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The Advancement of Voice Therapy and
the Contribution of Vocal Function Exercises

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Abstract

The human voice can transmit multiple streams of information about a person including physical, emotional, and social state. Voice disorders can interfere with social relationships, work productivity, and ultimately, impair an individual's image. Speech-language pathologists have developed several approaches to voice therapy over the past several decades. Vocal function exercises (VFE) are physiological in nature and aim to restore the balance between the three subsystems of vocal production: respiration, phonation, and resonance. With advancing technology and more sophisticated experiments, researchers have shown positive outcomes with VFE regimens in the normal voice population, superior voice population, and disordered voice population. Data continues to be collected to identify the specific elements of VFE that contribute the most to improving vocal function.

Keywords: voice disorders, voice therapy, vocal function exercises, holistic health

Basic Necessity and Principles of Normal Functioning Voice

Voice is a multi-faceted and uniquely human phenomenon that reveals a great deal of information about the status of a person. In fact, voice is an indicator of physical, emotional, and social well-being. Subtle changes in mood, personality, and attitude are all reflected in the acoustic properties of the voice. Humans not only express these more personal elements in their voice, but possess a sophisticated auditory system to decompose relevant streams of information from other voices. Speakers are constantly judged by the way they sound, giving voice a significant role in the image that each individual projects to the world (Stemple, 2015, p.132).

Yet, approximately 30% of the adult population will experience chronic (21.5%) or acute (78.5%) voice difficulties at some point in their life (Desjardins, Halstead, Cooke, & Bonilha, 2016). In children, the numbers are not as reliable, with estimates of dysfunction between 2% and 23% depending on the study (Lee, Stemple, Glaze, & Kelchner, 2004, p. 308). With disordered voice, there are often indirect negative impacts on quality of life including diminished social relationships, emotional state, and work productivity. The calculated costs associated with short-term disability claims associated with dysphonia lead to productivity losses of approximately \$5,000 per person per year. In addition, assessment and management of voice disorders have been shown to cause a significant burden on skyrocketing healthcare cost (Desjardins et al., 2016).

The physical and psychosocial consequences of voice disorders captured the attention of early speech-language pathologists in 1930's. Initial therapy methods were based on anecdotal reports or small case studies, and included a compilation of knowledge from the vocal arts, elocution, oral interpretation, and public speaking. The goal of therapy was focused to “develop and improve voice characterized by (1) adequate loudness, (2) clearness of tone, (3) a pitch

appropriate to the age and sex, (4) a slight vibrato, and (5) a graceful and constant inflection of pitch” (Stemple, 2005, p. 131). These goals became the accepted definition for normal vocal production and a variety of therapy approaches have been developed over time to train the voice to fit this ideal model.

Normal voice production is the result of a relative functional balance among three subsystems associated with human sound production: (1) airflow, powered by the respiratory system; (2) laryngeal muscle activity including balance, coordination, and stamina; and (3) coordination with supraglottic structures including the pharynx, oral cavity, and nasal cavity. The synchronization between each subsystem is as important as the strength of the whole system. Due to their interconnected nature, a disruption in a single subsystem will affect the other two, resulting in what is perceived as an ineffective voice quality (Stemple, 2005, p. 133).

Disordered Voice and Established Therapy Approaches

The American Speech-Language and Hearing Association (ASHA) promotes the definition that a voice disorder occurs when “voice quality, pitch, and loudness differ or are inappropriate for an individual’s age, gender, cultural background, or geographic location” (Lee et al., 2004, p. 308). It should also be noted that a voice disorder is considered present when an individual is concerned about having an abnormal voice that does not meet their daily needs. Even if others do not perceive the voice as deviant, an individual may feel it is not to their personal standard and may seek care.

