WALLER, WILLIAM N., M.A. A Voice Profile of the Adolescent Speaker and Singer. (2007)
Directed by Celia R. Hooper, Ph.D. 59pp.

The purpose of this research was to obtain a detailed profile of the adolescent speaking voice and to assess which style of singing causes the highest level of muscular tension. The three singing genres evaluated were classical, musical theater, and gospel. Twenty middle and high school choral students, 13 females and 7 males, comprised the sample. The KayPentax Computerized Speech Lab (CSL) was utilized to extract acoustic parameters. Laryngeal imaging was performed on each subject using the KayPentax Stroboscopy System while the subjects sang excerpts of the three styles of music. Results showed acoustic parameters that were outside of published normative ranges for both females and males. Laryngeal imaging revealed greater muscular tension while singing musical theater compared to classical and gospel singing.

A VOICE PROFILE OF THE ADOLESCENT

SPEAKER AND SINGER

by

William N. Waller

A Thesis Submitted to the
Faculty of The Graduate School at
The University of North Carolina at Greensboro
in Partial Fulfillment
of the Requirements for the Degree of
Master of Arts

Greensboro
2007

Approved by

____

Committee Chair

APPROVAL PAGE

This thesis has been approved by the following committee of the Faculty of The Graduate School at The University of North Carolina at Greensboro.

Committee Chair ______________________________
Celia R Hooper

Committee Members ______________________________
Robert Mayo

____
Robert Wells

____
Date of Acceptance by Committee

____
Date of Final Oral Examination

ACKNOWLEDGMENTS

I would like to express my gratitude to Dr. Celia Hooper, whose support and belief in my ability has made this experience a rewarding one. For her I am truly grateful. I would also like to express my appreciation to Robert Mayo and Robert Wells for offering their time and expertise as members of my thesis committee.

A special thank you to Dr. Denise Tucker and Beverly Vaughn for their assistance with this research and for the insight they provided.

Lastly, I would like to thank Ryan Hays for his continued support, friendship, and encouragement throughout this educational journey.

TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

Page

CHAPTER I

INTRODUCTION

Private music teachers, choral directors, and speech-language pathologists all are trained to work with the adolescent voice and each have their philosophies on how to train and handle these voices in such a fragile stage of laryngeal development. Even with these philosophies, there is only a limited amount of information describing the adolescent voice. Some researchers are inconclusive on whether or not vocal training is beneficial for males (Barlow & Howard, 2002) while others point out that information concerning the stages of change, methods of voice classification, and psychological ramifications for females is minimal (Gackle, 1991). Choral directors have a difficult job in that they are responsible for the healthy development of their students' voices at a time when adolescent singers are the most at risk for vocal difficulties (Tepe *et al.,* 2002). As Tepe *et al.* (2002) note:

> Possible explanations for this vulnerability include the cumulative effect of unhealthy techniques, an increase in vocal demands associated with a more mature repertoire, increased vocal abuse related to social and recreational activities other than singing, and the effects of the concurrent physiologic changes of puberty. (p. 249)

The benefit of obtaining normative data on the adolescent speaking voice and researching muscular tension in the adolescent larynx in various singing genres can only provide a positive direction in the care of managing the adolescent voice across professional disciplines. This information can help speech-language pathologists and voice instructors in preventing and identifying voice disorders.

Statement of the Problem

The purpose of this study was to examine selected acoustic characteristics of the adolescent speaking voice and to determine which style of singing (choral/classical, musical theater, gospel) causes the most laryngeal muscular tension. This research was conducted in conjunction with another study by a doctoral candidate in the UNC-Greensboro School of Music. The two investigators shared the same adolescent subjects. The School of Music study evaluated tension during singing using perceptual information and vocal fold imagery during singing. It did not evaluate the adolescent speaking voice.

Information obtained in this study will benefit the speech-language pathologist and other professions by providing insight on how to evaluate the adolescent voice and how to prevent and manage voice disorders in this population. Appropriate management of the speaking voice directly affects the singing voice. Likewise, appropriate technique and teaching of the singing voice can directly affect the speaking voice. To see definitions of the terms used throughout this paper, please refer to Appendix A.

CHAPTER II

REVIEW OF THE LITERATURE

Vocal Mutation in the Adolescent Voice

Much growth and development in the human voice occurs during the period of adolescence. Before this period, the voices and laryngeal areas of males and females are very similar. Puberty results in many anatomical changes to the larynx and to other anatomical structures that contribute to voice production. Before puberty, the laryngeal structure is much smaller than that of an adult larynx (Kahane, 1982). The larynx grows significantly during puberty and noticeable signs of vocal fold lengthening begin. By the time an adult male's larynx has finished growing the vocal fold length is approximately 17-21 mm and is 11-15 mm in the female's (Sapienza, Ruddy, and Baker, 2004). The larynx itself goes through extreme changes resulting in a very different picture compared to the larynx and surrounding muscles of a child. During puberty the adolescent female's vocal folds increase approximately 3-4 mm while the vocal folds of the male adolescent increases up to 1 cm (Gackle, 1991). The vocal ligament changes as well. In children the ligament is thin and does not touch the vocalis muscle and the lamina propria does not have a three-layer structure (superficial, intermediate, and deep layers) (Titze, 1993). Between the ages of 6 and 12, the ligament thickens and eventually a three-layer structure can be observed (Titze, 1993). As the larynx grows, the anatomical distinctions between the pediatric and adult larynx become less significant. There is an unfurling of the epiglottis, increased stiffness of the cartilages, and a decrease in the relative size of the arytenoids and aryepiglottic folds with development/maturation (Sapienza, Ruddy, and Baker, 2004).

What can be observed the easiest is the direction of the laryngeal growth. The male larynx grows in the anterior-posterior direction leading to the angular protrusion of the thyroid cartilage while the female larynx increases more in height (Gackle, 1991). With development, laryngeal-pharyngeal widening occurs along with an increased diameter of the cricoid cartilage and expansion of the alar wings of the thyroid cartilage (Sapienza, Ruddy, and Baker, 2004). In children, the laryngeal area lies between the first and third cervical level in comparison to an adult's, which continues to lower with advancing age, with the lower border of the cricoid cartilage hovering between the sixth and seventh cervical vertebrate (Fried, 1983).

Puberty also contributes to changes in the airway. The subglottal space in a child's airway is the narrowest part of the airway in comparison to the adult airway, with the full-term diameter of the subglottal space cited as 4 mm (Sapienza, Ruddy, and Baker, 2004). The narrowest portion of the adult airway is the glottis (Sapienza, Ruddy, and Baker, 2004). During puberty, there is also a great increase in breathing capacity with the expansion of the chest circumference (Weiss, 1950).

Other areas of development that occur during puberty and that can affect voice production are changes in oral facial structures which can affect resonance (Gackle, 1991).

Vocal Characteristics of the Adolescent Speaking Voice

Studies show that throughout preadolescence and adolescence, the fundamental frequency in both males and females decline from age 3 to 12 (Andrews, 2002). There is also a study conducted by White (1999) that found differences in the voices of males and females before vocal mutation. This study found that vowel formant frequencies can be ascribed, at least in part, by anatomic and morphologic characteristics that differentiate gender even before puberty. Whiteside and Hodgson (1999) found that female children showed a steady decrease in fundamental frequency between the ages of 6 and 10 and that males show a steady decrease between the ages of 8 and 10 years. Between the ages of 5 and 11, the mean fundamental frequency for boys is 226 Hz with the fundamental frequency lowering between the ages of 8 and 9 years. For girls, the mean fundamental frequency is 238 Hz (Andrews, 2002).

There is a small amount of research dedicated to vocal characteristics between races. One study used subjects who were between the ages of 8 and 10 and were either white males or African-American males. The researchers in this study found that there were no significant differences for modal speaking fundamental frequency between the two groups (Andrews, 2002)

The Adolescent Male Voice

There is agreement that during puberty, the adolescent male's voice passes through three different mutational phases: premutation, mutation and post mutation (Hacki & Heitmüller, 1999). As the larynx lowers and the folds thicken, the male voice drops in pitch. The lower limit of the voice drops an entire octave and the upper limit lowers about the interval of a sixth (Gackle, 1991). The lowering of the habitual pitch of the speaking voice as well as of the entire speaking pitch range occurs for boys at age 8-9 (Hacki & Heitmüller, 1999).

Vocal characteristics of the adolescent male may include huskiness and unsteadiness in the speaking voice (Weiss, 1950). A particular event that receives a great deal of attention is the “breaking of the voice”. This is a sudden and involuntary change in pitch and quality (Weiss, 1950). This event appears in only a minority of boy’s voices and is extremely seldom in girls (Weiss, 1950).

The Adolescent Female Voice

Developmental changes also occur in the female adolescent voice although these changes are not nearly as dramatic as males (Gackle, 1991). Often, changes in female voices occur about a year earlier than males. (Gackle,1991). The lowering of the habitual pitch of the speaking voice as well as of the entire speaking pitch range occurs for girls at the age of 7-8 (Hacki & Heitmüller, 1999). During puberty, characteristics of the female voice are as follows: instability of pitch, development of noticeable register breaks, increased roughness in the voice, decreased and inconsistent range capabilities, and pitch breaking (Gackle, 1991). Breathiness is also another characteristic of the adolescent female voice. A breathy voice is at the extremes of the continuum of adduction, representing more open adduction (Titze, 1992).

During puberty, female adolescents begin to deal with menstruation and the effects that menstruation can have on the voice, such as lowering of the pitch and changes in the coordination of the voice during singing (Gackle, 1991). Menarcheal age appears to be occurring 3-4 months earlier compared to the 1980s which means that changes in the voice can occur earlier as well (Gackle, 1991).

To compare the anatomic and acoustic differences of male and female voice development, please refer to the chart compiled by Lynne Gackle (Appendix B).

The Adolescent Singer and His/Her Vocal Health

Vocal mutation is a fragile period of laryngeal development in which vocal disorders can appear especially in adolescent singers who not only have speaking demands upon them but singing demands as well. Miller (1992) states that singing is more demanding than speaking in that it:

> …uses breath management of a higher order, the temporal nature of the vowel is dissimilar, the compass of the singing voice exceeds that of speech inflection, sung sound requires extended adjustments within the spectrum to meet the demands of power and pitch, and the aesthetics of singing requires "resonance balancing" beyond the needs of the speaking voice. (p. 20)

While the voice is changing, singing can be difficult and inconsistent. Adolescents, particularly males whose voices have recently begun to change, may possess little control over what pitch is being sung, how loud it is sung, or the vocal register in which it is being sung (Jamison, 1996).

Adolescent singers are increasingly more and more involved with various musical venues. In recent years, it has become common to involve young singers in more sophisticated musical tasks. They are often not trained in the technique of singing and are not cognizant of the physical limits of their voices (Jamison, 1996). This can be detrimental to the voice and can have a great impact on the lives of performance-oriented children (Andrews, 1997). This justifies the importance of teaching good technique for singing. Technique is a set of strategies for managing posture, respiration, articulation, and resonation (Jamison, 1996). Young singers in general must rely on vocal instructors and others to achieve good voice quality. It is difficult to determine the quality of the voice because, unlike other instruments, the voice is located within the performer's body (Jamison, 1996). A singer hears his/her own output not only through the air, but also by internal bone conduction, which reduces the perceived intensity of higher harmonics. As a result, the singer does not perceive his/her own sounds in the same way listeners perceive them (Jamison, 1996). Many adolescents experience vocal fatigue from singing too loudly. The fact that singers hear their own voices differently than do listeners is another inducement to singing too loudly. It may be tempting to "push" the voice in order to produce an internal sound with a more satisfactory tone (Jamison, 1996).

Adolescents also should be guided to perform proper repertoire, which is a collection of works that a singer can perform. The repertoire should not exceed a singer's control of the overall pitch range, points of transition between vocal registers, rhythmic complexity, lengthy phrases, loudness, or tone color (Jamison, 1996). Music with high tessituras, the range where most of the pitches lie in a piece, is also more physically demanding than lower tessituras (Jamison, 1996). The range of pitches to which a singer in the early stage of the voice change has access can change significantly over a relatively short period of time (Jamison, 1996).

It is important to re-evaluate adolescent singers frequently to make sure that they are singing in the correct classification (soprano, alto, tenor, bass). There is a longer developmental period for maturation of the singing voice than for the speaking voice (Jamison, 1996) so music directors should be patient and realize that changing voices may be placed in various classifications for a good period of time. It is unlikely that definitively distinguishing attributes of any classification would be evident in a teenage singer (Jamison, 1996).

