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Vocal Health of Middle School and High School Choral Directors

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UNIVERSITY OF MIAMI

VOCAL HEALTH OF MIDDLE SCHOOL AND HIGH SCHOOL
CHORAL DIRECTORS

By

Sandra M. Schwartz

A DISSERTATION

Submitted to the Faculty
of the University of Miami
in partial fulfillment of the requirements for
the degree of Doctor of Philosophy

Coral Gables, Florida

May 2006
Teachers are considered professional voice users because they depend on the regular and uninterrupted use of the voice. The nature of teaching requires more extensive use of the voice than other professions. Therefore, teachers are faced with a greater risk of developing voice problems. In addition to using the voice to present content to students, teachers must also manage the classroom and student behavior. All of these activities have potential to compromise vocal integrity.

The purpose of this study was to examine the vocal health of selected middle school and high school choral directors. Specifically, it explored relationships between vocal health condition as determined by the modified Voice Handicap Index (VHI) and self-report vocal health rating and (a) age, (b) gender, (c) years of teaching, (d) level of teaching, (e) vocal health education, and (f) fundamental frequency and intensity ranges of the voice as indicated by the voice range profile (VRP). This study also sought to determine the relationship between VRP, and age, gender, years of teaching, and level of teaching. Results indicate choral directors’ vocal intensity range is significantly smaller than the trained and untrained populations, choral directors’ minimum vocal intensity is significantly higher than the trained and untrained populations, and choral directors are able to produce significantly fewer semitones resulting in a smaller vocal frequency range than trained and untrained populations.
ACKNOWLEDGMENTS

I am sincerely grateful for the guidance, advice, patience, and encouragement provided by my dissertation advisor, Dr. Edward Asmus. His continuous “So what?” questions reminded me to never lose sight of how research can change our profession. This influence on my professional development is evident. I am indebted to him for this. Thank you.

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For my parents, thank you cannot do it justice.
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CHAPTER 1

INTRODUCTION

Teachers are considered professional voice users because they depend on the regular and uninterrupted use of the voice (Titze, Lemke, & Montequin, 1997). The nature of teaching requires more extensive use of the voice than other professions. Therefore, teachers are faced with a greater risk of developing voice problems (Roy, Merrill, Thibeault, Parsa, Gray, & Smith, 2004). In addition to using the voice to present content to students, teachers must also manage the classroom and student behavior. All of these activities have potential to compromise vocal integrity.

Choral directors have an additional vocal burden. They use their voices in the same way as regular classroom teachers, but they must also sing. Choral directors are dependent on the voice as it is often the best tool for communicating information or demonstrating a musical concept or technique. When a choral director’s voice is impaired or unusable, the job of directing the choir becomes nearly impossible. Some choral directors have vocal performing obligations in addition to their teaching responsibilities, which contribute another potential source for developing a vocal problem. Professional performance activities and teaching are jeopardized by vocal problems that undermine vocal function. Vocal health is a serious concern for choral directors and subsequently warrants investigation.

Background of the Problem

Future choral directors may learn about vocal production in undergraduate music methods courses. The studio voice lesson during teacher training is another location for future choral directors to absorb healthy vocal habits. Often, new choral directors begin
teaching and model the vocal behavior of their own previous choral directors regardless of the potential for harm. They may be tempted to assist the choir by singing voice parts other than their own or singing outside their natural vocal range. Choral directors may also sing or speak over the sound of the piano, the choir singing, or over ambient and environmental noise. Any of these behaviors can cause vocal problems if done regularly or in an abusive manner (Smith & Sataloff, 2000).

Vocal problems develop after repetitive injurious behaviors. Over time, a choral director may develop hoarseness, breathiness, loss of flexibility or range, or undependable vocal production (Smith & Sataloff, 2000). Smith, Gray, Dove, Kirchner, and Heras (1997) found that teachers were more likely to report a voice problem than non-teachers. In a study conducted by Titze, Lemke, Montequin (1997), teachers constituted 20% of the voice clinic patient load, representing a rate five times greater than other professions seeking voice therapy. Chronic voice problems in teachers can adversely affect career longevity in terms of quality of life, job satisfaction, and financial stability (Smith, Gray, Dove, Kirchner, & Heras, 1997).

Research regarding the vocal demands of teaching is found in the literature of several disciplines, including speech pathology, vocal music performance, occupational hazards, and music education. Bernstorff and Burk (1996) linked the vocational demands of music teaching with the probability of occurring and recurring vocal disorders. When comparing teachers who experienced vocal fatigue to teachers who did not, those with vocal fatigue spent more time on vocally demanding activities (Gotaas & Starr, 1993).

Speech pathologists consider functional voice disorders as those disorders that develop as a result of improper use of the voice (Titze, 1994). Hoarseness is the most
common manifestation of a vocal disorder in choral directors (Sataloff & Spiegel, 1991). Other vocal problems include excessive throat clearing, voice breaks, vocal fatigue, pain in the throat, and taut neck muscles (Cooper, 1996).

Individuals entering the field of music education most likely have a great deal of private and/or group vocal instruction, but this training is no guarantee that they will always follow adequate and healthy vocal production practices. They may sing well and with proper technique, yet abuse their voices while speaking. Teaching is a high-risk occupation for vocal problems (Roy et al., 2004), in which the additional vocal burden of singing will exacerbate the problem. Lack of knowledge about vocal health and long-term management of the voice can also contribute to the onset of vocal problems.

Problem Statement

Teaching habits and behaviors may beneficially or adversely affect a choral director’s vocal health. Vocal problems can include hoarseness, breathiness, pitch or register breaks, vocal fatigue, and vocal strain. Choral directors can develop vocal problems as a result of excessive demands on the voice or long-term vocally abusive habits.

The term ‘vocational dysphonia’ is used to describe vocally abusive behaviors such as rapid, excessive, and/or loud speech that is associated with vocation or work-related vocal overuse and abuse (Sapir, Atias, & Shahar, 1990). Choral directors who demonstrate these behaviors are more likely to have vocal problems resulting in poor work attendance (Smith et al., 1996). Speaking louder in order to gain students’ attention or enforce classroom order can contribute to deteriorating vocal health (Sataloff 1998). In many middle and high schools, the choir room is situated in close proximity to the band
room. Often insufficient acoustical treatment allows sound to travel from one room to the other. Choral directors may be faced with teaching, speaking, and singing over the sound of a band rehearsal without the benefit of electronic voice amplification. When teaching in conditions with excessive ambient or environmental noise, choral directors must increase their vocal intensity. Often without realizing it, they speak and sing above the sound of heating and cooling systems, noise from the hallway and other classrooms, or traffic noise (Smith et al., 1997). This tendency to increase vocal intensity in response to increased background noise is known as the Lombard effect (Sataloff, 1997a). The cumulative effect of extreme voice usage is vocal fatigue or dysfunction (Sataloff, 2001).

Bernstorf and Burk (1996) found that background and ambient noise are contributing factors to vocal stress for elementary music teachers. When trying to communicate over ambient noise, teachers generally succumb to the Lombard effect. Most professional voice users are aware of background noise in the workplace, yet unaware of the resulting rise in speech level, its frequency, and the potential result (Bernstorf & Burk, 1996). Because of these demands, it is imperative that choral directors maintain healthy vocal habits.

Bernstorf and Burk (1996) maintain that it is likely that teacher training programs do not include methods for maintaining vocal health. Future choral directors spend time in college methods classes learning proper vocal technique, conducting, singing, and perhaps even vocal pedagogy. However, pre-service education in how to maintain vocal quality and not abuse the voice while teaching is rarely present. Professional studio voice teachers, speech pathologists, and medical professionals encourage habits to maintain a healthy voice (Sataloff, Brandfonbrener, & Lederman, 1998). Healthy habits may include
refraining from speaking or singing over loud noise, giving classroom instructions in a non-verbal manner, drinking adequate amounts of water, warming-up the voice every morning before speaking, and speaking and singing only within the natural range of the voice (Sataloff, 1998). Interest in personal vocal health often surfaces only after the onset of a vocal problem (Sataloff, 1992).

Purpose

The voice range profile (VRP) is a graphical representation of frequency and intensity of the voice. This tool provides an indication of vocal deficiencies and inconsistencies by reporting the range of frequencies and intensities. This information is valuable because it supplies voice data unavailable by self-report or simple observation. Vocal intensity tends to increase as frequency rises (Colton, 1973; Colton, Mabis, & Hinson, 1977). The Voice Handicap Index (Jacobson et al., 1997) is an efficient self-report measure designed to determine the effect of voice problems in three aspects of life: emotional, physical, and functional. Intended for patients with voice problems, the Voice Handicap Index (VHI) was modified and piloted (Schwartz, 2005 April) by the author of the present study. This modified VHI was altered for use with participants who may or may not have a voice problem.

The purpose of this study was to examine the vocal health of selected middle school and high school choral directors. Specifically, it explored relationships between vocal health condition as determined by VHI and self-report rating and (a) age, (b) gender, (c) years of teaching, (d) level of teaching, (e) vocal health education, and (f) fundamental frequency and intensity ranges of the voice as indicated by VRP. This study
also sought to determine the relationship between VRP, and age, gender, years of
teaching, and level of teaching.

Importance

The voice is an essential tool for a music teacher. Choral directors use both the
speaking voice and the singing voice when teaching students to sing. Often, teachers’
habits and teaching behaviors may bring about clinical injury or complete loss of one’s
voice. Early intervention in the case of vocal injury may prevent additional harm. Being
able to identify vocally injurious behaviors could prove beneficial to young teachers in
training programs. Learning how to preserve and maintain a healthy voice so one can
sustain a lengthy teaching career should be a part of every teacher training program.
Interestingly, choral directors teach students how to sing, yet their own voices may be
subject to damage by poor vocal habits. Education that promotes intervention techniques
will reduce the potential for further harm or loss of use. A study to identify vocal
problems in choral directors was needed. Such a study benefits not only teachers and
choral directors, but all professionals who experience an inordinate amount of voice use.

Vocal faults and dysfunctions can be linked to excessive or abusive voice usage
including vocal strain in a teaching environment. In addition, there is evidence of a lack
of training in vocal instructors’ training programs (DeLoach, 2000). The voice can be
fragile, showing effects from slight allergies, changes in climate, muscle fatigue,
emotional stress, or lack of sleep (Gotaas & Starr, 1993).

The frequency of vocal problems in teachers (Titze, Lemke, & Montequin, 1997)
and the additional requirement of singing while teaching indicate a need to study the
increased vocal demands of middle school and high school choral directors and the
resulting implications on the voice. Vocal problems can lead to stress, and ultimately, educator burnout and attrition if the choral director is unable to execute job expectations as in the past (Simberg, Sala, & Rönnemaa, 2004). Without the voice as a communication tool, a choral director is partially disabled when delivering content and direct instruction. Because of their training and knowledge of the vocal mechanism and singing technique, it would seem unlikely that choral directors experience vocal attrition. However, choral directors regularly demonstrate the symptoms of or report vocal disorders (Kramer, 1994; McKinney, 1994). Teaching students to sing and directing choirs poses an occupational risk due to the demand placed on voice use (Smith & Sataloff, 1999). Minimal research has been conducted with regard to voice problems in choral directors.

The National Institutes of Health focused attention on vocal problems of teachers by supporting a preliminary investigation by Smith, Lemke, Taylor, Kirchner, and Hoffman (1998). The purpose of the preliminary investigation was to compare the frequency and types of vocal dysfunctions of a group of teachers with a group of workers employed in non-teaching occupations. The preliminary study also sought to determine if the severity of vocal dysfunctions was higher among teachers than non-teachers, what types of effects there were on past, current, and future employment and career plans between the two groups. Finally, the preliminary study sought to determine differences in specific communication problems and the association between number of symptoms and age.

The study was conducted using a questionnaire, given to both the group of teachers and the group of non-teachers, which requested the following information: (a) the frequency of ten specific current or past voice symptoms typically associated with
voice disorders, (b) identification of other voice problems they might have experienced, (c) degree of physical discomfort associated with the symptoms, (d) functional impact of voice problems on their work and communication, and (e) potentially confounding or biologic risk factors due to social and demographic characteristics of the study population.

The results of this study by Smith, Lemke, et al. (1998) indicated that the teachers were significantly more likely to report 6 out of 10 of the following conditions as compared to new patients: hoarseness (47.5%), difficulty with high note singing (34.6%), tired voice (19.5%), low-speaking voice difficulty (18.7%), weak voice (11.6%), and effortful voice (10.4%). For both teachers and non-teachers, hoarseness was the most common voice symptom, but teachers were twice as likely to report the problem. When the data were examined for the number of symptoms reported, teachers averaged twice as many symptoms as workers in non-teaching fields. When examining the work-related effects of having voice disorders, teachers were twice as likely to identify their voice as a problem in their career. This study was influential in confirming clinical impressions and anecdotal evidence that teachers have significantly more frequent voice symptoms and physical discomfort associated with those symptoms than people in other occupations.

This study also revealed that teachers are more likely to have work-related problems resulting from such voice conditions. Teachers had a greater frequency of vocal symptoms compared to non-teachers, and this suggests a high risk for the profession. Smith, Lemke, et al. (1998) concluded that teachers should be taught how to compensate for the voice demands of their vocation. The authors also refer to the high demands on the vocal mechanism caused not only because teachers must use their voices for long
periods of time, but they also have to speak over loud background noise. Smith, Lemke, et al. (1998) suggest teachers are constantly exposed to contagious upper respiratory infections which can adversely affect the vocal apparatus.

Major Variables Influencing Vocal Health

Major variables that influence vocal health are identified in the literature. Sataloff and Titze (1991) have repeatedly reported on vocal abuse resulting from excessive loudness. The nature of directing a choir results in more noise than one would find in a regular classroom. This additional loudness causes the teacher to succumb to the Lombard Effect, thereby leading vocal abuse and voice problems (Weiss, 2001). Middle school and high school choral directors must manage classroom behavior as well as direct the choir, which leads to increased classroom noise. Smith, Kirchner, et al. (1998) also refer to the high vocal demands of teaching, citing that teachers have to speak over loud background noise and are constantly exposed to contagious upper respiratory infections which can adversely affect the vocal apparatus.

Sataloff (1991) reported that as people age, the vocal mechanism undergoes natural and predictable changes. Muscle tone decreases in the abdomen, lungs lose elasticity, the thorax loses distensibility, mucosal secretions change character, nerve endings are reduced in number, and other biochemical, neurological, and psychological changes occur. The larynx loses muscle tone and laryngeal cartilages may become arthritic. Hormonal changes occur in the body, and vocal range, intensity, efficiency, and quality are altered. Sataloff and Smith (2000) suggested the aging voice may experience unsteadiness, loss of range, and vocal fatigue. Sataloff (1991) concluded that voice
problems often arise from unconscious attempts to maintain an accustomed pitch despite these changes.

