td>
<td>Multiple sclerosis</td>
<td>20</td>
<td>3 months</td>
<td>3 sets/15 breaths twice a day</td>
<td>Not reported</td>
<td>36%</td>
</tr>
<tr>
<td>Gosselink et al.</td>
<td>Multiple sclerosis</td>
<td>28</td>
<td>3 months</td>
<td>3 sets/15 breaths twice a day</td>
<td>60% of MEP</td>
<td>35%</td>
</tr>
<tr>
<td>Sapienza et al.</td>
<td>Band students</td>
<td>40</td>
<td>2 weeks</td>
<td>4 sets/6 breaths</td>
<td>75% of MEP</td>
<td>47% for females; 53% for males</td>
</tr>
<tr>
<td>Hoffman-Ruddy</td>
<td>High-risk performers</td>
<td>8</td>
<td>4 weeks</td>
<td>4 sets of 6 breaths/twice daily</td>
<td>80% of MEP</td>
<td>84%</td>
</tr>
<tr>
<td>Roy et al.</td>
<td>Teachers</td>
<td>27</td>
<td>6 weeks</td>
<td>5 sets of 5 breaths/twice daily</td>
<td>80% of MEP</td>
<td>21%</td>
</tr>
<tr>
<td>Baker</td>
<td>Healthy males and females</td>
<td>32</td>
<td>4 weeks and 8 weeks</td>
<td>5 sets of 5 breaths/5 days a week</td>
<td>75% of MEP</td>
<td>41% for 4 wk. Group; 50% for 8 wk. group</td>
</tr>
</tbody>
</table>
Expiratory muscle training was completed with high school wind instrumentalists, five days a week for a two-week period using four sets of six training breaths at loads between 14 and 80 cmH₂O. The valve was set at 75% of each subject's maximum expiratory pressure. With training, females showed an increase of 43 cmH₂O or a 47% increase from baseline. Males had an increase of 53 cmH₂O post-training, or an increase of 48% from baseline. This study found no change in maximum expiratory pressures for a control group (Sapienza, Davenport, & Martin, 2002).

In a study of 20 severely disabled multiple sclerosis patients, ten subjects completed three months of expiratory training using a threshold training device and were compared to five subjects who completed three months of sham training using the same device without an expiratory training threshold load (Smeltzer, Lavietes, & Cook, 1996). A significant increase in expiratory muscle strength was found in the training group. In another study with severely disabled multiple sclerosis patients, 28 subjects completed three months of training. Patients completed three series of 15 contractions at 60% of maximum expiratory pressure twice daily. The patients achieved a 35% increase in maximum expiratory pressure (Gosselink, Kovacs, Ketelaer, Catron, & Decramer, 2000).

Another study of expiratory muscle training was completed with a group of eight high-risk vocal performers with a high degree of vocal load. These performers trained daily for a period of four weeks. Mean maximum expiratory pressures for the experimental group post-training increased from 70.5 cmH₂O to 130 cmH₂O (84%). Subjects reported a decrease in breathlessness during performances and an increase in duration of sustained phrases. A control group experienced no substantial increase in
maximum expiratory pressure (Hoffman-Ruddy, 2001; Sapienza, Hoffman-Ruddy, Davenport, Martin, & Lehman, 2001).

Expiratory muscle training was also explored in a group of teachers as part of a larger study comparing three voice therapy treatments. Twenty-seven full-time teachers with vocal problems underwent expiratory muscle training. Training was performed five days a week, with five sets of five repetitions performed twice daily for six weeks. The expiratory muscle-training group showed a significant improvement in maximum expiratory pressure at the conclusion of the study. However, this group did not demonstrate significant change on self-ratings of voice severity or vocal disability (Roy et al., 2003). The training paradigm used with the teachers was not as carefully controlled as in previous studies as the load was not measured or changed weekly.

Baker (2003) examined changes in healthy individuals. Some subjects participated in 4 weeks of training while others completed 8 weeks of expiratory muscle training. The two groups showed increases in MEP of 41% and 50% respectively.

**Statement of the Problem**

While expiratory muscle training has been found to increase expiratory muscle strength, the benefits of expiratory muscle strength training for professional voice users have not been fully demonstrated across a range of occupational settings. Further, no studies have combined expiratory muscle strength with any other therapeutic intervention.

**Purpose of the Study**

The purpose of this study was to examine the use of expiratory muscle strength training combined with voice therapy in a group of professional voice users. Physiologic and acoustic changes occurring in the voice pre to post treatment will document outcome.
The changes in patient perception of vocal difficulty following treatment will also be compared.

**Hypotheses**

Central Hypothesis: It is hypothesized that expiratory muscle strength training combined with voice therapy will produce greater improvements in voice production than will voice therapy alone.

*Hypothesis 1:* Both groups will report a greater reduction in vocal symptoms and vocal effort following EMST-training plus voice therapy as compared to the voice therapy condition alone.

*Hypothesis 2:* Both groups will produce greater improvements in perceptual ratings post-EMST training plus voice therapy than with voice therapy alone.

*Hypothesis 3:* Both groups will produce greater improvement in respiratory pressure post-EMST training plus voice therapy than following voice therapy alone.

*Hypothesis 4:* Both groups will produce greater improvements in frequency and time domain measures, as measured by the phonetogram, post-EMST training plus voice therapy than following voice therapy alone.

*Hypothesis 5:* The group with benign vocal fold lesions will demonstrate greater improvements overall than the non-lesion group following the combined treatments of EMST and voice therapy than following voice therapy alone.
CHAPTER 2
METHODOLOGY

This study examined the use of expiratory muscle strength training combined with voice therapy for professional voice users currently experiencing complaints of vocal problems. Participants were grouped by laryngeal diagnosis. Both groups received voice therapy and expiratory muscle strength training. Half of the participants received voice therapy first and half received expiratory muscle strength training first in order to avoid an order effect.

Experimental Design

The design of this project was a prospective, complete repeated measures design. The independent variables were laryngeal diagnosis (lesion/non-lesion), gender, and treatment order. The dependent variables were: Voice Handicap Index (VHI) score, Vocal Rating Scale score, Voice Effort Scale score, irregularity and noise measures from the hoarseness diagram, total area, and the range of intensity and fundamental frequency obtained from the phonetogram, phonation threshold pressure, subglottal pressure, maximum expiratory pressure, and listener ratings of voice quality.

Participants

Sample size determination. Calculation of the sample size was performed using one response variable as suggested by Marks (2001). The VHI score was used as the variable to determine sample size since this measure is an important measure for determining the impact of voice problems as reported by individuals. The VHI is a measure of a person’s perception of their vocal difficulty on their quality of life. The
common standard deviation, denoted as \( \sigma \), was determined from the range of VHI scores obtained prior to treatment. The range was 77, which yielded a common standard deviation of 19.25. The critical relative difference of the VHI (or bound on error) was set at 18 points as suggested by the developers of the scale (Jacobsen et al., 1997). This is the minimum significant difference between administrations of the scale that is not due to a different test administration. Using the two obtained values as described above, Delta was calculated using the formula: \( \Delta = \text{bound}/\text{standard deviation} \) and was determined to be 0.93. The significance level (\( \alpha \)), or probability of committing a Type I error, was predetermined at 0.05. The power of the test, or the ability to reject the null hypothesis if the null is false, was set at 80%. Using Marks' sample size table (2001) for the obtained values, the number of participants needed was 9 per group. Therefore, at least 9 participants per group were needed to detect an average difference of eighteen points in VHI scores, pre to post-treatment. Thus, a total of 20 participants (10 participants \( \times \) 2 groups) were recruited for the study.

**Recruitment and selection.** Approval for the study was obtained from the University of Florida Health Science Center Institutional Review Board prior to enrolling participants. Participants were recruited from the Gainesville, Florida area. Flyers containing information about the study along with contact information were posted at various locations across campus (Appendix A). Additional copies of the flyer were distributed to schools, businesses, and organizations with members who were professional voice users.
Inclusion criteria. Participants were included based on the following criteria:

1. Age between 21 and 65 years,
2. Professional voice users who speak at least 4 hours a day on the job,
3. Complaints of vocal problems including fatigue, hoarseness, throat pain, and voice loss,
4. Normal hearing (25dB HL at 500 Hz; 20dB HL for 1000, 2000, and 4000 Hz.),
5. Persons who were able to maintain their current level of physical activity (including both aerobic exercise and weightlifting) throughout the entire training period. Participants were asked to report any changes in their level of activity throughout their participation in the study. Participants were excluded from the study if they made a significant change in activity level as described above.

Exclusion criteria. Participants were excluded from the study if they reported any of the following:

1. History of chronic and acute cardiac disease including hypertension, pulmonary disease, neuromuscular disease, and/or immune system disease as reported on a health questionnaire (Appendix B),
2. Upper respiratory infection at the time of baseline measurements as reported on the health questionnaire or during the training period,
3. Pulmonary function test values that were below 75% of the predicted normative value,
4. Vocal fold lesion requiring immediate medical attention,
5. History of smoking or tobacco use within the last 5 years.

Assignment of participants to groups. Participants meeting inclusion criteria were assigned to one of two groups, lesion versus non-lesion, based on their laryngeal examination. Participants with laryngeal irritation or edema were assigned to Group 1. Participants with evidence of benign vocal fold lesions were assigned to Group 2.

Participant demographics. Twenty participants, 12 females and 8 males, were enrolled in the study. One female participant (number 19) completed only the initial measures and withdrew from the study due to illness. In order to keep the two treatment
groups equal, one randomly selected participant’s data were removed from the analysis.

The final number of participants included in the study is 10 females and 8 males.

Demographic data for the participants are listed in Table 2-1. A total of 9 participants (2 males, 7 females) had vocal fold lesions. The lesions included vocal fold nodules (5 females), unilateral vocal fold polyp (1 female), bilateral sulcus vocalis (1 male), and petechial hemorrhage (1 male, 1 female). The average age of the participants was 41 years with a range of 22 to 59 years. The average number of years on the job was 12.

Participants reported on a written questionnaire that they spent an average of 61% of their time at work talking.