Several specific approaches have been developed to treat voice disorders including hygienic, symptomatic, psychogenic, and physiological voice therapy. Vocal hygiene is “do and don’t therapy” which serves to identify vocally abusive behaviors in order to modify or eliminate their occurrences. Shouting, talking over noise, singing out of range, screaming, coughing,

persistent throat clearing, and poor hydration are considered to be harmful to adequate vocal function. Symptomatic voice therapy disregards the cause of disordered voice and solely focuses on direct modification of divergent symptoms in terms of pitch, loudness, breathiness, hard glottal attacks, and glottal fry. Psychogenic voice therapy is interested in the underlying psychological origin of disordered voice, often related to psychological disorientation from emotional trauma or life changes. In most psychogenic cases, the vocal folds are fully functional yet the system remains out of functional balance.

Lastly, physiologic voice therapy targets the underlying physiology of the vocal mechanism using a series of systematic voice exercises, comparative in theory to physical therapy for the vocal musculature. Along with strengthening and coordinating the vocal fold and laryngeal muscles, this approach focuses on the relative balance of airflow, vocal fold vibration, and supraglottic treatment of phonation (Stemple, 2005, p. 131-132). Supporting evidence for physiological methods has increased steadily since the 1990's with the implementation of more stringent clinical research. Rigorously designed research was finally made possible by advances in instrumentation that allowed scientists to objectively measure various acoustic and aerodynamic outcomes during real-time vocalization and speech production. Accumulated data suggests that physiologic voice therapy approaches are the most scientifically supported with multiple, well-controlled studies demonstrating the efficacy of these strategy (Thomas & Stemple, 2007, p. 72).

Specific physiologic therapies include Confidential Voice Therapy, the Accent Method, Manual Laryngeal Musculoskeletal Reduction, Resonant Voice Therapy, Lee Silverman Voice Treatment and Vocal Function Exercises. The final exercise mentioned, Voice Function Exercises (VFE), are considered an expansion of the original work by Dr. Bertram Breiss, a seminal voice

scientist and classically trained singer from Syracuse University. Breiss became interested in voice disorders in the late 1950's and established "a direct relationship between the condition of the laryngeal musculature and the quality of voice" (Stemple, Lee, D'Amico, & Pickup, 1994, p. 271). Breiss was one of the first to recognize that intrinsic muscles of the larynx must be at a dynamic equilibrium, and believed that balancing the musculature would decrease hyperfunctioning muscles (Stemple, 2005, p. 134). Following this lead, speech-language pathologist, Dr. Joseph Stemple, created a series of exercises to strengthen the laryngeal musculature, rebalance airflow, and improve vocal fold flexibility. His aim was to balance the subsystems of voice production regardless of whether the disorder was hyperfunctional or hypofunctional (Thomas & Stemple, 2007, p. 68).

Evidence that Vocal Function Exercises Support Improved Functionality of Voice

The VFE training protocol includes four exercises that are performed two times each, once in the morning and once in the evening, for six to eight weeks. The first exercise in the series functions as a vocal "warm-up" where the patient produces the sound /i/ for as long as possible on the musical note (F) above middle (C) for females and below middle (C) for males. The second exercise serves as a stretching exercise for the laryngeal system and requires the patient to slowly produce a pitch glide upward on the word "knoll" from the lowest to the highest note in their pitch range. The third exercise initiates contraction of the laryngeal system by requiring the patient to pitch glide downward through the range on the same word "knoll." The final exercise is an adductory strengthening exercise. In this last exercise, the patient must sustain five, sequential notes (C-D-E-F-G) for as long as possible on the word "knoll". The warmup and the final exercises are timed, with patients capable of sustaining longer and continuous phonation periods as the training progresses.

The manner of production is considered of equal importance to the exercises themselves. VFE should be done as softly as possible. A forward focus is emphasized to avoid tension in the larynx, and glottal onsets are encouraged to be as gentle as possible. Using a rounded lip posture during the phonation tasks results in a buzzing sensation at the lips. Such a sensation is characteristic of a semi-occluded vocal tract coupled with the forward focus. Deep abdominal breathing is also stressed throughout the training. All patients are given a log to mark their sustained phonation times and to plot progress over the 6 to 8 week training. After that time period, patients are advised to taper the program accordingly (Stemple, 2005, p. 134-136)

The potential for VFE as an effective treatment for voice disorders was not fully understood until the mid-1990's when Stemple and colleagues carried out an objective voice analysis with 35 adult female subjects. The study intentionally used subjects who pre-tested with normal voice. Evidence was needed about VFE function in the normal population before considering the exercises for pathologic cases. This practice is consistent with other function exercise programs in different regions of the body.