In summary, adolescent singers are extremely susceptible to developing voice disorders. Vocal difficulty is common among young choral singers, with older adolescents particularly at an increased risk (Tepe *et al.,* 2002).

Types of Singing

Choral/Classical Singing

When choral music is taught, special attention is given to vocal technique and production. Most of the time, choral directors are sensitive to bad vocal production but sometimes that can be overlooked. For example, a study that investigated muscle tension in classical/choral singing found that muscle tension was lower compared to nonclassical singing styles (Koufman *et al.,* 1996). This may be due to the careful attention paid to vocal production by the singers and by the director.

It is common among choral singers to participate in one-on-one vocal training with a vocal coach. This could contribute to the lesser degree of muscle tension. According to Tepe *et. al* (2002), good vocal training is helpful in not only improving vocal performance capabilities but also in avoiding injuries. Overall, training a child's voice is likely to result in improved technique in voice production (Barlow & Howard, 2002). Barlow and Howard (2002) found that females exhibited a marked development of voice production according to the length of training received, while male subjects exhibited patterning according to both age and training received. Koufman *et al.* (1996) found that singers who had formal vocal training in all types of singing showed lower muscle tension scores than those who had not. High muscle tension scores imply high relative vocal/laryngeal work, whereas low muscle tension scores imply relative vocal/laryngeal efficiency (Koufman *et al.,* 1996). To determine muscle tension in

Koufman's study, transnasal fiberoptic laryngoscopy was used to assess patterns of laryngeal tension during singing to determine if the style of singing influences laryngeal muscle tension (Koufman *et al.,* 1996).

Musical Theater Singing

Many adolescents love participating in musical theater productions. With the growing number of shows that involve child and adolescent roles, for example *Annie,* more and more participation of young singers is anticipated. The downside of this trend is that musical theater incorporates some very intense singing that, if not properly taught, can damage the voice. Koufman *et al.* (1996), rank the muscle tension created by singing musical theater higher than that of choral, opera, and jazz singing in adult singers.

A particular singing technique utilized in musical theater is that of belting. Schutte and Miller (1993) define belting as:

> …a manner of loud singing that is characterized by consistent use of "chest" register (>50% closed phase of glottis) in a range in which larynx elevation is necessary to match the first formant with the second harmonic on open (high F1) vowels, that is, ~G4-D5 in female voices. (p. 147)

Pedagogues have defined the belt voice as an extension of the modal or speaking mode into a high frequency range or register (Burdick, 2005). This style of singing is more prevalent in females than males. There is controversy in the literature over the existence of a "male belt." (Burdick, 2005). Burdick (2005) claims that the male singer rarely leaves his speaking range in singing, unlike the female belter who must extend her speaking/modal range to produce the belt voice. Schutte and Miller (1993) provide a chart of the physiological and acoustical parameters characterizing different types of voice production in females (Appendix C).

Belt is a separate vocal mode from chest and head singing based on physiology and acoustic studies. The muscle activity energy required to produce belt exceeds chest, head, and speech (Burdick, 2005). Voice researchers have used EMGs (electromyography) to study the muscular activity during belting. These studies revealed that the belt has the highest level of vocalis (thyroarytenoid) activity, as compared to speech and opera production (Burdick, 2005).

Many vocal instructors argue that belting can be an abusive singing style. Shutte and Miller (1993) point out that "belters" seem to expose their voices to a unique degree of risk by challenging various risk factors such as high laryngeal positions and extreme use of the chest register. Undergoing vocal instruction can heighten awareness of the vulnerability of the voice and can provide some strategies to lessen the risks of abuse from belting (Shutte and Miller, 1993). Belt can be taught in a healthy manner if balance of the heavy and light mechanisms and frontal resonance are emphasized (Burdick, 2005).

Gospel Singing

Gospel music can be divided into several categories. Those categories are country gospel, black gospel, southern gospel, inspirational, and contemporary Christian. Though performed in both white and African-American churches, there is a distinct difference between the styles of singing. This difference is a cultural individuality with a primary emphasis on style. Black gospel music is known for its special effects such as growling, guttural, screaming, humming, and moaning. Because of continual changes in the music, mastering it requires skill, talent, and confidence in one's singing ability (Atkinson, 1999).

There is only a small amount of literature describing gospel music and laryngeal function. Koufman *et al.* (1996), found that singing gospel music causes the most muscle tension compared to other types of singing. In this study, it was also discovered that African-American singers tend to have a significantly higher muscle tension rating than those of Caucasians when examined through laryngeal imaging. Since gospel choirs are predominately made up of African-Americans, vocal damage can be considered a high risk factor for them. To see Koufman's complete ranking of mean muscle tension scores see Appendix D.

Glottal Configuration

Glottal configuration is another term for the shape of the glottis, surrounded by the opening or closing vocal folds. The degree of closure in the glottis can provide a researcher with a visual aide that can indicate too much closure or muscle tension (Murry, Xu, and Woodson, 1998). One may believe that complete glottal closure is a characteristic of a normal voice however this is not necessarily true. The degree of glottal closure, the configuration of the glottis, gender, age, vocal intensity, and fundamental frequency have all shown the presence of incomplete glottal closure (Murry, Xu, & Woodson, 1998). Incomplete closure is also found in higher fundamental frequencies and in decreased loudness (Murry, Xu, & Woodson, 1998). Women, during normal phonation, also exhibit incomplete glottal closure, especially in young and middle aged women (Murry, Xu, & Woodson, 1998). Murry, Xu, and Woodson (1998) investigated whether or not glottal configuration changes with transition from modal to falsetto vocal registers. They found that incomplete glottal closure is normal in high frequency modal and falsetto phonation.

There are various ways in which to determine glottal configuration. One procedure is electroglottography (EGG). The EGG procedure measures certain aspects of vocal fold motion and contact, and subtle vibratory characteristics appear to be reflected by the EGG wave form (Childers *et al.,* 1990). The EGG uses the measurement of electrical impedance to give a direct, noninvasive measurement of activity except that it is usually plotted as the inverse (Barlow & Howard, 2002). A downside of the electroglottogram is that it reveals little about voice quality (Childers *et al.,* 1990).

Another method of determining glottal closure is by observation of the vocal folds using a flexible fiberoptic nasendoscope. The American Speech-Language-Hearing Association (2004) describes this device as follows:

> A high-intensity light, transmitted by a fiberoptic bundle, illuminates structures to be viewed by the clinician and/or recorded. The advantages are an excellent image of the vocal folds and velophrayngeal structures during voicing, conversation, or singing, and the potential for image recording and instant replay. The disadvantages are equipment expense and possible patient discomfort. (p. 190)

This instrument allows the researcher to view symmetry of phase, regularity of periodicity, amplitudes and wave forms of individual folds, presence or absence of adynamic segments, speed and smoothness of abduction and adduction (Elias *et al.,* 1997). This device allows the researchers and clinicians to inspect glottal images and the degrees and shapes of glottal closure (Murry, Xu, & Woodson, 1998).

Summary and Purpose

Some limited research does exist on the characteristics of adolescent voices. There is also descriptive research that investigates and discusses muscle tension in various types of singing in adults, but not in adolescents. When the adolescent voice is considered, voice profiles are limited and there is a need for more investigation describing the various musical genres and their effects on the adolescent laryngeal mechanism.

The purpose of this study is to obtain a detailed profile on characteristics of the adolescent speaking voice, including acoustic and physiologic characteristics, and to investigate the degrees of muscular tension in the adolescent voice while singing choral/classical, musical theater, and gospel music. A study conducted at the same time as this one evaluated muscular tension during singing using the same protocol in addition to perceptual characteristics of the singing voice.

CHAPTER III

OUTLINE OF PROCEDURES

Subjects

Subjects for this study included twenty student volunteers from the Rockingham County School District. They were the students of a public school music teacher who was also a doctoral student at the University of North Carolina at Greensboro, School of Music. Since this was a descriptive study and we wanted to capture the diversity of the student singer, there were few eligibility criteria for subject participation other than having a known normal voice. Subjects were enrolled without regard to race or gender. The subjects were required to be active in a vocal training program and to be age appropriate for pubertal development. There were thirteen female participants and seven male participants. The subjects ranged from twelve years of age to seventeen years of age. Prior to testing, each subject completed a questionnaire with questions regarding dietary practices, medical history, and vocal hygiene (see Appendix E).

Instrumentation

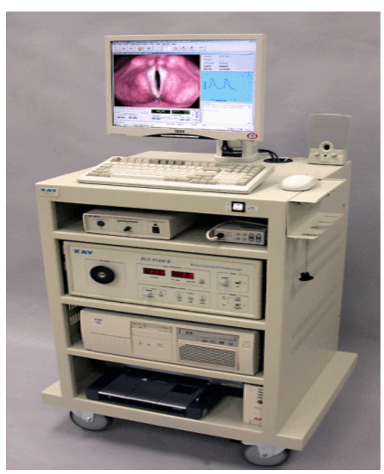
Measures for this study were taken by using a Welch Allen Flexible Rhinolaryngoscope, Model RL-150 for purposes of viewing the laryngeal anatomy of each subject. See Figure 1. The scope was disinfected between subjects following the standard of universal health precautions.

FIGURE 1: RL-150 Rhinolaryngoscope

(used for viewing the vocal folds)

Images recorded by the camera on the nasendoscope were viewed and recorded through the KayPentax Digital Video Stroboscopy System, Model 9295. See Figure 2.

Figure 2: KayPentax Stroboscopy System



(used for viewing and storing images of the vocal folds)
(Picture used with permission from KayPentax)

Voice profiles, digital recordings of the voice, were obtained through the use of the Kay Pentax Computerized Speech Lab (CSL). This microcomputer-based system is used for speech and voice acquisition, analysis, and playback. The CSL software that will be used includes the Multi-dimensional Voice Program Model 5105, (MDVP) and the Real Time Pitch program, Model 5121. Voice samples were recorded through the use of a *Shure* microphone, Model SM48. The recording was made with the microphone placed 15 cm (approximately 2 inches) from the subject's mouth with the use of a simple gauge constructed from a tongue depressor and attached to the microphone.

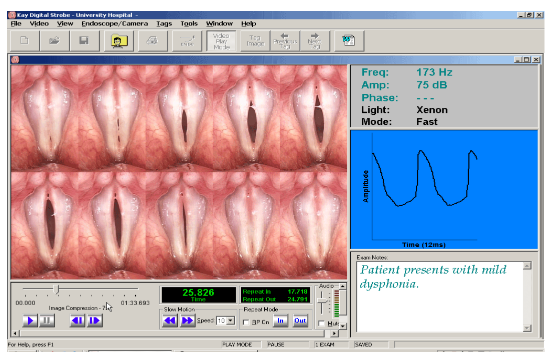
Procedures and Analysis

The study required the subjects to participate in one session in the UNC-Greensboro Applied Communicative Science Laboratory. The lab was set up as a three part rotation, e.g., each subject went to three different stations for data gathering by the investigator. Three dates were set to obtain all of the data with five to ten students assigned to each day. During the first rotation, each subject completed a vocal health questionnaire (see Appendix E). The questionnaire included questions such as vocal health, diet, medical background, and music performance. Before subjects began testing, the researcher explained the purpose and justification of this study and provided the subjects information in regards of any risks that may occur. The subjects were told that their identity would be held completely confidential and they could withdraw from the study at any time. Each subject was required to obtain the signature of a parent or guardian on a UNC-Greensboro approved consent form (Appendix F). Subjects came to the testing center with their voices warmed-up by their choral instructor.

During the second rotation of the day, each subject had his/her vocal acoustic parameters analyzed by the Kay Elemetrics' Computerized Speech Lab program (CSL). The CSL program consisted of the Multidimensional Voice Program (MDVP) and the Real Time Pitch program. The MDVP was used first to measure the acoustic parameters of each subject. Each subject was asked to phonate two vowel productions, three times each. These productions included: /a/ produced with a regular vocal onset and /a/ produced with an easy onset. Each vowel production needed to be produced for at least six seconds for valid acoustic analysis. These digitized recordings were saved to the computer's hard drive for later analysis. The following acoustic measures were examined: average fundamental frequency (Fo), jitter (pitch perturbation), and shimmer (amplitude perturbation). After completing the following tasks on the MDVP, more acoustic parameters were analyzed using the Real Time Pitch program. For this portion of the study, the subject was asked to read the first two sentences of the "Rainbow Passage," a standard text with all speech sounds of American English used for obtaining a running speech sample (Fairbanks, 1960). See Appendix G. Then the subject was asked to count from one to ten. Finally, subjects were asked to produce the vowel /i/ beginning with their lowest pitch and sliding up to their highest pitch. These tasks were used for measurements such as fundamental frequency during reading, habitual pitch, and pitch range.