Table 2-1. Demographic information for participants in the study.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Gender</th>
<th>Occupation</th>
<th>Age</th>
<th>Years on Job</th>
<th>Hours worked/week</th>
<th>Estimated Talking Time</th>
<th>Lesion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>Manager</td>
<td>27</td>
<td>1</td>
<td>20</td>
<td>70%</td>
<td>No</td>
</tr>
<tr>
<td>2</td>
<td>M</td>
<td>Professor</td>
<td>34</td>
<td>3</td>
<td>20</td>
<td>50%</td>
<td>No</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>Professor</td>
<td>37</td>
<td>5</td>
<td>35</td>
<td>38%</td>
<td>No</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>Attorney</td>
<td>49</td>
<td>7</td>
<td>40</td>
<td>50%</td>
<td>No</td>
</tr>
<tr>
<td>5</td>
<td>F</td>
<td>Teacher</td>
<td>25</td>
<td>4</td>
<td>40</td>
<td>68%</td>
<td>No</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>Chaplain</td>
<td>55</td>
<td>27</td>
<td>43</td>
<td>25%</td>
<td>Yes</td>
</tr>
<tr>
<td>7</td>
<td>F</td>
<td>Surgery Scheduler</td>
<td>38</td>
<td>8</td>
<td>40</td>
<td>90%</td>
<td>Yes</td>
</tr>
<tr>
<td>9</td>
<td>F</td>
<td>Corrections Officer</td>
<td>29</td>
<td>0.5</td>
<td>25</td>
<td>75%</td>
<td>Yes</td>
</tr>
<tr>
<td>10</td>
<td>F</td>
<td>Teacher</td>
<td>46</td>
<td>5</td>
<td>50</td>
<td>50%</td>
<td>Yes</td>
</tr>
<tr>
<td>11</td>
<td>M</td>
<td>Librarian/Teacher</td>
<td>48</td>
<td>7</td>
<td>40</td>
<td>40%</td>
<td>No</td>
</tr>
<tr>
<td>12</td>
<td>F</td>
<td>Teacher</td>
<td>59</td>
<td>38</td>
<td>55</td>
<td>55%</td>
<td>Yes</td>
</tr>
<tr>
<td>13</td>
<td>M</td>
<td>Professor</td>
<td>44</td>
<td>9</td>
<td>35</td>
<td>60%</td>
<td>Yes</td>
</tr>
<tr>
<td>14</td>
<td>F</td>
<td>Professor</td>
<td>53</td>
<td>32</td>
<td>55</td>
<td>75%</td>
<td>Yes</td>
</tr>
<tr>
<td>15</td>
<td>F</td>
<td>Computer Coordinator</td>
<td>41</td>
<td>18</td>
<td>50</td>
<td>75%</td>
<td>No</td>
</tr>
<tr>
<td>16</td>
<td>F</td>
<td>Marketing</td>
<td>36</td>
<td>9</td>
<td>37.5</td>
<td>60%</td>
<td>Yes</td>
</tr>
<tr>
<td>17</td>
<td>M</td>
<td>Minister</td>
<td>59</td>
<td>18</td>
<td>50</td>
<td>25%</td>
<td>No</td>
</tr>
<tr>
<td>18</td>
<td>M</td>
<td>Counselor</td>
<td>49</td>
<td>17</td>
<td>40</td>
<td>65%</td>
<td>No</td>
</tr>
<tr>
<td>20</td>
<td>F</td>
<td>Medical Technologist</td>
<td>35</td>
<td>10</td>
<td>40</td>
<td>85%</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Measures

Measures of voice production, subglottal pressure, and perceived vocal effort were obtained for each participant. Laryngoscopic evaluation and lung function measures were used as screening tools prior to the study. All other measures were taken before and after each of the training phases, for a total of three measurement points.

Screening Measures

An endoscopic examination of the vocal folds was performed on each participant prior to acceptance into the study. Examinations were completed using a rigid oral endoscope or a flexible nasal endoscope under medical supervision. As per previously cited exclusion criteria, participants were not included in the study if they had a vocal fold lesion requiring immediate medical attention. Participants were asked to fill out a health questionnaire (Appendix A) to ensure that all other criteria were met.

Measures of forced expiratory volume at one second (FEV1) and forced vital capacity (FVC) were taken for each participant. Participants were asked to inhale to their total lung capacity and then blow out as forcefully as possible into a computerized spirometer (Spirovision 3+, Futuremed of America). FEV1 is a measure of expiratory volume during the first second of expiration. FVC represents the total volume exhaled (West, 2000). The values of FEV1 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 (Appendix C). This thirty-item scale, developed by Jacobsen and colleagues (1997) was designed to measure the impact of voice problems on a person’s quality of life. The participant
responds to a series of statements and ranks each statement on a scale from 0 to 4 yielding a possible score of 120. It is divided into three scales to assess physical, emotional, and functional domains. The authors consider a minimum difference of eighteen points between administrations to be indicative of a statistically significant change in perceived handicap due to the voice problem.

The second perceptual scale, the Voice Rating Scale (Appendix D) was developed by the investigator for the present study to explore its use for further detailing work-related voice problems. This scale simply represents a pilot development to evaluate whether it has potential use for ascertaining problems that occur with the voice in the workplace. The Voice Rating Scale is a series of statements that required the participant to rank the magnitude of work-specific vocal problems. Statements concerned the degree of difficulty speaking and being heard, the degree of vocal fatigue and voice loss, and the degree to which the voice problem affected job performance. It employed a visual analog scale in which the participant was asked to rank their response to each question on a 100-millimeter line. The response was then converted to a percentage. Participants were not shown their previous responses on the rating scales. For data analysis, the percentages obtained for each question were totaled, yielding a possible total score of 1000 points.

The third scale, also developed by the investigator, was the Vocal Effort Scale (Appendix E). This also employed a 100-millimeter visual analog scale on which participants rated their vocal effort at work and in social situations during the previous week. Responses were converted to percentages. Again, participants were blinded to responses from any previous measurement sessions.
Voice Measures

Listener ratings. Voice recordings were collected for each participant at each of the three measurement points. Each participant produced three /ɑ/ and three /i/ vowels as well as seven sentences taken from the Consensus Auditory Perceptual Evaluation of Voice (CAPE-V). The CAPE-V was developed by the American Speech-Language-Hearing Association’s Special Interest Division 3 for Voice and Voice Disorders in 2002. The voice samples were recorded in a sound-treated room using a Shure SM48 cardioid microphone with a frequency response of 55 to 14,000 Hz. Mouth-to-microphone distance was kept constant at six inches as recommended by Kay Elemetrics. The samples were digitized directly in the Computerized Speech Lab Model 4300B (Kay Elemetrics). A sampling rate of 44,100 Hz was used for later analysis with the hoarseness diagram software. One sentence (“We were away a year ago”) from each measurement point for each speaker was selected for perceptual testing. Therefore, a total of 54 stimuli were used for perceptual tests (18 speakers X 3 measurement points). A group of 10 listeners, all speech pathologists with special training in voice disorders, were recruited to rate the voice quality for the sentence samples. The raters were blinded to subject group and were unaware of whether the recordings were pre, mid, or post treatment conditions. 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. Therefore, each listener rated a total of 540 sentences (54 sentences X 10 blocks). 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 five-point rating scale with “one” representing normal voice quality and “five” representing severe voice quality. To minimize fatigue, listeners were provided with at least two breaks during the test session. Listeners required approximately 50 minutes to rate all 10 blocks of stimuli. In order to minimize the variability within and across listeners, data from the multiple observations was averaged to obtain a single judgment for each stimulus (Shrivastav & Sapienza, 2004).

**Stroboscopic ratings.** A group made up of seven speech pathologists and one medical doctor rated the pre and post-treatment stroboscopic examinations for the participants in the lesion group only. Stroboscopic assessments were completed using a stroboscopic rating form (Appendix F) 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 on whether the examination was completed pre or post-treatment. Data for the multiple observations of each of the parameters was averaged across raters for analysis.

**Pulmonary Measures**

Measures of expiratory muscle strength were taken weekly during the respiratory training condition. 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, USA) 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 occluded with a
nose clip. After inhaling to total lung capacity, the participant placed their lips around the mouthpiece and blew out as forcefully as possible. Repeated measures were taken with a one to two minute rest between trials, until three measurements within five percent 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 (Gosselink et al., 2000; Smeltzer et al., 1996; Suzuki et al., 1995).

**Aerodynamic Measures**

Subglottal pressure was defined as the minimum lung pressure necessary for the initiation and maintenance of vocal fold vibration for voice production. Subglottal pressures may be estimated from measures of intraoral pressure as described by Smitheran and Hixon, (1981). Specifically, the pressure between two oral air pressure peaks was linearly interpolated during a syllable train of alternating voiceless plosives and voiced vowels, making it possible to estimate the subglottal pressure during the voiced vowel segment. The middle four /pə/ syllables produced during the syllable train were used to measure subglottal pressure. The syllable train was produced at both “comfortable” and “loud” intensity levels, as determined by the participants themselves. 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 cmH₂O 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 (Titze, 1994). The same syllable train used for measuring intraoral pressure was utilized for estimating phonation threshold pressure. Participants were instructed to initiate voice at the lowest possible intensity level without whispering. They were allowed to practice until they were able to barely produce voice. 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 10,000 samples per second for all pressure measures.

**Acoustic Measures**

**Sound pressure levels.** Root-mean-square (RMS) intensity levels were calculated for intraoral pressure tasks using Matlab, (Mathworks, Inc., Version 6.5.1.) An ATM75 headset cardioid microphone (Audiotechnica), connected to an ART Tube MP preamplifier, was set at a two-centimeter distance from the participant’s mouth to record intensity level simultaneously with the pressure measures. The intensity of the microphone signal was calibrated in using 180 Hz pure tone signal at an intensity of 80dB SPL.

**Phonetogram.** An individual phonetogram, or voice range profile, a display of vocal intensity range versus fundamental frequency (Titze, 1994) 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 six-inch mouth to microphone distance as recommended by Kay Elemetrics.
Participants were asked to produce maximum variations in fundamental frequency at minimum and maximum intensity levels while producing an /a/ 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. The participant was instructed to repeat the maneuver multiple times until he/she 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.

The Voice Range Profile hardware is internally calibrated. However, the accuracy of the module was verified at the beginning of the study. Three tones, C4 (261.63 Hz), C5 (532.25 Hz), and C6 (1046.4 Hz), an octave apart, and encompassing the speaking range were generated using a BK Precision 5 megahertz function generator attached to a JBL Pro III speaker. Sound levels were verified using a Radio Shack Sound Level Meter set on the C Scale. The greatest error was noted at the lowest frequency with an input of 50dB. The Voice Range Profile system read this tone as 60dB. Errors ranging from +5 to +7 dB were noted from 60 to 80dB at this frequency. Minimal errors of 1 to 3 dB were noted at C5 from 60 to 90dB. The VRP module was most accurate at the highest frequency tested, C6.

**Hoarseness diagram.** Measures were made to calculate the coordinates of the vowel /a/ produced by all speakers on the hoarseness diagram. The hoarseness diagram is a relatively new measure, which consists of four acoustic measures that are plotted together (Frolich et al., 2000). The measures, jitter, shimmer, and mean period
correlation, form the horizontal axis of the diagram, which is labeled as the irregularity component. The fourth measure, the glottal-to-noise excitation ratio, is plotted on the vertical axis and is 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 /a/ productions. Freeware available from the authors’ website, www.physik3.gwdg.de/micha/english/hd.html, was used for determining the irregularity and noise components.

**Training Protocol**

Each participant was assigned to one of two groups based on laryngeal diagnosis. Group 1 consisted of persons with a diagnosis of muscle tension dysphonia or laryngeal irritation. Group 2 consisted of persons with a diagnosis of benign vocal fold lesions. Both groups received twice weekly sessions of voice therapy for a period of three weeks for a total of six sessions. Both groups also received five weeks of expiratory muscle strength training. Four of the participants with lesions and five of the participants from the non-lesion group completed the respiratory training first. Conversely, five of the participants with lesions and four of those without lesions completed the voice therapy component first.

The voice therapy sessions lasted approximately 45 minutes each and were conducted by a speech-language pathologist with specialized training in voice therapy. A script was followed for each session to minimize variability between participants. Topics covered included vocal and respiratory anatomy and physiology, vocal hygiene, increased awareness and activation of abdominal musculature during voice production, vocal
projection and resonance exercises, and daily homework activities. The voice therapy protocol is contained in Appendix G.

**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 (Figure 2-1). 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. As stated previously, the participants’ MEP was measured at the initiation of the study and at the beginning of each subsequent training week. The threshold pressure was set at 75% of the participant’s MEP at the time of measurement (pre-training 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 (Baker, 2003; Roy et al., 2003; Hoffman-Ruddy, 2001).