Results of the study found that subjects in the group that performed the full VFE training program demonstrated enhanced vocal function. The subjects significantly increased phonation volumes at all pitch levels, with the largest increases observed at the extremes. The authors hypothesized that the VFE training increased the power of inspiratory muscles, therefore improving ventilatory strength and endurance. It was also found that the VFE subject group decreased their airflow rates, particularly at the high pitch level. Typically, people increase their airflow rates to compensate for stiffening laryngeal muscles; however, the subjects did the exact opposite, suggesting that increased laryngeal musculature strength and balance improved laryngeal timing and vibration. The authors also indicated this result could have been due to

improved coordination between aerodynamic and muscular activity (Stemple et al., 1994, p. 272-277).

An increase in maximum phonation times naturally followed from the previous two findings. Maximum phonation time is a measurement that is non-instrumental and often taken during voice evaluations to assess the efficiency of vocal fold vibration. Increased maximum phonation times “indicate improved ability to close the glottis more efficiently at low lung volumes while avoiding a pressed type of phonation” (Sabol, Lee, & Stemple, 1994, p. 33). Previous findings from Shipp et al. (1983) have shown that there is higher cricothyroid (CT) activity during phonation at lower lung volumes as air is squeezed out. This higher activity of the CT muscle suggests there is a strengthening benefit in sustaining a vowel at the same frequency at low lung volumes. Finally, pitch range was extended significantly by an average of 15 Hz at the low end and by 123 Hz at the high end (Stemple et al., 1994, p. 277). This study was significant for its robust demonstration of the effectiveness of VFE in terms of normal voice in a large sample using objective measurements.

The next logical step was to demonstrate that the effectiveness of VFE could crossover to populations under different voice conditions. Around the same time as the Stemple et al. (1994) study, Sabol et al. conducted a VFE study with twenty graduate-level voice students. The distinction between typical singing exercises and VFE training is important. Most established singing exercises are concerned with acceptable volume or tone color necessary for public singing. In contrast, VFEs are “concerned with the therapeutic effect at the voice source by giving the laryngeal and respiratory muscles a refined, sustained isometric workout at a very soft dynamic level” (Sabol et al., 1994, p. 38).

Both the control and experimental groups were asked to continue their regular singing practice regimens during the 4-week VFE program. Acoustic and aerodynamic results in the VFE experimental group demonstrated larger phonation volumes, smaller flow rates, and increased phonation times. Post-test objective measures demonstrated that the vocal mechanism of the experimental group functioned with less waste of energy and increased glottal efficiency. It is interesting to note that pre- and post-test differences in frequency range were not found between subject groups, indicating that VFE did not expand the frequency ranges of the singers. The authors hypothesized that the singers' ranges were already well-established due to years of singing experience and coaching. In general, the results indicated that VFE did offer a positive benefit on the phonation systems of young singers. Singers are considered to possess superior vocal abilities, yet in spite of focused vocal training, VFEs still demonstrated an ability to further improve overall vocal function. Sabol et al. goes on to state, "...if we consider the singer as an athlete who needs exercise for strength, endurance, timing, and agility, then the isometric principle is an essential ingredient for the singing athlete's training regimen" (35). The authors suggested that the VFE total coordination approach may be considered as a potential training option for singers to avoid or break hyperfunctional voice habits.