The last rotation was conducted following a five to ten minute rest period. This rotation included the nasendoscopy procedure which was performed to assess muscular tension. Each subject was given a mist of saline solution (sterile salt water) to help lubricate the nasal passage and to ease insertion of the scope. Once the scope was properly positioned above the vocal folds, the subjects were asked to sing three short passages of various choral pieces. The music excerpts used were: “Pueri Concinite” by Von Herbeck (classical), “Tomorrow from *Annie*” by Strouse, Charnin, and Meehan (musical theater), and “He never failed me yet” by Robert Ray (gospel). See Appendix H. Images were taken during singing of the vocal folds and of the surrounding laryngeal anatomy using the KayPentax stroboscopy system and the Welch Allen rhinolaryngoscope. The following picture demonstrates what the researcher saw and depicts normal vocal fold movement.

FIGURE 3: Image of vocal folds



(Picture used with permission by KayPentax)

Once the procedure was completed, the researcher saved the recorded video for later analysis.

Once the last rotation was completed, each subject received a digital photograph of his/her vocal folds and was given a print-out of his/her vocal acoustic parameters. The examiner explained what the picture and the acoustic print-out meant and answered any questions that the subject or his/her parents had.

The videos of each subject were evaluated by three investigators at a later time on all of the mentioned characteristics. Then each investigator determined whether there was any tension or abnormality in the vocal mechanism during singing, utilizing a common rating procedure devised by Diane Bless, Ph.D., CCC-SLP at the University of Wisconsin. The raters were trained using a training tape from KayPentax and rated the vocal fold movement using the Wisconsin LVES rating protocol (Appendix I). These recordings were rated by a speech-language pathologist, a speech-language pathology graduate student, and a vocal music instructor/doctoral candidate from the UNC-Greensboro School of Music.

The vocal fold characteristics examined included:

1. Supraglottic activity, which includes any movement in the ventricular (false) folds or any anterior/posterior tissue movement.

2. Vocal Fold Edge, which is the most medial portion of the vocal fold.

3. Amplitude, which refers to the extent of displacement of the medial edge of each vocal fold from midline observed at the time of maximum glottal opening (Karnell, 1994).

4. Mucosal Wave, the lack of which is associated with increased stiffness of the vocal fold cover. Variations in the mucosal wave may be among the first observable changes in vocal fold tissue (Karnell, 1994).

5. Non-Vibrating Portion. Vocal fold tissue should vibrate along the entire length of the membranous vocal fold during voice production (Karnell, 1994).

6. Phase Symmetry, which refers to the relative timing of motion of the vibrating vocal folds (Karnell, 1994).

7. Phase Closure, which indicates whether a closed phased or open phase predominates.

8. Glottal Closure, which indicates whether closure of the vocal folds is complete, incomplete, or inconsistent. A variety of glottal closure characteristics can occur. They include: complete, posterior chink, irregular, hourglass, spindle, anterior chink, and incomplete. To see a diagram of each of these closure characteristics, refer to Appendix H.

To watch an example of these characteristics in a normal larynx, please use the following website which is used by permission from the developer: http://www.voicemedicine.com/normal_voice_functioning.htm.

Design and Reliability

This was a descriptive study of the adolescent voice. To improve reliability of acoustic measures, the input level was adjusted so that the waveform on the CSL program was not overloaded during vocalizations. The CSL and MDVP programs will not analyze overloaded signals (Hube, 1996). To further insure reliability, each vocal production of sustained vowels was repeated three times. An average of each three productions was obtained and recorded. Any phonations that were not appropriately produced were deleted and the subject was asked to perform again.

Interjudge reliability was used during the rating of the laryngeal stroboscopy videos. The principal investigator reviewed and rated 15% of the subject’s videos, while a speech-language pathologist and choral director reviewed and rated all of the videos.

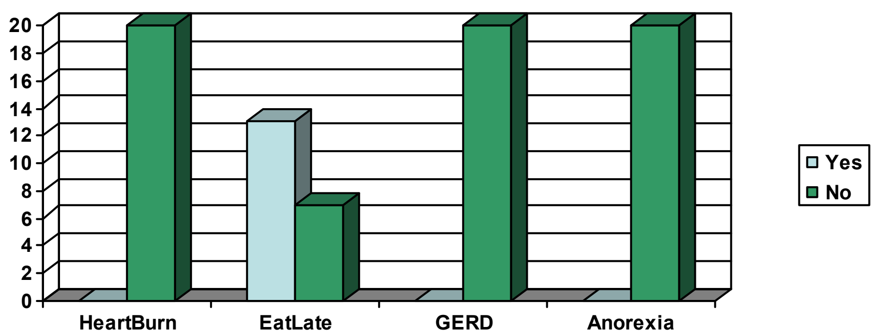
Even though there were twenty subjects who participated, subject #6 chose not to participate in the nasal stroboscopy procedure.

CHAPTER IV

RESULTS

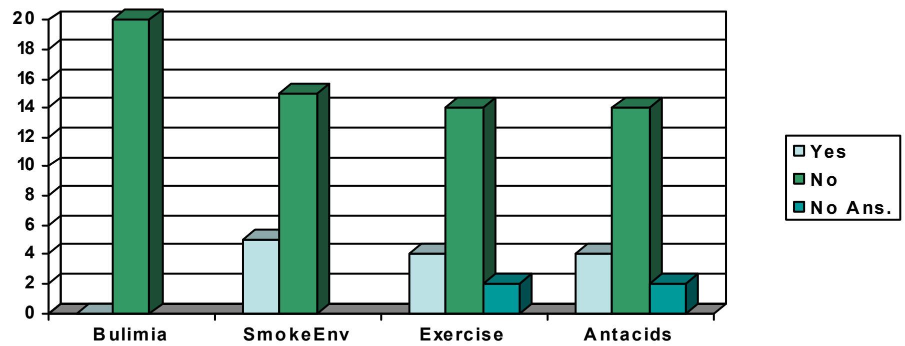
The purpose of this study was to look at the vocal characteristics of the adolescent speaking voice and to determine which type of singing (classical, musical theater, and gospel) causes the most muscular tension. At the beginning of the study, a subject questionnaire was completed by each subject. See Figure 4 for complete survey results.

FIGURE 4: Survey results including both male and female subjects

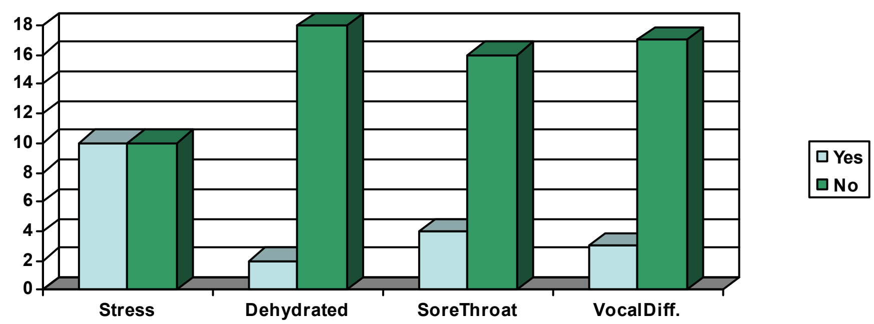


(HeartBurn = frequent heartburn, GERD = gastroesophageal reflux)

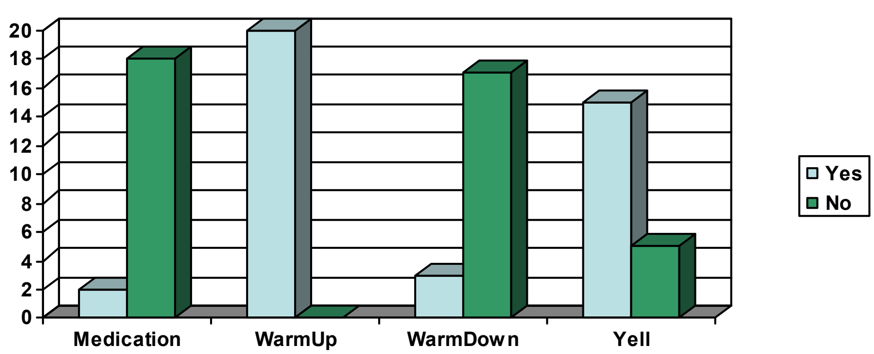
FIGURE 4 Continued…



(SmokeEnv = live in a smoke filled environment)

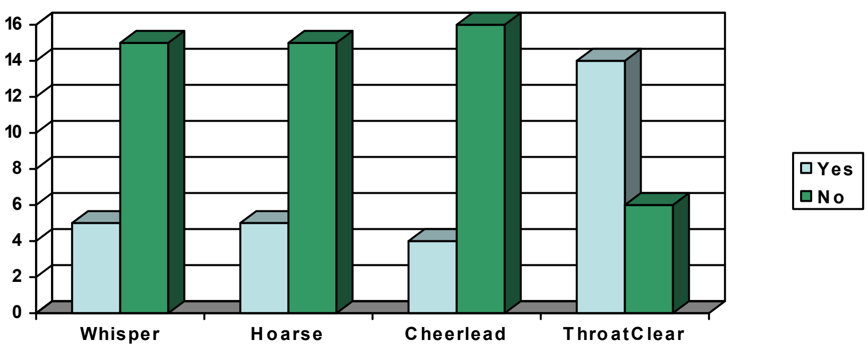


(SoreThroat = frequent sore throat, VocalDiff. = experiencing vocal difficulty)

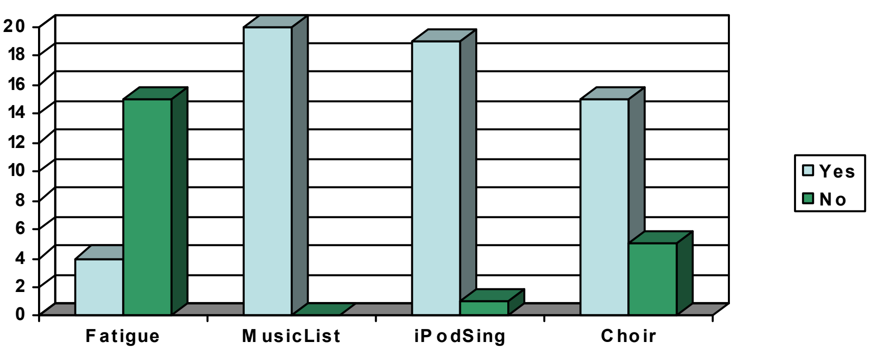


(Yell = yell frequently)

FIGURE 4 Continued…

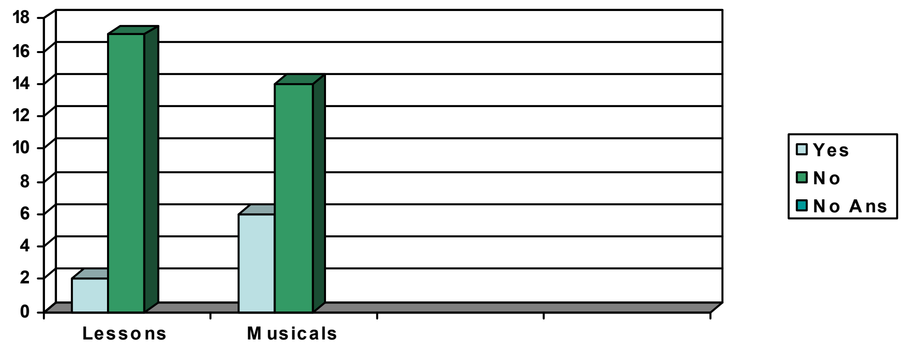


(Whisper = whisper frequently, Hoarse = hoarse in the morning,
Cheerlead = are you a cheerleader, ThroatClear = throat clear frequently)



(Fatigue = does voice feel worse later in the day, MusicList = listen to music frequently, iPodSing = sing along with your personal listening device, Choir = sing in your school or church choir)

FIGURE 4 Continued…



(Lessons = take voice lessons, Musicals = participate in musicals)

To establish an appropriate voice profile of each subject, multiple parameters of the voice were analyzed. These parameters include: fundamental frequency, shimmer, jitter, habitual pitch, pitch range, and fundamental frequency/range during reading. A student in the UNC-Greensboro School of Music evaluated muscular tension during singing using vocal imaging and perceptual measurements. The same subjects were used for both studies. See Table 1.

