CONTEMPORARY COMMERCIAL MUSIC (CCM) SINGERS: LIFESTYLE CHOICES AND ACOUSTIC MEASURES OF VOICE

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ABSTRACT

Contemporary commercial music (CCM) singers may be at a high risk for voice damage due to their increased vocal demands and the chronic exposure to chemical irritants associated with unhealthy lifestyle choices. Continuous mechanical damage, confounded with chemical trauma, has detrimental effects on the biomechanical properties of the vocal folds. Prior research on CCM singers has been limited, with efforts focused on physiologic aspects of voice production. The objective of the study was to report on the lifestyle choices of CCM singers and evaluate their vocal abilities according to healthy vs. unhealthy profile status via acoustic analyses as well as auditory perceptual assessments. The second objective was to evaluate if there were differences in lung volume associated with healthy vs. unhealthy lifestyle profiles.

Thirteen CCM singers participated in the study where they were assigned to either a healthy or unhealthy lifestyle vocal profile. Acoustic analyses of sound pressure level (SPL), signal-to-noise ratio (SNR), fundamental frequency (F0), and jitter/shimmer were collected during a prolonged singing /i/ in isolation as well as a singing /i/ in context of the "Star Spangled Banner" at three different vocal intensities *(low, comfortable, high).* Lung volume was recorded via a vital capacity maneuver. Voice recordings were then rated via an auditory perceptual assessment (CAPE-V). Results were compared with a Wilcoxon rank-sum test.

Differences with regard to group trends were observed across all dependent measures. SNR median values for unhealthy singers were significantly lower in both singing tasks during *low* vocal intensity ($p<0.05$), with differences approaching significance found during prolonged singing /i/ in isolation at *comfortable* vocal intensity ($p<0.10$). F0 analysis noted significantly lower median values for unhealthy singers during isolated /i/ productions at *low* vocal intensity ($p<0.05$). Jitter analysis among unhealthy singers showed significantly higher median values during isolated /i/ productions at *comfortable* vocal intensity ($p<0.05$), with differences approaching significance found during singing /i/ in context at *low* vocal intensity ($p<0.10$). Shimmer analysis among unhealthy singers showed significantly higher median values during isolated /i/ productions at *low* and *comfortable* vocal intensity ($p<0.05$), with differences approaching significance found during singing /i/ in context at *low* vocal intensity ($p<0.10$). Unhealthy singers showed lower vital capacity as compared to healthy singers, however results were nonsignificant ($p>0.05$). Auditory perceptual assessment of voice was perceived to be essentially normal for all participants regardless of healthy versus unhealthy profile status.

The findings provide a descriptive profile of contemporary commercial music singers and contribute to the existing literature on the harmful effects of exposure to cigarette smoke on voice production. Unhealthy singers displayed significant acoustic differences most often observed in *low* vocal intensity conditions, which suggest a decreased vocal ability. This may be explained by their repeated exposure to chemical irritants (i.e. cigarette smoke) and possible phonotrauma, causing changes in the biomechanical properties of the vocal folds. Given the disparity between acoustic measures and auditory perceptual assessment, it was concluded that the biomechanical changes might be in the early onset and suggest future voice difficulties.

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INTRODUCTION

Contemporary commercial music (CCM) is a recently new generic term used to categorize non-classical music. Genres under the CCM term include musical theater, pop, rock, gospel, R & B, soul, hip hop, country, rap, experimental music, folk, and all other styles of music not considered or derived from classical music (LoVetri, 2008). The formal classification of CCM entered the field of vocal pedagogy 15 years ago when the term was coined by Jeannette LoVetri, who intended to acknowledge and rightfully place all the different styles of music derivative of American culture, alongside the great classical music of the world (Woodruff, 2011). Until recently, the scientific and academic communities have largely ignored CCM and its viability as a distinct pedagogic establishment. Keskinen (2013) explained that the popularity of CCM singing has become a challenge for educational institutions with regard to the limited number of trained instructors and the increased demands for specialized curricula focused on the various vocal styles of CCM. Rosenberg and LeBorgne (2014) echo this concern and add that today's CCM vocal artist is one of a "hybrid" nature who must possess "responsive, adaptable, and agile" vocal abilities to meet current demands and the ever-evolving vocal music industry genres (p. ix). In the United States, CCM is considered the largest, and possibly the most popular genre of music performed (Gilman, Merati, Klein, Hapner, & Johns, 2009). LoVetri (2008) commented that the music field of CCM is a multi-million dollar annual industry and a vast number of singers who earn money do so in one of the many styles of CCM, rather than in classical music. Bartlett (2011) added that despite the high national and international public attention given within the music industry there is a lack of published data that profiles these CCM artists as a group in a detailed manner.

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In recent years, increased attention has been given to singers performing within the various genres of CCM. Subsequently, reported surgical procedures for vocal difficulties have also seen a rise in media headlines. In fact, there is enough anecdotal evidence available today that leads us to believe CCM singers are developing numerous problems with their voice. Recent research has shown that these performers rely heavily on their voice, however, may be unaware of the importance of proactive voice management and care (Gilman et al., 2009). Erickson (2012) addressed the need to educate the regional CCM artist, who often is unsigned or independent, and is less likely to be provided with information or services regarding healthy vocal practices that might come from record labels, producers, teachers, or other professionals. Muckala (2013) stated that independent artists without management or any guidance from a label are especially vulnerable and tend to seek professional help only after significant vocal damage has occurred. Gilman et al. (2009), in a study examining performers' attitudes towards seeking health care for voice issues, found that the young aspiring singer training in a conservatory or university setting tends to be better informed about health care options than singers who are self-trained. This is simply because their vocal training is done in an environment that is accustomed to medical intervention for vocal problems. Gilman et al. (2009) go on to explain that the self-taught, untrained CCM singer does not have the support system, typically found in the educational setting, to help guide them in seeking proper care from voice teachers, coaches, and medical professionals. In addition, results found that many CCM singers ignored their vocal problems and tended to either assign them to a cold, allergic reaction, or temporary hoarseness, which may therefore deepen the issues of concern by prolonging the vocal abusive behaviors without receiving the proper needed medical intervention (Gilman et al., 2009).

The different, more self-taught methodology combined with the lack of formalized voice education creates huge challenges for the CCM singer. The lack of vocal health knowledge may lead to unhealthy lifestyle choices, which ultimately has detrimental effects on how the body functions. Alcohol abuse, nicotine addiction, and recreational drug use are commonplace among CCM artists (Muckala, 2013). Prior research investigating voice production has demonstrated that unhealthy lifestyle choices such as cigarette smoking affect multiple aspects of voice, which can result in rough, breathy voice characteristics, decreased pitch, and lower vital capacities (Dworkin, 2008; Awan & Alphonso, 2007). Chronic cigarette smoking often leads to laryngeal problems, such as chronic inflammation, erythema, dryness, itching laryngeal mucosa, increased rates of laryngeal reflux, and Reinke's edema (Fitzpatrick & Blair, 2000). Awan and Alphonso (2007) explored the effects of smoking on respiratory capacity and control and found that smokers had significantly smaller vital capacities than nonsmokers. In addition, injuries to the vocal folds by way of phonotrauma as well as chemical trauma often result in changes to the lamina propria causing benign vocal fold lesions or vocal fold scarring. The pathophysiologic changes outlined above negatively impact the biomechanical functioning of the tissues of the larynx and respiratory system, ultimately affecting voice quality (Branski, Verdolini, Sandulache, Rosen, & Hebda, 2006).

Changes to the laryngeal sound source have been objectively assessed using physical acoustic measures such as sound pressure level (SPL), signal-to-noise ratio (SNR), fundamental frequency (F0), and voice perturbation measures (jitter/shimmer) to reflect changes in vocal fold function (Chai, Sprecher, Zhang, Liang, Chen, & Jiang, 2011; Gonzalez & Carpi, 2004; Milenkovic, 1987; Sorensen & Horii, 1982).