Vocal health differences between males and females were identified by Fritzell (1996), Russell, Oates, and Greenwood (1998), and Smith, Kirchner, et al. (1998). In each of the aforementioned studies, females were more likely than males to report a voice problem. Sataloff (1991) suggested that since the voice is sensitive to endocrine changes, often the resulting sound is different under altered hormonal conditions.

Years of teaching relates directly to age. The combined effects of hormonal and muscular changes coupled with years of teaching in noisy classrooms with abusive vocal habits indicate veteran choral directors are likely candidates for voice problems. Adding harmful vocal behaviors such as singing out of range or above the sound of the piano with a fragile or altered voice will decrease the vocal health condition of the choral director.

The need for vocal pedagogy and vocal hygiene training is abundant in the literature (Askren, 2000; Hendry, 2001; Russell et al., 1998; Sapir, 1993; Sapir et al., 1992; Simberg et al., 2000; Smith et al., 1997; Smith, Lemke, et al., 1998). During teacher training, preservice music teachers may learn proper voice use and healthy habits in studio voice lessons or ensemble rehearsals. Typically, care of the speaking voice is not included in this training. Askren (2000) found that approximately one-third of survey respondents received no vocal health training of any type in their teacher training programs. The need for vocal hygiene training was identified by Hendry (2001) as a major concern.
Smith and Sataloff (2000) emphasized the importance of a choral director learning proper use of the voice. Conductors who routinely sing during choir rehearsal, particularly outside their normal voice range, are more susceptible to hoarseness, vocal nodules, vocal fold hemorrhages, or permanent vocal injury.

Research Questions

This study sought to answer the following questions.

1. Does the vocal health of choral directors differ from the vocal health of the general population?

2. How are modified VHI subscale scores related to fundamental frequency and intensity ranges as indicated on VRP?

3. How are major variables that influence vocal health related to the three modified VHI subscale scores of middle school and high school choral directors?

4. How are major variables that influence vocal health related to the self-reported vocal health of middle school and high school choral directors?

5. How are major variables that influence vocal health related to fundamental frequency and intensity range as indicated on VRP?

Null Hypotheses

$H_{01}$ The vocal health of middle and high school choral directors does not differ from the vocal health of the general population.

$H_{02}$ There is no relationship between modified VHI subscale scores and fundamental frequency and intensity ranges indicated on VRP.

$H_{03}$ The major variables that influence vocal health are not related to the three modified VHI subscale scores of middle school and high school choral directors.
$H_04$ The major variables that influence vocal health are not related to the self-reported vocal health condition of middle school and high school choral directors.

$H_05$ The major variables that influence vocal health are not related to fundamental frequency and intensity ranges indicated on VRP.

Definition of Terms

To clarify terms used in this study, defined key terms are provided.

Amplitude. Amplitude of a sound wave is related to the perceived loudness; expressed as a logarithmic, comparative level measure using the decibel (dB) unit (Sataloff, 1997a)

Breathiness (breathy phonation). Phonation characterized by a lack of vocal fold closure causing air leakage during the quasi-closed phase. This produces turbulence that is heard as noise mixed in the voice (Sataloff, 1997a)

Decibel (db). One tenth of a bel; a unit of comparison between a reference and another point; it has no absolute value. For sound pressure, the reference is .0002 microbar (millionths of one barometric pressure). With different references, decibels may also be used to measure heat, light, and other physical phenomena (Sataloff, 1997a)

Dysphonia. Any disturbance of normal vocal function (Titze & Scherer, 1983)

Functional voice disorder. An abnormality in voice sound and function in the absence of an anatomic or physiologic organic abnormality (Sataloff, 1997a)

Fundamental frequency ($F_0$). The lowest frequency in a periodic waveform; also called the first harmonic frequency (Sataloff, 1997a)

Gain. Ratio of output to input of a sound source (Baken & Orlikoff, 2000)
Healthy voice. A voice which can produce sound with adequate muscular coordination and without any audible hyper-functions (Sataloff, 2001)

Hoarseness. A coarse or scratchy sound most often associated with abnormalities of the leading edge of the vocal folds, such as laryngitis (Sataloff & Spiegel, 1991)

Intensity. A measure of power per unit. With respect to sound, it generally correlates with perceived loudness (Sataloff, 1997a)

Lombard effect. Modification of vocal loudness in response to auditory input. For example, the tendency to speak louder in the presence of background noise (Sataloff, 1997a)

Loudness. The amount of sound perceived by a listener; a perceptual quantity that can only be assessed with an auditory system. Loudness corresponds to intensity and to the amplitude of a sound wave (Sataloff, 1997a)

Myoelastic-aerodynamic theory of phonation. The currently accepted mechanism of vocal fold physiology. Compressed air exerts pressure on the undersurface of the closed vocal folds. The pressure overcomes adductory muscle forces, causing the vocal folds to open. The elasticity of the displaced tissues causes the vocal folds to snap shut, resulting in sound (Sataloff, 1997a; Vennard, 1967)

Organic voice disorder. Disorder for which a specific anatomic or physiologic cause can be identified, as opposed to psychogenic or functional voice disorders (Sataloff, 1997a)

Phonetogram. See voice range profile

Phonetograph. See voice range profile
Pitch. Perceived tone quality corresponding to its fundamental frequency \((F_0)\) (Baken & Orlikoff, 2000)

Professional voice user. Individuals who depend on a consistent, special, or appealing voice quality as a primary tool of trade; those who, if afflicted with dysphonia, would generally be discouraged in their jobs (Titze et al., 1997)

Psychogenic voice disorder. Voice disorder caused by psychological factors rather than physical dysfunction. Psychogenic disorders may result in physical dysfunction of structural injury (Sataloff, 1997a)

Sound pressure level (SPL). Measure of the intensity of a sound, ordinarily in dB relative to 0.0002 microbar (millionths of 1 atmosphere pressure) (Sataloff, 1997a); average pressure of a sound wave (Baken & Orlikoff, 2000)

Vocal abuse. Use of the voice in specific activities that are deleterious to vocal health, such as screaming (Sataloff, 1997a); overuse of the voice resulting from extensive, vigorous, and inefficient voice use (Sapir et al., 1990)

Vocal attrition. ‘Wear and tear’ of the vocal mechanism (Sapir, 1993) and the overall reduction in vocal capabilities associated with acute or chronic abuse or misuse of the voice (Sataloff & Spiegel, 1991)

Vocal break. A planned time of complete vocal silence (Sataloff & Spiegel, 1991)

Vocal fatigue. An inability to continue the use of the voice for extended periods without change in voice quality (Sataloff, 1997b)

Vocal fry. Also known as glottal fry, glottal rattle, and glottal scrape. Loose glottal closure which permits air to bubble through with a popping or rattling sound of very low frequency (McKinney, 1994)
Vocal hygiene. Living habits and training procedures related to the care and preservation of the voice (Reid, 1983)

Vocal loading. Prolonged use of the voice (Vintturi et al., 2001)

Voice misuse. Habitual phonation using phonatory techniques that are not optimal and then result in vocal strain. For example, speaking with inadequate support, excessive neck muscle tension, and suboptimal resonance (Sataloff, 1997a)

Voice problem. Problem with vocal functioning that include abnormalities in voice output, phonatory effort, or any other voice-related function (Miller & Verdolini, 1995)

Voice range profile (VRP, also phonetogram, phonetograph). Recording of highest and lowest sound pressure level versus fundamental frequency that a voice can produce; phonetograms are often used for describing the status of voice function in patients (Sataloff, 1997a)

Volume. Amount of sound, best measured in terms of acoustic power or intensity (Sataloff, 1997a)

Scope and Delimitations

This study addressed the vocal health of middle school and high school choral directors. Since the specific demands of directing a choir were in question with regard to their effect on the voice, any choral director who did not teach middle school or high school was excluded from this research. Choral directors who solely worked with church, community, and college choirs were excluded due to the varying teaching schedules.
Organization of Document

The remainder of this document includes a review of literature section in which research is presented to establish support for the present study. The third section outlines the methods used to collect and examine data. Results were analyzed and are presented in the fourth section, followed by a discussion section containing implications of the research results and recommendations for further study and application.
CHAPTER 2
REVIEW OF LITERATURE

This study focuses on the vocal health of choral directors. Following is a description of voice production and a review of research related to vocal health and its measurement.

Voice Production

Phonation is the process of producing vocal sound by the vibration of vocal folds (Sataloff, 1997a). Vocal fold vibration (phonation) cannot occur without air. Natural breathing has three stages: inhalation, exhalation, and recovery (McKinney, 1994). Breathing for singing has four stages: inhalation, suspension to set-up controls, controlled exhalation or phonation, and recovery (Christy, 1975).

Historically, two major theories explain how vocal fold vibration, and subsequently phonation, is initiated. The myoelastic theory asserts that when the vocal folds are closed and air pressure is applied to them, the cords remain closed until the subglottic pressure beneath them is sufficient to push them apart. This allows air to escape and reduces pressure enough for muscle tension to pull the vocal folds together again. Pressure builds up again until the cords are pushed apart, and the cycle repeats. The rate at which the cords open and close, also called the number of cycles per second, determines the pitch of the phonation (McKinney, 1994; Vennard, 1967).

The aerodynamic theory, based on the Bernoulli Effect, states that breath flowing past the vocal folds causes them to be sucked into vibration before the arytenoids cartilages are fully together. Once the arytenoids are together, the air flow sucks the glottis closed and cuts off air flow until breath pressure pushes the folds apart and the
cycle repeats (McKinney, 1994). This air-flow is opposed by the force of muscle and ligament mass and by the Bernoulli Effect (Boone, 1977). The one minor difference between the theories is the factor that brings together the cords in each vibratory cycle. The myoelastic theory credits muscle tension and the aerodynamic theory credits the Bernoulli Effect (McKinney, 1994; Vennard, 1967).

Speech and singing professionals now accept the myoelastic-aerodynamic theory of phonation. This approach combines the two aforementioned theories and asserts that vocal fold vibration is determined by both muscular tension and breath pressure (Vennard, 1967).

Review of Literature

Literature is presented in this order: measurement of vocal health, including range profile and Voice Handicap Index (Jacobson et al., 1997), followed by vocal health of the general population, professional voice users, teachers, singers, and music teachers.

Measurement of Vocal Health

Vocal health in teachers has been studied primarily using self-reports and surveys. While self-reports and other subjective instruments are useful, participants may be unaware about their vocal health and therefore unable to accurately self-report. In other situations, participants may be unwilling to report the true status of their voice. A research study that includes objective measurement of vocal health unaffected by the aforementioned circumstances increases the level of objectivity.

Voice Range Profile

The range and powers at which voice can be produced is one indication of the limits of adjustment of the phonatory system and is therefore an important measure in the
assessment of vocal disorder (Michel & Wendahl, 1971; Hirano, 1989). When sustaining a vowel, normal speakers’ sound pressure level (SPL) will vary as a function of expected loudness and pitch level. Slight variation in intensity may be expected as a function of the vowel sustained due to acoustic phenomena in the vocal tract (Gelfer, Andrews, & Schmidt, 1991).

Minimum and maximum vocal intensity vary with fundamental frequency (Gramming, 1988; Gramming, Sundberg, Ternström, Leanderson, & Perkins, 1988), and both minimum and maximum intensity tend to increase as frequency rises (Wolf, Stanley, & Sette, 1935; Stout, 1938; Colton, 1973; Coleman, Mabis, & Hinson, 1977).

The voice range profile (VRP) is a technique used for the examination of voice behavior (Titze, 1992). A head-mounted microphone is used in order to standardize the microphone-to-mouth distance. Frequency tones generated by the computer prompt the participant to vocalize the specified target fundamental frequency at minimum and maximum intensities. This relatively lengthy procedure is comprehensive in that it elicits a full range of intensities for each fundamental frequency (Kay Pentax, 2005).

VRP plots a participant’s intensity and fundamental frequency ranges in a two-dimensional graph, with the x-axis representing fundamental frequency ($F_0$) and the y-axis representing intensity or sound pressure level (SPL) in dB (Titze, 1992; Kay Pentax, 2005). This graphical representation reflects a speaker’s ability to produce minimum and maximum vocal intensities as a function of frequency (Mathieson, 2001) under controlled conditions of vowel production and mouth opening (Schutte & Seidner, 1983). The graph is compiled from a series of frequencies produced by the participant at minimum and maximum intensity levels. Each frequency is produced at minimum and maximum
intensity before proceeding to the next semitone. The resulting image represents the lowest and highest frequencies at which the vocal folds are able to vibrate (Schutte & Seidner, 1983).

As frequencies are plotted against intensity levels, the voice range profile shows all combinations of frequency and intensity at which the participant is able to phonate (Baken & Orlikoff, 2000). Various terms have been used in related literature to describe the same procedure, phonetogram (Damsté, 1970; Schutte & Seidner, 1983; Gramming & Sundberg, 1988), phonogram (Komiyama, Watanabe, & Ryu, 1984), Stimmfeld (Klingholz & Martin, 1983; Seidner, Krüger, & Wernecke, 1985), voice profile (Bloothooft, 1982), voice field, voice area, and F0-SPL profile (Coleman, Mabis, & Hinson, 1977). The committee on Voice of the International Association Logopedics and Phoniatriecs recommended that the aforementioned names be replaced by the name voice range profile or its direct translation in other languages (Bless & Baken, 1992).

The VRP is useful for assessment of the normal voice (Schutte & Seidner, 1983). The National Center for Voice and Speech recommended using VRP as part of acoustic phonatory assessment (Titze, 1994 February). It is to be expected that professional singers’ voices cover a large frequency and intensity range field compared to normal voices, whereas pathological voices cover a much smaller field than normal voices. LeBorgne and Weinrich (2002) examined VRP changes in trained singers. After a nine month period of vocal training, significant improvements were identified in mean minimum intensity range and mean frequency range.

VRP was also used to identify time-of-day effects in vocally untrained adult women (van Mersbergen, Verdolini, & Titze, 1999). Twenty vocally untrained women
completed two VRPs, one in the morning and one in the evening. Relative to voice use, the authors theorized that both warm-up and fatigue effects could affect VRP performance. There was little evidence of time-of-day effect on VRP performance in young vocally untrained adult females. VRP maximum and minimum intensities did not vary reliably between morning and evening. Van Mersbergen et al. (1999) acknowledged the statistical power to detect time-of-day VRP changes was poor and larger participant groups are needed to identify reliable time-of-day effects.

Speyer, Wieneke, van Wijck-Warnaar, and Dejonckere (2003) studied the effects of voice therapy on the VRP of dysphonic patients. Each dysphonic patient recorded a VRP before voice therapy and again three months after therapy ceased. Speyer et al. (2003) found the main effect of voice therapy was increased low frequency and intensity. Although not statistically significant, high frequency and intensity also increased. Some VRPs did not show a change in shape or contour of the phonetogram, but this did not necessarily indicate lack of effect of voice therapy. Because the voice is multi-dimensional as an instrument and in its capabilities, a multi-dimensional approach to treatment and assessment of treatment effect is warranted.