TABLE 1: Description of subjects

SUBJECT 1

Age	Gender	Race	Ave. Fo	Ave. Jitter	Shimmer	Range
14	Male	Afr.Amer.	217.10	0.62	4.17	573.84

SUBJECT 2

Age	Gender	Race	Ave. Fo	Ave. Jitter	Shimmer	Range
14	Male	Caucasian	220.78	0.42	3.68	441.57

TABLE 1 continued…

SUBJECT 3

Age	Gender	Race	Ave. Fo	Ave. Jitter	Shimmer	Range
14	Female	Caucasian	188.76	1.81	3.20	424.88

SUBJECT 4

Age	Gender	Race	Ave. Fo	Ave. Jitter	Shimmer	Range
14	Female	Caucasian	250.29	2.02	2.92	424.88

SUBJECT 5

Age	Gender	Race	Ave. Fo	Ave. Jitter	Shimmer	Range
15	Male	Caucasian	138.63	1.08	2.04	822.46

SUBJECT 6

Age	Gender	Race	Ave. Fo	Ave. Jitter	Shimmer	Range
13	Female	Caucasian	252.69	1.52	2.89	1000.98

SUBJECT 7

Age	Gender	Race	Ave. Fo	Ave. Jitter	Shimmer	Range
17	Female	Caucasian	186.40	2.14	4.55	650.88

SUBJECT 8

Age	Gender	Race	Ave. Fo	Ave. Jitter	Shimmer	Range
13	Female	Caucasian	193.20	1.54	4.48	446.19

SUBJECT 9

Age	Gender	Race	Ave. Fo	Ave. Jitter	Shimmer	Range
12	Female	Caucasian	229.46	3.57	5.10	341.84

SUBJECT 10

Age	Gender	Race	Ave. Fo	Ave. Jitter	Shimmer	Range
13	Male	Caucasian	233.65	2.02	2.39	344.90

TABLE 1 continued…

SUBJECT 11

Age	Gender	Race	Ave. Fo	Ave. Jitter	Shimmer	Range
13	Female	Caucasian	231.31	2.15	4.81	297.67

SUBJECT 12

Age	Gender	Race	Ave. Fo	Ave. Jitter	Shimmer	Range
13	Female	Caucasian	215.48	1.29	4.16	1001.81

SUBJECT 13

Age	Gender	Race	Ave. Fo	Ave. Jitter	Shimmer	Range
14	Female	Caucasian	208.71	2.81	3.40	365.14

SUBJECT 14

Age	Gender	Race	Ave. Fo	Ave. Jitter	Shimmer	Range
15	Female	Caucasian	210.89	2.78	4.74	478.01

SUBJECT 15

Age	Gender	Race	Ave. Fo	Ave. Jitter	Shimmer	Range
12	Female	Afr.Amer.	229.02	1.89	4.88	367.68

SUBJECT 16

Age	Gender	Race	Ave. Fo	Ave. Jitter	Shimmer	Range
14	Female	Caucasian	238.34	2.89	4.50	292.13

SUBJECT 17

Age	Gender	Race	Ave. Fo	Ave. Jitter	Shimmer	Range
17	Male	Caucasian	114.51	1.18	2.17	526.72

SUBJECT 18

Age	Gender	Race	Ave. Fo	Ave. Jitter	Shimmer	Range
14	Female	Afr.Amer.	176.87	2.73	2.79	532.04

TABLE 1 continued…

<u>SUBJECT 19</u>

Age	Gender	Race	Ave. Fo	Ave. Jitter	Shimmer	Range
17	Male	Caucasian	118.37	1.06	2.60	582.72

<u>SUBJECT 20</u>

Age	Gender	Race	Ave. Fo	Ave. Jitter	Shimmer	Range
15	Male	Caucasian	105.63	0.89	5.17	409.12

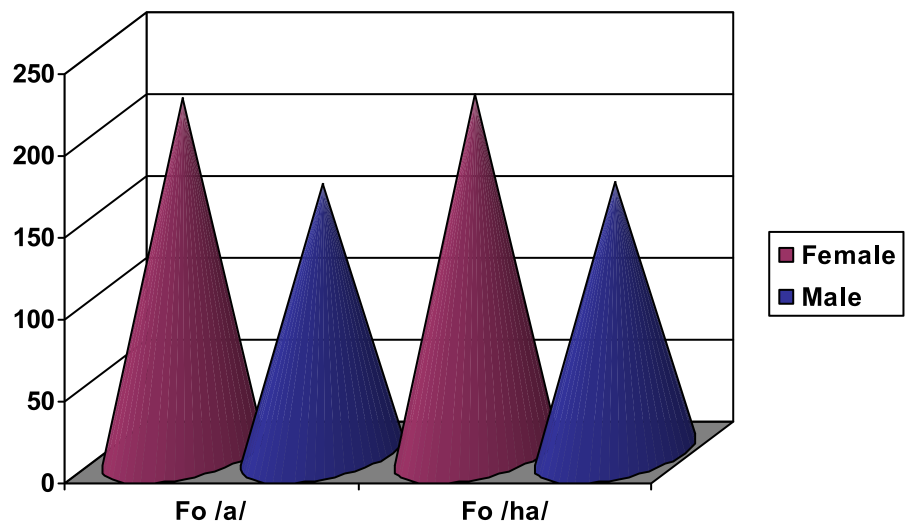
There were 13 females and 7 males who participated in this study and results indicate that females fell in the normal range for fundamental frequency at a mean of 216.26 Hz when compared to normative data in adults. See Table 2.

TABLE 2: Normative acoustic data for adults

<u>FEMALES</u>	<u>NORM.</u>
Fundamental Frequency (Fo)	180-250 Hz
Jitter Percent	1.04%
Shimmer Percent	1.997%
	SD 0.791
<u>MALES</u>	
Fundamental Frequency (Fo)	100-150 Hz
Jitter Percent	1.04%
Shimmer Percent	2.523%
	SD 0.997

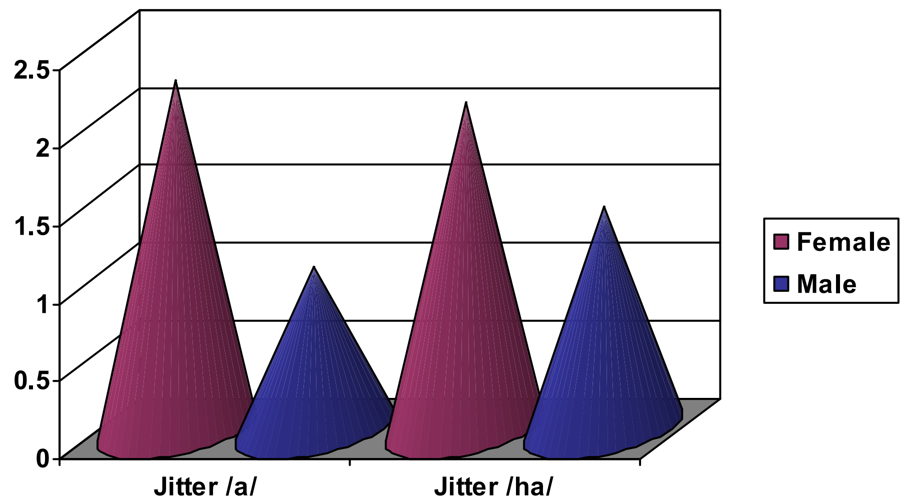
Colton and Casper (1996) indicate that the normal range for females (adult) are fundamental frequencies that range between 180 and 250 Hz. For males who participated in this study, the average fundamental frequency was 164.10 Hz which is higher than the adult norms provided by Colton and Casper (1996) who state that the average fundamental frequency range for males lies between 100 and 150 Hz. When producing the /a/ sound with an easy onset (/ha/), the fundamentals were approximately the same with females averaging 218.98 Hz and males averaging 164.93 Hz. See Figure 5.

FIGURE 5: Fundamental frequency results (Fo)



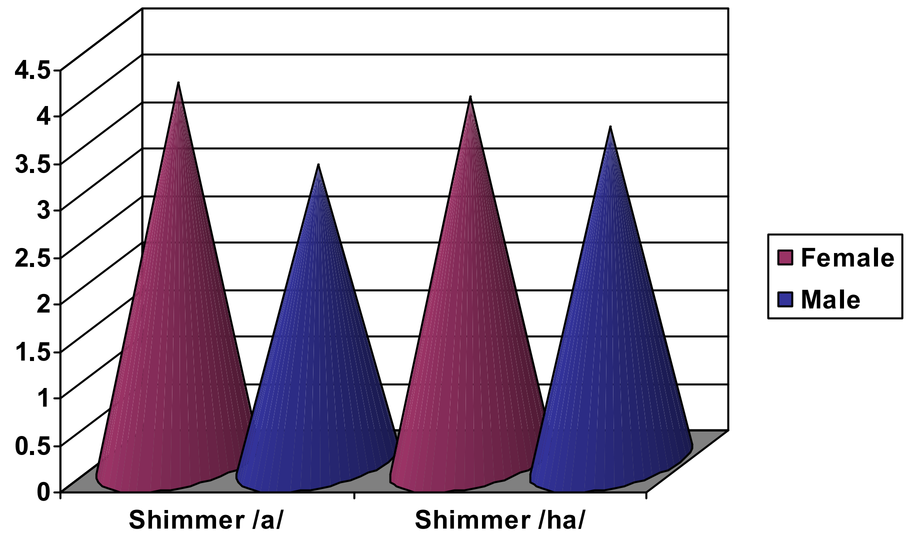
Normative data for jitter percent includes any percentage that falls under 1.04% (Kay Elemetrics, 1993). For females who participated in this study, the mean jitter percent was higher than normal at 2.241% when producing the vowel /a/. Males fell within normal limits with a mean jitter percentage of 1.039% while producing the vowel /a/. During unloaded productions (easy onset) of the vowel /a/ (/ha/), jitter decreased in females but still remained higher than normal at 2.105% while the percent in males slightly exceeded the norm at 1.437%. See Figure 6.

FIGURE 6: Jitter percentages



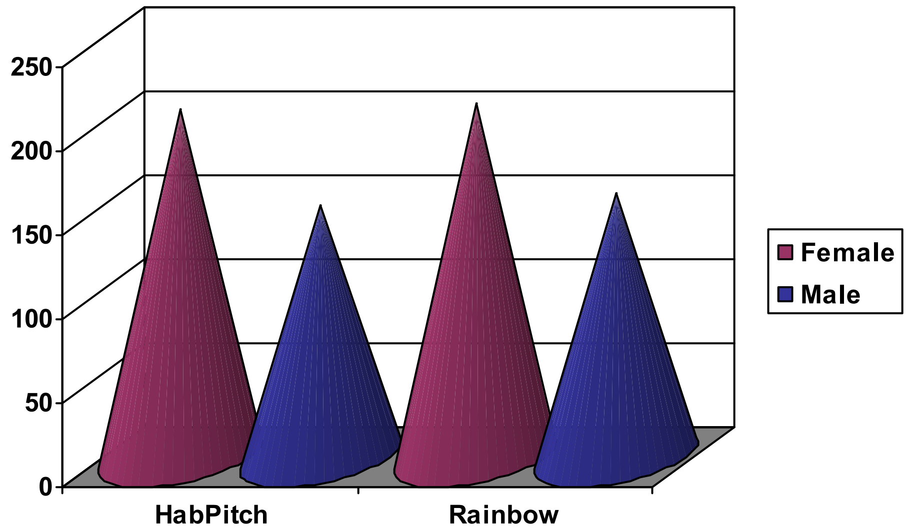
Normal shimmer percentages according to Kay Elemetrics (1993) are 1.997% for females with a standard deviation of 0.791. In males, the normal percentage in shimmer is 2.523% with a standard deviation of 0.997%. In this study, the mean shimmer percent for females while producing the /a/ vowel was above normal at 4.032%. During an unloaded production, their percentage mean remained outside of normal limits at 3.896%. For males, the mean shimmer percent while producing the /a/ vowel was within normal limits at 3.173%. During unloaded productions, the percentage mean was outside of normal limits at 3.566%. See Figure 7.