VFE were shown to be effective in the normal voice population and in superior voice users. The next objective was to demonstrate that VFE could be an effective treatment for those with disordered voices. This was not a senseless notion to suggest. In his 2005 publication, "A Holistic Approach to Voice Therapy," Stemple describes the process of knee rehabilitation as a parallel to voice rehabilitation. He points out that both the knee and the larynx contain muscles, cartilages, and connective tissues. After a knee injury, a brief period of immobilization to avoid further more severe injury is implemented. This rest is followed by "assisted ambulation and then

the primary rehabilitation begins in the form of systematic exercise” (134). The exercise is directed to rebalance and boost all of the supportive knee muscles so that the knee may return close to or at its normal operation. Comparatively speaking, voice rehabilitation may warrant a short period of vocal rest to allow the mucosa of the vocal folds to heal following acute injury or after an invasive surgical procedure. Next, the client can then use their voice with limitations and carry out appropriate management approaches. Total voice use is resumed when the therapy program is successful. Stemple raises a concern here and states, “...on many occasions these clients are not fully rehabilitated because one of the important rehabilitation steps was neglected. That step is the systematic exercise program that is often necessary to regain the balance among airflow, laryngeal muscle activity, and supraglottic placement of the tone” (134).

The possibility of whether VFE could rehabilitate disordered voice was put to the test in a study involving a number of teachers with self-reported voice difficulties. Voice disorders are a common occupational hazard of teaching due to the heavy demands placed on the vocal mechanism by speaking loudly over classroom background noise for long durations. Roy et al. (2001) conducted a large sample, randomized control study that split a population of teachers into a VFE group, a vocal hygiene treatment group, and a no-treatment control group. The Voice Handicap Index (VHI) and a four-question teacher questionnaire were used for pre- and post-treatment group comparisons. The VHI is a well normed survey instrument designed to quantify the self-perceived psychosocial consequences of a voice disorder. No direct measures of voice were used in this study, so the authors could not make conclusions regarding altered voice production or physiology.

The VFE treatment group demonstrated an overall reduction in VHI scores that changed from a pretreatment mean of 31.58 to a posttreatment mean of 19.95. This significant reduction

indicates a substantial and large improvement in the degree of perceived handicap compared to the vocal hygiene group. The experimental group reported overall voice improvement, with greater ease and clarity in their speaking after VFE treatment (291). This was the first study that examined VFE use with a disordered sample and ultimately provided support for the program's utility in improving functional voice outcomes in disordered populations of speakers.

Since the Roy et al. study of VFE and disordered voice in teachers, more sophisticated research has been developed to answer the question of what exactly VFEs may be doing to improve the disordered voice. Kaneko et al. (2015) investigated the effect of VFE on aged vocal fold atrophy using multidimensional analysis. Vocal change is typical throughout the lifespan, and age-related changes are often perceived as weak, harsh, and breathy. Specifically, aged vocal fold atrophy is characterized by, "decreased loudness, inconsistent hoarseness, decreased pitch for females, increase pitch for males, and increased vocal effort and vocal fatigue" (Kaneko, Hirano, & Tateya, 2015, p. 638). Phonatory efficiency is often further degraded by decreased lung elasticity, vital capacity, and respiratory strength. The atrophy is specific to the thyroarytenoid muscle with concurrent diminished pliability of the overlying vocal fold mucosa.

Kaneko et al. (2015) evaluated VFEs as a primary treatment for 16 patients with aged vocal fold atrophy. The measurements taken included a strain-related vocal scale (GRBAS), stroboscopic examination, aerodynamic assessment, intensity measures, acoustic analysis, vibratory analysis, VHI, and the degree of vocal fold bowing. The extent of subjective, objective, and patient self-evaluation data collection that is possible today has greatly increased our knowledge of VFE effectiveness.