One important acoustic variable reflecting underlying laryngeal functioning is sound pressure level (SPL). Sound pressure level is largely maintained through an interaction of respiratory and laryngeal mechanisms, which work together to develop the subglottal pressures needed for the production of the laryngeal sound source (Finnegan, Luschei, & Hoffman, 2000; Nagai, Ota, Konopacki, & Connor, 2005; Stathopoulos & Sapienza, 1993). On one hand, the respiratory system supplies the subglottal pressure by managing the combined passive and active compressive forces through the respiratory musculature. On the other hand, the laryngeal mechanism functions to create a dynamic valve to aid in the regulation of laryngeal airway resistance, subglottal pressure, and to determine glottal shape (Stathopoulos, Huber, Richardson, Kamphaus, DeCicco, Darling, Fulcher, & Sussman, 2014). In healthy individuals, inhalation to higher lung and rib cage volumes utilizes greater elastic recoil forces, ultimately reducing the amount of thoracic muscle contraction needed to increase subglottal pressure (Huber, 2007). It can be expected that given the lower vital capacities associated with smokers (Awan & Alphonso, 2007), they may be experiencing problems achieving the proper respiratory strategy needed for increased subglottal pressure to produce increased vocal intensity. Subsequent anatomical changes to the larynx from irritants such as cigarette smoking may also affect an individual’s ability to properly valve the air stream to produce increased vocal intensity. Overall, regulation and adjustments in vocal intensity are achieved through simultaneous changes in both respiratory and laryngeal systems (Stathopoulos & Sapienza, 1993).

Another important acoustic variable that could reflect voice quality is increased additive noise in the voice signal, and which may be a sign of underlying problems with vocal fold closure (Stathopoulos, Huber, & Sussman, 2011). Changes to the anatomical structures of the vocal folds have been known to result in physiologic changes such as glottal closure insufficiency and noise (Linville, 2002). Signal-to-noise ratio (SNR) and harmonic-to-noise ratio (HNR) have been useful tools in evaluating noise in the voice signal as well as identifying pathological voices (Milenkovic, 1987; Parsa & Jamieson, 2000). Previous data have shown that CCM singers' produce significant noise components in the higher harmonic frequencies, less distinct formant zones, less vibrato, and deliberately add more inharmonic frequencies to the voicing signal producing evidence of noise or roughness (American Association for Teachers of Singing, 2008). Data on voice production in chronic smokers has shown that these individuals are at an increased risk of voice difficulties and laryngeal pathologies and are more prone to voice quality changes (Branski et al., 2006; Fitzpatrick & Blair, 2000). Zeitels, Hillman, Bunting, and Vaughn (1997) stated that anatomical changes to the basal membrane of the vocal fold epithelium are due to the effects of smoking and may be associated with chronic glottal mucositis. As a result, patients presenting with difficulties in producing normal vocal fold vibrations may progress into vocal hyperfunction. Overtime, the continuous mechanical stress of a hyperfunctional voice results in a relatively permanent state of tissue repair or scarring, which may manifest as a benign vocal fold lesion and/or scar (Branski et al., 2006). These pathologies will inevitably create glottal insufficiency and lead to noise in the voiced signal.

Fundamental frequency (F0) is a third important acoustic variable impacting voice quality. Prior research has demonstrated the negative effects of long-term cigarette smoking on laryngeal health and fundamental frequency. Sorensen and Horii (1982) found a significant difference between the F0 of male smokers, who exhibited a lower F0, as compared to male non-smokers in oral reading and spontaneous speech tasks. Results also showed the same trend of decreased F0 in smokers during prolonged vowel phonations, however differences were not significant. A more recent investigation, Gonzalez and Carpi (2004), explored F0 during prolonged vowel phonations and found nearly significant differences between male smokers and non-smokers (119.4 Hz for smokers vs. 125.4 Hz for non-smokers), as well as significant differences for females (192.4 Hz for smokers vs. 206.4 Hz for non-smokers). Cigarette smoke is one of the most common irritants exposed to the laryngeal mechanism with prolonged exposure commonly resulting in vocal cord inflammation, otherwise, clinically known as Reinke's edema (Branski et al., 2006). The disease is characterized by the accumulation of fluid of the true vocal folds and perceptually results in a deeper and harsh voice quality (Fitzpatrick & Blair, 2000). Eighty percent of patients presenting with Reinke's edema are smokers (Volic, Kirincic, & Markov, 1996) with the incidence of the disease proportional to both the intensity and the duration of smoking (Fitzpatrick & Blair, 2000). Prior research investigating the F0 of smokers, although abundant, has shown variability in data with regard to statistically significant differences.

A final important acoustic variable affecting voice quality and reflecting underlying vocal fold processes is vibratory perturbation. Milenkovic (1987) hypothesized that healthy vocal folds form a well-balanced system that produces nearly periodic oscillations, while vocal pathologies disrupt this mechanical balance producing oscillations that change from period to period in both duration (jitter) and amplitude (shimmer). Throughout the years, voice perturbation analysis has commonly utilized the acoustic parameters jitter (cycle-to-cycle fundamental frequency variation) and shimmer (cycle-to-cycle amplitude variation) to assess regularity/irregularity differences or stability/instability of vocal fold vibration (Carding, Wilson, MacKenzie, & Deary, 2009). In addition, several studies have noted differences in jitter and shimmer measures among smokers, although not all reported results have been statistically significant (Damborenea, Fernandez, Llorente, Naya, Marin, Rueda, & Ortiz, 1999; Guimara˜es & Abberton, 2005; Wan & Huang, 2008). Prior investigations incorporating numerous acoustic parameters and visual laryngeal evaluation techniques suggest that jitter and shimmer may be valuable predictors of voice pathology (Gelzinis, Verikas, Bacauskiene, 2008; Ortega, Cassinello, Dorcatto, & Leopaldi, 2009).

To adequately assess the voice, both objective and subjective measures should be utilized that have been demonstrated to provide relevant information in evaluating effective outcomes (Bhuta, Patrick, & Garnett, 2004). However, the ability to accurately determine a 1-to-1 correspondence between acoustic information and psychophysical assessments of the voice signal has been problematic (Eadie & Doyle, 2005). Sodersten and Lindestad (1990) further state that a common problem in perceptual analysis of normal voices is that the variation of the voice quality parameter is usually limited with slight variations being difficult to detect and rate, even for experienced clinicians. Although the validity of perceptual-assessments require further research, it is widely acknowledged that combining acoustic and auditory-perceptual measures is necessary to define the multidimensional function of voice and to provide clinically meaningful information (Eadie & Doyle, 2005).

Based on previous research, we know that CCM singers have been shown to be at increased risk of vocal injury due to the physical nature and high vocal demands required of them (Koufman, Radomski, Joharji, Russell, & Pillsbury, 1996). Currently lacking in research are data on various lifestyle profiles and the subsequent effect on voice, especially with regard to the less studied, unrepresented CCM singer. The research aims of the current study are essential to our continued understanding of the CCM singer, and thus will ultimately improve the quality of care including the counseling and treatment of those with vocal abuse and voice disorders. Last, the acoustic measures discussed above which included SPL, SNR, F0, jitter and shimmer, along with auditory perceptual voice assessments (CAPE-V), may help describe and quantify impaired as well as healthy vocal fold vibration characteristics (Brockmann, Drinnan, Storck, & Carding, 2011; Eadie & Doyle, 2005).

The specific aims of studying CCM singers were to:

(1) Investigate and assess their lifestyles via the lifestyle questionnaire, assign each singer to either a healthy or unhealthy lifestyle profile based on smoking status and/or drinking consumption,

(2) Assess voices of the two groups using objective acoustic measures,

(3) Assess vital capacity of the two groups through a vital capacity maneuver, and

(4) Analyze their voice quality during singing to determine whether listeners perceive a voice problem.