FIGURE 7: Shimmer percentages



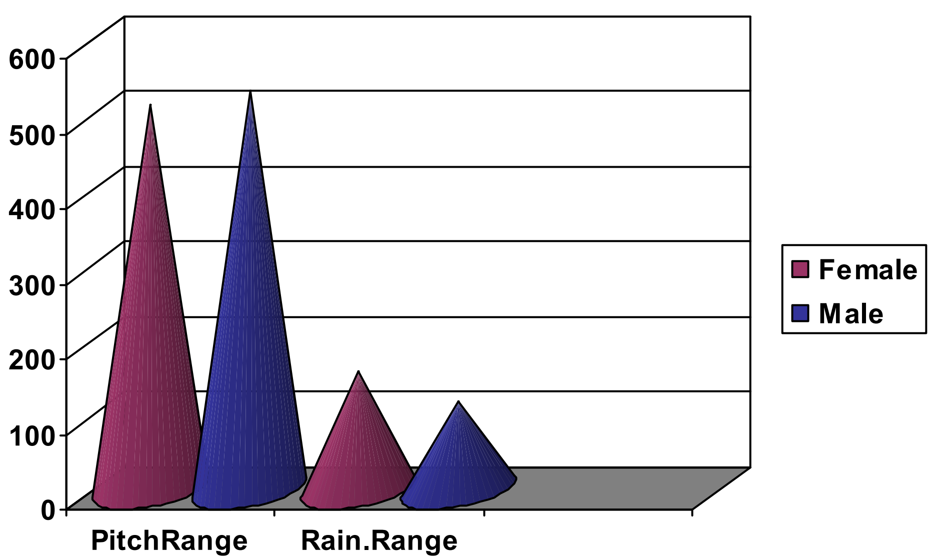
It is difficult to find material on normative data for habitual pitch during counting/reading, and for ranges. The literature that exists describing any of these qualities is not necessarily in agreement, especially when considering the adolescent voice. See Figures 8 and 9. Please refer to Table 3 to see the mean in each acoustic parameter recorded and the standard deviation of each.

FIGURE 8: Results for habitual pitch in counting and reading (Fo)



(Hab.Pitch = Fo during counting, Rainbow = Fo while reading the Rainbow Passage)

FIGURE 9: Results for range



(Rain.Range = Fo range while reading the Rainbow Passage)

TABLE 3: Means and standard deviations of acoustical data

	Gender	Mean	Standard Dev.	Minimum	Maximum
Fo /a/	Female	216.26 Hz	24.75	176.87 Hz	252.69 Hz
	Male	164.10 Hz	56.97	105.63 Hz	233.65 Hz
Fo /ha/	Female	218.98 Hz	21.72	185.38 Hz	248.83 Hz
	Male	164.93 Hz	52.31	104.36 Hz	226.69 Hz
Jitter /a/	Female	2.241%	.666	1.29 %	3.57 %
	Male	1.039%	.5109	.42%	2.02%
Jitter /ha/	Female	2.104%	.7492	.88%	3.39%
	Male	1.437%	.8506	.51%	2.60%
Shimmer /a/	Female	4.032%	.8583	2.79%	5.10%
	Male	3.173%	1.186	2.04%	5.17%
Shimmer /ha/	Female	3.895%	.9600	2.36%	5.28%
	Male	3.565%	1.312	2.04%	5.56%
HabPitchFo	Female	207.03 Hz	20.55	165.62 Hz	234.28 Hz
	Male	149.86 Hz	42.53	112.27 Hz	200.66 Hz
HabPitchRange	Female	89.85	40.05	38.75	149.16
	Male	55.16	22.51	31.29	89.71
PitchRange	Female	509.54 Hz	238.90	292.13 Hz	1001.81 Hz
	Male	528.76 Hz	156.48	344.90 Hz	822.46 Hz
Fo in Reading	Female	210.55 Hz	19.25	174.19 Hz	246.51 Hz
	Male	156.71 Hz	34.47	121.73 Hz	196.84 Hz
ReadingRange	Female	155.18 Hz	45.96	76.43 Hz	208.30 Hz
	Male	116.38 Hz	31.31	70.10 Hz	208.30 Hz

(HabPitchFo = Fo during counting, HabPitchRange = Range during counting)

When evaluating which singing style contributes to the most musculature tension, musical theater is the highest. Ratings on the stroboscopic rating form were normal except for the supraglottic activity category which shows abnormal laryngeal function. For inter-rater reliability, the speech-language pathologist and choral director looked at 57 combinations over the three musical styles and disagreed four times (four parameters).

These four parameters were with different subjects, thus they disagreed only .0701%. The raters then viewed the training video again and came to an agreement/consensus on all parameters, all subjects. Therefore the second, final, interjudge reliability score was in 100% agreement. Complete results will be published in a dissertation by a doctoral candidate in the UNC-Greensboro School of Music. See Figure 10.

FIGURE 10: Stroboscopic ratings for male and female subjects

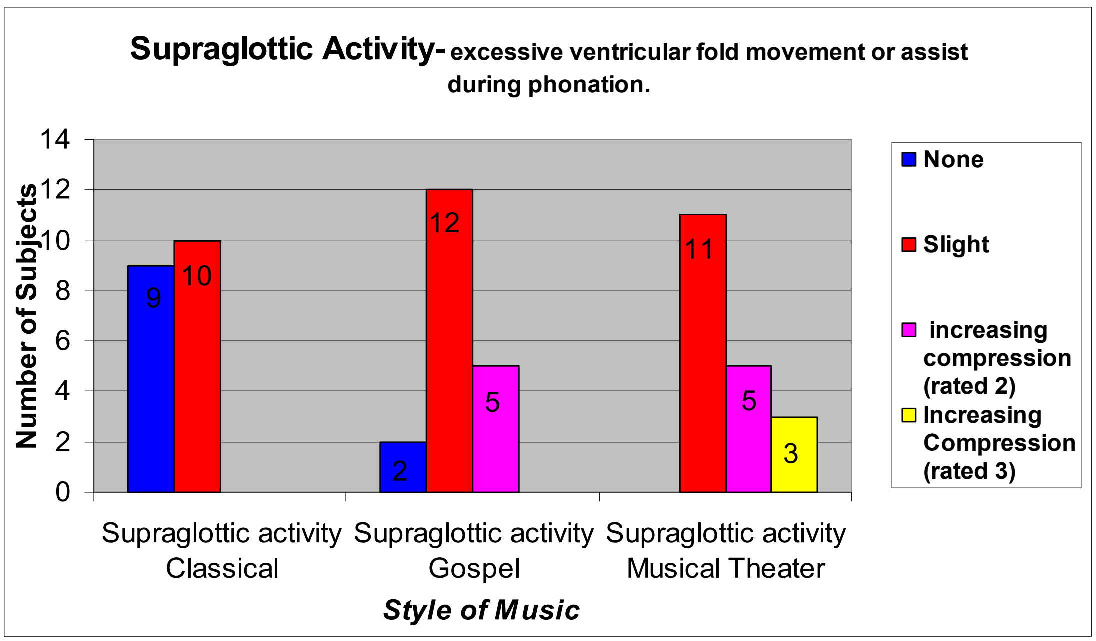
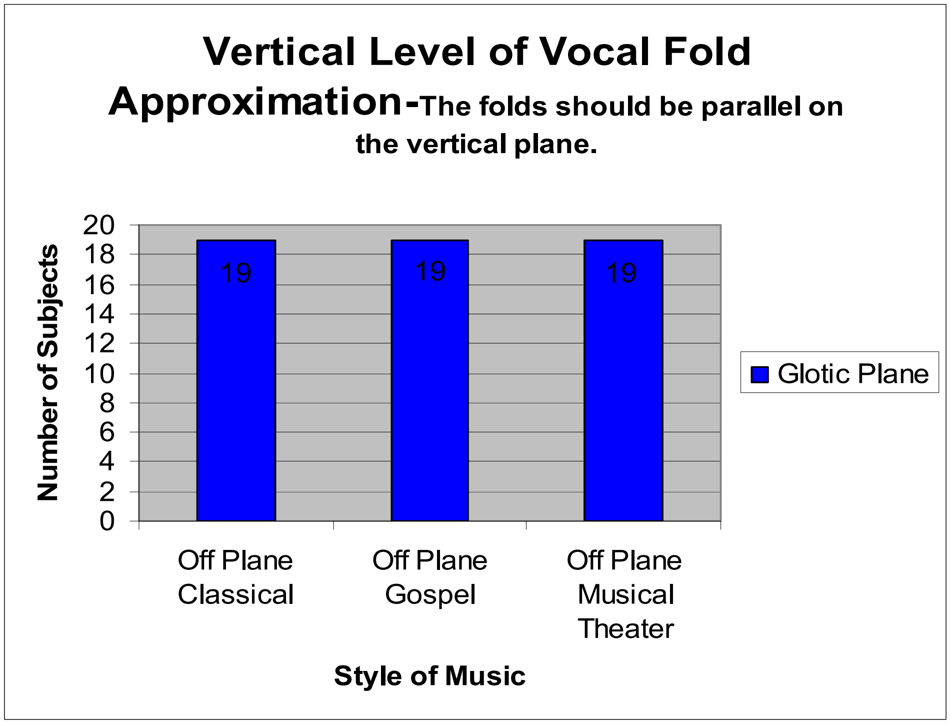


Figure 10 continued…



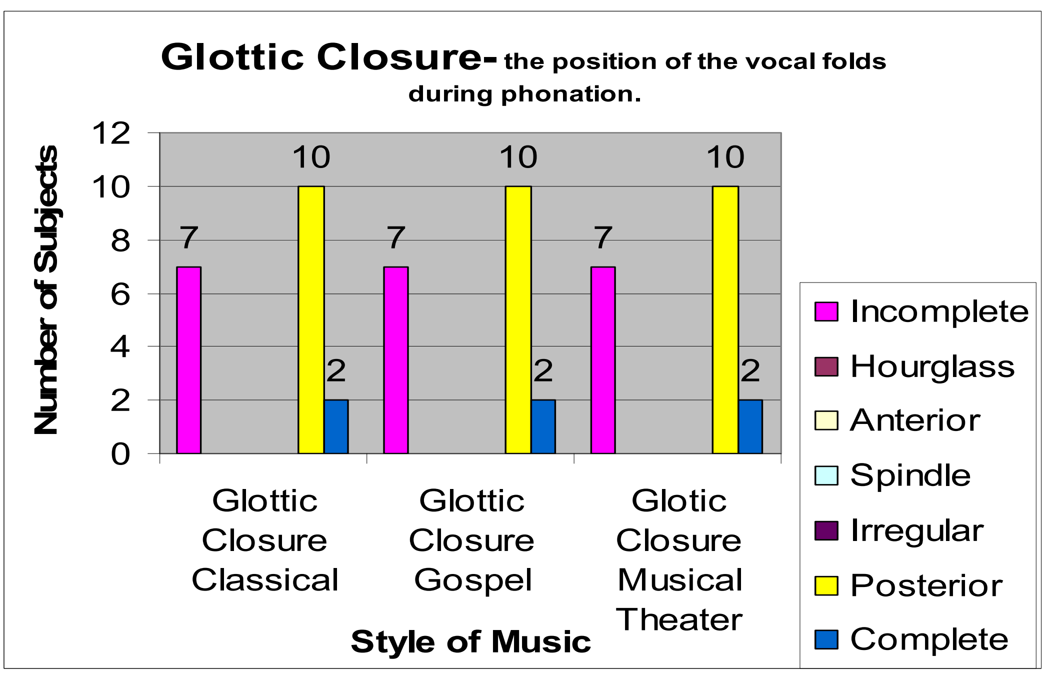
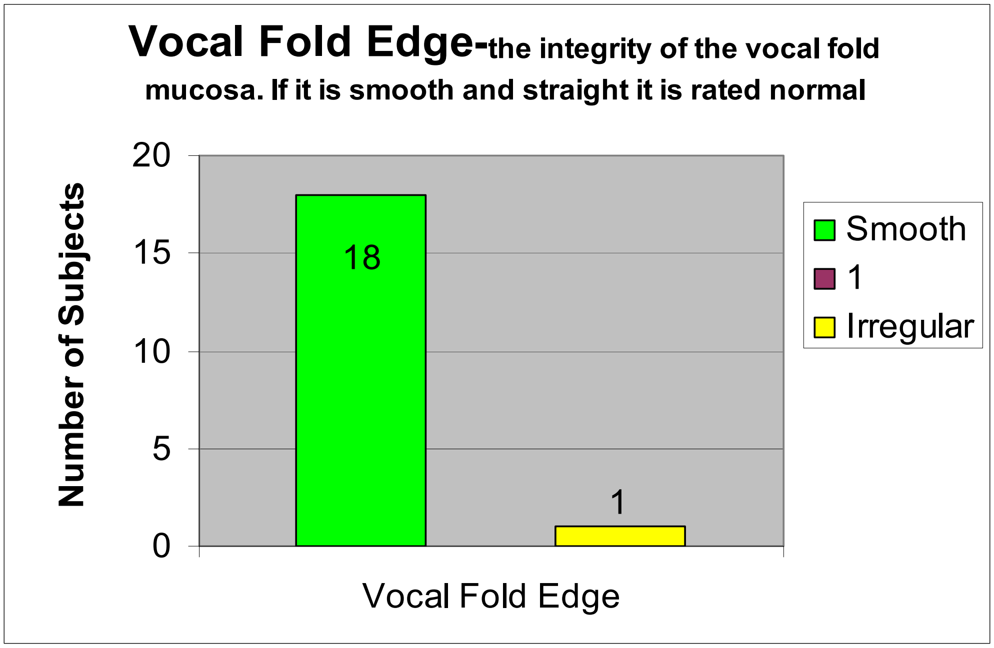