*Voice Handicap Index*

Jacobson et al. (1997) sought to develop a statistically robust instrument that quantified the psychosocial consequences of voice disorders. Because there were relatively few standardized measures proven to be useful in assessing the psychosocial consequences of voice disorders, Jacobson et al. developed and tested the Voice Handicap Index (VHI) to determine quality of life and daily functioning changes in patients exhibiting a variety of voice disorders.
The initial version of the VHI consisted of 85 items developed from case history interviews with voice clinic patients. Items were grouped into three content domains representing the functional (25 items), emotional (31 items), and physical (29 items) manifestations of a voice disorder. The functional domain included items that described the impact of a voice disorder on a person’s daily activities. The emotional domain included items that described a patient’s affective response to a voice disorder, and the physical domain included items that collected patients’ self-perception of laryngeal discomfort and voice output characteristics. Patients were instructed to read each item and circle one of the following responses: Never, Almost Never, Sometimes, Almost Always, and Always. Each response had a corresponding point value for researcher use. Never received 0 points, Almost Never received 1 point, Sometimes received 2 points, Almost Always received 3 point, and Always received 4 points.

This original 85-item VHI was administered to 65 voice clinic patients in the Voice Clinic at Henry Ford Hospital. Internal consistency reliability was evaluated using Cronbach’s alpha coefficient. All items with correlation below \( r = 0.50 \) were eliminated. Any item to which 50% or more of the patients responded Never was eliminated. This item reduction procedure resulted in the 30-item (120-point total) final edition VHI. The functional, emotional, and physical domains were each represented with a 10-item subscale.

The final edition was administered to 63 voice clinic patients on two occasions to assess test-retest reliability. A Pearson product moment correlation coefficient was used to determine test-retest reliability of the three domains. Reliability was found to be strong: functional subscale \( (r = 0.84) \), emotional subscale \( (r = 0.92) \) and physical
subscale \((r = 0.92)\). Cronbach’s alpha coefficient was calculated for the item-total correlation resulting in strong reliability \((r = 0.95)\). Relationships between the three subscales were moderate-strong with Pearson product moment correlations ranging from \(r = 0.70\) to \(r = 0.79\).

Rosen, Murry, Zinn, Zullo, and Sonbolian (2000) used the VHI to assess treatment efficacy in participants following treatment of a voice disorder. The researchers sought to determine patients’ perceptions of the impact of his or her voice disorder following treatment for one of four different voice disorders. The VHI revealed a significant change in patients’ perception following voice treatment. Results of this research support the use of the VHI as patient-based assessment tool to monitor voice disorder treatment efficacy.

*Vocal Health*

Voice disorders cause medical and professional challenges for teachers and specifically choral directors. In addition to undergoing treatment or therapy for the voice disorder, affected individuals also face decreased job effectiveness or even loss of work time due to their compromised vocal condition. Smith, Verdolini, Gray, Nichols, Lemke, Barkmeier, Dove, and Hoffman (1996) studied voice disorders’ impact on an under-researched area: quality of life. Voice clinic patients \((N = 174)\) and non-patients \((N = 173)\) completed questionnaires about the frequency and effect of voice disorders on quality of life: work, social, psychological, physical, and communication problems as a result of a voice disorder. Smith et al. (1996) found that participants with a voice disorder perceive adverse effects on their quality of life. The non-patient comparison group reported very few voice symptoms and minimal adverse effects on quality of life.
Participants with a voice problem reported having the same voice problem for a minimum of two years, a troubling finding since one would expect an individual with a chronic problem to seek professional help. People often think of voice problems as temporary and treatable, and voice problems are not typically painful. Individuals who are in pain and suffering are more likely to seek medical intervention.

_Vocal Health of Professional Voice Users_

Professional voice users are those individuals who depend on a consistent, special, or appealing voice quality as a primary tool of trade and those who, if afflicted with dysphonia, would generally be discouraged in their jobs (Titze, Lemke, & Montequin, 1997). Titze, Lemke, and Montequin (1997) sought to identify the numbers of professional voice users employed in a variety of careers. Specifically, the researchers sought to identify which professionals are most frequently treated in voice clinics, what percentage of the United States workforce may be classified as professional voice users, and what percentage of the U.S. workforce requires a healthy voice for public safety purposes.

Titze et al. (1997) found salesmen to be the largest occupation of professional voice users, yet teachers represented about 20% of the voice clinic load, a significant disproportion to other occupations of professional voice users. The most frequently cited reasons for teachers seeking treatment for a voice problem were hoarseness, vocal breathiness, weakness, tiredness, effortfulness, and low-pitched voice. The authors theorized that teachers represent the highest occupational group seen in the voice clinic because they are aware of health issues and know how and where to seek treatment for a voice problem. While teachers were not in the profession with the greatest risk, they were
most prepared to locate options for obtaining treatment. This finding was indicated by the frequency with which teachers sought treatment at a voice clinic.

Fritzell (1996) conducted a study \( (N = 1212) \) to determine the diagnosis, occupation, gender, and age of new voice patients in Sweden. Teaching professions were more frequently represented than any other profession, followed by health care professionals and salesmen. The most commonly reported voice disorder was vocal fatigue and nearly twice as many women as men were seeking treatment for a voice problem. Of particular interest was Fritzell’s finding that music teachers were eight times more likely than the general population to seek treatment for vocal problems. Fritzell suggests that music teacher training programs improve in their preventative voice care curriculum.

Vilkman (2000) examined voice problems at work in terms of occupational safety. The study focused on professions that not only required prolonged voice use, but also included excessive vocal loading, such as background noise, large speaking distance, poor room acoustics, and lack of adequate voice amplification. School teachers were categorized as those with heavy vocal loading. Vilkman (2000) described occupational voice disorders as consequences of repeated movements and collisions of vocal folds, and therefore classified voice disorders as repetitive strain injuries. Voice disorders also fulfill the criteria for repetitive strain injuries because of other factors, such as affected individuals stress and poor treatment of early symptoms.

*Vocal Health of Teachers*

Vocal fatigue is defined as the inability to continue the use of the voice for extended periods without change in voice quality (Sataloff, 1997). This problem usually
develops as the speaking day progresses, is most apparent at the end of the speaking day, and has disappeared by the following day. It may be characterized by changes in vocal quality, loudness, pitch, or effort.

Gotaas and Starr (1993) studied vocal fatigue among teachers by using a mail survey as well as by making recordings at the beginning and end of workdays of both teachers who experience vocal fatigue \((n = 22)\) and those who did not experience vocal fatigue \((n = 17)\). Teachers who had experienced fatigue in the past were recorded on days in which they did and did not fatigue. Both groups of teachers evaluated their vocal characteristics each time they made a recording. A listener panel evaluated the same vocal characteristics from the recordings.

Gotaas and Starr found that the vocal characteristics of teachers with vocal fatigue and those without vocal fatigue were similar on days the former group did not experience vocal fatigue. Additionally, the teachers who experienced vocal fatigue and those who did not are similar in the amount and loudness of their talking time at work and at home. Teachers who experienced vocal fatigue tended to spend more time on vocally demanding activities in the classroom. Based on their findings, Gotaas and Starr concluded that workday activities contribute to the development of vocal fatigue in teachers, however, neither the amount of time they talk nor the amount of time they talk loudly appear to be solely responsible for vocal fatigue among teachers.

Pekkarinen, Himber, and Pentti (1992) conducted a questionnaire study comparing the prevalence of vocal symptoms between teachers and nurses. In clinical practice, nurses are less likely to seek treatment for a voice problem than teachers. Vocal demands in the classroom due to acoustic environment lead to more frequent vocal
symptoms in teachers than in nurses, and teachers reported that they suffered symptoms longer than nurses. Pekkarinen et al. (1992) noted no positive correlation between age, length of teaching career, smoking, or personality of the teachers and frequency of vocal symptoms.

Vocal symptoms and behavior in teachers and a control group of nurses was studied by Ohlsson, Järvholm, Löfqvist (1987) using a questionnaire in Sweden. Participants in both groups reported no current voice problems and individuals were interviewed about voice use at work. VRP was used to collect acoustic data. On the questionnaire, teachers reported significantly more voice symptoms and professional vocal demands than nurses. Acoustic analysis showed no significant differences between teachers and nurses with the exception of fundamental frequency range; teachers had a wider range than nurses. Teachers use their voices as pedagogical and disciplinary tools in classrooms with varying degrees of noise. Therefore, Ohlsson et al. (1987) concluded that teachers run the risk of having more vocal strain and greater professional vocal demands than nurses.

Russell, Oates, and Greenwood (1998) examined the prevalence of voice problems in teachers using a survey. Teachers were asked to report voice problems for the day of the survey, during the current school year, and during their teaching careers. Sixteen percent of the teachers who responded reported a voice problem the day of the survey, 20% reported voice problems during the current school year, and 19% reported voice problems at some time in their careers. Females were twice as likely as males to report voice problems, a finding consistent with Fritzell (1996).
Russell et al. (1998) also found a significant relationship between career prevalence of voice problem and age of the teacher. Teachers between 31-40 years of age and teachers older than 50 were more likely to report a voice problem than teachers aged 21-30 years or 41-50 years. A significant relationship was also identified between the severity of the voice problem and recovery time. Predictably, more severe voice problems took longer to return to normal than mild voice problems.

In this study by Russell, Oates, and Greenwood (1998) the number of teachers who sought help for voice problems was considerably lower than the number of teachers who reported a voice problem. Sapir, Keidar, and Mathers-Schmidt (1993) found that less than 1% of teachers who reported a voice problem sought help from a voice specialist. The reluctance to obtain professional help suggests teachers view voice problems as an occupational hazard or are not aware of the available treatment options.

Using a survey designed to assess prevalence and impact of vocal attrition, Sapir et al. (1993) studied vocal attrition in 237 female teachers. More than half of the respondents reported more than three symptoms of vocal attrition. A significant number of teachers reported their vocal symptoms adversely impacted their ability to teach effectively. The same significant number of teachers reported that their voice was a source of stress and frustration when symptoms were manifesting. One third of the teachers who reported multiple vocal symptoms indicated they had to miss work because of their voice problem. Findings by Sapir et al. (1993) suggest vocal attrition may be prevalent among teachers and often, severe enough to necessitate loss of work. However, only 1% of teachers who reported multiple vocal symptoms sought professional treatment.
Simberg, Laine, Sala, and Rönnemaa (2000) examined the prevalence of voice disorders among 226 college students studying to become teachers. Students’ voices were evaluated by a speech therapist, and those students who had abnormal voice quality and students who reported vocal symptoms were referred to an otolaryngologist for clinical evaluation. Results indicated that voice problems were prevalent among college students studying to become teachers, and about 20% of the participants needed voice therapy and/or medical treatment. Simberg et al. (2000) suggested that a survey, while useful in providing substantial amounts of information, when used alone, is insufficient in detecting voice disorders. Additionally, Simberg et al. (2000) recommended more vocal training during college for individuals who are planning to be professional voice users.

In a similar study conducted by Simberg, Sala, and Rönnemaa (2004), the researchers sought to compare vocal symptoms reported by college students in general and college students studying to become teachers. Results indicated that college students in general reported frequently-occurring vocal symptoms. Meanwhile, students studying to become teachers reported a significantly greater number of frequently occurring vocal symptoms such as throat-clearing, vocal strain or fatigue, hoarseness, or pain in the throat.

Frequency and effects of teachers’ voice problems were compared to a group of individuals in other occupations by Smith, Gray, Dove, Kirchner, and Heras (1997). Teachers were more likely to report having a voice problem, and they averaged about two voice symptoms such as hoarseness, difficulty with high notes, tired voice, or low speaking voice, compared with none for non-teachers. Teachers also were more likely to perceive that their future career options would be adversely impacted by voice problems.
None of the non-teachers missed work due to a voice problem, yet over 20% of teachers missed days of work due to a voice problem. Findings by Smith et al. (1997) suggest that teaching is a high-risk occupation for voice disorders and that as a health problem, voice disorders can negatively impact career options.

Smith, Kirchner, Taylor, Hoffman, and Lemke (1998) studied voice problems among teachers and examined the differences by gender and teaching characteristics. Over 38% of the teachers in this study reported that teaching had a negative impact on their voice, and 39% of those teachers had to reduce the amount of teaching as a direct result of their voice problem. Females reported voice problems with greater frequency than males even when teaching characteristics and years of teaching were very similar to males. Additionally, Smith et al. (1998) found that with increasing age, the frequency with which teachers reported vocal problems also increased.

Prolonged voice use, often in the presence of background noise, is often cited as a major contributor to voice problems among teachers. Smith, Lemke, Taylor, Kirchner, and Hoffman (1998) found that elementary and high school teachers have a higher rate of self-reported voice problems than individuals who work in other professions. Again, female teachers were significantly more likely to report voice problems even after the researchers controlled for effects of age and years of teaching.

**Vocal Health of Singers**

Broaddus-Lawrence, Treole, McCabe, Allen, and Toppin (2000) suggest vocal hygiene education should be used as a tool to prevent voice disorders in professional singers. They assert proactive and preventative measures in an effort to reduce the probability of developing a voice problem later in life.
Sapir (1993) studied vocal attrition in female university voice students using a survey. Of the 79 respondents, 10 students were free of vocal symptoms, 19 students had one or two voice symptoms, and 45 students had three or more symptoms. Forty-seven percent of the singers sought professional help for voice problems since they began singing. Sapir found that students with three or more vocal symptoms were more likely to be frustrated or worried about their voice, quit performing, speak in a low voice, and had a tendency to be anxious or depressed. Sapir concluded that vocal attrition is prevalent among untrained and partially trained singers, and this has a significant impact on performance goals and overall well-being. Vocal attrition affects well-being because an impaired voice may be viewed as a disability, and therefore it becomes a source of stress and frustration. Findings were interpreted by Sapir with caution due to the limitations of a survey and number of participants. He also concluded that results suggest the need for intensive training in vocal hygiene as a regular part of voice student’s formal education.

In a pilot survey, Tepe et al. (2002) sought to gain insight into the incidence of voice problems in young singers and to identify risk factors for developing voice problems in adolescence and adulthood. After completing a survey, singers were grouped into categories based on the presence or lack of voice problems and whether they ever had formal singing lessons. Tepe et al. (2002) found late adolescent singers were most at risk for vocal difficulties as determined by the self-report survey. Two risk factors were identified as having an increased frequency in singers with vocal difficulty: (a) perception that the singer’s voice feels worse in the morning, and (b) chronic fatigue or insomnia. A history of taking voice lessons did not ensure good vocal practice, according to this study, and it did not appear to decrease the risk of vocal difficulties in young amateur singers.
This result must be interpreted with caution, however, and it suggests that taking voice lessons is not a guarantee for pre-empting voice disorders.