Based on the knowledge of unhealthy lifestyle choices like smoking, drinking, and vocal abuse, and the associated physical changes to the vocal folds, we specifically hypothesized the following:

(1) SPL will be higher for healthy singers reflecting better respiratory and laryngeal health as compared to unhealthy singers for all singing tasks.

(2) SNR will be higher indicating lower levels of noise in the voice signal for healthy singers thereby reflecting better laryngeal health as compared to unhealthy singers for all singing tasks.

(3) Median F0 will be higher in the healthy singers thereby reflecting better laryngeal health as compared to the unhealthy singers for all singing tasks.

(4) Voice perturbation parameters of jitter and shimmer will be lower for healthy singers thereby reflecting better laryngeal health as compared to unhealthy singers for all singing tasks.

(5) Healthy singers will display larger vital capacities thereby reflecting better respiratory health as compared to unhealthy singers.

(6) CAPE-V scores will reflect a lesser degree of “perceived deviance from normal” for healthy singers thereby reflecting better laryngeal health as compared to the unhealthy singers.

METHODS

PARTICIPANTS

The current study was focused on local Western New York (WNY) CCM artists. Thirteen singers between the ages of 21 and 49 were recruited for this study. These participants were required to meet the two essential inclusionary criteria: (1) they were performers of contemporary, commercial vocal styles (i.e. rock, pop, musical theatre, jazz, R & B, folk, country, and sub-sets of these styles) who maintain consistent public performances, and (2) they were performing for at least six hours per week, either out in the public as live performances, or in weekly rehearsals. Participants were screened either by an informal interview via the telephone or an electronic correspondence before qualification of inclusion was determined. Participants were excluded if they reported either a history of diagnosed voice disorders or prior vocal surgeries, and any current health problems involving voice such as reflux, respiratory disease, and prescription medication. Both males and females were eligible for this study. However, women who self-reported as pregnant, via the telephone interview or electronic correspondence, were not included due to the impact pregnancy has on vocal fold physiology in the pregnant individual (Lã, & Sundberg, 2012). On the day of testing, participants did not exhibit any acute conditions such as allergies, colds, or flu.

Once the participants were included for study, they completed the 48-item lifestyle questionnaire and were assigned either to a healthy or unhealthy vocal profile, as determined, a priori, by the primary investigator. Guidelines for inclusion are as follows: (1) Participants' profile qualified as unhealthy if they listed that they currently smoke cigarettes or quit within the past 2 years. Also judged as an inclusionary criterion for the unhealthy profile was alcohol consumption. According to the Dietary Guidelines for Americans (2010), moderate alcohol consumption, is defined as having up to 2 drinks per day for men and up to 1 drink per day for women. Therefore, exceeding these guidelines was classified as unhealthy. (2) Participants' profile will subsequently qualify as healthy if they do not have a recent history of smoking and do not ingest more than 2 drinks per day for men or 1 drink per day for women.

The lifestyle health questionnaire identified eight participants (6 males, 2 females; age range = 21-32 years; mean age = 27) for inclusion in the healthy voice profile group and five participants (5 males; age range = 26-48 years; mean age = 33) in the unhealthy voice profile group for a total of thirteen participants (see Table 1a). Healthy voice participants declared no history of smoking with one subject declaring he quit three years ago and only maintained a smoking history of 1 pack a week for six months. The decision to include this subject in the healthy group was based on a previous study investigating the effects of cigarette smoke on the human airway epithelial cell transciptome. The reversibility of altered gene expression was explored after smoking cessation and found that the expression level of smoking-induced genes amongst former smokers began to resemble that of never smokers after 2 years of quitting (Spira, Beane, Shah, Liu, Schembri, Yang, Palma, & Brody, 2004). Unhealthy voice participants declared current cigarette smoking use with a range of <1 pack a day to 1-2 packs a day. Based on the Dietary Guidelines for Americans (2010), all participants maintained healthy levels of alcohol intake. Due to the variation of consumption practices and lack of research, marijuana usage was not an inclusionary measure, however it should be noted that 11 out of the 13 participants engaged in this behavior through various inhalation devices (see Table 1b).

Singers were recruited using flyers posted in cafés around the city of Buffalo and distributed through social media outlets. Additional recruitment came from the researchers background involvement and connections within the local music scene, by reaching out to local theatre companies and singers of prominent local and regional bands. All participants were volunteers. Data were collected through the Speech Science laboratory at the University at Buffalo. All data collection procedures were approved by the Social and Behavioral Institutional Review Board (IRB) at the University at Buffalo.

EQUIPMENT AND PROCEDURES

In a single 90-minute session, procedures were followed to collect informed consent (per University at Buffalo IRB), conduct hearing screenings, administer questionnaires, perform vital capacity maneuvers, and make acoustic recordings for all subjects. Hearing screenings consisted of pure tone testing at 250, 500, 1,000, 2,000, and 4,000 Hz at 20 dB HL (ANSI, 2010).

QUESTIONNAIRE

Equipment: Administration of an Erickson (2012) modified 48-item lifestyle questionnaire (see Appendix I) served as an assessment tool and assigned each singer, by 'a priori' inclusion guidelines, to either a healthy or unhealthy lifestyle profile.

Procedures: The 48-item lifestyle questionnaire was a modified version of the 53-item questionnaire used by Erickson (2012) and consisted of six sections: *musical background, performance & lifestyle demands, vocal characteristics, vocal performance, vocal health, and vocal preservation.* The *musical background* section was designed to determine the singers' previous voice training, identified styles of music performed, current age and sex, and potential artist representation. The *performance & lifestyle demands* section examined the frequency of performance, current professional level, hours spent in the act of singing, types of venues played, and additional non-singing related work. The *vocal characteristics* section asked the singer to categorize and describe their current vocal characteristics, desired vocal quality, and happiness vs unhappiness with their current vocal quality. The *vocal performance* section aided to further describe any performance singing habits. The *vocal health* section inquired about current voice concerns, access to vocal health information, and voice health professionals previously seen. The *vocal preservation* section aided to identify the involvement in healthy vs. unhealthy vocal practices with regard to substance abuse and vocal hygiene. The *vocal preservation* section also served as the ‘a priori’ guidelines for inclusion/exclusion criteria.

ACOUSTIC RECORDINGS

Equipment: Voice recordings were obtained using a Shure Countryman, E610P5L2 cardioid dynamic microphone, Mackie ONYX Satellite preamplifier, and a MacBook laptop computer.

Procedures: The microphone was mounted on the participant’s head and held at a constant 6 cm mouth-to-microphone distance and a 45-degree angle (to avoid transducing noise associated with consonants). The microphone signal was sent through the preamplifier and was directly digitized into a MAC laptop computer using Audacity (Mazzoni, 1999) computer software at a sampling rate of 44.1 kHz. The preamplifier, coupled between microphone and computer, amplified the microphone signal. Calibration of the acoustic signal for sound pressure level (SPL) measurements were performed prior to testing using a SPL meter attached to the microphone set to a 6-cm mouth-to-microphone distance from the tone generator. The Quest Piston Phone CA22 tone generator was set at 110 dB at a frequency of 1 kHz. The SPL meter was set at C-weighting and slow-response. Sound pressure level was calibrated before data acquisition using the Mackie preamplifier at max gain (100%), -10, -20, -30, -35, -40, and -50 dB SPL, respectively, to allow for maximum deflection. Sound pressure level was calculated by inputting the calibration tones from the Quest Piston Phone CA22 to Audacity (Mazzoni, 1999) utilizing the gain level meter. When there were problems with TF32 not automatically calculating fundamental frequency, a low pass filter (LPF) set at 1000 Hz, was applied to the acoustic waveform.