Figure 10 continued…



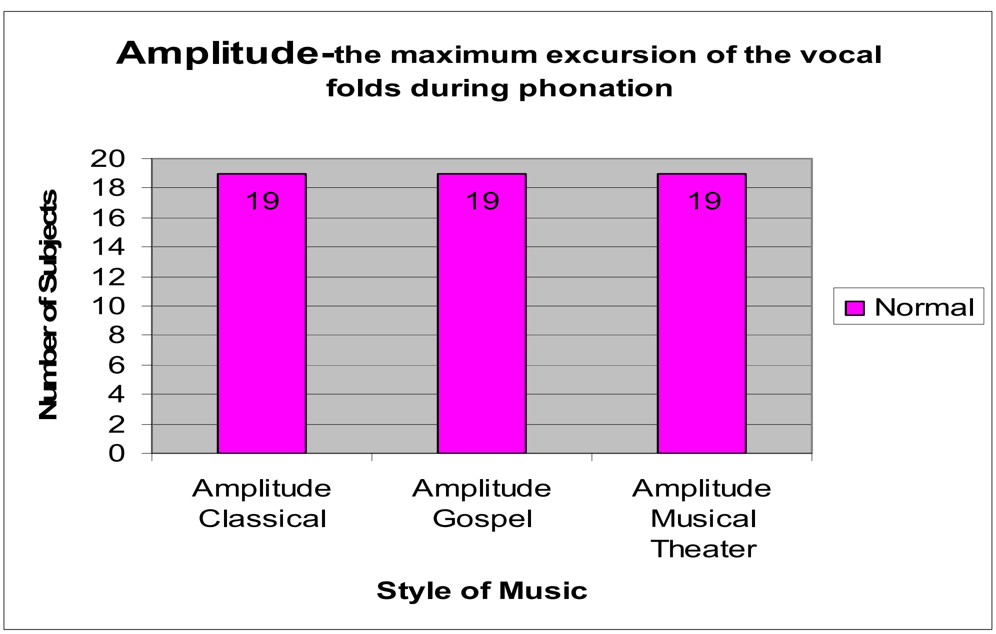
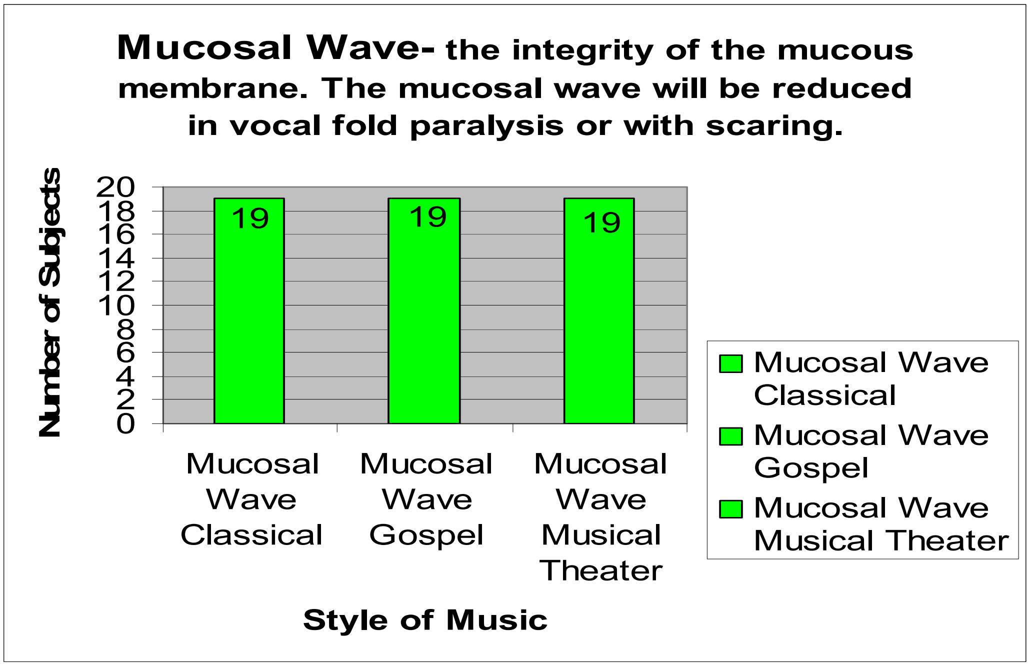


Figure 10 continued…



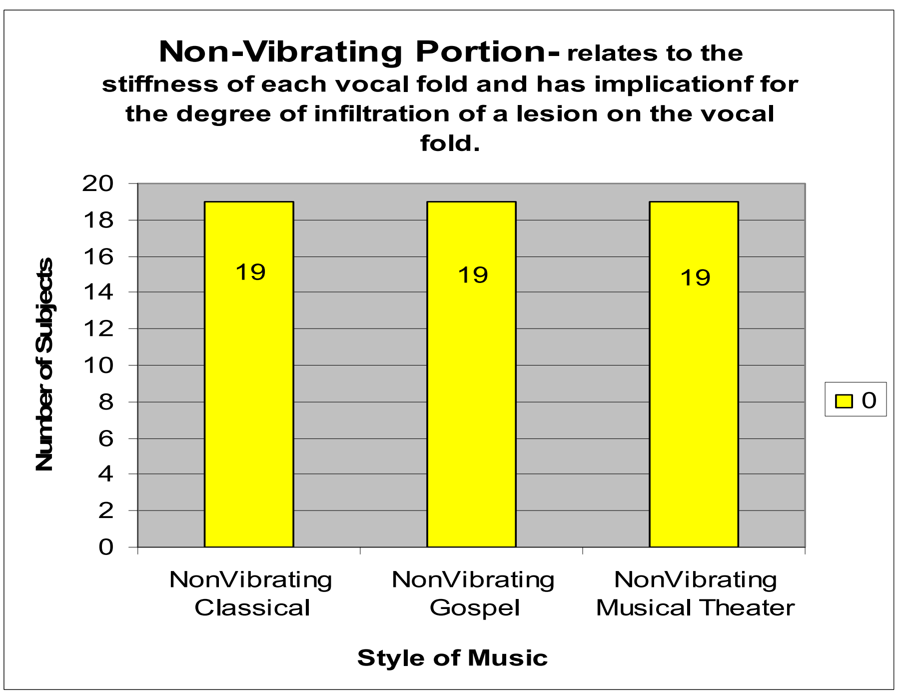
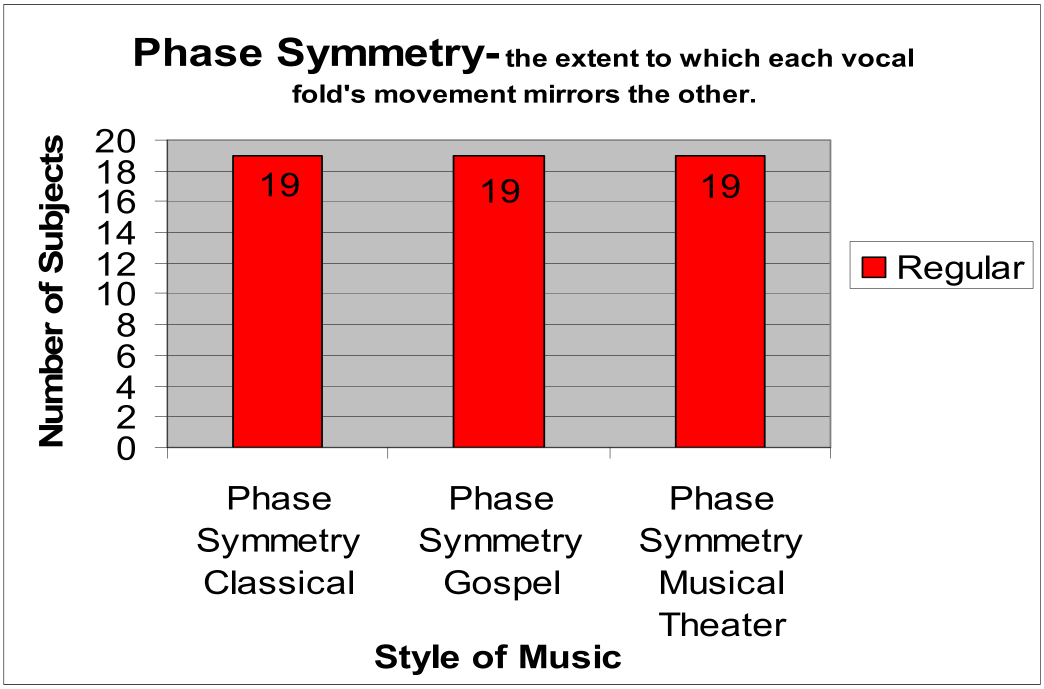
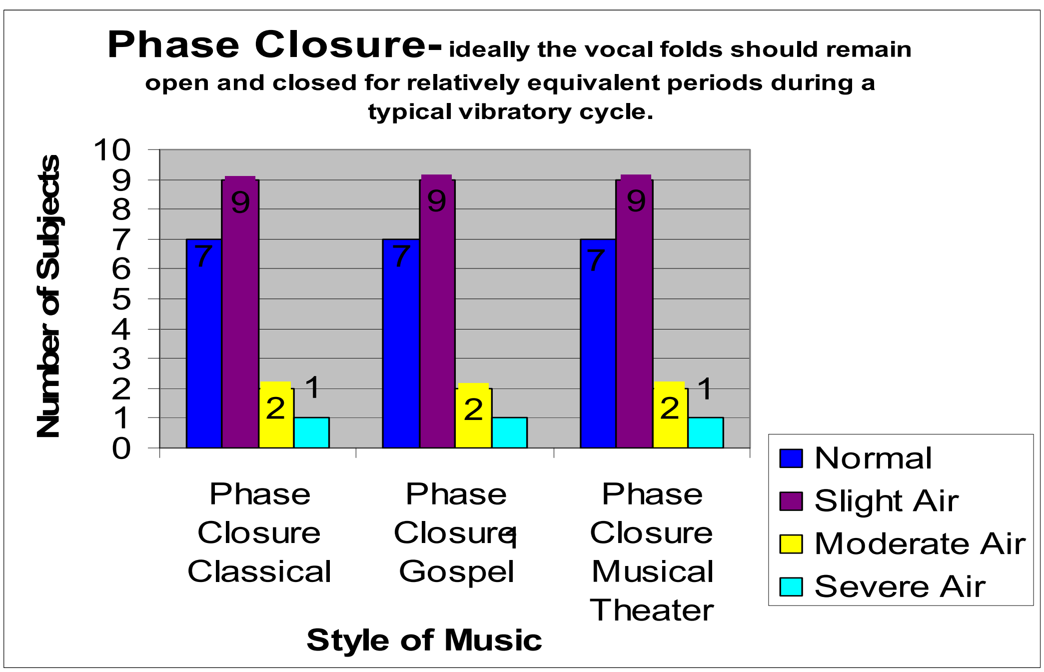


Figure 10 continued…





CHAPTER V

SUMMARY AND CONCLUSIONS

The purpose of this study was to obtain a better description of the adolescent speaking voice and to determine what style of singing causes the most muscular tension. The types of singing styles investigated include: classical choral, musical theater, and gospel music.

When considering speaking characteristics in the adolescent voice, the results of this study show both agreement and disagreement with the existing normative data for adults since so little data exists on the adolescent voice. The information obtained in this study was compared to the normative data of an adult voice. See Table 2. Females in this study had a mean fundamental frequency that was normal (216.26 Hz) while males had a mean fundamental frequency which was higher than normal (164.10 Hz). Jitter percentages revealed higher than normal percentages in females and normal percentages for males. Shimmer percentage results were similar to those of jitter with females exceeding the normal limits and males achieving normal results.