![Figure 2-1. Expiratory Pressure Threshold Training Device](image)
Both groups received five weeks of expiratory muscle strength training. MEP was measured weekly at approximately the same time of day. Participants were provided with written and verbal instructions for the completion of the training protocol (Appendix H).

**Compliance**

Participant compliance during the voice therapy phase was documented by the participant’s practice record (see Appendix G). Likewise, participants completed a training log daily during the expiratory muscle-training phase (Appendix I). Participants were provided with written instructions for the therapy component and for the use of the device during the expiratory muscle-training phase. Participants were instructed to call their voice therapist or the author at any time if they had questions or if problems arose in their practice regimen.

**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 since only pre and post-treatment measures were taken. The Wilcoxon Signed Ranks test was used to analyze rater evaluations of stroboscopic examinations. All analyses were carried out using SPSS software version 11.5.

Inter- and intra-rater reliability was carried out on 10% of the data that was measured by hand. To test the inter-judge reliability of the dependent variables, a
different examiner, a student trained in scoring the various measures, re-analyzed 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 intra-rater reliability, the author re-analyzed 10% of the data and compared the first set of measures against the second using Pearson $r$ correlations.
CHAPTER 3
RESULTS

This study determined the effects of expiratory muscle strength training combined with voice therapy on voice production in two groups of professional voices users, those with and without vocal fold lesions. The central hypothesis stated that expiratory muscle strength training combined with voice therapy would produce greater improvements in voice production than would voice therapy alone. Specific hypotheses were also proposed that a) both groups of participants would produce greater improvements in self-ratings of voice symptoms and effort following the combined modality treatment; b) that both groups would produce greater improvements in perceptual ratings of voice following the combined treatment modality; c) that both groups would produce greater improvement in respiratory pressures following the combined modality treatment; d) that both groups would produce greater improvements in acoustic measures, specifically the phonetogram and hoarseness diagrams, reflecting improvement in voice production, following the combined treatment approach; and e) that there would be a significantly greater response to treatment for the lesion group as compared to the non-lesion group. In order to test these hypotheses, a repeated measures analysis was used. Main effects were tested and comparisons of the pre-treatment, mid-treatment, and post-treatment conditions were completed. The mid-treatment condition indicated the time where each of the independent intervention methods was examined. At the mid-treatment condition, the effects of EMST or voice therapy were interpreted. The post-treatment condition reflected the effect of the combined modality treatment. 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 Voice Handicap Index, Vocal Rating Scales, MEPs, subglottal pressure produced at loud intensity, phonetogram area, and dynamic range.

**Reliability**

High correlations were found between the two sets of measurements made by the experimenter, suggesting high intra-judge reliability. High correlations were also found between ratings across multiple judges suggesting high inter-judge reliability. The Pearson $r$ between the first and second set of measurement (intra-judge reliability) ranged from 0.81 to 1.00 (Table 3-1). Likewise, for inter-judge measures, there was a strong positive correlation between the two measurers for the dependent variables listed (Table 3-2) with a range of 0.406 to 1.00. The reliability for the strobe ratings, although statistically significant, raises a question regarding their consistency and utility. Given this data, the reliability of the majority of the dependent variables was considered adequate for the purpose of the present experiment.

Table 3-1: Intra-judge reliability

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>$r$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEPs</td>
<td>1.000</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Strobe ratings</td>
<td>0.81</td>
<td>.015</td>
</tr>
<tr>
<td>Subglottal pressure – comfortable</td>
<td>1.000</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Subglottal pressure – loud</td>
<td>1.000</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Phonation threshold pressure</td>
<td>1.000</td>
<td>&lt;.01</td>
</tr>
</tbody>
</table>
Table 3-2: Inter-judge reliability

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>$r$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEPs</td>
<td>1.000</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Strobe ratings</td>
<td>.406</td>
<td>.026</td>
</tr>
<tr>
<td>Subglottal pressure-comfortable</td>
<td>.979</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Subglottal pressure – loud</td>
<td>.959</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Phonation threshold pressure</td>
<td>.931</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Perceptual Measures of Effort and Handicap

The first hypothesis stated that both treatment groups would report a greater reduction in vocal symptoms and vocal effort following EMST-training plus voice therapy as compared to the voice therapy condition alone. The results of the present study suggest this to be true, thus the first hypothesis was accepted. 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, $F(1,10) = 8.416, p = 0.016$, and 4 points between the mid and post-treatments which was not significantly different, $F(1,10) = 3.68, p = 0.084$. Similarly, the VRS scores were found to reduce by 83 points between pre and mid-treatment, $F(1,10) = 2.48, p = 0.146$ and 43 points between the mid and post-treatments, $F(1,10) = 5.493, p = 0.041$. Results for the group averages for the VHI are illustrated in Figure 3-1 and individual VHI scores are detailed in Figure 3-2. 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. Following 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 3-3 and individual VRS scores are in Figure 3-4. 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) while 23% had an increase in their scores (range = 28 to 358 points). Following the combined modality treatment, 61% of the participants indicated a decreased in VRS scores (range = 7 -235 points) while 39% of the participants had an increase in their VRS scores (range = 14 to 136 points).

Figure 3-1. Mean Voice Handicap Index scores before treatment, at the mid-point and following treatment.

Figure 3-2. Individual VHI scores before treatment, at the mid-point, and following treatment.
The VHI and VRS were highly correlated across treatment conditions across different speakers with correlations ranging from 0.751 to 0.894 (Table 3-3).

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 prior to the initiation of treatment \((r = 0.668, p = 0.002)\). No significant main effect was found for the vocal effort scales, \(F(1, 30) = 0.930, p = 0.343\).

Table 3-3. Correlations for VHI and VRS scales as well as VRS to functional and emotional subscales of VHI.

<table>
<thead>
<tr>
<th>Treatment Point</th>
<th>Total Scale (r)</th>
<th>(p)</th>
<th>Functional subscale</th>
<th>(p)</th>
<th>Emotional subscale</th>
<th>(p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>0.894</td>
<td>&lt;.001</td>
<td>0.668</td>
<td>0.002</td>
<td>0.326</td>
<td>0.187</td>
</tr>
<tr>
<td>Mid</td>
<td>0.751</td>
<td>&lt;.001</td>
<td>0.483</td>
<td>0.042</td>
<td>0.241</td>
<td>0.334</td>
</tr>
<tr>
<td>Post</td>
<td>0.783</td>
<td>&lt;.001</td>
<td>0.193</td>
<td>0.442</td>
<td>-0.003</td>
<td>0.991</td>
</tr>
</tbody>
</table>

**Voice Measures**

The second hypothesis stated that both groups would produce greater improvements in perceptual ratings of voice post-EMST training plus voice therapy than with voice therapy alone. The listener ratings for voice quality showed no significant main effect in the severity of voice quality ratings \(F(1.544, 24.712) = 3.233, p = 0.068\) (Figure 3-5). No significant differences were seen between the pre to mid treatment, \(F(1.544, 24.712) = 3.777, p = 0.07\) and the mid to post-treatment conditions, \(F(1.544, 24.712) = 3.603, p = 0.076\). The sphericity assumption was not met; therefore, the Huynh-Feldt correction was used to adjust the degrees of freedom for the averaged tests of listener ratings. 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). The ratings for individual participants are illustrated in Figure 3-6. 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) while 11% had no change and 11% had an improvement in voice quality (range = 0.1-0.74 points). Following 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 post-treatments (range = 0.07-0.1 points).

Figure 3-5. Changes in mean ratings of voice quality pre-treatment, at the mid-point, and following treatment.

Figure 3-6. Listener ratings for individual subjects before treatment, at the mid-point point, and following treatment.
**Stroboscopic 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 post-treatment. 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 post-examination as evidenced by visual examination. For the purpose of illustration, Figures 3-7 and 3-8 show the pre and post-treatment endoscopic images for two of the participants with resolution of their lesions. 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 post-treatment. The change in other ratings obtained was not statistically significant. The results for all the stroboscopic ratings are detailed in Table 3-4 and individual ratings for vocal edge and mucosal wave are illustrated in Figure 3-9 and Figure 3-10 respectively. Ratings of “0” represent normal with ratings of “6” representing severe abnormality. Pre to post-treatment, 75% of the subjects showed a decrease in rating for the left vocal fold edge (range = 0.13-1.42 points) while 1 participant (12.5%) showed no change in rating and 1 participant (12.5%) showed an increased rating. For the right vocal fold edge, 63% of the participants showed decreased ratings post-treatment (range = 0.125-0.875 points), 1 participant (12%) had no change and 25% had an increased rating (range = 0.02-0.875 points). For mucosal wave, 1 participant did not receive ratings due to an inadequate stroboscopic examination so data are reported for only 7 participants. For the left mucosal wave, 43%
of the participants had an increase in rating (range = 0.25-1.37 points), 1 participant (0.05%) had no change, and 43% had a decrease in rating (range = 0.125-1 point). For right mucosal wave, 57% had decreased ratings (range = 0.375-1.25 points), 1 (14%) had no change, and another 29% had increased ratings pre to post-treatment (range = 0.25-0.75 points). The second hypothesis was rejected based on the results obtained.

Figure 3-7. Pre and post treatment endoscopic image for participant 10.

Figure 3-8. Pre and post endoscopic images for participant 12.
Table 3-4. Rater evaluations of stroboscopic evaluations pre to post-treatment.

<table>
<thead>
<tr>
<th>Stroboscopic Parameter</th>
<th>Z</th>
<th>p</th>
<th>Mean pre</th>
<th>S.D.</th>
<th>Mean Post</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vocal fold edge left</td>
<td>-2.201</td>
<td>.028</td>
<td>1.05</td>
<td>.722</td>
<td>639</td>
<td>.54</td>
</tr>
<tr>
<td>right</td>
<td>-1.103</td>
<td>.270</td>
<td>.89</td>
<td>.55</td>
<td>676</td>
<td>.46</td>
</tr>
<tr>
<td>Mucosal wave left</td>
<td>-1.350</td>
<td>.156</td>
<td>1.58</td>
<td>1.55</td>
<td>1.16</td>
<td>1.16</td>
</tr>
<tr>
<td>right</td>
<td>-.677</td>
<td>.498</td>
<td>1.03</td>
<td>.66</td>
<td>.91</td>
<td>.41</td>
</tr>
<tr>
<td>Amplitude left</td>
<td>-.933</td>
<td>.351</td>
<td>1.17</td>
<td>.68</td>
<td>1.07</td>
<td>.52</td>
</tr>
<tr>
<td>right</td>
<td>-.734</td>
<td>.463</td>
<td>1.17</td>
<td>.64</td>
<td>1.07</td>
<td>.39</td>
</tr>
<tr>
<td>Closure</td>
<td>-.700</td>
<td>.484</td>
<td>2.99</td>
<td>.89</td>
<td>3.36</td>
<td>.8</td>
</tr>
</tbody>
</table>

Figure 3-9. Stroboscopic ratings pre to post-treatment for left and right vocal fold edges.

Figure 3-10. Stroboscopic ratings pre to post-treatment for left and right vocal fold mucosal wave.
Pulmonary and Aerodynamic Measures

The third hypothesis theorized that both groups would produce greater improvement in respiratory pressure post-EMST training plus voice therapy than following voice therapy alone. This was true for maximum expiratory pressures that showed a significant main effect from pre to post-treatment \( t(17) = -8.063, p = <.001 \). Mean MEP pre-treatment was 85.92 cmH\(_2\)O (s.d. = 26.14) and mean MEP post-treatment was 147.87 cmH\(_2\)O (s.d. = 42.27). Increases in MEP post-treatment ranged from 17.88% to 130% with an average increase of 76.94%. Results for MEP are shown in Figure 3-11 with individual measures of MEP illustrated in Figure 3-12.