SINGING TASKS

Participants were given 10 minutes to engage in their preferred singing warm-up routine prior to beginning the singing recorded tasks. Participants were asked to vocalize a sustained vowel /i/ production for 5-seconds in their singing voice at three different vocal intensities (*low*, *comfortable*, *high*), attempting to keep pitch constant. Three trials were performed for each loudness condition. *Low, comfortable* and *high* vocal intensities were defined by the following instructions: (1) *Comfortable* vocal intensity was the condition in which the subjects were instructed to vocalize in their everyday, typical singing voice. (2) *Low* vocal intensity was the condition in which subjects were instructed to vocalize twice as soft as their comfortable everyday, typical singing voice. (3) *High* vocal intensity was the condition in which the subjects were instructed to vocalize twice as loud as their comfortable everyday, typical singing voice.

Participants also sang the 1st verse lyrics of “The Star-Spangled Banner” (Dykema, Peter, Earhart, McConathy, & Dann, 1917). The decision to use “The Star-Spangled Banner” (SSB) was adopted from a previous study conducted by Monson (2011). Monson (2011) based his decision on the assumption of participants’ familiarity with the SSB, therefore: (1) reducing any potential learning curve and/or difficulty with material comprehension, and (2) allowing the participants to more easily psychologically put themselves into a “performance” state of mind. Participants were given the lyrics and sheet music as a reference guide and instructed to use their singing voice within their preferred comfortable pitch range. Instructions for *low, comfortable,* and *high* vocal intensities were identical to those given in isolated vowel productions. A final production of a sustained vowel /i/ during the textual lyric “free” occurring at the end of the first verse. Participants were instructed to lengthen the production of the target word for at least 3-seconds to ensure proper data capture.

VITAL CAPACITY MEASUREMENT

Equipment: Participants’ lung volumes were recorded through a vital capacity maneuver using an analog ventilation meter (VacuMed Universal Ventilation Meter) directly digitized into a PC desktop computer using LabChart computer software (ADInstruments, version 7.3.7).

Procedures: Calibration was performed once a week using the Glottal Enterprises calibrator (Glottal Enterprises Inc., 2014) and was set to 1 liter/sec flow rate and 2 liters volume. A one-time use tube was placed between the lips and participants were asked to maintain a tight lip seal. Participants were instructed to breathe naturally and once three cycles of rest breathing were observed, instructions were given to inhale as much air as possible and then exhale as much air as possible out of their lungs. Participants performed three vital capacity maneuvers and lung volume was recorded by calculating the greatest peak-to-peak difference of the three trials.

AUDITORY-PERCEPTUAL RATING SCALE

Equipment: The Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V; see Appendix II) was used to perceptually analyze voice quality and indicate the degree of "perceived deviance" from normal voice (Behlau, 2003).

Procedures: The CAPE-V, was developed from a consensus meeting sponsored by the American Speech-Language Hearing Association's (ASHA) Division 3: Voice and Voice Disorders, and the Department of Communication Science and Disorders, University of Pittsburgh as a tool for clinical auditory-perceptual assessment of voice. Six aspects of voice including overall severity, roughness, breathiness, strain, pitch and loudness are rated by the listeners. The CAPE-V was used to analyze the singer's vocal quality during singing and was completed from randomized recordings by two experienced, certified speech pathologists who were knowledgeable and qualified to make accurate clinical judgments regarding the degree of "perceived deviance" from normal voice (Behlau, 2003). Participants' recorded *comfortable* prolonged /i/ productions in isolation as well as *comfortable* /i/ productions during the SSB were used for analysis. Measurements of interest for the present investigation from the CAPE-V were based upon the perceptual voice parameters of "overall severity, breathiness, and loudness" (Behlau, 2003).

MEASUREMENTS

ACOUSTIC MEASURES

The following acoustic measurement procedures were adapted from those used in a previous study done by Stathopoulos, Huber, and Sussman (2011), and modified for the conditions of this study. The middle interval of an isolated prolonged sung vowel /i/

production (2 seconds) was extracted for data measurement as well as a prolonged vowel /i/ production (2 seconds) during the singing of "The Star-Spangled Banner" at all three intensity levels. Measurements listed below were based on the middle 2-second interval as one uninterrupted singing sample using TF32 Jitter/Shimmer/Voice Aperiodicity SNR Analysis (Milenkovic, 2001), thereby excluding voicing onsets and offsets.

1. SPL in dB: SPL provides information on *vocal intensity* level of the sound production. SPL measurements of the sample amplitudes were calculated using the difference from a reference amplitude. Sound pressure level (SPL), is the sound pressure of the speech sample as measured using the meter at the 6 cm distance from the source, and is expressed as:

$$\text{dBSPL speech sample} = \text{dBSLM reference} - \text{dBTF32 reference} + \text{dBTF32 speech sample} \qquad (1)$$

where all values are in decibels, dBTF32 speech sample gives the sound pressure of the calibration tone as read off the sound level meter, and dBTF32 reference is the value of dBTF32 speech sample as measured using TF32 (Milenkovic, 2001) software with microphone at the meter, and dBSLM reference is the value of the audio sample as measured using TF32 software with the microphone at the 6 cm distance from the source.

2. SNR in dB: SNR is the ratio of the periodic energy in the vowel signal to the energy in the aperiodic component of the voiced signal. Reported values were averaged across the 2 sec sample. Signal-to-noise ratio (SNR), is expressed as:

$$\mathrm{SNR} = [10 \log_{10}(s\, s^T/E_{opt})] \qquad (2)$$

where SNR is in decibels, $s\, s^T$ gives the energy in the speech signal within the observation interval, and E_{opt} is the interpolated minimum value of E_0 (Milenkovic, 1987). The “newjit” option in TF32 was used on accounts of a shorter sliding waveform window for SNR calculation (1.5 ms). Milenkovic states that these higher values represent the “upper bound” on the true SNR (2001).

3. F0 in Hz: The average F0 was calculated by averaging the values over the selected mid-vowel sample and then by averaging across the three trials for each participant. F0 computation employs zero crossings and signal amplitude to make voice/unvoiced decisions on the original waveform, and it performs LPC inverse filtering on the down-sampled waveform prior to cross-correlation analysis to reduce formant artifact on pitch tracking (Milenkovic, 2001).

4. Jitter in %: TF32 calculates mean jitter in ms using a least mean square approach to estimate the differences in duration of two consecutive periods, given an estimate of F0 supplied by the user (Milenkovic, 1987). Jitter is the fluctuation in the time interval between the speech waveform peaks, and is expressed as:

$$\mathrm{JITTER} = [t_p(n_0) - t_p(n_0 - N_p)] \qquad (3)$$

where t_p is the period, n_0 is the reference sample position within the speech waveform, and N_p is the number of samples contained in a period. Parabolic interpolation is applied (Milenkovic, 1987). Percent jitter is then calculated by dividing mean jitter in ms by the mean period in ms and multiplying by 100. Linear interpolation is applied when a zero crossing is marked, and parabolic interpolation is used when a peak is chosen (Titze et al., 1987).

5. Shimmer in %: Shimmer is the cycle-to-cycle variation in the amplitudes of the speech waveform peaks, and is expressed as:

$$\text{SHIMMER} = [100(1\text{-K})] \tag{4}$$

where K describes the change in waveform amplitude between periods (Milenkovic, 1987).

STATISTICAL ANALYSIS

All calculations and graphics were completed using *JMP 5.0.1.2* (SAS Institute, Inc.). The Wilcoxon rank-sum test was used to compare the healthy with the unhealthy voice participant groups for each task by condition. A one-tailed, chi-squared approximation to the Wilcoxin (X^2, $p < 0.05$) was used for all statistical analyses.