When evaluating which singing style contributes to the most musculature tension, musical theater is the highest as determined by increased supraglottic activity. This may be attributable to the technique that is incorporated when singing in this genre. Classical choral singing and gospel singing cause the least muscular tension with classical singing resulting in lesser tension of the two. This finding is contradictory to the Koufman *et. al.* (1996) study which concluded that gospel singing results in the highest degree of muscular tension. Since students were not singing in a "gospel context," the data in this present study may not represent the "church style" of most gospel singers.

Limitations of this study include a limited diversity of subjects. Determining that singing musical theater causes the most tension would be an inaccurate statement given that there were only three African-American subjects. A study that evaluates muscular tension in African-American students singing gospel music learned outside of an academic setting (i.e. church, community) would yield more appropriate measurements. Another limitation is that the age range of subjects in this study was 12 to 17 years of age. This wide range in age could have resulted in less consistent averages for each speaking characteristic studied.

Future studies are warranted which could replicate this study several ways. A subject population which is more diverse should be targeted. The use of electroglottography would provide insight on open and closed quotients while singing and would also be used to determine degrees of closure in the speaking voice.
It would be interesting to do this study looking at specific ages instead of a wide age range to provide more accurate and detailed information on each age group.

In conclusion, the results of this study indicate that future research would be needed to provide more information on the adolescent speaking voice and to confirm that musical theater causes the most muscular tension in adolescent singers. Speech-Language Pathologists should be cautious when evaluating the adolescent voice using the multidimensional voice profile and the real time pitch program and should realize that numerical values may vary in this population due to various stages that take place during vocal mutation and due to the rate of pubertal growth in the laryngeal area. Speech-

Language Pathologists and vocal music instructors should practice caution when teaching or working with singers in this age group due to the fact that laryngeal growth is taking place and that the vocal structures are fragile at this time. Both professions should remember that the speaking voice and singing voice impact each other and appropriate treatment in both should be practiced. Musical theater and gospel music should still be included in the adolescent singer's repertoire but caution should be used when teaching and performing these styles of music.

REFERENCES

American Speech-Language-Hearing Association. (2004). Knowledge and Skills for Speech-Language Pathologists With Respect to Vocal Tract Visualization and Imaging. *ASHA Supplement 24,* 184-192.

Andrews, M. (1997). The Singing/Acting Child: A Speech-Language Pathologist's Perspective. *Journal of Voice, 11*(2), 130-134.

Andrews, Moya L. with Anne C. Summers. *Voice Treatment for Children and Adolescents.* San Diego: Singular Publ. Group, 2002.

Atkinson, Gloria J. (1999). Acoustic Characteristics of African-American Gospel Singers: A Cultural Perspective.

Barlow, C.A., & Howard, D.M. (2002). Voice source changes of child and adolescent subjects undergoing singing training- preliminary study. *Log Phon Vocol, 27,* 66-73.

Böhme, G., & Stuchlik, G. (1995). Voice Profiles and Standard Voice Profile of Untrained Children. *Journal of Voice, 9*(3), 304-307.

Burdick, B. (2005). Vocal Techniques for Music Theater: The High School and Undergraduate Singer. *Journal of Singing, 61,* 261-268.

Carson, C., Ingrisano, D., & Eggleston, K. (2003). The Effect of Noise on Computer-Aided Measures of Voice: A Comparison of CSpeechSP and the Multi-Dimensional Voice Program Software Using the CSL 4300B Module and Multi-Speech for Windows. *Journal of Voice, 17*(1), 12-20.

Childers, C., Hicks, D.M., Moore, G.P., Eskenazi, L., & Lalwani, A.L. (1990) Electroglottography and Vocal Fold Physiology. *Journal of Speech and Hearing Research, 33*, 245-254.

Cleveland, T. (1994). A Clearer View of Singing Voice Production: 25 Years of Progress. *Journal of Voice, 8*(1), 18-23.

Colton, R & Casper, J. *Understanding Voice Problems: A Physiological Perspective for Diagnosis and Treatment.* Philadelphia: Lippincott Williams & Wilkins, 1996.

Dixon, E.A. *Gospel music: Vocal cords and related issues.* Mantua, NJ: Eureka Publications, 1992

Doscher, Barbara M. *The Functional Unity of the Singing Voice.* Lanham, M.D. & London: The Scarecrow Press, Inc., 1994.

Elias, M., Sataloff, R., Rosen, D., Reinhardt, H., & Spiegel, J. (1996). Normal Strobovideolaryngoscopy: Variability in Healthy Singers. *Journal of Voice, 11*(1), 10-107.

Fairbanks, G. (1960). *Voice and Articulation Drillbook* (2nd Edition). New York: Harper and Bros. p. 127.

Fried, M. (1983). *The larynx: A multidisciplinary approach* (2nd Edition). St. Louis, MO: Mosby.

Gackle, ML. (1991). The adolescent female voice: characteristics of change and stages of development. *Choral Journal, 31*(8), 17-25.

Hacki, T., & Heitmüller, S. (1999). Development of the child's voice: premutation, mutation. *International Journal of Pediatric Otorhinolarnygology, 49,* 141-144.

Hertegard, S., & Gaufin, J. (1995). Glottal Area and Vibratory Patterns Studied With Simultaneous Stroboscopy, Flow Glottography, and Electroglottography. *Journal of Speech and Hearing Research, 38,* 85-100.

Heylen, L., Wuyts, F., Mertens, F., De Bodt, M., Pattyn, J., Croux, C., & Van de Heyning, P. (1998). Evaluation of the Vocal Performance of Children Using a Voice Range Profile Index. *Journal of Speech, Language, and Hearing Research, 41,* 232-238.

Hooper, C. (2004). Treatment of Voice Disorders in Children. *Language, Speech, and Hearing Services in Schools, 35,* 320-326.

Hube, L. (1996). The Effects of Caffeine on Acoustic Measures of the Voice.

Jamison, W. (1996). Some Practical Considerations When Evaluating the Exceptional Adolescent Singing Voice. *Language, Speech, and Hearing Services in Schools, 292-300.*

Kahane, J. (1982). Growth of the Human Prepubertal and Pubertal Larynx. *Journal of Speech and Hearing Research, 25,* 446-455.

Karnell, Michael. *Videoendoscopy from Velopharynx to Larynx.* Singular Publishing Group Inc., 1994.

Kay Elemetrics Corporation. *Operations Manual: Multi-Dimensional Voice Program (MDVP)Model 4305.* Lincoln Park, MJ: Kay Elemetrics Corporation; 1993.

Koufman, J., Radomski, T., Joharji, G., Russell, G., & Pillsbury, D. (1996). Laryngeal biomechanics of the singing voice. *Otolaryngology-Head and Neck Surgery, 115*(6)*,* 527-537.

Leder, S., Ross, D., Kenneth, B., Clarence, S. (1997). A Prospective, Double-Blind, Randomized Study On the Use of a Topical Anesthetic, Vasoconstrictor, and Placebo During Transnasal Flexible Fiberoptic Endoscopy. *Journal of Speech, Language, and Hearing Research, 40*, 1352-1357.

Lim, V., Oates, J., Phyland, D., & Campbell, M. (1998). Effects of Laryngeal Endoscopy on the Vocal Performance of Young Adult Females with Normal Voices. *Journal of Voice, 12*(1), 68-77.

Lundy, D., Roy, S., Casiano, R., Xue, J., & Evans, J. (2000). Acoustic Analysis of the Singing and Speaking Voice in Singing Students. *Journal of Voice, 14*(4), 490-493.

Mapson, J.W. *The ministry of music in the black church.* Valley Forge, PA: Judson Press., 1984.

Miller, R. (1992). How singing is not like speaking. *The NATS Journal, 48*(5), 20.

Murry, T., Xu, J., & Woodson, G. (1998). Glottal Configuration Associated with Fundamental Frequency and Vocal Register. *Journal of Voice, 12*(1), 44-9.

Omori, K., Kacker, A., Carroll, LM., Riley, WD., & Blaugrund, SM. (1996). Singing power ratio: quantitative evaluation of singing voice quality. *Journal of Voice, 10,* 228-235.

Poburka, B. (1999). A New Stroboscopy Rating Form. *Journal of Voice, 13*(3), 403-413.

Sapienza, C., Ruddy, B., & Baker, S. (2004). Laryngeal Structure and Function in the Pediatric Larynx: Clinical Applications. *Language, Speech, and Hearing Services in Schools, 35,* 299-307.

Sataloff, RT., Spiegel, JR., & Hawkshaw, MJ. (1991). Strobovideolaryngscopy: results and clinical value. *Ann. Otol. Rhinol. Laryngol., 100,* 725-727.

Schneider, B., & Wolfgang, B. (2003). Influence of glottal closure configuration on vocal efficacy in young normal-speaking women. *Journal of Voice, 17*(4), 468-484.

Schutte, H., & Miller, D. (1993). Belting and Pop, Nonclassical Approaches to the Female Middle Voice: Some Preliminary Considerations. *Journal of Voice, 7*(2), 142-150.

Tepe, E., Deutsch, E., Sampson, Q., Lawless, S., Reilly, J., & Sataloff, R. (2002). A Pilot Survey of Vocal Health in Young Singers. *Journal of Voice, 16*(2), 244-250.

Titze, I. (1993a). Critical periods of voice change - puberty. *The NATS Journal, 49*(3), 24.

Titze, Ingo R. *Vocal Fold Physiology.* San Diego: Singular Publ. Group, 1993.

Weiss, D. (1950). The Pubertal Change of the Human Voice. *Folia Phoniatrica, 2,* 125-159.

Welch, A.R. (1982). The practical and economic value of flexible system laryngoscopy. *Journal of Laryngology and Otology, 96,* 1125-1129.

White, P. (1999). Formant frequency analysis of children's spoken and sung vowels using sweeping fundamental frequency production. *Journal of Voice, 13,* 570-582.

Whiteside, S. and Hodgson, C. (1999). Acoustic characteristics in 6-10 year old children's voices: some preliminary findings. *Log Phon Vocol, 24,* 6-13.

Wuyts, F., Heylen, L., Metens, F., De Bodt, M., & Van de eyning, P. (2002). Normative Voice Range Profiles of Untrained Boys and Girls. *Journal of Voice, 16*(4), 460-465.

APPENDIX A

DEFINITIONS OF TERMS

Acoustic Analysis – evaluation of the sound properties as produced by the vocal folds.

African-American Gospel Music – a religious music characterized by improvisational freedom of rhythm, style, tone, and structure not bound by written music (known as Black gospel).

Belting – style of singing that uses an adjustment producing heavy tone throughout the vocal range. The effect is a dramatic sound, relatively loud and sounds pushed.

Formant - a formant is a peak in an acoustic frequency spectrum which results from the resonant frequencies of any acoustical system.

Fundamental Frequency – number of vibrations per second produced by the vocal folds (a physical correlate of pitch).

Harmonic - a component frequency of a signal that is an integer multiple of the fundamental frequency.

Jitter – the variability in the fundamental frequency from vibratory cycle to vibratory cycle.

Passagio – the area of the voice between registers where preparation for change in registration should take place (i.e., a transition from the middle register to the high register).

Phonation – 1. Physiological process whereby the energy of moving air in the vocal tract is transformed within the larynx. 2. Production of voiced sound by means of vocal fold vibration.

Pitch – the subjective quality of frequency.

Pitch Range – the distance between the lowest fundamental frequency to the highest fundamental frequency.

Repertoire – a collection of works that a singer can perform.

Shimmer – measures the cycle-to-cycle variation in the amplitude of the sound signal.

Tessitura - in music, tessitura is a range of pitches compared to the instrument for which it was intended to be used. The tessitura of a composition, usually used for a vocal work or a particular voice within the work, is the general range within which the notes lie. Tessitura can also refer to the part of a singer's voice, or sometimes a musical instrument, that has the most musically acceptable and comfortable timbre. In musical notation, tessitura is the range of notes implied by a clef.

Unloaded – phonation of a vowel with an easy onset and minimal effort.