**Vocal Health of Music Teachers**

Using a questionnaire, 125 teachers of singing and 49 control participants were asked to report if they had current or past voice problems as well as detailed demographic information (Miller & Verdolini, 1995). Rates of current voice problems were analyzed using a Fisher two-tailed test of exact probability. Current voice problems did not differ across the groups. However, the same results indicated group differences in the frequency of past voice problems. Sixty-four percent of teachers of singing reported having a voice problem in the past, as opposed to 33% of the control group. Based on the results of this study, Miller and Verdolini (1995) concluded that teachers of singing were about as likely to report a voice problem as the general population. However, teachers of singing were almost four times more likely to perceive a voice problem at some point. Risk factors identified as likely catalysts for voice problems were use of drying medication and reports of past voice problems. These two factors reliably predicted an increased rate of reporting a voice problem. Another noteworthy finding was that females were almost twice as likely as males to report a voice problem. Significance was not identified between teachers of singing and frequency of current voice problems. Miller and Verdolini (1995) suggested that perhaps as teachers of singing lessen their performance and travel schedule, they practice healthier vocal and living habits.

Bernstorf and Burk (1996) studied the personal and environmental factors affecting vocal integrity of elementary school vocal music teachers. They used three factors associated with professional voice use to predict teachers’ scores on the Voice
Conservation Index (VCI), a self-report index of vocal integrity. The factors used by Bernstorf and Burk were percentage of life span spent in teaching, teaching schedule, and dosimeter measures of classroom noise. Maximum classroom noise level emerged as a significant predictor of VCI scores. This finding indicated that in classrooms with significant background noise, teachers were more likely to report voice problems, perhaps from the additional vocal loading or strain.

Burnout and self-reported vocal health of music teachers was studied by Hendry (2001). She found the most frequently reported symptoms of a voice problem were loss of high notes in the singing range, loss of loudness in singing and speaking range, register transition problems in singing, and register breaks. Most of the voice teachers in Hendry’s study were not currently studying with a voice teacher and some had gone years without voice lessons. Hackworth (2003) found that following vocal hygiene training, vocal music teachers reported fewer vocal problems. The same vocal music teachers also reported taking more vocal breaks throughout the day. Using a survey, Kramer (1994) found that the majority of music educators are either unaware of or ignore vocal dysfunction. Their vocal problems began gradually and progressed to moderately severe.

Summary

A choral director’s voice is the primary form of communication, yet often this tool is overused or misused. An overused or misused voice can lead to a voice disorder, loss of work, or decreased job satisfaction. Many of the aforementioned studies related to vocal health relied upon teacher self-report measures and surveys to collect data. Researchers expect participants to report an accurate portrayal of their vocal health and habits. However, a teacher who admits to having a voice problem may also be admitting
to compromised job performance. Another drawback to using self report to collect information regarding voice problems is lack of awareness. Voice problems usually develop over a period of time, and teachers may not be aware of their decreased vocal function. An objective measure such as the Voice Range Profile controls for misrepresented self report responses. Participants cannot alter the results and the results are not dependant upon participant knowledge about their current vocal function. The measurement of vocal health using the Voice Range Profile raises the level objectivity in the present study and also explores an under-researched field: vocal health of choral directors.

Previous studies have not addressed the specific speaking and singing practices in middle and high school choral music instruction, nor have they been concerned with the impact of those practices on the vocal health of choral directors. The teaching profession appears in the literature as having a significant number of vocal health issues (Gotaas & Starr, 1993; Titze et al., 1997; Pekkarinen, Himber, & Pentti 1992; Ohlsson, Järvholm, & Løfqvist, 1987). Choral directors are part of a profession that requires extensive use of both the speaking and singing voice during the school day, often in noisy classrooms. There is a need to study the vocal health of choral directors with specific regard to the variables that may influence this condition. This research examined the vocal health of middle school and high school choral directors via self-report rating, VHI, and VRP. Using the methodology outlined in the following chapter, this study identifies how major influencing variables are related to vocal health. Following this research, future studies may examine vocal pedagogy and vocal health courses in undergraduate teacher training
programs. It is also appropriate to examine the vocal health of choral directors in a direct manner such as utilizing videostrobscopy.
This section describes the methodology, research design, identification of the variables, selection of participants, and instrumentation. Field procedures, data collection and recording, data processing and statistical analysis, and limitations of the study are also presented. A summary follows the methodology. This study examined the vocal health of middle school and high school choral directors. The variables of age, gender, years of teaching, level of teaching, and vocal health education were also examined because of their importance in the research literature.

Four months prior to the start of data collection, the author traveled to Kay Pentax in New Jersey, the manufacturer of the VRP equipment used in this study. At that time, several hours were spent with a manufacturer’s representative who is a licensed speech pathologist for the purpose of receiving training in the proper use of VRP equipment. The author was in regular contact with the manufacturer regarding test techniques and options until data collection began. Guidance by an experienced local speech pathologist was received throughout the duration of this research.

Description of Methodology

The research methodology of this project is in three parts. First, study participants completed the modified Voice Handicap Index (VHI). The modified VHI was designed to assess the impact of voice use and function on quality of life within three content domains: functional, emotional, and physical. A brief questionnaire developed by the author provided background information: (a) age, (b) gender, (c) years of teaching, (d) level of teaching, (e) vocal health education, and (f) self-report rating of vocal health.
Collection of the VRP also occurred during this section of the study. The second part of the methodology included coding data and data entry. The third section involved analyzing the data and interpreting the results.

Research Design

This study utilized a number of different analytical strategies. While attempting to answer research question number one, independent samples t-tests were conducted to compare fundamental frequency and intensity of choral directors and other population group. Canonical correlation was used to determine relationships between age, gender, years of teaching, level of teaching, vocal health education, modified VHI score, and VRP ranges.

Using the modified VHI, fundamental frequency and amplitude ranges as indicated on the VRP, and the background information such as age, gender, years of teaching, level of teaching, vocal health education, and self-report of vocal health, the vocal health of middle school and high school choral directors was collected and analyzed. The VRP graphically represents a participant’s minimum and maximum intensity (loudness) for all possible frequencies (pitches).

Selection of Participants

Geographic regions of the country were selected for recruitment of a nationally representative sample of middle school and high school choral directors. The author identified school districts within the targeted region and collected potential participant email addresses from local school websites. An email composed by the researcher was sent to potential participants requesting volunteers. Contents of the recruitment letter included summary and importance of the project, brief description of participant
requirements, background information and qualifications of the researcher, Institutional Review Board (IRB) contact information and approved protocol number. Participants were asked in the recruitment email to reply directly to the researcher if they were willing to volunteer, after which a mutually convenient appointment was set. The author traveled to each region, and subsequently, each participant’s school in order to collect data (Figure 1).

Figure 1. Cities represented in the sample

Participants were full-time middle school or high school choral directors. Institutional Review Board approval of this protocol was granted prior to beginning the data collection process (Appendix E). Volunteers signed an informed consent form before participating.
Instrumentation

Instrumentation in this study consisted of the modified VHI, voice range profile (VRP), and 7-item questionnaire appended to the modified VHI. The original VHI was developed to quantify the psychosocial consequences of voice disorders (Jacobson et al., 1997). Subscale reliability within the VHI was tested by the original authors and found to be strong, ranging from $r = 0.84$ to $r = 0.92$. Overall VHI reliability was also tested during development by the original authors and found to be robust ($r = 0.95$).

Vocal health status of participants in the present study was unknown, therefore original VHI items that presumed a voice disorder was present were modified. The neutral response option of ‘Sometimes’ was eliminated. This minimally modified VHI was piloted by the present author in a study of the vocal health of preservice music teachers (Schwartz, 2005 April). An internet-based version of the modified VHI was administered to preservice music teachers in Florida and South Carolina ($n = 120$). Cronbach’s alpha was calculated for the 30-item modified VHI and found to be strong ($r = .94$). Reliability of the emotional, functional, and physical subscales was calculated and also found to be strong, ranging from $r = .84$ to $r = .89$. The strength of the modified VHI reliability and its similarity to the original VHI reliability indicates the modifications have not compromised the instrument.

VRP has been a standard part of European phoniatrics and logopedics for many years, with increasing popularity and use in the United States (Baken & Orlikoff, 2000). While VRP testing is becoming more frequent, there is very little standardization of either the method for administering the VRP or the manner in which the results are
displayed. VRP produces a two-dimensional contour of vocal intensities through the
frequency range of the voice.

The absence of formalized VRP data acquisition techniques necessitated
significant examination of the various collection methods represented in the literature.
Baken and Orlikoff (2000) suggested certain elements of the procedure may be
considered ‘common usage’ in obtaining VRPs. These elements are test setting, mouth-
to-microphone distance, stimulus tones, vowel, stimulus frequencies, intensity
measurement, vocal quality, duration, and plotting the data. Many of the aforementioned
elements have been simplified by the use of computer-assisted generation of the VRP.
Each element has been addressed later in this chapter with regard to protocol in the
present study.

**Field Procedures**

The author recruited participants as outlined previously. After signing the
informed consent form, each participant was assigned a code to preserve privacy in
compliance with IRB regulations. Participants were coded consecutively in the order of
participation beginning with 01. An additional letter code was added to designate the city
in which the participant was a choral director. Participant code was noted on the first
page of the participant’s modified VHI. VRPs were also saved according to participant
code.

**Data Collection and Recording**

The modified VHI produced a score from 0 to 4 for each item and the subscale
item scores have been summed for a numerical score for each participant within each
subscale. The VRP generates maximum and minimum intensity and frequency as well as
ranges in numerical form. Age, years of teaching, and vocal health education remained continuous variables. Gender was coded as Female = 0 and Male = 1. Level of teaching was coded Middle School = 1, High School = 2, Both Middle School and High School = 3. Self-report of vocal health is a single, 4-point rating scale.

Due to the nature of acoustic data acquisition for the VRP, the author requested that participants secure a quiet room for testing purposes. Schutte and Seidner (1983) recommended that VRP testing is done in an acoustic environment that approximates a normal conversational setting. While every effort was made to ensure ambient noise in the test environment did not exceed 40 dB as recommended by Schutte and Seidner (1983), the design, atmosphere, and activity of middle schools and high schools made this very difficult. Most data collection, including VRP testing was conducted in the participant’s classroom during a planning period or before or after the school day.

Ambient noise in the test environment was measured using Martel Electronics model 325 sound level meter. Ambient noise level ranged from 36.1 to 52.2 dB (M = 42.1) in the testing rooms, approximately the equivalent sound level as a small office or quiet residential area. While it was not ideal to conduct sensitive acoustic testing in environments where the ambient noise averaged 42.1 dB, acoustic limitations of the existing facilities and lack of availability of alternative test space prevented relocation.

The computer used for mobile data acquisition was a Toshiba Qosmio G25, on which Kay Pentax Multi-Speech and Voice Range Profile software were pre-loaded. Sound Blaster PCMCIA Audigy 2 Z5 sound card for notebook computers was used to capture the external sound source from the preamplifier. Kay Pentax Voice Range Profile Preamplifier for models 4326-1 and 4326-2 was used to accept the input signal from the
microphone and provide enough signal gain in order to make the signal suitable for further processing (Baken & Orlikoff, 2000). The Voice Range Profile Preamplifier was connected to the computer through the Sound Blaster Audigy 2 Z5 sound card using the attenuated patch cable designed for VRP use supplied with the preamplifier from the manufacturer.

Condenser microphone C 420 III PP manufactured by AKG was used. This headset-style has an adjustable boom-mounted microphone. The condenser was connected to the Voice Range Profile Preamplifier through a Deltron DGS Pro-Audio 20 dB attenuator. The purpose of the attenuator is to improve isolation or buffering between circuits and reducing the effects of mismatched impedances. The attenuators also serve to extending the sensitivity range of measurement instruments, receivers, and amplifiers (Kay Pentax, 2005).

The input level was automatically detected on the data-acquisition computer in response to signal strength. When the high-gain channel approached overload, the software automatically switched to the lower-gain input channel. When the input channel is switched, the VRP software takes the change of gain into account and plots the SPL data accordingly. This technique allows the system to track pitch over a wide dynamic range (Kay Pentax, 2005).

A small, external, powered speaker (Cyber Acoustics CA-MP30 Portable Stereo Speaker System) was connected to the computer through the Sound Blaster Audigy 2 Z5 Sound Card. The purpose of the external powered speaker system was to amplify the stimulus tone of the VRP for the participant.
After measuring ambient noise with a sound level meter, the Voice Range Profile Preamplifier was calibrated using the calibration cable supplied by the manufacturer. The Voice Range Profile Preamplifier takes an incoming single-channel signal and splits it into two channels, where one is 26 dB lower than the other. The low-level signal is input to channel 1 and the high-level signal is input to channel 2 (Kay Pentax, 2005).

The boom-mounted condenser microphone was sterilized before and after each use with alcohol swabs. Mouth-to-microphone distance was maintained at approximately 15 cm. Stimulus tones were generated by the computer and played for the participant through the external speaker.

The VRP is generated from multiple sustained vowel sounds. Schutte and Seidner (1983) recommended the use of /a/, /i/, and /u/. The vowel /a/ as in ‘father’ was selected for use in the present study to avoid interaction between the fundamental and the first formant frequency on the majority of phonations (Gramming & Sundberg, 1988). All sustained vowel phonations were required to be sustained for a duration of at least 3 seconds at the target frequency (Awan, 1991).

Participants first signed the informed consent. While the author set up the equipment, the participant completed the modified VHI and appended questionnaire of background information. Once the VRP equipment was calibrated, VRP testing began at the participant’s lowest functional frequency, excluding vocal fry. Use of vocal-vibrato was discouraged in order to capture a steady-state prolongation of the vowel (Baken & Orlikoff, 2000).

Minimum phonatory intensity was assessed first. Instructions adapted from Awan (1991) were spoken by the author to the participant:
The computer will play a stimulus tone. I would like you to match the pitch by sustaining the vowel /a/ as softly as possible for at least 3 seconds without whispering. We will continue to ascend the scale by half-steps until you are unable to sustain the pitch.

This procedure was followed by maximum phonatory intensity with instructions adapted from Awan (1991) spoken by the author to the participant:

Now we will go back to your lowest functional note. The computer will play a stimulus tone. This time I would like you to sustain the vowel /a/ as loudly as possible for at least 3 seconds without shouting or screaming. We will continue to ascend the scale by half-steps until you are unable to sustain the pitch.

Using this VRP acquisition procedure, all semitones within the musical range of phonation were captured in the VRP plot and converted for comparative purposes. Lowest functional frequency was determined by self-reported voice classification and comfortable phonation.

Plotting the data was done automatically by VRP software at the time of testing. The vertical or Y-axis was dB of sound pressure level, or intensity. The x-axis was frequency. The Z-axis represented the density value of a cell. Each time the participant sustained the same frequency at the same sound pressure level, the Z-axis cell became darker (Kay Pentax, 2005).