The results of this study demonstrated that the VFE group experienced significant improvements in the strain scale, maximum phonation time, jitter, normalized mucosal wave

amplitude (NMWA), normalized glottal gap (NGG), and VHI compared to the control group. It was suggested that VFEs may improve the contractile function of the atrophic thyroarytenoid muscle in the aged vocal folds through the repetition of sustained phonation under controlled and gliding pitch conditions. Stroboscopy showed improved vocal fold vibratory dynamics, which may be related to better mucosal vibration and thus improved sound source generation (6). Typically, treatments for aged vocal fold atrophy are invasive and include framework surgery or injection laryngoplasty. However, these treatments are typically unappealing to patients and lead to only modest improvements in vocal quality. The multidimensional analysis aspect of this study is particularly convincing that VFE may be an ideal exercise program to improve deviant voice due to this particular voice pathology.

A single-subject before and after study by Patel et al. (2012) focused on the application of high-speed digital imaging (HSDI) to provide additional data on any resulting structural changes from VFE. The subject of the study was a 51-year-old male with unilateral contact granuloma. HSDI images of the vocal folds were recorded at 4k frames per second, for a maximum duration of 4.094 seconds. The HSDI was utilized to expand the understanding of impact stress and vibratory dynamic changes resulting from VFE treatment with contact granuloma. The researchers used multidimensional assessments of HSDI, stroboscopy, acoustic analysis, aerodynamics, and perceptual assessments of voice quality before and after the 6-week VFE program (Patel et al., 2012, p.735). Pre-treatment, the subject had a small anterior glottal gap and complete posterior closure. Post-treatment HSDI indicated that voice onset time was reduced from 140 to 77 milliseconds, which remarkably put the subject back into the normal range. The HSDI also showed mean maximum amplitude of vocal fold vibration was increased from 7.8% to 10% of the glottal length. Vocal folds were demonstrated to move greater distances over a

shorter period of time, reflecting increased strength and efficacy. Post-treatment HSDI images also revealed improved closure, a small posterior glottal gap, and increased maximum amplitude of vibration, all indicating improved vocal flexibility. The peak to average velocity function of both vocal folds was decreased from pre- to post-treatment, indicating a reduction of impact stress of the vibrating vocal folds (378).

As this study exhibits, further understanding of VFE is emerging due to advances in instrumentation. The pre- and post-treatment HSDI images clearly demonstrate that VFEs “promote a glottal closure pattern (barely adducted/abducted arytenoids) that enhances efficient vocal fold vibration through the use of semi-occluded posturing of the vocal tract” (741). The role of HSDI was beneficial in this study and provided an improved understanding of VFE influence on the laryngeal mechanism. Future large scale studies using HSDI for clinical assessment of VFE in terms of impact stress and patterns of glottal closure are warranted to pursue.

In summary, various clinical assessment studies have evaluated the effectiveness of VFE in regards to normal voice subjects, superior voice subjects, and disordered voice subjects. With the explosion of technology over the past three decades, researchers have been able to accumulate a substantial amount of evidence to support the effectiveness of VFE in each population. VFEs have become more popular for treatment of a variety of voice disorders due to its non-invasive nature, manageable time commitment, and alignment with the principles of holistic health.

Holistic Health and Vocal Function Exercises

Holistic health accentuates well-being as a matter of the whole person in terms of physical, nutritional, environmental, emotional, social, spiritual, and lifestyle values. These parts

are interdependent and constantly interact. If a single part is impacted, a ripple effect will ensue and the other parts of the person will be influenced. Holistic health is appreciated as an ongoing process laid out on a wellness continuum. In terms of vocal health, normal would be at the midpoint of the continuum, disordered voice to the left, and superior voice would fall to the right. This model implies that people can work to improve their vocal well-being, regardless of current health status, by moving toward the right side of the wellness continuum. Finally, holistic health emphasizes a personal commitment and responsibility to health. The role of the healthcare provider is to educate the patient, provide them with the proper tools, and set them up for change.