The six comparisons of interest (see Figure 1) were between healthy (H) vs. unhealthy (U) singers for the prolonged singing /i/ in isolation at: (1) *low, (2) comfortable (comf), (3) high*, and during singing /i/ in context of SSB at: (4) *low*, (5) *comf*, and (6) *high*. Descriptive statistics (median & 1st 2nd 3rd 4th quartiles, range) were presented for SPL, SNR, F0, jitter and shimmer.

RESULTS

All analyses of dependent measures reflects male and female participants combined, with the exception of F0, which reflects only male participants since comparing this measure would result in sex differences not reflective of group differences.

SOUND PRESSURE LEVEL (SPL)

Based on the statistical analyses, results between the healthy and unhealthy singers were statistically nonsignificant on all conditions regarding vocal intensity comparisons. Descriptively, the median is higher in vocal intensity in 5 out of 6 comparisons for the healthy singer group versus the unhealthy singer group (see Figure 1 for all comparisons).

During the prolonged /i/ in isolation, healthy singers produced *low* vocal intensity with a median of 83.25 dB while the unhealthy singers produced /i/ at a median SPL of 82.5 dB with ranges of 80.6-97.7 dB, and 80.3-88.1 dB, respectively. Healthy singers produced c*omfortable* vocal intensity with a median SPL of 94.65 dB while the unhealthy singers produced a median SPL of 92.3 dB with ranges of 89.4-99.6 dB, and 89.2-95.4 dB, respectively. *High* vocal intensity productions resulted in the healthy singers reporting a median SPL of 102.45 dB while the unhealthy singers produced a median SPL of 102.9 dB with ranges of 99.6-104.1 dB, and 96.7-108.7 dB, respectively.

During /i/ in the SSB, healthy singers produced *low* vocal intensity with a median SPL of 94.8 dB while the unhealthy singers produced /i/ at a median SPL of 94.7 dB with ranges of 92.2-103.2 dB, and 87.5-98.2 dB, respectively. Healthy singers produced c*omfortable* vocal intensity with a median SPL of 105.15 dB while the unhealthy singers produced a median SPL of 102.4 dB with ranges of 98.7-110.5 dB, and 99.5-103 dB, respectively. *High* vocal intensity productions resulted in the healthy singers reporting a median SPL of 108.8 dB while the unhealthy singers produced a median SPL of 106.2 dB with ranges of 101.4-117.9 dB, and 101-110.2 dB, respectively.

SIGNAL-TO-NOISE RATIO (SNR)

Healthy singers produced a greater SNR than the unhealthy singers during singing /i/ in isolation in the *low* condition ($X^2_1 = 4.20$, p=0.040) as well as in the *low* condition during singing /i/ in context of SSB ($X^2_1 = 4.82$, p=0.028). In addition, the difference between healthy singers as compared to unhealthy singers involving prolonged singing /i/ in isolation, in *comfortable* comparisons approached statistical significance ($X^2_1 = 3.62$, p=0.057). The median signal-to-noise ratio was higher in 6 out of 6 comparisons for healthy singers compared to the unhealthy singers (see Figure 2 for all comparisons). No other comparisons were statistically significant.

During the prolonged /i/ in isolation, healthy singers produced *low* vocal intensity with a median of 36.8 dB while the unhealthy singers produced /i/ at a median SNR of 30.1 dB with ranges of 26.6-43.5 dB, and 23.3-34.3 dB, respectively. Healthy singers produced c*omfortable* vocal intensity with a median SNR of 34 dB while the unhealthy singers produced a median SNR of 31.3 dB with ranges of 28.9-36.8 dB and 27.7-33.4 dB, respectively. *High* vocal intensity productions resulted in the healthy singers reporting a median SNR of 31.85 dB while the unhealthy singers produced a median SNR of 31.5 with ranges of 28.6-35.9 dB, and 25.5-33.9 dB, respectively.

During /i/ in the SSB, healthy singers produced /i/ during *low* vocal intensity with a median SNR of 38.9 dB while the unhealthy singers produced /i/ at a median SNR of 32.4 dB with ranges of 34.9-46.5 dB, and 27.7-39.2 dB, respectively. Healthy singers produced c*omfortable* vocal intensity with a median SNR of 36 dB while the unhealthy singers produced a median SNR of 28.7 dB with ranges of 24.6-39.9 dB, and 27.6-34.5 dB, respectively. *High* vocal intensity productions resulted in the healthy singers reporting a median SNR of 34.6 dB while the unhealthy singers produced a median SNR of 27.5 dB with ranges of 21.7-43 dB, and 24.8-31.8 dB, respectively.

FUNDAMENTAL FREQUENCY (F0)

Healthy singers produced a higher F0 than the unhealthy singers during singing /i/ in isolation in the *low* condition ($X^2_1 = 4.80$, p=0.029). The descriptive analysis shows a higher median F0 in 6 out of 6 comparisons for healthy singers as compared to the unhealthy singers (see Figure 3 for all comparisons). No other comparisons were statistically significant.

During the prolonged /i/ in isolation, healthy singers produced *low* vocal intensity with a median F0 of 193.1 Hz while the unhealthy singers produced /i/ at a F0 of 143.3 Hz with ranges of 162.5-273.7 Hz, and 125.1-211.9 Hz, respectively. Healthy singers produced c*omfortable* vocal intensity with a median F0 of 213.25 Hz while the unhealthy singers produced /i/ at a median F0 of 182.9 Hz with ranges of 165.7-267.2 Hz, and 139.3-279 Hz, respectively. *High* vocal intensity productions resulted in the healthy singers reporting a median F0 of 231.7 Hz while the unhealthy singers produced /i/ at a median F0 of 212.1 Hz with ranges of 179.2-278.3 Hz, and 143.1-385 Hz, respectively.

During /i/ in the SSB, healthy singers produced *low* vocal intensity with a median F0 of 360.5 Hz while the unhealthy singers produced /i/ at a median F0 of 296.4 Hz with ranges of 282.9-400.8 Hz, and 255.7-390.1 Hz, respectively. Healthy singers produced c*omfortable* vocal intensities with a median F0 of 336.7 Hz while the unhealthy singers produced /i/ at a median F0 of 312.5 Hz with ranges of 247.8-452.9 Hz, and 272.9-382.8

Hz, respectively. *High* vocal intensity productions resulted in the healthy singers reporting a median F0 of 377.85 Hz while the unhealthy singers produced /i/ at a median F0 of 329.2 Hz with ranges of 269.5-507.6 Hz, and 300.8-383.4 Hz, respectively.

JITTER

Healthy singers produced a lower percent jitter than the unhealthy singers during singing /i/ in isolation in the *comfortable* condition ($X^2_1 = 4.54$, p=0.033). In addition, the difference between healthy singers as compared to unhealthy singers involving singing /i/ in context of the SSB in *low* comparisons approached statistical significance ($X^2_1 = 3.37$, p=0.067). The descriptive analysis shows a lower median percent jitter in 5 out of 6 comparisons for healthy singers as compared to the unhealthy singers (see Figure 4 for all comparisons). No other comparisons were statistically significant.

During the prolonged /i/ in isolation, healthy singers produced *low* vocal intensity with a median of 0.2 percent jitter while the unhealthy singers produced /i/ at a median of 0.23 % jitter with ranges of 0.08-0.38 %, and 0.21-0.59 %, respectively. Healthy singers produced c*omfortable* vocal intensity with a median % jitter of 0.155 while the unhealthy singers produced a median % jitter of 0.24 with ranges of 0.11-0.26 % and 0.18-0.31 %, respectively. *High* vocal intensity productions resulted in the healthy singers reporting a median % jitter of 0.14 % while the unhealthy singers produced a median % jitter of 0.13 with ranges of 0.09-0.26 %, and 0.1-0.28 %, respectively.