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, \( F (2, 20) = 0.406, p = .672 \) 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 post-treatment for subglottal pressure at comfortable loudness or for phonation threshold pressure. Based on this data and the data for MEPs, the third hypothesis was accepted.

![Figure 3-11](image.png)

Figure 3-11. Maximum expiratory pressure changes before and after treatment.
Figure 3-12. Individual changes in maximum expiratory pressure pre to post-treatment.

**Acoustic Measures**

The fourth hypothesis predicted that both groups would produce greater improvements in frequency and time domain measures post-EMST training plus voice therapy than following voice therapy alone. This proved to be true for the phonetogram (Figure 3-13). The area of the phonetogram increased significantly from pre to post-treatment, \( F(2, 20) = 21.667, p = <0.001 \). After the first treatment condition, the increase was not statistically significant, \( F(1, 10) = 0.859, p = 0.376 \). Between mid and post-treatment, the area increased significantly, \( F(1, 10) = 48.74, p = <0.001 \). Changes for each participant for phonetogram area are detailed in Figure 3-14 with examples of pre and post-treatment phonetograms shown in Figures 3-15 and 3-16. 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) while area for 2 of the 18 (11%) remained the same or decreased (range = 0-84 units). Dynamic range increased
significantly pre to post-treatment $F(2, 20) = 7.153, p = 0.007$ (Figure 3-17) with the
greatest change occurring between the mid and post-treatment conditions, $F(1, 10) = 20.793, p = 0.001$. No significant increase occurred between the pre and mid-treatment
conditions, $F(1, 10) = 0.443, p = 0.521$). Individual data for change in dynamic range is
detailed in Figure 3-18. 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) while 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 post-treatment conditions, $F(1, 10) = 4.344, p = 0.064$. There was a
significant difference noted for frequency range between males and females. This
suggests that the increase in the phonetogram area following treatment was primarily a
consequence of a change in the intensity dynamic range.

![Figure 3-13. Change in phonetogram area following treatment.](image)
Figure 3-14. Changes in phonetogram area for individual participants pre, mid, and post-treatment.

Figure 3-15. Pre-treatment phonetogram for participant 7.

Figure 3-16. Post-treatment phonetogram for participant 7.
Figure 3-17. Average dynamic range pre-treatment, at the mid-treatment point, and following treatment.

Figure 3-18. Change in dynamic range for each participant pre, mid, and post-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. Therefore, the fourth hypothesis was accepted based on the improvements in the phonetogram.

**Differences between Lesion and Non-lesion groups**

The fifth hypothesis proposed that the group with benign vocal fold lesions would demonstrate greater improvements overall than the non-lesion group following the combined treatments of EMST and voice therapy compared to voice therapy alone. Only
one dependent variable, estimated subglottal pressure at loud intensity levels, showed a statistically significant difference between the lesion and non-lesion groups $F(1,30) = 26.543, p = <.001$). This is highlighted in Figure 3-19. Data for the remaining dependent variables is shown in Table 3-5. Therefore, the fifth hypothesis was rejected.

Table 3-5. Effect of lesion on dependent variables.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>$F$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voice Handicap Index</td>
<td>.004</td>
<td>.950</td>
</tr>
<tr>
<td>Vocal Rating Scale</td>
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<td>.321</td>
</tr>
<tr>
<td>Speaking effort at work</td>
<td>602</td>
<td>.444</td>
</tr>
<tr>
<td>Speaking effort socially</td>
<td>029</td>
<td>.866</td>
</tr>
<tr>
<td>Subglottal pressure, comfortable intensity</td>
<td>3.681</td>
<td>.065</td>
</tr>
<tr>
<td>Subglottal pressure, loud intensity</td>
<td>26.543</td>
<td>$&lt;.001$</td>
</tr>
<tr>
<td>Phonation threshold pressure</td>
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<td>.841</td>
</tr>
<tr>
<td>Phonetogram area</td>
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</tr>
<tr>
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<td>Frequency range</td>
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<tr>
<td>Irregularity</td>
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<td>.481</td>
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<tr>
<td>Noise</td>
<td>.725</td>
<td>.401</td>
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Figure 3-19. Estimated subglottal pressure at loud intensity for non-lesion and lesion groups.
CHAPTER 4
DISCUSSION

The central hypothesis for this study was that expiratory muscle strength training combined with voice therapy would produce greater improvements in voice production than would voice therapy alone. In general, this was the case. 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. While there was some significant effect found when comparing the pre to mid-treatment conditions, the number of dependent variables that responded to the independent treatments were fewer. Certainly it could be argued that it was simply the greater duration of treatment that influenced the dependent variables as opposed to the combination of EMST and voice therapy this argument cannot be resolved from the study. The findings of this study do indicate that EMST plus voice therapy when combined did result in different and more improved function than EMST or voice therapy alone. Future study of additional research arms is suggested.

Perceptual Measures of Effort and Handicap

Voice Handicap Index. The first hypothesis was that both therapy groups would report greater reduction in vocal symptoms and vocal effort following the combined treatments as compared to the voice therapy condition alone. Significant improvements from pre to mid-treatment were found for the VHI but not for the mid to post-treatment condition, suggesting that the individual treatments (EMST or voice therapy) resulted in a decrease in vocal handicap as perceived by the participants involved in those treatments.
The individual subject ratings support the pre to mid post treatment contrast showing that 83% of the patients responded positively on the VHI following the individual treatments.

The finding of no significant effect from mid to post-treatment indicates that combining treatments did not further benefit the participant by decreasing vocal handicap to a greater extent. It may be that once the participant perceived a change in the status of their voice, they responded more 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 can result in a positive effect within 4 to 6 weeks. 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 (Haas, Hill, Lambert, & Morrell, 2002). 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 (Rosen & Murry, 2000). Therefore, the patient’s perception of improvement following treatment is an important factor to indicate the success of treatment (Rosen et al., 2000). 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 (Roy et al., 2003; Roy et al., 2001; Rosen, Murry, Zinn, Sullo & Sonbolian, 2000).
**Vocal Rating Scale.** The statements on the VRS were pertinent to the problems of professional voice users on the job, with content focusing on specific situations and needs in the workplace. The majority of the statements were of a functional nature. This scale was developed by the author to complement the VHI that has functional (physical), emotional, and social subscales related to overall functioning including home and social settings. The VRS was found to be highly correlated with overall VHI score but not highly correlated with the functional or emotional subscales. So while there is some redundant information being gathered from the use of the VHI and VRS it is also apparent that there is information on the VRS that is distinct from the VHI.

Interestingly, the VRS scores did not show significant change pre to mid-treatment but did change mid to post-treatment. The individual participant data showed that 61% of the participants decreased their VRS scores following the combined modality treatments. This suggests that the combined modality treatment served to decrease the participant’s perception of how their voice difficulty was impacting functional activities in daily living. There must be a reason that the participants felt like there was a greater improvement with the combined modality treatment. First, it could be that the VRS was more specific to issues surrounding work and as the participants spent more time in therapy, they were able to learn how to modify their voice in the workplace, therefore impacting their rating of their vocal difficulties. And while the VHI and VRS were highly correlated, correlation does not equate with specificity. While items may have a relationship with each other, certain questions are able to specifically target a participant’s perception of how well they are performing in a particular situation better than others. For example, participants were asked to rank the degree to which their job...
performance was affected by their voice problem or the degree to which they lost their voice after prolonged talking. These statements are much more highly focused and specific than the statements on the VHI. For example, the VHI asks the participant to rank how their voice difficulty restricts their personal and social life, a much more general question that does not target specifically work performance. The professions of these participants were all very reliant on the use of the voice. Any degradation of the voice in these professional voice users would highly impact their job performance. So, it appears that the VHI and the VRS are complementary but yet different in their specificity with regard to how voice disorders handicap individual situations.

**Vocal effort scales.** The ratings of effort to speak, both at work and socially, did not show a statistical main effect. However, notably 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. While these scores were not statistically significant, the decrease in effort scores appears to have some clinical significance. As previously 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 prior to 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 appear to develop as positive reinforcement is repeated over time (Aarts, Paulussen & Shaalma, 1997). The exact time frame required for establishment of habit vary among individuals but may take six months or more to become fully established (Vallis, Ruggiero, Greene, Jones, Zinman et al., 2003). 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.

**Voice Measures**

**Listener ratings.** The second hypothesis predicted that both groups would produce greater improvements in voice quality as judged by perceptual ratings made by qualified listeners post EMST training plus voice therapy than with voice therapy alone. This hypothesis was supported by listener evaluation of voice quality for all of the participants. The listener ratings between the pre and mid-treatment conditions and the mid and post conditions were not significant.

There were 2 subjects that had fairly high ratings when evaluated in the mid-treatment condition, which may have skewed the results to some degree. Participant 12, a middle school classroom teacher, showed a large increase in voice quality rating at the mid-treatment test point. She reported that she might have been developing a throat infection at the time. Additionally, she was in a period of high personal stress due to illness in her family. Also, participant 18 may have an emerging diagnosis of spasmodic dysphonia, in the opinion of the author and the clinician who provided the treatment for
the study. His voice quality was typically inconsistent throughout the study. However, when the results were re-analyzed with these 2 participants removed from the database, the contrast of the mid to post-treatment condition remained non-significant. Finally, it is important to recall that the majority of participants reported improvement by self-rating and that other quantitative measures showed improvements as well.

The main reason that the listener ratings did not result in significant effects with either the individual or combined modality treatments 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 pre-treatment, obtaining a change in quality as a function of treatment was difficult.

The individual subject data does positively describe however that 72% of the participants improved their voice quality with the combined modality treatments, although the differences in ratings were small.

**Stroboscopic ratings.**

**Lesion status.** Half of the participants in the lesion group had some resolution of their benign vocal fold lesions from mid to post-treatment. The other half did not show measurable improvement on stroboscopic examination post-treatment. This is similar to results obtained by Holmberg and colleagues (2001) with a group of women with vocal fold nodules. Following voice therapy, 80% of their participants demonstrated a decrease in nodule size and edema. Resolution of 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, following an 8 to 9 week time course of rehabilitation, would respond better than at a 4 week time frame. Obviously, in order to determine this potential criticism, one would have to study multiple treatment techniques while manipulating duration of treatment. Of note, the participants whose lesions resolved all had reductions in VHI from pre to post-treatment and all but one had reductions in VRS scores pre to post-treatment.

**Other physiologic parameters.** Only one parameter, the left vocal fold edge, showed a statistically significant improvement pre to post-treatment. The mid to post-condition 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-post condition was examined. In performing the stroboscopic examinations, 3 different clinicians were involved using 2 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 strobe parameters for each examination as they felt the samples were inadequate for evaluation. Furthermore, in our study there were 8 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 (1998) 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. Rather than drawing specific conclusions about the changes that occurred in the laryngeal dimensions in the stroboscopic examinations, it appears that more careful control of the stroboscopic
system requirements as well as the number of clinicians who are rating the examinations must be considered. These concerns were evident based on the poor inter-rater reliability found for the stroboscopic parameters.

**Pulmonary and Aerodynamic Measures**

The third hypothesis stated that both groups would produce greater improvement in respiratory pressure post-EMST training plus voice therapy than following voice therapy alone. This was the case for MEP and for subglottal pressure produced at loud intensity level.