APPENDIX B

COMPARISON OF MALE AND FEMALE ADOLESCENT VOICES
(Gackle, 1991)

	Male Voice	**Female Voice**
Laryngeal Growth:	Greatest growth is posterior-anterior (length); protrusion of Adam's apple.	Comparatively, the overall growth is much less, but still the greatest growth is superior (height).
Pitch: (LTP)*	Lowers one octave;	Lowers a third;
(UTP)**	Lowers a sixth.	Rises slightly.
Range:	Lowers and decreases; Ultimately increases again.	Stays within the treble range and ultimately increase; Tessituras decrease and greatly fluctuate.
Voice Quality:	Lacks clarity; has huskiness/breathiness; Changes dramatically.	Lacks clarity; has huskiness/breathiness; Changes in *weight, color,* or *timbre.*
Register Development:	Transition notes/lift points change throughout development; falsetto becomes apparent.	Transition notes/lift points change throughout development; adult passaggi become apparent.
Vocal Instability:	Yes	Yes

* = Lower Terminal Pitch

** = Upper Terminal Pitch

APPENDIX C

PHYSIOLOGICAL AND ACOUSTICAL PARAMETERS CHARACTERIZING FOUR TYPES OF FEMALE VOICE PRODUCTION
(Schutte and Miller, 1993)

	Vocal-fold adjustment	Larynx position	Subglottal pressure	Frequency range
Pop	"Falsetto"	Intermediate to high	Moderate	Low to middle
Legit	"Falsetto"	Low to intermediate	Moderate	Middle to high
Belt	"Chest"	High to very high	High	Middle
Classical chest	"Chest"	Low to intermediate	Moderate	Low

APPENDIX D

MEAN MUSCLE TENSION SCORES BY SINGING STYLE
(Koufman *et al*., 1996)

Singing Style	No. of Subjects	MT score +/- SD (%)	p Value*
Choral	18	41.1 +/- 44.8	-
Art Song	16	46.9 +/- 41.1	0.6742
Opera	19	57.7 +/- 42.7	0.2421
Barbershop	7	61.3 +/- 37.1	0.2630
Popular/jazz	9	65.1 +/- 42.9	0.1472
Musical Theater	17	73.5 +/- 38.6	0.0192**
Bluegrass/C&W	7	85.6 +/- 37.7	0.0149**
Rock/Gospel	7	94.0 +/- 14.6	0.0040**

*Calculated by comparison of the MT score of each group with that of the choral group, which had the lowest MT score.
**Denotes statistical significance ($p<0.05$).

APPENDIX E

STUDENT QUESTIONAIRE

DIETARY

1. **Do you have frequent heartburn?**
2. **Do you eat late at night (after 9 p.m. or later) ?**
3. **Are you being treated for Gastroesophageal reflux disorder?**
4. **Have you ever had an episode of Anorexia?**
5. **Have you ever had an episode of Bulimia?**
6. **Do you live in a smoke filled environment?**
7. **Do you exercise frequently? (more than 3x week)**
8. **Do you ever use antacids (Rolaids, Tums)?**

HEALTH QUESTIONS:

1. **Are you under particular stress at present?**
2. **Are you thirsty or dehydrated frequently?**
3. **Do you have a frequent sore throat?**
4. **Are you currently experiencing vocal difficulties?**
5. **Are you taking any medicines for a medical condition?**
   If so, what? ___________________

VOCAL CARE:

1. **Do you warm up your voice before signing?**
2. **Do you warm down your voice when you finish?**
3. **Do you yell or speak loudly frequently?**
4. **Do you whisper frequently?**
5. **Are you hoarse first thing in the morning?**
6. **Are you a cheerleader?**
7. **Do you frequently clear your throat?**
8. **Does your voice feel worse later in the day, after it has been used?**

MUSIC LISTENING AND PERFORMANCE

1. **Do you listen to music frequently?**
2. **Do you sing along with your personal listening device (iPod, Mp3 player, etc.)?**
3. **Do you sing in your school or church choir?**
4. **Do you take voice lessons?**
5. **Do you participate frequently in musicals?**

APPENDIX F

PARENTAL CONSENT FORM

Project Title: The Impact of Singing Styles on Tension in the Adolescent Singing Voice
And
Glottal Configuration in the Adolescent Speaking Voice

Project Director: Beverly J. Vaughn and W. Nathan Waller

Dear Parent, we are seeking your permission to allow your child to participate in a research project being conducted at the Music Research Institute at UNCG. This study is designed to study the impact of singing styles on tension in the adolescent singing voice. The specific aim is to determine whether singing in three different styles (traditional choral, Broadway, and gospel) has any differential effect on tension in the voice. The other objective in the research is to learn the vocal characteristics of the adolescent speaking voice and to obtain a detailed voice profile.

Description and Explanation of Procedures

Place: The study will take place at the Applied Communicative Science Laboratory in the Department of Communication Science and Disorders at UNCG (map enclosed).

Time: Participants will spend between 30 and 60 minutes in the lab on a Saturday. No time will be taken from classroom instruction for this study.

Procedures: Students' time in the lab will be divided into three stages.

1. When participants arrive, they will be asked to fill out a brief questionnaire that asks simple questions about dietary (e.g., Do you have frequent heartburn?), medical (e.g., Do you have a frequent sore throat?), vocal care (e.g., Do you frequently yell or speak loudly?), and music listening and performance issues (e.g., Do you take voice lessons?). This information will be helpful in interpreting results of the study. For example, such information might be useful in understanding why particular students show an unusually high degree of vocal tension. A copy of the questionnaire is attached.

2. Next, in a private room, participants will sing in three different musical styles (traditional choral, Broadway, and gospel). While they are singing, a visual examination of the vocal folds will be made, along with a measurement of voice tension.
   - Using an endoscope, a moving digital picture of the vocal folds, as well as still photographs, will be taken while the child is singing. This is done as follows: (a) a

mist of saline (salt water) solution is sprayed in the nasal area to moisten the nasal passage and to minimize discomfort. (b) A thin scope with a small fiberoptic camera on the tip will be inserted into the nasal passage until it rests above the vocal folds. The endoscope has a working length of 30 mm and the camera at the tip is 3.4 mm in diameter. This equipment is approved for use with children as young as four years old. The camera creates a slow-motion effect to allow detection of characteristics of vocal fold movement.

- Four electrodes will be placed on the subject's neck with a soft collar to measure muscular tension in the larynx. There is no sensation during this measurement.
- Subjects will be audiotaped while singing in the three vocal styles.

This procedure should take approximately eight minutes.

3. At another station, participants will speak (not sing) two vowels and a phrase into a microphone. Acoustical measurements of the speaking voice will be made with a computer program. This procedure will take approximately five minutes.

No participant will be identified by name, so confidentiality is assured. Data will be locked in the closet of the UNCG Applied Communicative Sciences Laboratory file cabinet. Data will be kept for five years, after which time, shredding will destroy CDs, tapes, and questionnaires.

Risks and Precautions

Minimal risks are associated with placement of the endoscope into the nasal passage, including mild discomfort and the rare possibility of nosebleeds or coughing. Dr. Celia Hooper, a licensed speech-language pathologist, will supervise the procedure. Dr. Hooper is Professor and Head of the Department of Communication Sciences and Disorders at UNCG. Nate Waller, a graduate student who has received appropriate training in this procedure, will be assisting Dr. Hooper.

Sterile saline (salt water) will be sprayed into the nasal passage prior to insertion of the endoscope to minimize discomfort. Each spray will not touch (be contaminated by) any other subject. There are no known reactions to saline solution. In addition, we will be using sterile, disposable barrier sheaths for the nasal scope which will be changed from subject to subject, as required by universal precautions and UNCG Health and Safety guidelines. This is to ensure that no germs are passed. Protective jackets and gloves are worn so that germs are not transmitted.

There are no known risks associated with other aspects of the study.

If your child experiences frequent nosebleeds and/or has had reconstructive nose surgery, s/he should not participate and we ask that you not complete this consent form.

Potential Benefits to Participants and to Society

Participants will be given photos of their vocal cords while speaking and singing and will receive a printout of baseline acoustic measures with an explanation of its meaning.

This type of research has not been conducted with adolescents. The knowledge gained will indicate whether specific singing styles may differentially affect tension in the singing voice of the adolescent child. It will give vocal specialists, speech-language pathologists and otolaryngologists further information about the normal adolescent voice. It will also aid choral directors and voice teachers as they work with students.

By signing below, you agree to allow your child to participate in the project described in this consent form. Furthermore, you affirm that your child does not experience frequent nosebleeds and has not had reconstructive surgery and thus is eligible to participate in this study. You are free to refuse to allow your child to participate or to withdraw your consent for them to participate in this research at any time without penalty or prejudice. Likewise, your child's participation is entirely voluntary and s/he may withdraw at any time for any reason. This project is not connected in any way to the school music program and participation or non-participation has no effect on grades in music class. Your child's privacy will be protected because s/he will not be identified by name as a participant in this project. If you have any questions, please feel free to call Celia Hooper at 336-334-5184. You may also contact her via email: chooper@uncg.edu.

If your child should be ill on the day of his/her appointment please do not bring him/her. Please call to reschedule the appointment.

The University of North Carolina at Greensboro Institutional Review Board, which insures that research involving human subjects follows federal regulations, has approved the research and this consent form. Any questions you may have regarding your child's rights as a participant in this project can be answered by calling Mr. Eric Allen, the Research Compliance Officer at UNCG, at 336-256-1482.

By signing below, you agree to allow your child to participate in the project described in this consent form. Furthermore, you affirm that your child does not experience frequent nosebleeds and has not had reconstructive nose surgery and thus is eligible to participate in this study.

Parent's Signature____________________________ Date________________

Child's Name ________________________________

APPENDIX G

THE RAINBOW PASSAGE
By Grant Fairbanks

When the sunlight strikes raindrops in the air, they act like a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long, round arch, with its path high above, and its two ends apparently beyond the horizon. There is according to legend, a boiling pot of gold at one end. People look, but no one ever finds it. When a person looks for something beyond his or her reach, friends say he or she is looking for the pot of gold at the end of the rainbow.

Throughout the centuries people have explained the rainbow in various ways. Some have accepted it as a miracle without physical explanation. To the Hebrews it was a token that there would be no more universal floods. The Greeks used to imagine that it was a sign from the Gods to foretell war or heavy rain. The Norsemen considered the rainbow as a bridge which the Gods passed from earth to their home in the sky. Other people have tried to explain the phenomenon physically. Aristotle thought that the rainbow was caused by reflection of the sun's rays by the rain. Since then physicists have found that it is not reflection but refraction by the raindrops which causes the rainbow.

APPENDIX H

MUSICAL EXCERPTS

APPENDIX I

STROBOSCOPIC RATING FORM

STROBOSCOPIC ASSESSMENT OF VOICE

NAME ____________________ HOSPITAL ID # ______________ DATE__________

COMPLAINT____
Abuse____
Allergies____
Arthritis____
Aspiration____
Esophageal reflex______________________________________
Neurological____
Psychological____
Thyroid____
Other Health Problems__________________________________

	Supraglottic Activity		Vertical Level of VF Approximation	Left	Vocal Fold Edge	Right	Left	Amplitude	Right
5	Dysphonia plica Ventricularis VFolds not visible	5	OFF Plane	5	Rough Irregular	5	5	No Visible Movement	5
4		4		4		4	4	Barely Perceptible	4
3		3		3		3	3	Severely Decreased	3
2		2		2		2	2	Moderately Decreased	2
1		1		1		1	1	Slightly Decreased	1
0		0	Glottic Plane	0	Smooth Straight	0	0		0

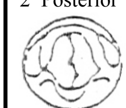
Left	Mucosal Wave	Right	Left	Nonvibrating Portion	Right	Left	Phase	Right	Fundamental Frequency
5		5	5		5	5	Always Irregular	5	
4		4	4		4	4	Generally Irregular 75%+	4	
3		3	3		3	3	Irregular During 50%+	3	
2		2	2		2	2	Irregular during extremes Pitch or loud	2	
1		1	1		1	1	Irregular During end or Begin tasks	1	______Hz
0		0	0		0	0	Regular	0	

	Phase Closure
(-5)	Open Phase Predominates (Whisper dysphonia)
(-4)	
(-3)	
(-2)	
(-1)	
0	Normal
1	
2	
3	
4	
5	Closed Phase Predominates (Glottal fry – extreme hypo adduction)

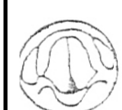
Glottic Closure

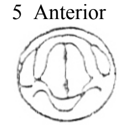

1 Complete

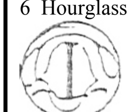

2 Posterior


3 Irregular


4 Spindle


5 Anterior


6 Hourglass


7 Incomplete

AERODYNAMICS Flow_____ Volume ____ Pressure ACOUSTICS Frequency ____ Intensity ____ PERCEPTUAL QUALITY Pitch ____ Loudness ____ Stridor ____ Hoarseness ____ Breathiness_______________	RECOMMENDATIONS ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ______________________________

Adapted by C.R. Hooper (UNC-GREENSBORO) from a form by D. Bless (U.WI), 1991

.