During /i/ in the SSB, healthy singers produced /i/ during *low* vocal intensity with a median percent jitter of 0.12 while the unhealthy singers produced /i/ at a median % jitter of 0.15 with ranges of 0.04-0.2 %, and 0.12-0.31 %, respectively. Healthy singers produced c*omfortable* vocal intensity with a median % jitter of 0.115 while the unhealthy singers produced a median % jitter of 0.23 with ranges of 0.05-0.41 %, and 0.11-0.33 %, respectively. *High* vocal intensity productions resulted in the healthy singers reporting a median % jitter of 0.12 while the unhealthy singers produced a median % jitter of 0.14 with ranges of 0.04-0.56 %, and 0.09-0.26 %, respectively.

SHIMMER

Healthy singers produced a lower percent shimmer than the unhealthy singers during singing /i/ in isolation in the *low* condition ($X^2_1 = 6.19$, p=0.013) as well as in the *comfortable* condition ($X^2_1 = 6.19$, p=0.013). In addition, the difference between healthy singers compared to unhealthy singers involving singing /i/ in context of the SSB in *low* comparisons approached statistical significance ($X^2_1 = 3.66$, p=0.056). The descriptive analysis shows a lower median percent shimmer in 5 out of 6 comparisons for healthy singers as compared to the unhealthy singers (see Figure 5 for all comparisons). No other comparisons were statistically significant.

During the prolonged /i/ in isolation, healthy singers produced *low* vocal intensity with a median of 0.86 percent shimmer while the unhealthy singers produced /i/ at a median % shimmer of 1.26 with ranges of 0.48-1.77 %, and 1.11-2.57 %, respectively. Healthy singers produced c*omfortable* vocal intensity with a median % shimmer of 0.65 while the unhealthy singers produced a median % shimmer of 1.17 with ranges of 0.49-0.93 % and 0.74-1.38 %, respectively. *High* vocal intensity productions resulted in the healthy singers reporting a median % shimmer of 0.98 while the unhealthy singers produced a median % shimmer of 0.63 with ranges of 0.31-1.87 %, and 0.55-1.38 %, respectively.

During /i/ in the SSB, healthy singers produced /i/ during *low* vocal intensity with a median percent shimmer of 0.55 while the unhealthy singers produced /i/ at a median % shimmer of 1.47 with ranges of 0.28-0.91 %, and 0.54-1.66 %, respectively. Healthy singers produced c*omfortable* vocal intensity with a median % shimmer of 0.66 while the unhealthy singers produced a median % shimmer of 0.93 with ranges of 0.37-3.4 %, and 0.63-1.42 %, respectively. *High* vocal intensity productions resulted in the healthy singers reporting a median % shimmer of 1.06 while the unhealthy singers produced a median % shimmer of 1.24 with ranges of 0.22-1.76 %, and 0.66-1.49 %, respectively.

VITAL CAPACITY

Based on the statistical analyses, results between the healthy and unhealthy singers were statistically nonsignificant on differences regarding vital capacity. However, the descriptive analysis shows a larger median vital capacity for healthy singers as compared to the unhealthy singers (see Figure 6). Vital capacity, as measured in liters of lung volume (L), resulted in a median of 4.864 L for the healthy group, while the unhealthy singers produced a median vital capacity of 4.323 L, with ranges of 3.569-6.599 L, and 3.835-5.969 L, respectively.

DISCUSSION

The purpose of the present investigational study was to administer a qualitative lifestyle profile to contemporary commercial music singers, and then to identify important lifestyle differences that could have an effect on their vocal health. After dividing the singers into healthy and unhealthy groups, there were no discriminating factors among the participants across groups. According to their smoking status and alcohol use, the only lifestyle choice that differentiated healthy vs unhealthy was their smoking history. Nonsmokers in the present study were classified as “healthy” and smokers were classified as “unhealthy.” Caffeine and water consumption were purposefully not used as inclusion/exclusion criteria due to the varying recommendations in the literature as well as complex and questionable direct impact on voice function. The Mayo Clinic (2014) stated that water needs depend on many factors including your health, how active you are, and where you live. Erickson-Levendoski and Sivasankar (2011) investigated the effects of caffeine on phonation and found that caffeine did not adversely affect voice production or exacerbate the detrimental phonatory effects of vocal loading concluding that elimination of caffeine from ones’ diet, as a component of a vocal hygiene program, should be evaluated on an individual basis.

After grouping the singers into a healthy and unhealthy group, two additional analyses were conducted: an analysis of their vocal quality by expert listeners, and, objective acoustic measures of their voice. Based on the knowledge of unhealthy lifestyle choices, it was predicted that the unhealthy singers as compared to healthy singers would display a decreased vocal ability as shown via qualitative perceptual analysis and acoustic analyses. Overall, our acoustic results with regard to statistical significance and group trends are in agreement with our hypotheses and in line with previously published literature on the effects of cigarette smoking on voice production (Chai et al., 2011; Gonzalez & Carpi, 2004; Sorensen & Horii, 1982). The voices of the two groups showed that the healthy singers sang using higher SPLs, higher SNRs, higher F0s, and less jitter and shimmer than the unhealthy singers. These differences were especially apparent during *low* vocal intensity conditions.

The present acoustic measures are discussed in terms of the possible changes to the underlying anatomical and physiological components involved in voice production. The predictions regarding SPL, were not statistically significant, however, in five out of six comparisons across loudness and singing conditions, healthy singers produced vocalizations at a higher median SPL than the unhealthy group. It had been hypothesized that healthy singers would be able to better control vocal intensity producing greater SPL across all group comparisons. We predicted that the unhealthy singers would display less control of vocal intensity due to cigarette smoking causing anatomical and physiological changes to their vocal fold mucosa. The association of smoking and vocal abuse with inflammation of the vocal folds has been well established in the literature (Branski et al., 2006; Fitzpatrick & Blair, 2000; Van der Vaart, Postma, Timens, & Ten Hacken, 2004). Furthermore, Zeitels et al. (1997) noted the physiologic changes of elevated aerodynamic driving pressures compensating for irregular vocal fold vibrations that were the result of mass loading associated with Reinke's edema. It was expected that due to the increased mass of the vocal folds and irregular vibratory patterns typically associated with vocal folds of smokers, that they would exhibit a greater period where the vocal folds were open as well as a slower speed of closure. Both of these physiologic changes to glottal shape and airflow resistance would result in reduced subglottic pressures. To compensate, this would lead them to develop hyperfunctional strategies of increased driving pressures to allow for more complete vocal fold adduction and vibration to produce increased vocal intensity. Our results, however not significant, support the hypothesis and show that healthy singers not only had on average higher median vocal intensity levels, but also displayed a clear distinction in their ability to reach high intensity levels.

The second prediction regarding SNR was confirmed and in line with previous literature, which hypothesized that healthy singers would display lower levels of noise in the voice signal as compared to unhealthy singers for all singing tasks. Results showed statistically significant differences between the groups during *low* vocal intensity conditions. In all six comparisons across loudness and singing conditions, healthy singers produced vocalizations with a higher SNR than the unhealthy singers. In other words, healthy singers produced voice with less amounts of aperiodic noise in the signal than the unhealthy singers. Previous studies have shown that chronic irritant exposure to the laryngeal mechanism alters the biomechanical functioning of the vocal folds producing voice quality changes (Branski et al., 2006; Fitzpatrick & Blair, 2000), with glottal closure insufficiency directly associated with perceived breathiness in normal speakers (Sodersten & Lindestad, 1990).