The average increase in MEP of nearly 77% was consistent with increases in MEP found in previous studies with healthy individuals, performers, and high-school band students (Baker, 2003; Hoffman-Ruddy, 2001; Sapienza et al., 2001). All participants increased MEP from pre to post treatment.

It is reasonable to conclude that the increased MEP could aid in improving the overall voice quality produced by the participants. For the group that initiated the therapy program with EMST first, the increase in MEP was associated with a positive change in VHI score. For the group that initiated EMST training second with regard to treatment order, there was a significant decrease in VRS scores. Given the correlation between the VHI and VRS, it is reasonable to conclude that both groups exposed to the EMST training paradigm experienced reductions in vocal handicap and/or vocal difficulties. A greater demand for increased respiratory drive exists during long speaking tasks (Hixon, 1987). This necessitates the active use of expiratory muscles to increase the drive for phonation, as passive lung recoil is not able to meet the pressure demands. The increased strength of the respiratory muscles may enhance the individual’s ability to generate and
maintain the required pressure because the driving force of the respiratory system is increased (Baker, 2003), thereby improving the physiological function of the vocal folds.

Subglottal pressure for normal conversation typically ranges from 4 to 6 cmH$_2$O (Baken & Orlikoff, 2000). Subglottal pressures for participants without lesions were within the normative range pre (3.6-8.7 cmH$_2$O) and post-treatment (5.3-8.6 cmH$_2$O). The participants identified as having vocal fold lesions demonstrated an average higher subglottal pressure both pre (5.1-16.4 cmH$_2$O) and post-treatment (4.3-14.8 cmH$_2$O). This is consistent with reports of higher transglottal air pressure in patients with benign lesions. In a study by Holmberg and colleagues (2003), transglottal pressures were 2 to 6 standard deviations higher for patients with lesions as compared to normal subjects. This may reflect the increased mass and stiffness of the vocal fold and/or hyperfunctional voice production. No significant main effect was seen in subglottal pressure produced at comfortable intensity post-treatment. This 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 cmH$_2$O following the combined treatment.

Subglottal pressures associated with increased vocal intensity typically range from 8 to 20 cmH$_2$O (Baken & Orlikoff, 2000; Hixon, 1987). The non-lesion group showed a range of 5.2-11 cmH$_2$O pre-treatment, which is within normal limits but on the lower end of the normal range (Isshiki, 1964). Following the combined modality treatment, the range increased from 6.5-14, a 1 to 3-cmH2O 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 previously.
The capability to increase the subglottal pressures used to produce a louder voice certainly would impact 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, individuals 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 (Case, 1991; Titze, 1994). 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 (Titze, 1994).

Phonation threshold pressures did not show significant main effect. Phonation threshold pressure is reported to be between 3 to 4 cmH2O (Baken & Orlikoff, 2000; Titze, 1994). The non-lesion group demonstrated a range of 1.97 to 10.6 cmH2O pre-treatment with a range of 2.7-5.4 cmH2O post-treatment. This indicates some move toward more normalized phonation threshold pressures for the non-lesion group. The lesion group did not show a similar trend (pre-treatment: 2.25-7.24 cmH2O; post-treatment: 1.96-9.90 cmH2O).

Admittedly, producing phonation threshold pressures was a difficult task for the participants to perform, as is evident from the wide range of values acquired. During completion of the phonation threshold task it appeared as if the participants were performing the task correctly, yet the pressure values remained high. With cases of voice disorders, obtaining the softest phonation could have resulted in a glottal configuration that was more likened to a whisper rather than a more abducted state for soft phonation.
In fact, while not perceptually notable, the participants could have been producing the task with a certain degree of hyperfunction thus resulting in a higher phonation threshold pressure. Colton and Casper (1990) discussed how patients can obtain a targeted voice quality with a variety of glottal configurations, therefore concluding that what you hear is not always related to what is expected in glottal configuration.

**Acoustic Measures**

The fourth hypothesis predicted that both groups would produce greater improvements in acoustic measures taken from the phonetogram and hoarseness diagram, post-EMST training plus voice therapy than following voice therapy alone. Although significant increases in the phonetogram area and the dynamic range were observed, measures of irregularity and noise did not show any significant main effect.

Phonetograms are representative of the output of the entire phonatory mechanism (Coleman, 1993) and have been considered as a measure of voice coordination (Ikeda, Masuda, Manako, Yamashita, Yamamoto, et al., 1999). The increased area shown mid to post-treatment is considered a positive outcome of the combined modality treatment (Speyer, Weineke, VanWijck-Warnaar, & Dejonckere, 2003). 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 seen 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 (Akerlund, 1993; Gelfer, 1986). 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 while it may differ up to 10dB across administrations, on average the variation is about 3dB (Gramming et al., 1991). The participants in this study demonstrated a significant change mid to post-treatment (i.e. combined modality) with an average increase of 10dB. Individual participants increased dynamic range from 3 to 22 dB above and beyond the 1 to 19 dB range acquired with the individual treatments. This change may also be attributed to the combined treatment modality and reflects increased power.

The hoarseness diagram, particularly its noise component, is applicable for highly irregular oscillations (Michaelis et al., 1997). The measures of irregularity and noise did not demonstrate a significant main effect. The group mean for the irregularity component prior to treatment was 4.304 and decreased to 4.084 post-treatment. The group mean for noise was 1.128 pre-treatment and decreased to 0.867 post-treatment. While this is generally a sensitive measure, it may not be sensitive enough to detect differences in moderately or mildly impaired voices. According to Frolich and colleagues (2000), 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 (p. 716). The stroboscopic ratings for the participants in this study also did not indicate a disturbance to glottal closure or irregularity of vocal fold vibration. This explains why no significant improvement was seen for this measure. This measure was selected prior to enrolling participants in the study. It was unanticipated 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.

**Differences Between Lesion and Non-Lesion Groups**

The fifth hypothesis stated that the group of participants with benign vocal fold lesions would show greater improvements in all measures following the combined EMST training and voice therapy. The only difference between the two groups was 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 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 (i.e., small vocal nodules). Future studies of the impact of therapy on benign lesions needs 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.
Combined Modality Treatment

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. Basiouny (1998) studied the efficacy of the Accent Method of voice therapy, which combines respiratory and phonatory exercise. The therapy protocol consisted of ten sessions over a five-week period. Like the present study, he found improvements in vocal and aerodynamic parameters. Murry and Woodson (1995) compared the effect of Botox treatment alone to Botox treatment combined with 5 sessions of voice therapy for patients with adductor spasmodic dysphonia. Therapy targeted muscle hyperfunction and regulation of airflow during phonation. They found a prolonged effect of Botox when it was combined with voice therapy. Holmberg et al. (2001) found that significant changes in voice parameters occurred after direct facilitation of voice and respiration phases of treatment. The direct facilitation phase utilized reduction of loudness and yawn-sigh exercises. The respiration phase focused on decreased effort for speech breathing and improved breath management. Holmberg's experiment was similar to the present study but was spread over 15 sessions occurring in a 4 to 6 month time frame. The current study is the first to combine specific expiratory muscle training 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. Each of the studies references above examined one particular patient group (those with nodules and spasmodic dysphonia). The lack of data on EMST and how it effects 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, in order 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 4 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.

**Strengths of the Present Study**

The present study is an easily followed program with strong applicability to professional voice users. The time frame is reasonable and results occur within a relatively short period of time (8 to 9 weeks). The EMST component is device-driven and serves to illustrate quantifiable results to participants immediately, providing positive reinforcement for continued practice. Many participants commented that they felt this aspect of the program made a discernible difference in their daily respiratory patterns for speech. The voice therapy component is easy to follow and allows for daily practice by the participant in a reasonable amount of time. The emphasis is on speaking activities that can be readily incorporated into routine speaking activities for the professional voice user. Further, this program requires minimal training for voice clinicians and could easily be incorporated into their clinical practice.

**Limitations of the Current Study**

The therapy protocol for this study was scripted so that all participants received the same instruction. However, this did not allow for individual differences in speed of learning for each phase of the treatment. Likewise, there was no provision for dealing
with specific problems that are commonly encountered in voice therapy, such as excessive laryngeal tension. Additionally, some participants may have benefited from additional practice with the resonance and projection exercises which were covered in two sessions. These concepts were difficult for some participants to fully master within the limited time frame.

The study did not address maintenance of the behaviors learned. This is an area that is lacking in most therapy programs. As previously noted, habituation of learning may take up to 6 months to occur. Therefore, a provision for intermittent follow-up may be of use in the future.

**Application of the Protocol**

The current protocol demonstrated success in affecting change in many voice parameters that are important for professional voice users. The reasonable time frame is attractive to the larger population of professional voice users. The time demands should be easily incorporated into most work schedules. The activities utilized can be quickly applied in the employment setting, minimizing time away from work. The ultimate result of the voice improvements seen should be a reduction in missed workdays due to vocal problems.

**Future Studies**

Future studies should add additional research arms as stated above as well as comparing longer treatment protocols to the current protocol to fully determine the impact of time on these vocal changes. Additionally, the development of a maintenance component to study carryover of behavior is needed. Comparison of participants receiving maintenance therapy to those receiving no follow-up should be explored.
To determine if changes in the phonetogram were a result of the combined modality treatment or resulted from a practice effect, a study of changes in the phonetogram over time, with no treatment offered, should be undertaken for a sample of professional voice users.

Other types of voice treatment, specifically Vocal Function Exercises (Stemple et al., 1994) and the Lee Silverman Voice Treatment (Ramig, Countryman, Thompson, & Horii, 1995) should be combined with EMST training. By comparing different combinations of treatments, recommendations for designing a highly effective program for occupational voice users could be made.

The VHI and VRS should be utilized in future studies as they effectively demonstrate clinically significant improvements in self-perception. Additionally, the phonetogram appears to be a sensitive and efficient means for quantifying vocal change. As previously mentioned, other acoustic analysis may be more sensitive for documenting vocal improvement in professional voice users than the measures used in the current study.

Further, the prevention of voice disorders is an area lacking in research. Future research, of a longitudinal nature, could be undertaken with professional speakers to determine if the combination of EMST and voice therapy might help delay or prevent the development of vocal problems in occupational voice users.
APPENDIX A
INFORMATION FLYER

DO YOU HAVE PROBLEMS WITH YOUR VOICE?

To be eligible you must:
♦ have complaints of voice problems
♦ use your voice at work for 4 or more hours a day
♦ be between 21 and 65 years of age
♦ have no history of cardiac, lung, neuromuscular, or immune system disease, or hypertension
♦ have no history of smoking or tobacco use in the last five years

As part of this study you will receive voice therapy. For more information contact Judy Wingate at (352) 392–2046, ext. 221, Department of Communication Sciences and Disorders, University of Florida.

This study is supervised by Christine Sapienza, (352) 392–2046, ext. 221
APPENDIX B
SCREENING QUESTIONNAIRE

WRITTEN QUESTIONNAIRE

I. Demographics

Name__________________________________ Sex________
Address__________________________________
City____________ State_______ Zip Code_______
Birthdate________ Tel: (H)______________ (W)________
Occupation__________________________ # years in occupation _______
# of hours worked per week _______

II. Physical Characteristics

Height_________ Weight_________

1. Rate your health on this scale compared to others your age.

1= very good
2= good
3= fair
4= poor
5= very poor

2. List the major surgeries you have had within the last 5 years.

3. Are you being treated at the present time for any medical conditions? If yes, please specify.
4. Please list your medications.