Single, unwanted values, or artifacts tend to occur when a VRP is captured over a number of sustained phonations of varying frequencies. These artifacts are typically breath or articulator sounds. Such artifacts are unwanted in the final plots. Any non-contiguous artifact was deleted from the plot before converting the VRP into semitones, hertz, and decibels.

Intensity measurement complied with a “C” weighting, or fast sound level meter response. At the outer extremes of the vocal frequency range, the participant may be able
to sustain the sound for a very brief time. Fast sound level meter response is required in order to capture the signal and reach final value before the participant stops sustaining the sound (Baken & Orlikoff, 2000; Coleman, Mabis, & Hinson, 1977; Gramming, 1988).

Data Processing and Statistical Analysis

Data consisted of fundamental frequency and intensity as indicated on the VRP, modified VHI score, three modified VHI domain scores, self-report rating of vocal health, and background information. Descriptive statistics for each of this study’s major variables influencing vocal health were calculated, including sample size, mean, standard deviation, and Cronbach’s alpha reliability.

\[ H_0 \text{1} \quad \text{The vocal health of middle and high school choral directors does not differ from the vocal health of the general population.} \]

The first null hypothesis has been tested using independent samples t-tests. Vocal health of the general population was determined from published normative ranges of fundamental frequency and intensity.

\[ H_0 \text{2} \quad \text{There is no relationship between VHI subscale scores and VRP scores.} \]

The second null hypothesis was tested utilizing canonical correlation. This assessed the relationship between two sets of variables with one set, VHI subscale scores functioning as predictors of the other set, VRP scores.

\[ H_0 \text{3} \quad \text{The major variables that influence vocal health are not related to the three VHI domains (functional, emotional, physical) for middle school and high school choral directors.} \]

The third null hypothesis was assessed using canonical correlation in a similar procedure as described for \( H_0 \text{2}. \) This assessed the relationship between two sets of variables with one set, major
variables influencing vocal health, functioning as predictors of the other set, VHI subscale scores.

\(H_4\) The major variables that influence vocal health are not related to the self-reported vocal health rating of middle school and high school choral directors. The fourth null hypothesis was tested using multiple regression. This assessed the relationship between a set of variables, VHI subscale scores and a single item vocal health rating.

\(H_5\) The major variables that influence vocal health are not related to VRP amplitude and fundamental frequency. The fifth null hypothesis has been assessed using canonical correlation in a similar procedure as described for \(H_2\). This assessed the relationship between two sets of variables with one set, major variables influencing vocal health, functioning as predictors of the other set, VRP fundamental frequency and amplitude ranges.

Limitations

One potential weakness in this study is the sampling procedure. The author pre-selected geographic regions and recruited participants from those areas. Another possible weakness was the varied test locations. In order to recruit a greater number of participants, the author chose to travel to each participant’s school. This method limited the inconvenience to the participant and also reduced the time commitment. Despite the fact the equipment was sterilized and recalibrated before every VRP, the ambient noise was varied in every test location. Finally, this study relied on middle school and high school choral directors to volunteer. There is potential that individuals who suspected
they had a voice problem did not volunteer to participate, and only those who assumed
they were vocally healthy volunteered.

Summary

The purpose of this study was to examine the vocal health of middle school and
high school choral directors. The modified VHI and VRP are professionally recognized
tools for measuring quality of life and voice production, respectively. Once the
relationship between the selected variables is identified and vocal health conditions have
been determined, the profession may begin to evaluate teaching behaviors, voice habits,
and vocal health education.
CHAPTER 4
RESULTS

This study utilized both subjective and objective data pertaining to the vocal health of middle school and high school choral directors. Following descriptive data, answers to research questions are presented in the following order.

1. Does the vocal health of choral directors differ from the vocal health of the general population?
2. How are Voice Handicap Index subscale scores related to fundamental frequency and amplitude ranges as indicated on the Voice Range Profile?
3. How are major variables that influence vocal health related to the three Voice Handicap Index subscale scores of middle school and high school choral directors?
4. How are major variables that influence vocal health related to the self-reported vocal health of middle school and high school choral directors?
5. How are major variables that influence vocal health related to Voice Range Profile amplitude and fundamental frequency range?

Descriptive Statistics

Participants were full-time middle school (n = 26) and high school (n = 25) choral directors. Six participants were teaching both middle school and high school. Years of teaching ranged from 1 to 36 (M = 15.02, SD = 11.24). Choral directors ranged in age from 22 to 60 years (M = 40.12, SD = 12.11). Thirty-five participants were female (61.4%) and 22 were male (38.6%). The average age was 39.97 (SD = 12.8) for female participants and 40.36 (SD = 11.23) for male participants. Singing voice parts included 19
sopranos (33.3%), 15 altos (26.3%), 11 tenors (19.3%), and 12 basses (21.1%).

Participants were asked how many vocal pedagogy or vocal health-related classes or workshops they had taken. Number of classes/workshops ranged from 0 – 12 ($m = 2.81$, $SD = 2.38$). When asked how they would rate their present vocal health status, 22.8% ($n = 13$) responded ‘Excellent,’ 54.4% ($n = 31$) responded ‘Good,’ and 22.8% ($n = 13$) responded ‘Fair.’ No choral directors responded that they rated their vocal health condition as ‘Poor.’

Research Question 1

The first research question sought to determine if there is a difference between voices of choral directors and general population. Acoustic characteristics of middle school and high school choral directors’ voices were collected using the voice range profile.

VRP generates a two-dimensional plot of a participant’s voice with frequency along the x-axis and intensity (or energy) on the y-axis (Figure 2). Examination of the contour provides insight into vocal capabilities, but making direct comparisons is very difficult due to the varying shapes of the profile. The two-dimensional phonetogram plot was converted by the computer into semitones, hertz, and decibels in order to compare choral directors to other segments of the population (Figure 3).
Figure 2. VRP of female professional singer

Figure 3. VRP and computer-generated numerical conversion summary
Sulter, Schutte, and Miller (1995) studied male and female subjects with and without vocal training by comparing frequency and sound pressure level characteristics. Sulter et al. had 224 male and female participants with and without vocal training. Untrained participants were volunteers without vocal complaints or history of vocal pathology and consisted of 92 women (mean age = 20.3) and 47 men (mean age = 25).

The same study (Sulter et al., 1995) had 42 women (mean age = 35.1) and 43 men (mean age = 47.5) in the vocally trained group. Participants in the trained group must have had a minimum of 2 years of vocal training that consisted of either singing in a choir or individual singing lessons at least once a week.

In the present study, phonetograms using minimum and maximum SPL were constructed at 10% intervals of each participant’s frequency range to enable direct comparison to Sulter, et al. This 10% rescaling method has been used in several studies involving use of the phonetograms (Coleman, Mabis, & Hinson, 1977; Gramming & Sundberg, 1988; Awan, 1991; Akerlund, Gramming, & Sundberg, 1992) because it determines dynamic ranges within fixed distances in a participant’s frequency range. This allows data to be treated and compared numerically (Sulter et al., 1995).

In order to answer the first research question and determine if the vocal health of choral directors differs from the general population, 2-tailed independent sample t-tests were conducted. Table 1 shows the mean maximum intensities of choral directors, trained, and untrained male participants at each 10% frequency interval. Significant differences between male choral directors and untrained male singers were identified in 7 of 11 maximum frequency intervals. Significant differences between male choral
directors and male trained singers were identified in 5 of 11 maximum frequency intervals.

Table 1.

<table>
<thead>
<tr>
<th>Frequency level</th>
<th>Choral Directors (n=22)</th>
<th>Untrained (n=47)</th>
<th>t (df=67) p &lt;</th>
<th>Trained (n=43)</th>
<th>t (df=63) p &lt;</th>
</tr>
</thead>
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<td>11.90 .001*</td>
<td>59.80</td>
<td>15.89 .001*</td>
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<td>5.33</td>
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<td></td>
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<td>10%</td>
<td>90.36</td>
<td>77.20</td>
<td>8.39 .001*</td>
<td>74.90</td>
<td>8.60 .001*</td>
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<td>20%</td>
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<td>85.70</td>
<td>6.25 .001*</td>
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<td>6.11 .001*</td>
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<td>6.38</td>
<td></td>
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<tr>
<td>30%</td>
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<td>90.70</td>
<td>4.12 .001*</td>
<td>90.60</td>
<td>3.74 .001*</td>
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<tr>
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<td>4.66</td>
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<td>5.36</td>
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</tr>
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<td>40%</td>
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<td>94.80</td>
<td>2.38 .02*</td>
<td>95.10</td>
<td>2.36 .02*</td>
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<td>4.37</td>
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<td>50%</td>
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<td>97.90</td>
<td>1.75 .09</td>
<td>98.60</td>
<td>1.37 .18</td>
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<td>98.00</td>
<td>2.99 .004*</td>
<td>101.20</td>
<td>0.98 .33</td>
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<td>5.92</td>
<td></td>
<td>4.91</td>
<td></td>
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<tr>
<td>80%</td>
<td>103.18</td>
<td>97.30</td>
<td>3.08 .003*</td>
<td>100.70</td>
<td>1.38 .17</td>
</tr>
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<td>7.56</td>
<td>7.31</td>
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<td>6.47</td>
<td></td>
</tr>
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<td>90%</td>
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<td>0.93 .35</td>
<td>99.20</td>
<td>0.055 .96</td>
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<td>10.47</td>
<td>11.19</td>
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<td>10.80</td>
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</tbody>
</table>

Choral director data from present study
Untrained and trained data from Sulter et al. (1995)
At each 10% frequency interval, male choral directors’ minimum intensity differed significantly from the untrained male participants. Male choral directors’ minimum intensity differences from the vocally trained group were statistically significant in all but one frequency interval. Table 2 shows mean minimum intensity differences between male choral directors and trained and trained groups from Sulter et al. (1995).
### Table 2.

**Minimum Intensity of Male Choral Directors, Untrained, and Trained Singers**

<table>
<thead>
<tr>
<th>Frequency level</th>
<th>Choral Directors (n=22)</th>
<th>Untrained (n=47)</th>
<th>t (df=67)</th>
<th>p &lt;</th>
<th>Trained (n=43)</th>
<th>t (df=63)</th>
<th>p &lt;</th>
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</thead>
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<tr>
<td>0%</td>
<td>Mean (db) 75.36</td>
<td>52.00</td>
<td>13.10</td>
<td>.001*</td>
<td>52.40</td>
<td>13.95</td>
<td>.001*</td>
</tr>
<tr>
<td></td>
<td>SD (db) 4.75</td>
<td>7.69</td>
<td></td>
<td></td>
<td>6.92</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10%</td>
<td>Mean (db) 75.55</td>
<td>46.90</td>
<td>20.01</td>
<td>.001*</td>
<td>46.20</td>
<td>22.04</td>
<td>.001*</td>
</tr>
<tr>
<td></td>
<td>SD (db) 4.32</td>
<td>6.02</td>
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<td></td>
<td>5.42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20%</td>
<td>Mean (db) 77.23</td>
<td>46.60</td>
<td>22.17</td>
<td>.001*</td>
<td>45.70</td>
<td>27.29</td>
<td>.001*</td>
</tr>
<tr>
<td></td>
<td>SD (db) 4.36</td>
<td>5.74</td>
<td></td>
<td></td>
<td>4.43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30%</td>
<td>Mean (db) 77.73</td>
<td>48.70</td>
<td>21.83</td>
<td>.001*</td>
<td>47.50</td>
<td>22.76</td>
<td>.001*</td>
</tr>
<tr>
<td></td>
<td>SD (db) 4.96</td>
<td>5.23</td>
<td></td>
<td></td>
<td>5.12</td>
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<td></td>
</tr>
<tr>
<td>40%</td>
<td>Mean (db) 78.64</td>
<td>52.00</td>
<td>18.96</td>
<td>.001*</td>
<td>50.10</td>
<td>22.00</td>
<td>.001*</td>
</tr>
<tr>
<td></td>
<td>SD (db) 4.87</td>
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<td></td>
<td>4.99</td>
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<tr>
<td>50%</td>
<td>Mean (db) 79.41</td>
<td>56.90</td>
<td>14.92</td>
<td>.001*</td>
<td>54.30</td>
<td>19.85</td>
<td>.001*</td>
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<tr>
<td></td>
<td>SD (db) 4.93</td>
<td>6.21</td>
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<tr>
<td>60%</td>
<td>Mean (db) 79.36</td>
<td>61.50</td>
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<td>.001*</td>
<td>58.30</td>
<td>14.21</td>
<td>.001*</td>
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<tr>
<td></td>
<td>SD (db) 5.63</td>
<td>7.23</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>70%</td>
<td>Mean (db) 79.95</td>
<td>65.30</td>
<td>7.57</td>
<td>.001*</td>
<td>62.90</td>
<td>10.48</td>
<td>.001*</td>
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<tr>
<td></td>
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<td>6.27</td>
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<tr>
<td>80%</td>
<td>Mean (db) 81.14</td>
<td>71.20</td>
<td>4.80</td>
<td>.001*</td>
<td>68.60</td>
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<td>SD (db) 6.17</td>
<td>8.72</td>
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<td></td>
<td>8.06</td>
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<tr>
<td>90%</td>
<td>Mean (db) 82.36</td>
<td>77.90</td>
<td>2.04</td>
<td>.05*</td>
<td>75.30</td>
<td>2.63</td>
<td>.01*</td>
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<tr>
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<td>SD (db) 6.48</td>
<td>9.23</td>
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<td></td>
<td>11.70</td>
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</tr>
<tr>
<td>100%</td>
<td>Mean (db) 85.27</td>
<td>92.00</td>
<td>2.34</td>
<td>.02*</td>
<td>90.60</td>
<td>1.597</td>
<td>.12</td>
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<tr>
<td></td>
<td>SD (db) 8.21</td>
<td>12.22</td>
<td></td>
<td></td>
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</tbody>
</table>

Choral director data from present study
Untrained and trained data from Sulter et al. (1995)

Female choral directors’ vocal intensity was compared to untrained and trained vocal group data presented in Sulter et al. (1995) using 2-tailed independent sample *t*-tests. Significant differences between female choral directors’ and untrained females
maximum intensity in 7 of 11 frequency intervals were identified. Female choral
directors’ maximum intensity capabilities also differed significantly from trained female
singers in 6 of 11 frequency intervals. Table 3 provides the direct comparisons of female
choral directors’ and untrained and trained singers’ maximum intensity in 10% frequency
intervals.
### Table 3.