Chronic exposure to cigarette smoke has been shown to cause changes in the laryngeal mechanism such as dryness and inflammation of the vocal folds (Dworkin, 2008). These changes produce alterations in voice production and subsequent secondary vocal abusive behaviors such as chronic cough reflexes (Dworkin, 2008). Prior research has shown that chronic and acute phonotrauma are directly linked to the development of scar tissue or benign vocal fold lesions that disrupts normal vibratory function by changing the physical properties of the tissue destroying the body-cover interface (Benninger, Alessi, Archer, Bastian, Ford, Koufman, Sataloff, Spiegel, & Woo, 1997). Furthermore, Benninger et al. (1997) stated that the increased effort to overcome the localized mucosal stiffness caused by the scarring results in a poor voice quality, often with glottal insufficiency. It was expected that given the chemical trauma from cigarette smoke in combination with mechanical damage from possible secondary vocal abusive behaviors, unhealthy singers would display increased aperiodicity in their voice signal and significant differences in SNR than healthy singers. Our findings confirm the hypothesis showing that the unhealthy singers displayed significantly more noise in their voice signal across all conditions suggestive of voice difficulties within this group. Prior studies have also found a soft or low voice in healthy adults tends to be breathier to begin with (Gelfer, 1995; Sodersten & Lindestad, 1990), and our results further support this finding with statistically significant differences occurring in both *low* conditions.

Based on these findings, vocal ability differences were observed most often in the *low* voice production tasks, leading us to believe that *low* intensities are the most representative diagnostic tool predicting current voice difficulties. We concluded that this observation was the result of the difficulty in controlling a *low* vocal intensity due to an inadequate air stream flow or “oscillation threshold pressure.” Titze (1988) defined “oscillation threshold pressure” as the lung pressure required to initiate vocal fold vibration and is determined as a function of vocal fold geometry and viscoelastic properties (p. 1536). He further explained that the glottal airstream and vocal folds together form a mechanical system that may exhibit instability under specific flow conditions. For example, if minimal flow conditions are not met, the continual transfer of energy from the glottal airstream to the tissue will be overcome by the frictional loss of energy occurring within the vocal folds (Titze, 1988). In other words, more energy must be provided by the flow than is lost by friction in the tissue. We speculate that the unhealthy singers who displayed significant acoustic differences in the *low* vocal intensity conditions may have a decreased vocal ability due to their repeated exposure to chemical irritants and possible phonotrauma, causing changes in the viscoelastic properties of the mucosa. These changes result in faulty mechanical properties of the vocal folds as observed via acoustic analyses. Overall, the results suggest that SNR is an effective and useful tool in evaluating and screening singers to identify the early onset of vocal difficulties.

The third prediction that has been widely researched in the literature (Damborenea, et al., 1999; Gonzalez & Carpi, 2004; Guimara˜es & Abberton, 2005; Sorensen & Horii, 1982; Wan & Huang, 2008), hypothesized that the F0 of unhealthy singers would be lower than that of the healthy group. Our predictions were confirmed and parallel with prior research reporting lower F0 among smokers. Clinically, exposure to cigarette smoke is one of the most common chemical agents that negatively impact vocal fold function. As previously stated in the text, Reinke's edema is a common clinical entity associated with prolonged exposure to cigarette smoke irritants and patients typically present with vast, diffuse inflammation and erythema of the true vocal folds (Branski et al., 2006). The increase in the anatomical mass of the vocal folds creates a thicker vibratory mechanism, and subsequently oscillates at a slower cyclic speed resulting in a lower F0. In all six comparisons across loudness and singing conditions, healthy singers produced vocalizations with a higher F0 than the unhealthy singers. Statistically significant differences, however, was only noted in the *low* vocal intensity condition during prolonged singing /i/ in isolation. The direct association between intensity and duration of cigarette smoke exposure as well as individual biological thresholds may explain the variation in data. Branski et al. (2006) hypothesized that individual thresholds for the elicitation of a wound healing response in the vocal folds exist and contribute to why some individuals may be more susceptible to injury from irritant agents. Overall, our findings show lower F0 across all tested conditions suggestive of the unhealthy singers displaying possible inflammation of their vocal folds.

The fourth prediction was that the healthy singers would show less jitter and shimmer in the voice signal than the unhealthy singers across all group comparisons, suggestive of a healthy, stable laryngeal mechanism. This prediction was supported by the data. Statistically significant differences were realized, with regard to jitter and shimmer, across various vocal intensity conditions. In five out of six comparisons across loudness and singing conditions, healthy singers produced vocalizations with a lower jitter % as well as lower shimmer % than the unhealthy singers. Our results are in agreement with previous literature on the increased perturbation parameters of jitter and shimmer among smokers (Chai et al., 2011; Damborenea et al., 1999; Gonzalez & Carpi, 2004; Guimara˜es & Abberton, 2005; Wan & Huang, 2008). Cigarette smoke has been identified as one of the main contributors of anatomical changes to the laryngeal histology including chronic inflammation, erythema, dryness, and itching laryngeal mucosa (Dworkin, 2008; Fitzpatrick & Blair, 2000; Sorensen & Horii, 1982; Spira et al., 2004). Its irritant effects to the mucous membrane and epithelial lining of the larynx disrupts the free vibrating edge of the vocal folds creating irregular vibratory patterns. This physiologic change to the vocal folds has been quantified using voice perturbation parameters of jitter and shimmer to assess healthy voice production with greater values reflecting an impaired vocal ability (Carding, Wilson, MacKenzie, & Deary, 2009). Chai el al. (2011) investigated perturbation measures of smokers and found significance between jitter % of smokers and non-smokers (0.364 % for smokers vs. 0.283 % for non-smokers), as well as significant differences between shimmer % (4.569 % for smokers vs. 2.497 % for non-smokers). Several other studies have also noted differences, however with varying statistical significance (Damborenea et al., 1999; Gonzalez & Carpi, 2004; Guimara˜es & Abberton, 2005). Chai et al. (2011) explained that variance in methodology, analysis software, sample sizes, and participant selection criteria may be contributing to the limited significance in previous literature. Perturbation measures are also highly variable when applied to disordered voices (Rabinov, Kreiman, Gerratt, & Bielamowicz, 1995). Brockmann, Drinnan, Storck, and Carding (2011), however, examined vowel and gender effects on jitter and shimmer measurements while correcting for F0 and SPL, and found voice SPL to have the biggest impact on jitter and shimmer reliability. They further stated phonations at a minimum predefined voice SPL of 80 dB to enhance measurement reliability. Brockmann, Storck, Carding, and Drinnan (2008) explained that below 80 dB, small variations in SPL lead to large changes in jitter and shimmer and these greater values might be reflective of a physiological laryngeal tension change in normal voices associated with low SPL. Our results are in accordance to the criteria with all vocalizations above 80 dB across all tested vocal intensity conditions. The present study displayed trends in line with prior investigations as well as statistically significant differences found between jitter and shimmer values in healthy and unhealthy singers. The results suggests that participating in unhealthy lifestyle choices such as chronic cigarette smoking can lead to a deterioration of stable vocal fold vibration and may be valuable predictors of future voice difficulties.

Significantly lower vital capacities have been found in smokers versus nonsmokers (Awan & Alphonso, 2007). Results from the current study, although not statistically different, showed the healthy group had larger average vital capacity as compared to the unhealthy group. The respiratory system provides the power for speech production with respiratory function directly associated with phonation. Awan and Alpshonso (2007) stated that vocal fold oscillation is dependent upon the sequenced buildup of subglottal pressure followed by regulated and coordinated transglottal airflow. The physiologic events of phonatory airflow and air pressure may provide significant understanding into normal and pathologic voice production. It is widely known that smoke inhalation has detrimental effects on both respiratory and laryngeal functioning with chronic obstructive pulmonary disease (COPD) as a worldwide leading cause of morbidity and mortality (Murray & Lopez, 1997). Prior research has also found that cigarette smoke resulted in evidence of mild airway obstruction and slowed growth of lung function in adolescents (Gold, Wang, Wypij, Speizer, Ware, & Dockery, 1996). In addition, Zeitels et al. (1997) noted the compensatory strategy of elevated aerodynamic driving pressures in smokers who exhibited Reinke's edema due to glottal insufficiency. From the confounding negative effects of cigarette smoke on respiratory function as well as laryngeal integrity, it was expected that unhealthy singers would exhibit lower vital capacity as compared to healthy singers. Although comparisons were not statistically significant, trends in the data provides insight into initial underlying deficits that may limit the capabilities of the voicing system, and could lead to maladaptive phonatory strategies over time if tobacco consumption is continued.