5. Do you have asthma or other conditions that affect your breathing? ___Y___N

6. ___Y___N Have you had a recent cold or flu?

7. ___Y___N Do you have allergies?

8. ___Y___N Have you ever smoked tobacco products?
   If you used to smoke, for how many years and when did you stop?

III. Past Medical History (Have you had a past medical history for any of the following? Circle as many as apply.)

- high blood pressure
- kidney disease
- urinary tract infections
- diabetes
- gastritis
- diverticulosis
- gall bladder disease
- lung disease
- hormonal problems
- ovarian or uterine problems
- prostate problems
- spastic bowel syndrome
- cardiac problems
- gastroesophageal reflux disease
- thyroid problems
- liver diseases
- bleeding problems
- peptic ulcer
- hiatal hernia
- skin conditions
- colitis
- pancreatitis
- arthritis
- neurological problems
- history of cancer
- hernias
- incontinence

10. Do you plan to increase or decrease your physical activity over the next several months? Yes/No  If yes, how do you plan to change? ________________

11. How much water do you drink each day?

12. How much caffeine do you drink each day?

13. Do you use an amplifier or microphone when you are at work? ___Y___N

14. Please estimate the percentage of time you spend talking while at work. ________________

15. Do you participate in any of the following when you are not at work?
   ___Singing  ___Coaching  Other activities requiring voice use ___(Please describe)
APPENDIX C
VOICE HANDICAP INDEX

Instructions: These are statements that many people have used to describe their voices and the effects of their voices on their lives. Circle the response that indicates how frequently you have the same experience.

0 = Never 1 = Almost Never 2 = Sometimes 3 = Almost Always 4 = Always

Part I-F

1. My voice makes it difficult for people to hear me.
   0 1 2 3 4

2. People have difficulty understanding me in a noisy room.
   0 1 2 3 4

3. My family has difficulty hearing me when I call them throughout the house.
   0 1 2 3 4

4. I use the phone less often than I would like to.
   0 1 2 3 4

5. I tend to avoid groups of people because of my voice.
   0 1 2 3 4

6. I speak with friends, neighbors, or relatives less often because of my voice.
   0 1 2 3 4

7. People ask me to repeat myself when speaking face-to-face.
   0 1 2 3 4

8. My voice difficulties restrict personal and social life.
   0 1 2 3 4

9. I feel left out of conversations because of my voice.
   0 1 2 3 4

10. My voice problem causes me to lose income.
    0 1 2 3 4
Part II-P

1. I run out of air when I talk.
   0 1 2 3 4
2. The sound of my voice varies throughout the day.
   0 1 2 3 4
3. People ask, “What is wrong with your voice?”
   0 1 2 3 4
4. My voice sounds creaky and dry.
   0 1 2 3 4
5. I feel as though I have to strain to produce voice.
   0 1 2 3 4
6. The clarity of my voice is unpredictable.
   0 1 2 3 4
7. I try to change my voice to sound different.
   0 1 2 3 4
8. I use a great deal of effort to speak.
   0 1 2 3 4
9. My voice sounds worse in the evening.
   0 1 2 3 4
10. My voice “gives out” on me in the middle of speaking.
    0 1 2 3 4

Part III-E

1. I am tense when talking to others because of my voice.
   0 1 2 3 4
2. People seem irritated with my voice.
   0 1 2 3 4
3. I find that other people don’t understand my voice problem.
   0 1 2 3 4
4. My voice problem upsets me.
    0 1 2 3 4

5. I am less outgoing because of my voice problem.
    0 1 2 3 4

6. My voice makes me feel handicapped.
    0 1 2 3 4

7. I feel annoyed when people ask me to repeat.
    0 1 2 3 4

8. I feel embarrassed when people ask me to repeat
    0 1 2 3 4

9. My voice makes me feel incompetent.
    0 1 2 3 4

10. I am ashamed of my voice problem.
    0 1 2 3 4
APPENDIX D
VOICE RATING SCALE

Name ______________________________________ Date __________________________

Please rank the severity of each statement by marking an “x” 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:
   ____________________________
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 E
ESTIMATE OF VOCAL EFFORT

Please rank the severity of each statement by marking an “x” 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
## APPENDIX F
### STROBOSCOPY ASSESSMENT FORM

Exam #: __________

Please rank the following by circling your choice:

<table>
<thead>
<tr>
<th></th>
<th>Normal</th>
<th>Mod. Decrease</th>
<th>Absent</th>
<th>Rough/Irregular</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vocal Fold Edge</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Right</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

| **Mucosal Wave**     |        |               |        |                 |
| Left                 | 0      | 1             | 2      | 3               | 4 | 5 |
| Right                | 0      | 1             | 2      | 3               | 4 | 5 |

| **Amplitude**        |        |               |        |                 |
| Left                 | 0      | 1             | 2      | 3               | 4 | 5 |
| Right                | 0      | 1             | 2      | 3               | 4 | 5 |

| **Glottic Closure**  | Complete | Posterior Irreg. | Spindle Anterior | Hourglass | Incomplete |
|                      | 0        | 1               | 2             | 3         | 4 | 5 | 6 |

| **Phase Closure**    | Whisper | Normal | Hyperadduction |
|                      | 1       | 2      | 3             | 4         | 5 |

Adapted from University of Wisconsin, Stroboscopic Assessment Form
Session 1: Controlled Breathing (Clinician Script)

Your voice is produced using a power source and a sound source. The power source for your voice is air coming from your lungs. The sound source is the larynx. The lungs take in air. As you exhale and close your vocal folds, the vocal folds vibrate and produce sound. The sound is then shaped into speech by the tongue, teeth and lips.

In order to sing or to produce long utterances, it is useful to prolong exhalation. The abdominal muscles help control exhalation. Good posture allows the abdominal muscles to work best. Your spine should be straight with shoulders relaxed. Your head should be in a neutral position with the chin parallel to the floor. Ideally, you should be standing and your knees should be relaxed so that you can shift your weight easily.

You should do each of these exercises daily until your next session and record your practice on the exercise sheet. We will go through these together and make sure that you understand each exercise and can perform it correctly.

Exercise 1:

1. Correct your posture as described above.
2. Blow out all of your air.
3. Now, breathe in through an open, relaxed mouth. Concentrate on the movement of your abdominal muscles. They will move in an outward direction as air comes in. You should not experience movement in your chest or shoulders as you breathe in.
4. Next, exhale slowly on “f” and concentrate on keeping the flow of air steady. You should feel the abdominal muscles begin to pull in as you near the end of your breath.
5. Repeat slowly until you feel comfortable with this exercise.

Exercise 2:

1. Place yourself in correct posture.
2. Blow out all of your air.
3. Pant like a dog for 5 seconds. Feel the abdominal muscles contract and release. Be sure to let your tongue hang out of your mouth as you pant.
4. Repeat 5 times.
Exercise 3:

1. Place yourself in correct posture.
2. Blow out all of your air then inhale.
3. Blow out 5 times on “sh” as if you are blowing out candles. Stop and start the airflow.
4. Repeat 4 times. Feel the movement of your abdominal muscles.

Session 1, Exercise 1 (Subject Practice Worksheet):

1. Place yourself in correct posture.
2. Blow out all of your air.
3. Now, breathe in through an open, relaxed mouth. Concentrate on the movement of your abdominal muscles. They will move in an outward direction as air comes in. You should not experience movement in your chest or shoulders as you breathe in.
4. Next, exhale slowly on “f” and concentrate on keeping the flow of air steady. You should feel the abdominal muscles begin to pull in as you near the end of your breath.
5. Repeat slowly until you feel comfortable with this exercise.

Session 1, Exercise 2:

1. Place yourself in correct posture.
2. Blow out all of your air.
3. Pant like a dog for 5 seconds. Feel the abdominal muscles contract and release. Be sure to let your tongue hang out of your mouth as you pant.
4. Repeat 5 times.

Session 1, Exercise 3:

1. Place yourself in correct posture.
2. Blow out all of your air then inhale.
3. Blow out 5 times on “sh” as if you are blowing out candles. Stop and start the airflow.
4. Repeat 5 times. Feel the movement of your abdominal muscles.

Practice Record

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Ex. 1 - # reps</th>
<th>Ex. 2 - # reps</th>
<th>Ex. 3 - # reps</th>
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</table>
Session 2: Voice Onset (Clinician Script)

Today’s session will focus on how you turn your voice on. First we will review the exercises from the previous session. Please let me know if you have any questions. (Review exercises from session 1 on previous sheet.)

As you speak, it is important that you use exhalation. Remember, the air flowing out of your body is the power supply for your voice. With the following exercises, you will learn to coordinate airflow and your voice. To avoid any excessive force when turning on your voice, you will begin by letting out a small amount of air and then turning on your voice. When speaking, you will take a short inhalation followed by a prolonged exhalation. The drawing below illustrates this idea. Your voice will continue as long as you have air available.

![Drawing of airflow for voice on]

We will go over the next set of exercises. Again, you will practice these exercises daily until your next session. Record your practice in the table provided. You may also use these exercises as a “warm-up” before speaking on the job.

Exercise 1:

1. Take a short breath in. Begin to release air and prolong the sound “ha”. Feel the air at your mouth as you begin to exhale. Sustain the “ha” for as long as you can.
2. Repeat 4 times. Remember to always begin with air.

Exercise 2:

1. Repeat the exercise above with each of the following vowels: “he”, “ho”, “who”. Be sure to do 4 repetitions of each, sustaining as long as you can.

Session 2, Exercise 1 (Subject Practice Worksheet)

1. Take a short breath in. Begin to release air and prolong the sound “ha”. Feel the air at your mouth as you begin to exhale. Sustain the “ha” for as long as you can.
2. Repeat 5 times. Remember to always begin with air.
Session 2, Exercise 2:

1. Repeat the exercise above with each of the following vowels: “he”, “ho”, “who”. Be sure to do 5 repetitions of each, sustaining as long as you can.

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>“ha” - # reps</th>
<th>“he” - # reps</th>
<th>“ho” - # reps</th>
<th>“who” # reps</th>
</tr>
</thead>
<tbody>
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Session 3: Breathing for Speech (Clinician Script)

Review the exercises from Session 2 and ask if there are any questions or concerns.

So far, you have practiced breathing and coordinating the breath and your voice. Today, you will begin applying what you have learned to speech. You will continue to use a short inhalation followed by a prolonged exhalation. Remember to let air out as you speak. You will practice first with sentences and then with short paragraphs.

You will practice these exercises daily until your next session. We will go through them together to make sure you understand how to do them.

Exercise 1:

1. Take a breath.
2. As you exhale, count for as long as possible. Try to count at a normal speed. See if you can count a little further on each breath as you practice.

Exercise 2:

1. Take a breath.
2. As you exhale, read a sentence from the list provided.
3. Continue with 10 sentences. Take a breath in the middle of the sentence if you feel you are running low on air.

Exercise 3:

1. Select a paragraph to read. (Two are provided for you.)
2. Read aloud, just as you read the sentences in exercise 2. Take a breath at each punctuation mark and whenever you feel the need to breathe.
3. Read aloud for 5 minutes each day.

**Session 3, Exercise 1 (Subject Practice Worksheet)**

1. Take a breath.
2. As you exhale, count for as long as possible. Try to count at a normal speed. See if you can count a little further on each breath as you practice.