**Maximum Intensity of Female Choral Directors, Untrained, and Trained Singers**

<table>
<thead>
<tr>
<th>Frequency Level</th>
<th>Choral Directors (n=35)</th>
<th>Untrained (n=92)</th>
<th>Trained (n=42)</th>
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<td></td>
<td>Mean (db)</td>
<td>SD (db)</td>
<td>Mean (db)</td>
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<td>89.57</td>
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<td>63.10</td>
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<td>10%</td>
<td>92.14</td>
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<td>82.40</td>
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<td>94.03</td>
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<td>90.00</td>
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<td>30%</td>
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<td>94.50</td>
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<td>40%</td>
<td>97.29</td>
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<td>5.66</td>
<td>102.00</td>
</tr>
<tr>
<td>90%</td>
<td>107.26</td>
<td>5.65</td>
<td>103.80</td>
</tr>
<tr>
<td>100%</td>
<td>107.00</td>
<td>5.68</td>
<td>102.70</td>
</tr>
</tbody>
</table>

Choral director data from present study
Untrained and trained data from Sulter et al. (1995)

Minimum intensity of female choral directors also differed significantly from data presented in Sulter et al. (1995). Differences were identified as significant at every
frequency interval when comparing female choral directors to the untrained vocal group, and in 10 or 11 frequency intervals when comparing female choral directors to the trained singers. Table 4 shows minimum intensity comparisons between female choral directors and untrained and trained vocal group.
<table>
<thead>
<tr>
<th>Frequency level</th>
<th>Choral Directors (n=35)</th>
<th>Untrained (n=92)</th>
<th>t (df=125)</th>
<th>p &lt;</th>
<th>Trained (n=42)</th>
<th>t (df=75)</th>
<th>p &lt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>Mean (db) 76.51</td>
<td>53.90</td>
<td>18.04</td>
<td>.001*</td>
<td>49.60</td>
<td>16.66</td>
<td>.001*</td>
</tr>
<tr>
<td></td>
<td>SD (db) 4.53</td>
<td>6.86</td>
<td></td>
<td></td>
<td>8.61</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10%</td>
<td>Mean (db) 77.14</td>
<td>51.40</td>
<td>21.07</td>
<td>.001*</td>
<td>44.20</td>
<td>30.82</td>
<td>.001*</td>
</tr>
<tr>
<td></td>
<td>SD (db) 5.03</td>
<td>6.52</td>
<td></td>
<td></td>
<td>4.35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20%</td>
<td>Mean (db) 77.57</td>
<td>53.40</td>
<td>19.21</td>
<td>.001*</td>
<td>46.00</td>
<td>27.50</td>
<td>.001*</td>
</tr>
<tr>
<td></td>
<td>SD (db) 5.56</td>
<td>6.60</td>
<td></td>
<td></td>
<td>4.51</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30%</td>
<td>Mean (db) 77.69</td>
<td>56.10</td>
<td>17.34</td>
<td>.001*</td>
<td>49.20</td>
<td>23.94</td>
<td>.001*</td>
</tr>
<tr>
<td></td>
<td>SD (db) 5.69</td>
<td>6.47</td>
<td></td>
<td></td>
<td>4.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40%</td>
<td>Mean (db) 77.89</td>
<td>58.40</td>
<td>15.71</td>
<td>.001*</td>
<td>52.80</td>
<td>20.48</td>
<td>.001*</td>
</tr>
<tr>
<td></td>
<td>SD (db) 6.10</td>
<td>6.30</td>
<td></td>
<td></td>
<td>4.64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50%</td>
<td>Mean (db) 78.54</td>
<td>61.00</td>
<td>15.71</td>
<td>.001*</td>
<td>56.20</td>
<td>16.39</td>
<td>.001*</td>
</tr>
<tr>
<td></td>
<td>SD (db) 6.47</td>
<td>6.71</td>
<td></td>
<td></td>
<td>5.49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60%</td>
<td>Mean (db) 79.40</td>
<td>65.20</td>
<td>9.94</td>
<td>.001*</td>
<td>60.80</td>
<td>13.74</td>
<td>.001*</td>
</tr>
<tr>
<td></td>
<td>SD (db) 6.61</td>
<td>7.40</td>
<td></td>
<td></td>
<td>5.27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>70%</td>
<td>Mean (db) 81.60</td>
<td>70.60</td>
<td>7.43</td>
<td>.001*</td>
<td>66.20</td>
<td>10.61</td>
<td>.001*</td>
</tr>
<tr>
<td></td>
<td>SD (db) 6.65</td>
<td>7.74</td>
<td></td>
<td></td>
<td>6.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>80%</td>
<td>Mean (db) 83.74</td>
<td>76.80</td>
<td>4.20</td>
<td>.001*</td>
<td>71.70</td>
<td>7.15</td>
<td>.001*</td>
</tr>
<tr>
<td></td>
<td>SD (db) 7.50</td>
<td>8.60</td>
<td></td>
<td></td>
<td>7.24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>90%</td>
<td>Mean (db) 88.40</td>
<td>63.60</td>
<td>12.95</td>
<td>.001*</td>
<td>80.20</td>
<td>4.11</td>
<td>.001*</td>
</tr>
<tr>
<td></td>
<td>SD (db) 7.81</td>
<td>10.24</td>
<td></td>
<td></td>
<td>9.41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100%</td>
<td>Mean (db) 92.11</td>
<td>97.70</td>
<td>2.64</td>
<td>.009*</td>
<td>94.50</td>
<td>1.008</td>
<td>.32</td>
</tr>
<tr>
<td></td>
<td>SD (db) 7.99</td>
<td>11.47</td>
<td></td>
<td></td>
<td>11.95</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Choral director data from present study
Untrained and trained data from Sulter et al. (1995)

Awan (1991) studied phonetograms and frequency-sound pressure level characteristics of untrained and trained vocal groups. Participants were 20 trained singers from a university choir (mean age = 22.3) who had received at least 2 years of formal
vocal training and were receiving vocal training at the time of participation. Twenty untrained participants (mean age = 21.3) had no more than casual singing experience (Awan, 1991).

Direct comparison of frequency capabilities between choral directors and trained and untrained singers (Awan, 1991) was made using 2-tailed independent sample $t$-tests. Choral directors had a significantly smaller semitone range when compared to trained singers, yet there was no difference between choral directors’ and untrained singers’ semitone ranges. Accordingly, there was a significant difference between choral directors and trained singers frequency range in hertz, and there was no difference between frequency ranges in hertz of choral directors and untrained singers (Table 5).

Table 5.  
*Mean Range in Semitones and Hertz for Choral Directors, Trained, and Untrained Singers*

<table>
<thead>
<tr>
<th></th>
<th>Choral directors ($n=57$)</th>
<th>Trained ($n=20$)</th>
<th>$t$ ($df=75$)</th>
<th>$p &lt;$</th>
<th>Untrained ($n=20$)</th>
<th>$t$ ($df=75$)</th>
<th>$p &lt;$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency range (Hz)</td>
<td>501.43 (163.61)</td>
<td>729.65 (165.89)</td>
<td>5.35</td>
<td>.001*</td>
<td>511.40 (171.15)</td>
<td>0.23</td>
<td>.82</td>
</tr>
<tr>
<td>Frequency range (ST)</td>
<td>25.79 (3.83)</td>
<td>34.40 (3.19)</td>
<td>9.01</td>
<td>.001*</td>
<td>27.45 (5.10)</td>
<td>1.53</td>
<td>.13</td>
</tr>
</tbody>
</table>

Choral director data from present study  
Untrained and trained data from Awan (1991)

Further comparisons were made of choral directors’ voices and healthy and dysphonic professional speakers. Siupsinskiene (2003) identified professional speakers as persons who received practical voice education for about 2 years and were members of a professional choir at the time of participation. Healthy voices were defined in the same
study as free from organic vocal pathology after phoniatic examination and no history of voice surgery. Dysphonic professionals were those identified during examination as having laryngitis, nodules, polyps, cysts, and/or functional dysphonia (Siupsinskiene, 2003).

Significant differences between male choral directors and healthy professional speakers were identified for semitone range, minimum energy, and energy range. There was no significant difference between male choral directors and healthy professional speakers’ maximum energy. Table 6 shows significant differences between male choral directors and dysphonic professional speakers’ semitone range, minimum energy, and energy range. The difference between male choral directors and dysphonic professional speakers’ maximum energy was not statistically significant.

Table 6.

<table>
<thead>
<tr>
<th></th>
<th>Choral directors (n=22)</th>
<th>Healthy professionals (n=21)</th>
<th>t (df=41)</th>
<th>p &lt;</th>
<th>Dysphonic professionals (n=23)</th>
<th>t (df=43)</th>
<th>p &lt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semitone range</td>
<td>26.73 (4.84)</td>
<td>37.70 (3.90)</td>
<td>8.16</td>
<td>.001*</td>
<td>34.10 (4.80)</td>
<td>5.13</td>
<td>.001*</td>
</tr>
<tr>
<td>Maximum energy</td>
<td>103.32 (18.58)</td>
<td>98.30 (4.40)</td>
<td>1.21</td>
<td>.24</td>
<td>96.00 (5.30)</td>
<td>1.82</td>
<td>.08</td>
</tr>
<tr>
<td>Minimum energy</td>
<td>74.32 (4.45)</td>
<td>50.80 (4.30)</td>
<td>17.60</td>
<td>.001*</td>
<td>51.30 (4.10)</td>
<td>18.05</td>
<td>.001*</td>
</tr>
<tr>
<td>Energy range dB</td>
<td>32.55 (5.23)</td>
<td>47.50 (6.20)</td>
<td>8.57</td>
<td>.001*</td>
<td>44.70 (6.60)</td>
<td>6.83</td>
<td>.001*</td>
</tr>
</tbody>
</table>

Choral director data from present study
Healthy and dysphonic data from Siupsinskiene (2003)
Comparisons using 2-tailed $t$-tests were made between female choral directors and healthy and dysphonic professional speakers’ semitone range, maximum and minimum intensity, and energy range. Table 7 shows differences between female choral directors and both healthy and dysphonic professional speakers in each area tested.

Table 7.

*Female Mean Semitone Range and Energy*

<table>
<thead>
<tr>
<th></th>
<th>Choral directors ($n = 35$)</th>
<th>Healthy professionals ($n = 59$)</th>
<th>$t$ ($df=92$)</th>
<th>$p &lt;$</th>
<th>Dysphonic professionals ($n = 80$)</th>
<th>$t$ ($df=113$)</th>
<th>$p &lt;$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semitone range (SD)</td>
<td>25.20 (2.96)</td>
<td>34.40 (2.90)</td>
<td>14.76 .001*</td>
<td></td>
<td>31.10 (5.70)</td>
<td>5.78 .001*</td>
<td></td>
</tr>
<tr>
<td>Maximum energy dB (SD)</td>
<td>108.40 (5.71)</td>
<td>100.60 (6.20)</td>
<td>6.07 .001*</td>
<td></td>
<td>95.10 (6.60)</td>
<td>10.34 .001*</td>
<td></td>
</tr>
<tr>
<td>Minimum energy dB (SD)</td>
<td>74.86 (4.95)</td>
<td>48.70 (4.10)</td>
<td>27.66 .001*</td>
<td></td>
<td>50.30 (3.90)</td>
<td>28.55 .001*</td>
<td></td>
</tr>
<tr>
<td>Energy range dB (SD)</td>
<td>33.54 (5.94)</td>
<td>51.80 (6.50)</td>
<td>13.58 .001*</td>
<td></td>
<td>45.60 (10.30)</td>
<td>6.46 .001*</td>
<td></td>
</tr>
</tbody>
</table>

Choral director data from present study
Healthy and dysphonic data from Siupsinskiene (2003)

Behrman, Agresti, Blumstein, and Sharma (1996) studied voice range profile characteristics for 15 patients with organic vocal fold pathologies pre- and post-operatively. A control group of healthy men and women ($n = 10$; age range 19-70) also participated to make certain dysphonic patients’ VRPs were distinctive due to the diagnosed pathology and not procedural or instrumental differences (Behrman et al.,
Comparisons between choral directors in the present study and dysphonic patients from Behrman et al. (1996) are difficult due to varying vocal fold pathologies in the latter study. Choral directors’ mean semitone range was significantly less than healthy subjects from Behrman et al. (1996). Maximum and minimum intensities were also significantly different from healthy subjects. While a direct comparison to dysphonic subjects is not robust, it is interesting to note the lack of significance between choral directors’ and dysphonic patients’ minimum intensity (Table 8).

Table 8.

<table>
<thead>
<tr>
<th></th>
<th>Choral directors (n = 57)</th>
<th>Healthy subjects (n=10)</th>
<th>t (df=65)</th>
<th>p &lt;</th>
<th>Dysphonic subjects (n=15)</th>
<th>t (df=70)</th>
<th>p &lt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Semitone range (SD)</td>
<td>25.79 (3.83)</td>
<td>30.30 (4.80)</td>
<td>3.31</td>
<td>.002*</td>
<td>18.00 (7.20)</td>
<td>5.71</td>
<td>.001*</td>
</tr>
<tr>
<td>Maximum intensity (SD)</td>
<td>106.44 (12.47)</td>
<td>91.90 (5.00)</td>
<td>3.62</td>
<td>.001*</td>
<td>83.60 (7.70)</td>
<td>6.74</td>
<td>.001*</td>
</tr>
<tr>
<td>Minimum intensity (SD)</td>
<td>74.65 (4.73)</td>
<td>63.90 (3.60)</td>
<td>6.83</td>
<td>.001*</td>
<td>72.50 (5.30)</td>
<td>1.53</td>
<td>.13</td>
</tr>
</tbody>
</table>

Choral director data from present study
Healthy and dysphonic data from Behrman et al. (1996)

Research Question 2

The modified Voice Handicap Index used in this study consists of three subscales: Functional, Physical, and Emotional. Scoring of the modified VHI was 0 = Never, 1 = Almost Never, 2 = Almost Always, 3 = Always. This method represents a scoring
alteration from the original VHI in that the original measure contained a Sometimes option between Almost Never and Almost Always. Removal of this option was done to eliminate a neutral response and force the participant to choose from four options rather than five. The highest possible score on the modified VHI is 90 with subscale maximums totaling 30 each.

The second research question sought to determine the relationship between the three VHI subscales and fundamental frequency and amplitude as indicated on the VRP. Before examining this relationship, descriptive statistics and reliability of the modified VHI were calculated (Table 9).

Table 9.

*Modified VHI Descriptive Statistics and Reliability*

<table>
<thead>
<tr>
<th></th>
<th>Cronbach's Alpha</th>
<th>Mean Score</th>
<th>Variance</th>
<th>Standard Deviation</th>
<th>Number of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional subscale</td>
<td>.761</td>
<td>3.95</td>
<td>9.73</td>
<td>3.12</td>
<td>10</td>
</tr>
<tr>
<td>Emotional subscale</td>
<td>.836</td>
<td>3.39</td>
<td>13.74</td>
<td>3.70</td>
<td>10</td>
</tr>
<tr>
<td>Physical subscale</td>
<td>.849</td>
<td>7.37</td>
<td>18.52</td>
<td>4.30</td>
<td>10</td>
</tr>
<tr>
<td>Total modified VHI</td>
<td>.928</td>
<td>14.70</td>
<td>104.78</td>
<td>10.24</td>
<td>30</td>
</tr>
</tbody>
</table>

Canonical correlation was used to determine how VHI subscale scores are related to fundamental frequency range and intensity range as indicated on the VRP. VHI subscale scores failed to predict fundamental frequency and intensity ranges (Table 10).
Table 10.