In terms of holistic health and voice, the subsystems of respiration, phonation, and resonance are involved and heavily intertwined. If an issue arises with any of the three subsystems, the result in an imbalance of the entire vocal mechanism and consequently, a voice disorder. VFEs fit well into the concept of holistic health because they work directly to set these interdependent parts back to a dynamic equilibrium where voice can return to normal or even become enhanced. VFEs address all three subsystems in one exercise, directly modifying inappropriate physiologic activity through direct exercise and manipulation. Research has shown that VFE both improve disordered voice and boost normal voice, relating back to the holistic health idea of wellness laid out over a continuum. VFE also puts power back in to the patient's hands to make an improvement in their own voice by committing to performing the core exercises of the VFE protocol (Stemple, 2015, p. 132-133).

My Personal Experience

Over this past semester, I was granted the opportunity to assist with a VFE research study led by Ms. Megan Brown, a graduate student in the Division of Communication Sciences and Disorders. Using a study design similar to that used by Stemple et al. (1994), the present study

utilized a large sample of young females with normal voice, with the goal of the study to determine if the semi-occluded vocal tract posture itself is a critical factor in VFE efficacy.

My role was to serve as one of four research assistants on the study. Dr. Joseph Stemple, the originator of the VFE approach, was the faculty mentor overseeing the study and taught us how to perform each vocal function exercise at our first training. Over the course of a week, we were to practice the VFE regimen at home and fill out the corresponding log. This practice helped to prepare us for our main responsibility in the study, which was to teach participants the VFE method and follow up with their performance on a weekly basis.

The subject population was randomly assigned into three groups that varied by mouth posture. The first group performed VFEs with a semi-occluded vocal tract as typically performed. The second group produced the VFEs using a mouth posturing similar to that used to say the vowel /ah/. Finally, the third group produced the VFEs using a mouth posturing similar to that used to say the vowel /o/. Participants were unaware of the potential significance of their assigned posture. Each research assistant had to be precise in teaching participants the VFE method using the correct posture as indicated by their group assignment.

The first session required initial data collection from the participants, including acoustic and aerodynamic analysis, CAPE-V (Consensus Auditory-Perceptual Evaluation of Voice), vital capacity, videostroboscopic analysis, and Voice-Related Quality of Life measurement (VRQOL). Following data collection, each participant was given VFE instruction by a research assistant. A licensed speech-language pathologist recorded the participant's baseline phonation times and checked that the participant performed each VFE correctly. The most difficult mouth posturing to teach was the semi-occluded vocal tract. The participants in this group took the longest to learn the exercises because the posturing is so precise and atypical. Research assistants had to be

diligent about the participants establishing a frontal focus with a lip buzz for the semi-occluded vocal tract position to be considered accurate. After the initial session, the participants were given a log to record their phonation times twice per day as they completed the VFE protocol.

The participants were scheduled to check in with a research assistant once per week over the course of the 6-week study. We saw the vast majority of participants every Friday throughout the morning and afternoon. At each session, the participants turned in their logs, filled out a VRQOL, and ran through each exercise twice for the research assistant to record their phonation times. Once it was evident that the participants understood the basic structure of the exercises, the research assistants could be more meticulous about proper VFE production. We continued to give participants cues and constructive feedback during each session. It was also essential to reiterate the importance of deep abdominal breathing, good posture, low volume, etc. After six weeks, all of the initial measurements were collected from the participants again. Following a one month break, participants returned for a final CAPE-V, and the research assistants recorded final phonation times and gathered one last set of VRQOL data. The one month break was intentionally programmed into the study to determine if progress could be maintained without daily practice.

In hindsight, my one concern was compliance monitoring of the subjects. The exercises take about 8 minutes to perform at twice per day, and I suspected that some of the participants did not fully take on that commitment. The participants were mostly undergraduate students that may or may not feel the motivation to take time out of their busy schedules to perform the exercises for means of valid research. A study by Ellis & Beltyukova (2011) investigated compliance monitoring of VFE on voice outcome measures. It was determined that participants benefited whether or not they submitted recordings to verify their compliance with daily

performance of exercises. However, the participants that did record and submit their recordings of the daily practice improved voice production significantly more than those who did not. These results are not unexpected, but add evidence to the importance of monitoring participant compliance with daily VFE regimens (735).

The results of this study are currently pending analysis.

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