**Session 3, Exercise 2:**

1. Take a breath.
2. As you exhale, read a sentence from the list provided.
3. Continue with 10 sentences. Take a breath in the middle of the sentence if you feel you are running low on air.

**Session 3, Exercise 3:**

1. Select a paragraph to read. (Several are provided for you.)
2. Read aloud, just as you read the sentences in exercise 2. Take a breath at each punctuation mark and whenever you feel the need to breathe.
3. Read aloud for 5 minutes each day.

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Exercise 1</th>
<th>Exercise 2</th>
<th>Exercise 3</th>
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</table>
Session 4: Resonance and Projection (Clinician Script)

Review exercises from Session 3 and answer any questions or concerns.

As sound waves travel through the vocal tract, they are modified by the oral and nasal cavities, including the palate and teeth. The sound waves may be dampened or enhanced as they travel through the tract. In general, the more open the tract is, the more the voice can resonate and achieve a rich, full sound. Your vocal tract functions as an inverted megaphone that helps to move sound out. As you perform the following exercises, try to keep this megaphone position.

Think about voices you have heard in places where people are making announcements on the street (newspaper vendor or fair barker) or those speaking without microphones. The words are stretched out slightly, the mouth is open, the quality is slightly nasal, the volume is slightly louder, and the pitch varies more than in normal speaking. All of these combined help the voice to carry or “project”. Remember the demonstration provided for you and practice phrases produced in this way during the week.

As usual, we will practice your exercises together. Remember to record your practice each day on your practice sheet.

Exercise 1:

1. Keep your mouth and vocal tract in an open, relaxed position.
2. Hum on “m”. Feel the buzz created around your nose and sinus cavities.
3. Now say the following phrases using an exaggerated nasal quality. Continue to feel the buzz in your face.

   Oh my  Oh me  Oh no  Oh my no  Oh me oh my

3. Say the phrases again at a slow rate. Repeat at a fast rate.

Exercise 2:

1. Keep your mouth and vocal tract in an open, relaxed position.
2. Say the following phrases. Concentrate on keeping an open mouth position. Prolong the vowels and emphasize the accented syllables. Be sure to use breath.

   Fore!  Hey!  Go away  Hang on
   Over here  Help me  You may go  Where were you?
   Hurry up  Come here  Hey you  Who is it?
   Oh no  Hello there  Go and see  You may go
   Hooray  Up, up and away  Hold your horses
   Read all about it  Take it away  Places everybody
Exercise 3:

1. Using an open vocal tract, good breath, and projection, read the following sentences aloud as if you need to be heard in a large room.
2. Concentrate on breath. Do not force the sound.

I would if I could, but I can’t so I won’t.

Peter Piper picked a peck of pickled peppers.

Don’t you ever dare do that again.

I’m very sorry but the meeting has been cancelled.

Can you hear me in the back?

Please stand up.

All the world’s a stage and all the men and women merely players.

Exercise 4:

Read the following paragraphs in the same manner. Take a breath whenever you need to.

I have a dream that one day every valley shall be exalted, every hill and mountain shall be made low, the rough places shall be made plain, and the crooked places shall be made straight and the glory of the Lord will be revealed and all flesh shall see it together. This is our hope. This is the faith that I will go back to the South with.

With this faith we will be able to hew out of the mountain of despair a stone of hope. With this faith we will be able to transform the jangling discords of our nation into a beautiful symphony of brotherhood. (Martin Luther King)

The world is very different now. For man holds in his mortal hands the power to abolish all forms of human poverty and all forms of human life. And yet the same revolutionary beliefs for which our forebears fought are still at issue around the globe—the belief that the rights of man come not from the generosity of the state, but from the hand of God. We dare not forget today that we are the heirs of that first revolution. Let the word go forth from this time and place, to friend and foe alike, that the torch has been passed to a new generation of Americans – born in this century, tempered by war, disciplined by a hard and bitter peace, proud of our ancient heritage – and unwilling to witness or permit
the slow undoing of those human rights to which this Nation has always been committed, and to which we are committed today at home and around the world. Let every nation know, whether it wishes us well or ill, that we shall pay any price, bear any burden, meet any hardship, support any friend, oppose any foe, in order to assure the survival and the success of liberty. (John F. Kennedy)

Session 4, Exercise 1 (Subject Practice Worksheet)

1. Keep your mouth and vocal tract in an open, relaxed position. Hum and feel the buzz.
2. Say the following phrases using an exaggerated nasal quality.

   Oh my    Oh me    Oh no    Oh my no    Oh me oh my

3. Say the phrases again at a slow rate. Repeat at a fast rate.

Session 4, Exercise 2:

1. Keep your mouth and vocal tract in an open, relaxed position.
2. Say the following phrases. Concentrate on keeping an open mouth position. Prolong the vowels and emphasize the accented syllables. Be sure to use breath.

   Fore!     Hey!       Go away     Hang on
   Over here Help me    You may go    Where were you?
   Hurry up  Come here  Hey you      Who is it?
   Oh no     Hello there Go and see    You may go
   Hooray    Up, up and away Hold your horses
   Read all about it Take it away Places everybody

Session 4, Exercise 3:

1. Using an open vocal tract, good breath, and projection, read the following sentences aloud as if you need to be heard in a large room.
2. Concentrate on breath. Do not force the sound.

I would if I could, but I can’t so I won’t.

Peter Piper picked a peck of pickled peppers.

Don’t you ever dare do that again.

I’m very sorry but the meeting has been cancelled.

Can you hear me in the back?
Please stand up.

All the world’s a stage and all the men and women merely players.

Session 4, Exercise 4:

Read the following paragraphs in the same manner. Take a breath whenever you need to.

I have a dream that one day every valley shall be exalted, every hill and mountain shall be made low, the rough places shall be made plain, and the crooked places shall be made straight and the glory of the Lord will be revealed and all flesh shall see it together. This is our hope. This is the faith that I will go back to the South with.

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The world is very different now. For man holds in his mortal hands the power to abolish all forms of human poverty and all forms of human life. And yet the same revolutionary beliefs for which our forebears fought are still at issue around the globe—the belief that the rights of man come not from the generosity of the state, but from the hand of God. We dare not forget today that we are the heirs of that first revolution. Let the word go forth from this time and place, to friend and foe alike, that the torch has been passed to a new generation of Americans – born in this century, tempered by war, disciplined by a hard and bitter peace, proud of our ancient heritage – and unwilling to witness or permit the slow undoing of those human rights to which this Nation has always been committed, and to which we are committed today at home and around the world. Let every nation know, whether it wishes us well or ill, that we shall pay any price, bear any burden, meet any hardship, support any friend, oppose any foe, in order to assure the survival and the success of liberty. (John F. Kennedy)
Session 5: Sustained Speaking (Clinician Script)

Review exercises from previous session and answer any questions or concerns.

In the last four sessions, you have learned about breath, voice onset, resonance, and projection. You have the tools to continue speaking for longer periods of time. Practice during this session will be with sustained talking. Be sure to use good breathing techniques, keep the megaphone position, and project your voice.

We will go over the next set of exercises together. Record your practice on the table provided for you.

Exercise 1:

Practice the following sentences using loud voice, resonance, and projection.

1. Don’t ever take down a fence until you know why it was put up. (Robert Frost)
2. If you can’t convince them, confuse them. (Harry S. Truman)
3. Good breeding consists in concealing how much we think of ourselves and how little we think of the other person. (Mark Twain)
4. Trust yourself. You know more than you think you do. (Dr. Benjamin Spock)
5. A man can’t get rich if he takes proper care of his family. (Navaho saying)
6. Better to understand a little than to misunderstand a lot.
7. The greatest lesson in life is to know that even fools are right sometimes. (Winston Churchill)
8. We are what we repeatedly do. Excellence, then, is not an act, but a habit. (Aristotle)
9. A man cannot be comfortable without his own approval. (Ralph Waldo Emerson)
10. Do not go where the path may lead, go instead where there is no path and leave a trail. (Ralph Waldo Emerson)

Exercise 2: Read aloud for 10 to 15 minutes. Read as if you must be heard in a large room. You may use any of the readings provided or you may find your own in a newspaper, magazine, etc.

Reading 1: (Patrick Henry, 1775)

There is no longer any room for hope. If we wish to be free—if we mean to preserve inviolate those inestimable privileges for which we have been so long contending—if we mean not basely to abandon the noble struggle in which we have been so long engaged, and which we have pledged ourselves never to abandon until the glorious object of our contest shall be obtained—we must fight! I repeat it, sir, we must fight! An appeal to arms
and to the God of hosts is all that is left us! They tell us, sir, that we are weak; unable to cope with so formidable an adversary. But when shall we be stronger? Will it be the next week, or the next year? Will it be when we are totally disarmed, and when a British guard shall be stationed in every house? Shall we gather strength but irresolution and inaction? Shall we acquire the means of effectual resistance by lying supinely on our backs and hugging the delusive phantom of hope, until our enemies shall have bound us hand and foot? Sir, we are not weak if we make a proper use of those means which the God of nature hath placed in our power. The millions of people, armed in the holy cause of liberty, and in such a country as that which we possess, are invincible by any force which our enemy can send against us. Besides, sir, we shall not fight our battles alone. There is a just God who presides over the destinies of nations, and who will raise up friends to fight our battles for us. The battle, sir, is not to the strong alone; it is to the vigilant, the active, the brave. Besides, sir, we have no election. If we were base enough to desire it, it is now too late to retire from the contest. There is no retreat but in submission and slavery! Our chains are forged! Their clanking may be heard on the plains of Boston! The war is inevitable—and let it come! I repeat it, sir, let it come.

It is in vain, sir, to extenuate the matter. Gentlemen may cry, Peace, Peace—but there is no peace. The war is actually begun! The next gale that sweeps from the north will bring to our ears the clash of resounding arms! Our brethren are already in the field! Why stand we here idle? What is it that gentlemen wish? What would they have? Is life so dear, or peace so sweet, as to be purchased at the price of chains and slavery? Forbid it, Almighty God! I know not what course others may take; but as for me, give me liberty or give me death!

Reading 2: (Martin Luther King, 1963)
I say to you today, my friends, that in spite of the difficulties and frustrations of the moment, I still have a dream. It is a dream deeply rooted in the American dream. I have a dream that one day this nation will rise up and live out the true meaning of its creed: "We hold these truths to be self-evident: that all men are created equal."
I have a dream that one day on the red hills of Georgia the sons of former slaves and the sons of former slaveowners will be able to sit down together at a table of brotherhood.
I have a dream that one day even the state of Mississippi, a desert state, sweltering with the heat of injustice and oppression, will be transformed into an oasis of freedom and justice.
I have a dream that my four children will one day live in a nation where they will not be judged by the color of their skin but by the content of their character.
I have a dream today.
I have a dream that one day the state of Alabama, whose governor’s lips are presently dripping with the words of interposition and nullification, will be transformed into a situation where little black boys and black girls will be able to join hands with little white boys and white girls and walk together as sisters and brothers.
I have a dream today.
I have a dream that one day every valley shall be exalted, every hill and mountain shall be made low, the rough places will be made plain, and the crooked places will be made straight, and the glory of the Lord shall be revealed, and all flesh shall see it together.
This is our hope. This is the faith with which I return to the South. With this faith we will be able to hew out of the mountain of despair a stone of hope. With this faith we will be able to transform the jangling discords of our nation into a beautiful symphony of brotherhood. With this faith we will be able to work together, to pray together, to struggle together, to go to jail together, to stand up for freedom together, knowing that we will be free one day.