VHI Subscale Scores Predicting Frequency and Intensity Ranges

<table>
<thead>
<tr>
<th></th>
<th>Wilks’ Lambda</th>
<th>Mean Square</th>
<th>F</th>
<th>Hypothesis df</th>
<th>Error df</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>.939</td>
<td>1.13</td>
<td>3</td>
<td>52</td>
<td>.346</td>
<td>.973</td>
</tr>
<tr>
<td>Range</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VHI Emot</td>
<td>.017</td>
<td>1.672</td>
<td>.118</td>
<td></td>
<td>.733</td>
<td></td>
</tr>
<tr>
<td>VHI Func</td>
<td>.008</td>
<td>8.237</td>
<td>.833</td>
<td></td>
<td>.366</td>
<td></td>
</tr>
<tr>
<td>VHI Phys</td>
<td>.008</td>
<td>.008</td>
<td>.005</td>
<td></td>
<td>.946</td>
<td></td>
</tr>
<tr>
<td>Intensity range</td>
<td>.995</td>
<td>.092</td>
<td>3</td>
<td>52</td>
<td>.464</td>
<td>.711</td>
</tr>
<tr>
<td>VHI Emot</td>
<td>.037</td>
<td>1.974</td>
<td>.139</td>
<td></td>
<td>.635</td>
<td></td>
</tr>
<tr>
<td>VHI Func</td>
<td>.008</td>
<td>2.26</td>
<td>.228</td>
<td></td>
<td>.799</td>
<td></td>
</tr>
<tr>
<td>VHI Phys</td>
<td>.008</td>
<td>1.228</td>
<td>.065</td>
<td></td>
<td>.101</td>
<td></td>
</tr>
</tbody>
</table>

*p < .05

Research Question 3

The third research question sought to determine if the major variables that influence vocal health are related to the three VHI subscale scores of middle school and high school choral directors. Using canonical correlation, the function of the major variables influencing vocal health as predictors of VHI subscale scores was assessed. Major variables that influence vocal health were previously defined as age, gender, years of teaching, level of teaching, and vocal health/pedagogy training.

Prior to beginning the canonical correlation, Pearson’s product moment correlation was conducted on age and years of teaching variables. The result of a 2-tailed Pearson product moment correlation indicated the variables age and years of teaching were positively correlated ($r = .913, N = 57, p < .01$). For the purpose of this hypothesis test, years of teaching was removed from the model due to its redundancy with age. Age, gender, and vocal health education as a set of variables failed to predict the other set of variables, VHI subscale scores (Table 11).
Table 11.

*Age, Gender, and Vocal Health Education Predicting VHI Subscale Scores*

<table>
<thead>
<tr>
<th></th>
<th>Wilks’ Lambda</th>
<th>Mean Square</th>
<th>F</th>
<th>Hypothesis df</th>
<th>Error df</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>VHI Emotional</td>
<td>.949</td>
<td>.908</td>
<td>3</td>
<td>51</td>
<td>.444</td>
<td></td>
</tr>
<tr>
<td>age</td>
<td>54.71</td>
<td>.381</td>
<td>.54</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>gender</td>
<td>.452</td>
<td>1.852</td>
<td>.179</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>vocal health education</td>
<td>4.359</td>
<td>.761</td>
<td>.387</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VHI Functional</td>
<td>.953</td>
<td>.832</td>
<td>3</td>
<td>51</td>
<td>.482</td>
<td></td>
</tr>
<tr>
<td>age</td>
<td>355.463</td>
<td>2.473</td>
<td>.122</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>gender</td>
<td>.014</td>
<td>.056</td>
<td>.814</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>vocal health education</td>
<td>1.237</td>
<td>.216</td>
<td>.644</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VHI Physical</td>
<td>.993</td>
<td>.118</td>
<td>3</td>
<td>51</td>
<td>.949</td>
<td></td>
</tr>
<tr>
<td>age</td>
<td>.337</td>
<td>.002</td>
<td>.962</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>gender</td>
<td>.053</td>
<td>.218</td>
<td>.642</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>vocal health education</td>
<td>.749</td>
<td>.131</td>
<td>.719</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < .05*

Research Question 4

To answer the fourth research question, multiple regression analysis was conducted. Age, gender, years of teaching, level of teaching, and vocal health education combined to account for 1.4% of the variance in self-reported vocal health rating. Model 1 including age, gender, years of teaching, level of teaching, and vocal health education failed to significantly predict self-reported vocal health rating ($F_{5, 51} = 1.663, p = .16$). Subsequent models were regressed and each failed to account for a significant $\Delta R^2$ (Table 12).
Table 12.

*Prediction of Vocal Health Self-Report Rating*

<table>
<thead>
<tr>
<th>Model</th>
<th>$\Delta R^2$</th>
<th>$F\Delta$ (df)</th>
<th>Sig. $F\Delta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1</td>
<td>.140</td>
<td>1.663 (5, 51)</td>
<td>.160</td>
</tr>
<tr>
<td>Model 2</td>
<td>.000</td>
<td>.011 (4, 52)</td>
<td>.917</td>
</tr>
<tr>
<td>Model 3</td>
<td>-.004</td>
<td>.216 (3, 53)</td>
<td>.644</td>
</tr>
<tr>
<td>Model 4</td>
<td>-.013</td>
<td>.775 (2, 54)</td>
<td>.383</td>
</tr>
</tbody>
</table>

*Model 1: Age, gender, years of teaching, level of teaching, and vocal health education*
*Model 2: Age, gender, level of teaching, and vocal health education*
*Model 3: Age, gender, and vocal health education*
*Model 4: Age and gender*

The lack of $\Delta R^2$ when Model 2 was imposed is likely due to the removal of years of teaching from the regression equation. Years of teaching and age were determined to be highly positively correlated ($r = .913$) in the analyses for Research Question 3, hence the removal from regression Model 2 results in no change in $R^2$. Since each regression model failed to produce a significant $\Delta R^2$, there is no need to further examine coefficients for significance.

Research Question 5

Canonical correlation was utilized to assess the ability of age, gender, level of teaching, and vocal health education to predict frequency and intensity ranges produced by the VRP. Individually and collectively as a set of variables, age, gender, level of teaching, and vocal health education failed to predict frequency and intensity ranges of
choral directors (Table 13). Years of teaching was not introduced into the equation because of the redundancy caused by its positive correlation with age.

Table 13.

*Age, Gender, Level of Teaching, and Vocal Health Education Predicting Frequency and Intensity*

<table>
<thead>
<tr>
<th></th>
<th>Wilks' Lambda</th>
<th>Mean Square</th>
<th>F</th>
<th>Hypothesis df</th>
<th>Error df</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency range</td>
<td>.915</td>
<td>1.186</td>
<td>4</td>
<td>51</td>
<td>.328</td>
<td></td>
</tr>
<tr>
<td>age</td>
<td>4.653</td>
<td>.031</td>
<td>.031</td>
<td>.862</td>
<td>.052</td>
<td></td>
</tr>
<tr>
<td>gender</td>
<td>.913</td>
<td>3.945</td>
<td>1.206</td>
<td>.277</td>
<td>.301</td>
<td></td>
</tr>
<tr>
<td>level teaching</td>
<td>.546</td>
<td>1.091</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>voc ped train</td>
<td>5.994</td>
<td></td>
<td>.1091</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensity range</td>
<td>.936</td>
<td>.874</td>
<td>4</td>
<td>51</td>
<td>.486</td>
<td></td>
</tr>
<tr>
<td>age</td>
<td>32.312</td>
<td>.213</td>
<td>.213</td>
<td>.646</td>
<td>.149</td>
<td></td>
</tr>
<tr>
<td>gender</td>
<td>.496</td>
<td>2.144</td>
<td>.257</td>
<td>.614</td>
<td>.327</td>
<td></td>
</tr>
<tr>
<td>level teaching</td>
<td>.116</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>voc ped train</td>
<td>5.369</td>
<td>.977</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\( p < .05 \)
CHAPTER 5
DISCUSSION

Summary

This purpose of this study was to investigate the vocal health of middle school and high school choral directors. The research design utilized objective measurement of vocal health by examining acoustic characteristics of the voice from the voice range profile. This study also incorporated the use of subjective measurement of vocal health by using the modified Voice Handicap Index which allowed participants to self-report on the physical, functional, and emotional aspects of voice use or interruption. The combination of objective and subjective testing permits thorough analysis of individual measures as well as relationships between results.

The vocal demands of teaching are high and teaching music presents a unique challenge. Music teachers, including choral directors, are encouraging, motivating, and teaching their students to create sounds. As a result, the use causes increased vocal volume. Choral directors teach students how to open their mouths and phonate simultaneously, in contrast to traditional non-music classes where students sit and listen while the teacher lectures. Choral directors’ teaching situation has an inherent classroom management challenge in that the choral director must be able to communicate and maintain control in a potentially noisy environment. This leads to increased vocal intensity from teachers in order for students to hear them.

The first research question sought to determine if the vocal health of middle school and high school choral directors differs from the general population. Three trends emerged in the results of the objective acoustic analysis in this study.
1. Choral directors’ vocal intensity range is significantly smaller than both trained and untrained populations.

2. Choral directors’ minimum vocal intensity is significantly higher than both trained and untrained populations.

3. Choral directors are able to produce significantly fewer semitones resulting in a smaller vocal frequency range than both trained and untrained populations.

In essence, choral directors’ intensity range, or perceived volume, is significantly smaller than trained and untrained populations. In the comparison to Siupsinskiene (2003), male choral directors’ intensity range was significantly less than both healthy professionals and dysphonic professionals (Figure 4). Female choral directors’ intensity range was also significantly smaller than healthy and dysphonic professionals (Figure 5).
Figure 4. Male vocal intensity range

Figure 5. Female vocal intensity range

The decreased intensity capabilities illustrated in Figures 4 and 5 indicate the reduced ability of choral directors to differentiate between soft and loud phonation. The
comparison to dysphonic professionals is difficult due to various diagnoses represented in the dysphonic participant group. It is interesting to note, however, that both male and female dysphonic professionals had the ability to vocalize within a greater decibel range than choral directors.

Perhaps healthy professionals were able to vocalize within a greater intensity range than choral directors due to the fact that the healthy professionals were taking voice lessons at the time of participation in the study (Siupsinskiene, 2003). Most choral directors who participated in the present study were not taking voice lessons and no longer considered themselves to be performers.

The VRP testing procedure used in this study elicited minimum and maximum intensities over the entire vocal frequency range of a participant. Although the contour and shape of the two-dimensional phonetogram were not analyzed, upon visual inspection one expects to see ‘white space’ between the lower (minimum) and upper (maximum) contour outlines. Presumably, intensity levels exist in between a participant’s minimum and maximum intensities that were not produced in the course of this VRP. However, even casual examination of the physical area of VRP plots leads the author to the same conclusion. Choral directors’ versions of soft and loud are either very similar or exactly the same (Figure 6).
The inability to differentiate between soft and loud phonation can be caused by continuous vocal loading within the same intensity area. Teachers often use a ‘teacher voice’ in order to garner greater authority in the classroom. The resulting voice is usually louder than comfortable speech level. When the teacher needs to raise his or her voice in order to project or manage the classroom, there is little or no room for this increase in intensity since he or she is already speaking with great intensity. In addition to the increased intensity level, choral directors also raise the vocal frequency level when speaking with greater effort which is supported by previous research (Black, 1961; Titze, Jiang, & Druker, 1988; Titze, 1989).

The difference between choral directors’ and healthy non-singer participants’ from Behrman et al. (1996) mean minimum intensity was significant, indicating choral directors’ reduced ability to phonate softly. One would expect choral directors who are typically trained singers to have greater volume control, especially at extreme

Figure 6. Minimum-maximum intensity VRP
frequencies, than vocally healthy non-singers. Interestingly, there was also a significant difference between choral directors’ and healthy participants’ mean maximum intensity. However, this difference represents choral directors’ ability to vocalize louder during the maximum intensity task.

The second trend apparent in the results of the study is that choral directors’ minimum intensity is significantly higher than the general population. When asked to produce as soft a sound as possible, male choral directors were still louder than the untrained comparison groups at every frequency interval except the 100% frequency interval. At the 100% frequency interval, male choral directors were able to phonate significantly more softly than the untrained group. When compared to the vocally trained group, male choral directors were significantly louder at every frequency interval with the exception of the 100% interval. At the 100% frequency interval, or highest pitch area in their vocal range, male choral directors were able to phonate more softly than the vocally trained comparison group. Figure 7 illustrates the significantly higher minimum intensities of male choral directors than vocally trained and untrained groups.
It is also interesting to note the relative stability of male choral directors’ minimum intensity. The male vocally trained and untrained groups from Sulter et al. (1995) show a steady but noticeable increase in intensity as frequency intervals increased. In contrast, male choral directors, though producing significantly louder sounds at all but the highest frequency interval, were able to maintain steady intensity even as the frequency increased. On the other hand, this finding can also be interpreted as a lack of volume control, meaning male choral directors have one intensity level at which they are able to vocalize, and that level tends to be significantly louder than vocally trained and untrained comparison groups. This interpretation also supports the first trend identified: choral directors’ intensity range is significantly smaller than the general population.

Female choral directors were significantly different on the minimum intensity task when compared to vocally trained and untrained groups from Sulter et al. (1995). Female choral directors present similar acoustic characteristics as the male choral directors.

Female choral directors also vocalized at significantly higher intensities on all frequency
intervals with the exception of the 100% frequency interval, where choral directors presented statistically the same intensity as the trained group. Female choral directors had significantly higher intensities at every frequency interval when compared to the untrained group, except in the 100% frequency interval where female choral directors were able to vocalize with significantly less intensity (Figure 8).

Figure 8. Female mean minimum intensities

This finding represents the exact same pattern of significance as male choral directors when compared to vocally trained and untrained groups across 10% frequency intervals. Another similarity between male and female choral director minimum intensity is the relative stability across frequency intervals as discussed previously. Although this appears to be a positive finding, it contradicts previous research that found intensity increased as frequency increased (Wolf & Sette, 1935; Wolf, Stanley, & Sette, 1935; Stout, 1938; Colton, 1973; Coleman, Mabis, & Hinson, 1977), providing further evidence that choral directors have little or no difference between soft and loud phonation.
The third trend that emerged from the results of the acoustic analyses was the reduction in vocal frequency range of choral directors compared to the general population. The comparison of choral directors to Behrman et al. (1996) indicated choral directors are able on average to produce 25.79 semitones, slightly over 2 octaves and significantly fewer than healthy non-singers, yet significantly more than dysphonic individuals. The healthy participants in Behrman et al. (1996) were a control group without vocal training for the purpose of that study. The result of the present study indicates choral directors, presumably trained as singers during college, were able to produce a significantly smaller semitone range than vocally untrained, healthy participants (Behrman et al., 1996) and vocally trained participants (Awan, 1991), but statistically the same number of semitones as vocally untrained participants (Awan, 1991). Figure 9 illustrates these comparisons.