This will be the day when all of God's children will be able to sing with a new meaning, "My country, 'tis of thee, sweet land of liberty, of thee I sing. Land where my fathers died, land of the pilgrim's pride, from every mountainside, let freedom ring."

Reading 3: (John F. Kennedy, 1961)

In your hands, my fellow citizens, more than in mine, will rest the final success or failure of our course. Since this country was founded, each generation of Americans has been summoned to give testimony to its national loyalty. The graves of young Americans who answered the call to service surround the globe.

Now the trumpet summons us again- not as a call to bear arms, though arms we need; not as a call to battle, though embattled we are- but a call to bear the burden of a long twilight struggle, year in and year out, "rejoicing in hope, patient in tribulation" - a struggle against the common enemies of man: tyranny, poverty, disease, and war itself.

Can we forge against these enemies a grand and global alliance, North and South, East and West, that can assure a more fruitful life for all mankind? Will you join in that historic effort?

In the long history of the world, only a few generations have been granted the role of defending freedom in its hour of maximum danger. I do not shank from this responsibility- I welcome it. I do not believe that any of us would exchange places with any other people or any other generation. the energy, the faith, the devotion which we bring to this endeavor will light our country and all who serve it- and the glow from that fire can truly light the world.

And so, my fellow Americans: ask not what your country can do for you – ask what you can do for your country.

My fellow citizens of the world: ask not what America will do for you, but what together we can do for the freedom of man.

Finally, whether you are citizens of America or citizens of the world, ask of us the same high standards of strength and sacrifice which we ask of you. With a good conscience our only sure reward, with history the final judge of our deeds, let us go forth to lead the land we love, asking His blessing and His help, but knowing that here on earth God's work must truly be our own.
Session 5, Exercise 1 (Subject Practice Worksheet)

Practice the following sentences using loud voice, resonance, and projection.

1. Don't ever take down a fence until you know why it was put up. (Robert Frost)
2. If you can't convince them, confuse them. (Harry S. Truman)
3. Good breeding consists in concealing how much we think of ourselves and how little
   we think of the other person. (Mark Twain)
4. Trust yourself. You know more than you think you do. (Dr. Benjamin Spock)
5. A man can't get rich if he takes proper care of his family. (Navaho saying)
6. Better to understand a little than to misunderstand a lot.
7. The greatest lesson in life is to know that even fools are right sometimes. (Winston
   Churchill)
8. We are what we repeatedly do. Excellence, then, is not an act, but a habit. (Aristotle)
9. A man cannot be comfortable without his own approval. (Ralph Waldo Emerson)
10. Do not go where the path may lead, go instead where there is no path and leave a trail.
    (Ralph Waldo Emerson)

Session 5, Exercise 2: Read aloud for 10 to 15 minutes. Read as if you must be heard in
a large room. You may use any of the readings provided or you may find your own in a
newspaper, magazine, etc.

Reading 1: (Patrick Henry, 1775)

There is no longer any room for hope. If we wish to be free—if we mean to preserve
inviolate those inestimable privileges for which we have been so long contending—if we
mean not basely to abandon the noble struggle in which we have been so long engaged,
and which we have pledged ourselves never to abandon until the glorious object of our
contest shall be obtained—we must fight! I repeat it, sir, we must fight! An appeal to arms
and to the God of hosts is all that is left us! They tell us, sir, that we are weak; unable to
cope with so formidable an adversary. But when shall we be stronger? Will it be the next
week, or the next year? Will it be when we are totally disarmed, and when a British guard
shall be stationed in every house? Shall we gather strength but irresolution and inaction?
Shall we acquire the means of effectual resistance by lying supinely on our backs and
hugging the delusive phantom of hope, until our enemies shall have bound us hand and
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is now too late to retire from the contest. There is no retreat but in submission and
slavery! Our chains are forged! Their clanking may be heard on the plains of Boston! The war is inevitable--and let it come! I repeat it, sir, let it come.
It is in vain, sir, to extenuate the matter. Gentlemen may cry, Peace, Peace--but there is no peace. The war is actually begun! The next gale that sweeps from the north will bring to our ears the clash of resounding arms! Our brethren are already in the field! Why stand we here idle? What is it that gentlemen wish? What would they have? Is life so dear, or peace so sweet, as to be purchased at the price of chains and slavery? Forbid it, Almighty God! I know not what course others may take; but as for me, give me liberty or give me death!

Reading 2: (Martin Luther King, 1963)
I say to you today, my friends, that in spite of the difficulties and frustrations of the moment, I still have a dream. It is a dream deeply rooted in the American dream.
I have a dream that one day this nation will rise up and live out the true meaning of its creed: "We hold these truths to be self-evident: that all men are created equal."
I have a dream that one day on the red hills of Georgia the sons of former slaves and the sons of former slaveowners will be able to sit down together at a table of brotherhood.
I have a dream that one day even the state of Mississippi, a desert state, sweltering with the heat of injustice and oppression, will be transformed into an oasis of freedom and justice.
I have a dream that my four children will one day live in a nation where they will not be judged by the color of their skin but by the content of their character.
I have a dream today.
I have a dream that one day the state of Alabama, whose governor's lips are presently dripping with the words of interposition and nullification, will be transformed into a situation where little black boys and black girls will be able to join hands with little white boys and white girls and walk together as sisters and brothers.
I have a dream today.
I have a dream that one day every valley shall be exalted, every hill and mountain shall be made low, the rough places will be made plain, and the crooked places will be made straight, and the glory of the Lord shall be revealed, and all flesh shall see it together.
This is our hope. This is the faith with which I return to the South. With this faith we will be able to hew out of the mountain of despair a stone of hope. With this faith we will be able to transform the jangling discord of our nation into a beautiful symphony of brotherhood. With this faith we will be able to work together, to pray together, to struggle together, to go to jail together, to stand up for freedom together, knowing that we will be free one day.
This will be the day when all of God's children will be able to sing with a new meaning, "My country, 'tis of thee, sweet land of liberty, of thee I sing. Land where my fathers died, land of the pilgrim's pride, from every mountainside, let freedom ring."
Reading 3: (John F. Kennedy, 1961)

In your hands, my fellow citizens, more than in mine, will rest the final success or failure of our course. Since this country was founded, each generation of Americans has been
summoned to give testimony to its national loyalty. The graves of young Americans who answered the call to service surround the globe.

Now the trumpet summons us again- not as a call to bear arms, though arms we need, not as a call to battle, though embattled we are- but a call to bear the burden of a long twilight struggle, year in and year out, “rejoicing in hope, patient in tribulation” – a struggle against the common enemies of man: tyranny, poverty, disease, and war itself.

Can we forge against these enemies a grand and global alliance, North and South, East and West, that can assure a more fruitful life for all mankind? Will you join in that historic effort?

In the long history of the world, only a few generations have been granted the role of defending freedom in its hour of maximum danger. I do not shrink from this responsibility- I welcome it. I do not believe that any of us would exchange places with any other people or any other generation. The energy, the faith, the devotion which we bring to this endeavor will light our country and all who serve it- and the glow from that fire can truly light the world.

And so, my fellow Americans: ask not what your country can do for you – ask what you can do for your country.

My fellow citizens of the world: ask not what America will do for you, but what together we can do for the freedom of man.

Finally, whether you are citizens of America or citizens of the world, ask of us the same high standards of strength and sacrifice which we ask of you. With a good conscience our only sure reward, with history the final judge of our deeds, let us go forth to lead the land we love, asking His blessing and His help, but knowing that here on earth God’s work must truly be our own.

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<th>Date</th>
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<th>Exercise 1</th>
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**Session 6: Practice Summary (Clinician Script)**

During the previous sessions, you have learned more about using your voice efficiently. You have gradually increased your voice practice each week. As you recall, the voice is produced using muscles in the larynx working in combination with airflow controlled by expiratory muscles. These muscle systems need consistent exercise to maintain your
current level of function. The best exercise is using your voice each day. You may continue using the exercises you have learned to exercise your voice. Another method of practice is to read out loud for at least a few minutes each day, giving attention to breath support, voice onset and resonance.

Today we will review some of the readings from your previous session. During this time, I will try to point out any things that may help improve your performance and projection. Please be sure to ask any questions that you may have.

**Session 6, Exercise 1 (Subject Practice Worksheet)**

Speak aloud, using moderate to loud volume level, for 10 to 15 minutes per day.
APPENDIX H
RESPIRATORY MUSCLE TRAINING PROGRAM

INSTRUCTIONS

The most important number to remember throughout this training period is the number 5. You will complete this training program 5 days per week. You will complete 5 sets of the exercises with 5 repetitions each time you complete your training.

You have been given a respiratory trainer to complete your training at home. You will use this same trainer for the entire time that you are participating in this study.

FIRST WEEK OF TRAINING

1. Place the nose clip on your nose.
2. Breathe in as much air as you can then place the mouthpiece in your mouth.
3. As soon as the mouthpiece is in your mouth, breathe out as much air as you can.
   * Be sure to keep a tight seal with your mouth around the mouthpiece.
   * When the pressure is strong enough to open the valve, you will hear a rush of air move through the device.
4. Repeat this expiratory exercise 5 times (steps 1-4), resting for 30 seconds to 1 minute in between each breath.
5. When you have finished all 5 expirations, rest for 2 minutes (you have now completed one set.)
6. After you have rested for 2 minutes, repeat steps 1-5 (for 5 repetitions of the exercise).
7. You will continue with this pattern of 5 expirations and 2 minutes breaks until you have completed the 5 expirations procedure 5 times.
8. On your training log, record the date and the time you completed these exercises.
9. You will need to complete steps 1-9 5 times during the week.
10. At the end of this training week, you will have an appointment during which your maximum expiratory pressure will be taken and your respiratory trainer will be reset.
SECOND, THIRD, FOURTH AND FIFTH WEEKS OF TRAINING:

During the second, third, fourth, and fifth week of training, you will follow the procedures described for the first week.
APPENDIX I
TRAINING LOG

Start date ________________

Trainer setting ____________ (If trainer moves off this mark, adjust back to this number)

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Next appointment: Date ________________ Time ________________

Questions or problems??? Contact Judy Wingate at 392-2046 x221 or after hours at (352) 332-5977, Email at wingate@csd.ufl.edu
LIST OF REFERENCES


BIOGRAPHICAL SKETCH

Judith Maige Wingate received a Bachelor of Arts in music therapy from Charleston Southern University in 1976. After working as a music therapist for several years, she completed a Master of Science in speech pathology in 1983 at the University of South Florida. Since that time, she worked as a speech pathologist in several settings, most recently as a clinical faculty member in the Department of Communicative Disorders at the University of Florida. She enrolled in the doctoral program at the University of Florida in January 2001. Her research during her doctoral program has focused on the professional voice user. She will graduate from the University of Florida with a Doctor of Philosophy in December 2004. She will begin work in September 2004 as a clinical assistant professor in the Department of Communication Sciences and Disorders at the University of Florida.
I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Christine M. Sapienza, Chair
Professor of Communication Sciences and Disorders

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

William S. Brown, Jr.
Professor of Communication Sciences and Disorders

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Rahul Shrivastav
Assistant Professor of Communication Sciences and Disorders

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Paul Davenport
Professor of Veterinary Medicine
This dissertation was submitted to the Graduate Faculty of the Department of Communication Sciences and Disorders in the College of Liberal Arts and Sciences and to the Graduate School and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

December 2004

Dean, Graduate School