Figure 9. Mean semitone ranges
According to McKinney (1994), a professional singer should have a usable two-octave range in order to sing most solo vocal literature within his or her voice classification. While most choral directors are not professional singers, choral directors as a group produced slightly more than two octaves. However, McKinney referred to the singing voice range. Choral directors do not have a singing range of two octaves, rather their entire usable range is about two octaves. Presumably, the usable vocal range is larger than the singing range.

Informal VRP plot visual inspection confirms the reduced semitone range of choral directors. This reduction is represented by the relatively narrow plot width from left to right (Figure 10).

![VRP plot with small semitone range](image)

**Figure 10.** VRP plot with small semitone range

Modified VHI subscale scores did not predict objective acoustic characteristics of the voice, frequency and intensity as shown in the VRP. The modified VHI was piloted
(Schwartz, 2005, April) and had strong reliability ($r = .939$), and its reliability was similarly as robust in the present study ($r = .928$). The three modified VHI subscales address the functional, physical, and emotional impact of the voice in a respondent’s life. Considering the significantly different frequency and intensity ranges between choral directors and other population groups, one would expect to see a relationship with at least the functional subscale. This relationship would represent a self-reported reduction in vocal function which was apparent in the frequency and intensity range analyses. The lack of a significant relationship between any of the three modified VHI subscales and frequency and intensity characteristics from the VRP indicates that choral directors do not realize they have poor vocal health.

Despite the strength of the measure, modified VHI subscale scores were not predicted by major variables influencing vocal health, age, gender, years of teaching, level of teaching, and vocal health education. Age (Sataloff, 1991; Sataloff, 1997a; Sataloff & Smith. 2000), gender (Miller & Verdolini, 1995; Sataloff, 1991), years of teaching (Pekkarinen, Himberg, & Pentti, 1992), level of teaching (Sarfati, 1989; Unger & Bastian, 1981), and vocal health education (Gunderman, 1963; Askren, 2000; Hendry, 2001; Russell et al., 1998; Sapir, 1993; Sapir et al., 1992; Simberg et al., 2000; Smith et al., 1997; and Smith, Lemke, et al., 1998) have been documented in the literature as influences on vocal health, therefore it was expected that the aforementioned variables would predict modified VHI subscale scores in the present study. The lack of power of the major variables influencing vocal health to predict modified VHI subscale scores supports the conclusion that choral directors are unaware of ongoing reduced vocal
function, and therefore unable to report this reduction and its effects accurately on the modified VHI.

The self-reported vocal health rating was regressed on age, gender, years of teaching, level of teaching, and vocal health education. This test was conducted to determine the ability of major variables influencing vocal health to predict choral directors’ self-reported vocal health rating of Excellent, Good, Fair, or Poor. Similarly, the major variables influencing vocal health were canonically correlated to predict frequency and intensity ranges in choral directors. The major variable set accounted for very little of the variance in self-reported vocal health rating. The major variables influencing vocal health were also unable to predict frequency and intensity ranges.

These results support two substantial conclusions. The first conclusion reflects a previous statement: choral directors are unaware of their reduced vocal capabilities and as a consequence are unable to self-rate vocal health condition accurately. The second conclusion is that age, gender, years of teaching, level of teaching, and vocal health education are rejected as potential contributors to choral directors reduced frequency and intensity ranges. If in fact the major variables are affecting teachers’ vocal health, the problem seems to be much more widespread for choral directors. This implies that every choral director is affected, therefore no differences were identified in the present study. Frequency and intensity ranges were unaffected by age, gender, years of teaching, level of teaching, and vocal health education, indicating reduced frequency and intensity ranges are not limited or controlled by any variable considered in the present study. Because there was no relationship between the variables, all choral directors are experiencing similar vocal issues.
Conclusions and Recommendations

The results of this research provide evidence that choral directors are at risk for developing vocal problems as a result of the reduced frequency and intensity ranges identified in this study. Vocal demands of teaching are significant, and this challenge is compounded for choral directors. Strong evidence has emerged, indicating that directing choirs as a profession may be hazardous for vocal health, and therefore additional research is required.

1. *Replication.* This is the first study of choral directors’ voices using both objective and subjective analyses. It is suggested that this study is replicated with a larger and more nationally representative sample of middle school and high school choral directors.

2. *Teacher training.* The vocal demands of teaching are well-documented in related literature. Vocal fatigue, dysphonia, and other vocal problems are prevalent among teachers. Research about teacher education regarding these vocal demands is necessary to identify how teachers, and specifically choral directors, are equipped to manage these vocal demands. Teacher training programs need to be reviewed to determine level of preparation for preservice teachers. Courses related to the vocal demands of teaching and voice management and conservation are needed in teacher training programs.

3. *Choral ensemble voice training.* All choral directors have experience singing in choirs, whether collegiate or civic. Study of the varying vocal techniques between studio voice lessons and choral ensemble rehearsals is
warranted. Since choral directors’ voices were significantly worse than even trained singers, a systematic review of choral versus solo singing is justified. This will help to determine if there are differences between future choral directors’ and future professional singers’ voices even during the preservice stage.

4. **Hearing loss.** It is well-known that many musicians suffer from noise-induced hearing loss. As an individual progressively loses the ability to hear, the result is typically louder speech. Future research should consider the relationship between hearing loss and diminished vocal capacity.

5. **Teaching environment.** Research about teaching environment, including ambient noise and air and ventilation systems is needed to assess potential acoustic impedances and vocal irritants.

Results of this study indicate that significant differences exist between choral directors’ voices and the voices of other population groups. Maximum intensity differences may be attributable to choral directors’ voice training compared to vocally untrained groups. However, minimum intensity production is more difficult than maximum intensity, yet vocally untrained and healthy groups performed better than choral directors on this task. Vocal intensity control is severely lacking in choral directors such that there is little difference in the acoustic or perceptual loudness of the sound.

Further study of acoustic characteristics of choral directors’ voices is needed. Specifically, frequency and intensity ranges should be recorded regularly, beginning during teacher training. Longitudinal research will help isolate the onset time of the beginning of reduced vocal function. Once the time is identified, professional and
personal activities and behaviors may be studied as potential contributors to the resulting vocal problems.
REFERENCES


Hello, Sandra:

Permission is granted to reproduce the Voice Handicap Index in your thesis subject to approval of the primary author and inclusion of a complete citation and copyright statement:

Reprinted by permission from The Voice Handicap Index (VHI):

Sincerely,

Brent Jacocks

>>> "Sandra M. Schwartz" <S.Schwartz4@umiami.edu> 4/22/2005 10:36:34 AM
>>> I am a PhD student at the University of Miami and I administered the Voice Handicap Index (see citation below) as part of my dissertation. The authors gave permission via email. However, I would like to request permission to reproduce the Voice Handicap Index as an appendix in my dissertation since it is an integral part. Could you please tell me how to proceed in terms of copyright/permissions?

Thank you very much for your assistance.

Sandra M. Schwartz

American Journal of Speech-Language Pathology

Volume 6 (1997), Issue 3

August 1997


Page: 66
APPENDIX B

VOICE HANDICAP INDEX AUTHOR PERMISSION

Sandra M. Schwartz

From: Jacobson, Barbara H [barb.jacobson@Vanderbilt.edu]
Sent: Monday, March 14, 2005 9:08 AM
To: Sandra M. Schwartz
Subject: RE: VHI request

Sandra:

You are more than welcome to use the VHI in your studies. If it is to be published in a journal, than you must obtain permission to reprint from the American Speech-Language-Hearing Association. They hold the copyright as it was originally published in their journal. I would be most interested in hearing about your work.

Best of luck to you,

Barbara Jacobson, Ph.D.
The Vanderbilt Voice Center
Department of Otolaryngology
1500 21st Avenue South, Suite 2700
Nashville, TN 37212-3202

-----Original Message-----
From: Sandra M. Schwartz [mailto:S.Schwartz4@umiami.edu]
Sent: Friday, March 04, 2005 10:23 AM
To: Jacobson, Barbara H
Subject: VHI request

Dear Dr. Jacobson,

My name is Sandra Schwartz and I am a Ph.D. student in Music Education (Choral/Vocal) at the University of Miami. I am writing to request your permission to administer the Voice Handicap Index in 2 studies I am conducting.

Study I: Vocal Health of Preservice Music Teachers (Pilot Study)
I would like to administer the VHI online to undergraduate music education majors to determine how they are using their voices and how voice use (or lack) affects their lives.

Study II: Vocal Health of Middle School and High School Choral Directors (Dissertation Project)
My dissertation will examine the vocal health of middle school and high school choral directors. Specifically, participants will complete the VHI. It will also look at the relationship between VHI and age, gender, years of teaching, level of teaching, vocal pedagogy training, teaching behaviors, and Voice Range Profile. One of my dissertation committee members is a speech pathologist, and she is assisting me with this project.

May I please have your permission to administer the VHI in the aforementioned studies? If you would like any more information about my projects, I am happy to supply it. Thank you very much for your consideration.

Sincerely,

Sandra M. Schwartz
Frost School of Music at the University of Miami
APPENDIX C

MODIFIED VOICE HANDICAP INDEX

Modified Voice Handicap Index


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

F1. My voice makes it difficult for people to hear me.
   Never     Almost Never   Almost Always   Always

P2. I run out of air when I talk.
   Never     Almost Never   Almost Always   Always

F3. People have difficulty understanding me in a noisy room.
   Never     Almost Never   Almost Always   Always

P4. The sound of my voice varies throughout the day.
   Never     Almost Never   Almost Always   Always

F5. My family has difficulty hearing me when I call them throughout the house.
   Never     Almost Never   Almost Always   Always

F6. I use the phone less often than I would like.
   Never     Almost Never   Almost Always   Always

E7. I’m tense when talking to others because of my voice.
   Never     Almost Never   Almost Always   Always

F8. I tend to avoid groups of people because of my voice.
   Never     Almost Never   Almost Always   Always

E9. People seem irritated with my voice.
   Never     Almost Never   Almost Always   Always
P10. People ask, “What’s wrong with your voice?”
   Never  Almost Never  Almost Always  Always

F11. I speak with my friends, neighbors, or relatives less often because of my voice.
   Never  Almost Never  Almost Always  Always

F12. People ask me to repeat myself when speaking face-to-face.
   Never  Almost Never  Almost Always  Always

   Never  Almost Never  Almost Always  Always

P14. I feel as though I have to strain to produce voice.
   Never  Almost Never  Almost Always  Always

E15. I find other people don’t understand my voice.
   Never  Almost Never  Almost Always  Always

F16. My voice restricts my personal and social life.
   Never  Almost Never  Almost Always  Always

P17. The clarity of my voice is unpredictable.
   Never  Almost Never  Almost Always  Always

P18. I try to change my voice to sound different.
   Never  Almost Never  Almost Always  Always

F19. I feel left out of conversations because of my voice.
   Never  Almost Never  Almost Always  Always

P20. I use a great deal of effort to speak.
   Never  Almost Never  Almost Always  Always

P21. My voice is worse in the evening.
   Never  Almost Never  Almost Always  Always

F22. My voice causes me to lose income.
   Never  Almost Never  Almost Always  Always

E23. My voice upsets me.
   Never  Almost Never  Almost Always  Always

E24. I am less outgoing because of my voice.
   Never  Almost Never  Almost Always  Always
E25. My voice makes me feel handicapped.
Never  Almost Never  Almost Always  Always

P26. My voice “gives out” on me in the middle of speaking.
Never  Almost Never  Almost Always  Always

E27. I feel annoyed when people ask me to repeat.
Never  Almost Never  Almost Always  Always

E28. I feel embarrassed when people ask me to repeat.
Never  Almost Never  Almost Always  Always

E29. My voice makes me feel incompetent.
Never  Almost Never  Almost Always  Always

E30. I’m ashamed of my voice.
Never  Almost Never  Almost Always  Always

Age:  

Years of Teaching:  

Gender:  M  F

Level of Teaching:  Middle School  High School  Both

How many vocal pedagogy or vocal health classes/workshops have you taken?

How is your singing voice part?  

How would you rate your overall vocal health/status?
Excellent  Good  Fair  Poor
APPENDIX D

INFORMED CONSENT

Consent to Participate in Research

Vocal Health of Middle School and High School Choral Directors

I agree to participate in the research project entitled Vocal Health of Middle School and High School Choral Directors, being conducted by Edward P. Asmus, Associate Dean for Graduate Studies and Professor of Music Education, and Sandra M. Schwartz, a graduate student at University of Miami Frost School of Music. I have been informed that the purpose of this study is to study the vocal health condition of middle school and high school choral directors using the modified Voice Handicap Index (Jacobson et al., 1997; Schwartz, 2005), a questionnaire, and Voice Range Profile, a non-invasive manner of analyzing speech and voice patterns.

I have been informed that there are no risks associated with my participation in this study.

I understand that if I agree to participate in this study, I will be asked to complete a survey and also to vocalize into a microphone for the purpose of collecting samples of my voice.

I am aware that my participation is voluntary and I am free to refuse to participate in the study or withdraw my consent at any time without prejudice. I understand that if I have any additional questions concerning this study, I may contact Edward P. Asmus, Ph.D. at (305) 284-2241 and Sandra M. Schwartz at (305) 284-2161 x87603. I understand that if I would like further information regarding my rights as a research subject, I may contact the Director of the Human Subjects Research Office at the University of Miami at (305) 243-3195.

I understand no direct benefit is promised to me for my participation in this study.

I understand that all information gathered during this study will be kept confidential.

By signing below I indicate my willingness to participate in this research study.

Participant Signature ________________________ Date ______________

I.R.B.
APPROVAL DATE __________________________
EXP DATE __________________________
INITIALS __________________________
APPENDIX E

IRB PROTOCOL APPROVAL

EXPEDITED – APPROVAL

June 21, 2005

Edward Assmus
Department of Music Education
Locator Code: 7610

HSRO Study Number: 2005231
Title: Vocal Health of Middle School and High School Choral Directors

ACTION DATE: 6/17/05

STUDY APPROVAL EXPIRES: 6/16/06

On June 17, 2005 a member of the IRB Committee approved the following item(s) under the expedited review process pursuant to category [(6) (7)].

APPROVAL INCLUDES:
New Protocol
Consent
Surveys, Questionnaires
Permission letter

Sincerely,

[Signature]
Judith Aguirre, C.I.P.
Associate Director

IRB/jina
cc: IRB files
Attachment

Human Subjects Office (34-8099)
P.O. Box 016660 Tel: 305-284-3195
Miami, Florida 33101
Fax: 305-243-5528