It was also of interest to find that vocal "deviance," as judged by the CAPE-V assessment via overall severity, breathiness, and loudness, was perceived to be essentially normal for all participants regardless of healthy versus unhealthy profile status (see Table

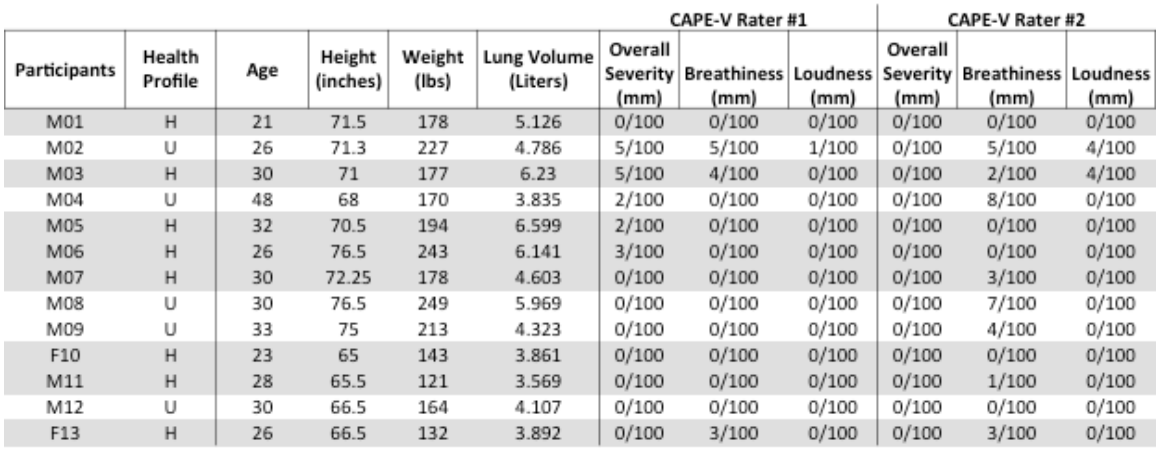
1a). The perceptual analysis of normal voices has seen many problems within the literature with regard to the inability to accurately identify a 1-to-1 correspondence between acoustic information and psychophysical assessments (Eadie & Doyle, 2005). Sodersten and Lindestad (1990) stated that the variation of the voice quality parameter is usually limited with slight variations being difficult to detect and rate, even for experienced clinicians. Our findings support prior research and raise a concern for the development of an auditory-perceptual rating scale specifically tailored for the intricacies of the singing voice. Findings also emphasize regular training sessions for perceptual evaluations and their use as a secondary collection source alongside objective instrumental data.

Statistical significance was not realized across all dependent variables. This could possibly be explained by the following: (1) small sample size, (2) and marijuana inhalation as contributing factors. It was noted that 11 out of the 13 participants engaged in the consumption of marijuana through various inhalation devices (see Table 1b), which may have affected the acoustic data. More research is needed to evaluate the effects of marijuana smoking alone on voice production, especially given the recent legalization of its use in certain states in America. The lack of uniform statistical significance however does not mean the results do not hold clinical significance. Meline and Wang (2004) argue that statistical significance tests have very little to do with practical significance. They further state that a small sample size may fail to reach statistical significance although the result may be clinically important. Given these limitations, the nonsignificant data presented in the current study displayed trends that were shown to be parallel with prior research. Therefore, interpretation of these results should hold pragmatic significance in everyday clinical practice.

CONCLUSION

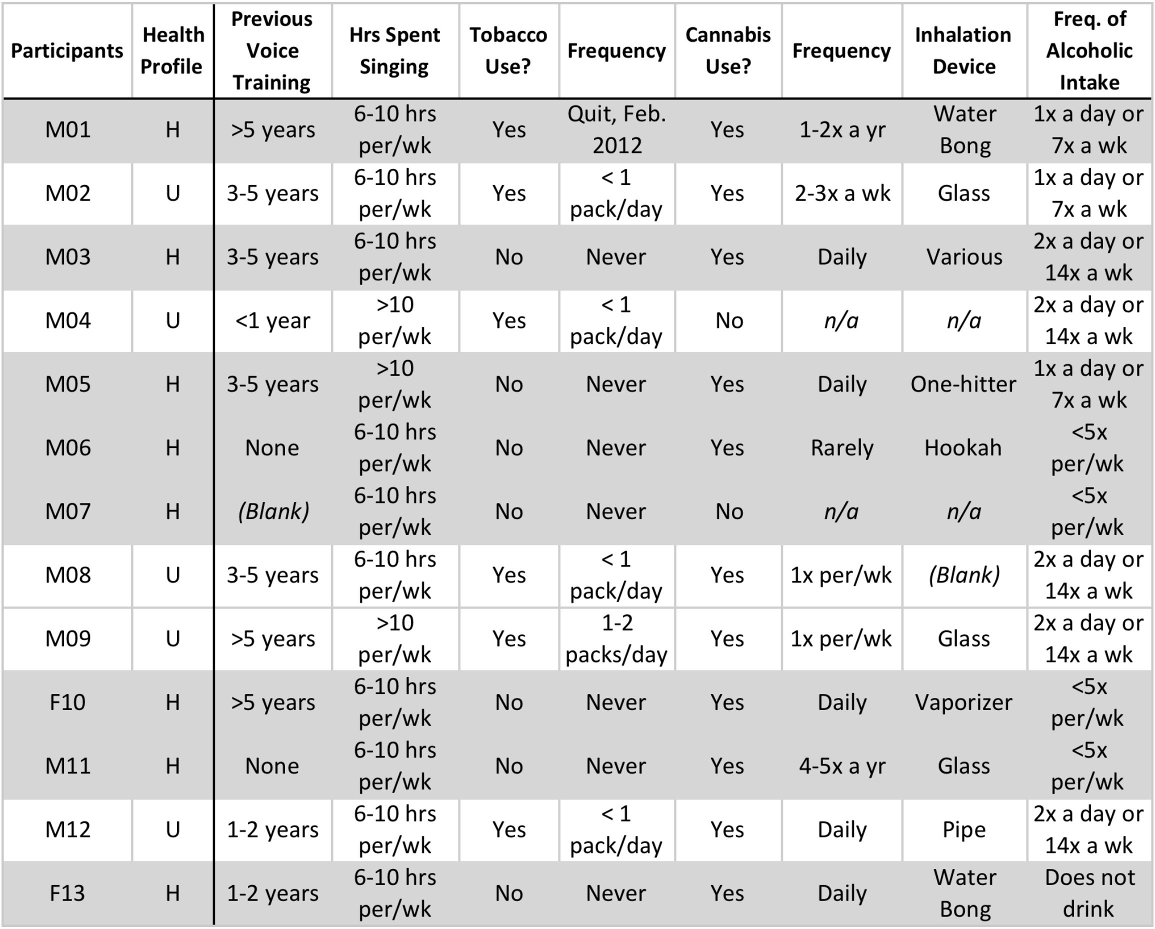
The current study attempts to provide a descriptive profile of nonclassically trained singers who have been viewed in the literature to be at an increased risk of voice damage, and to better understand what lifestyle factors might be contributing to the anecdotal evidence of increased vocal difficulties. Tepe, Deutsch, Sampson, Lawless, Reilly, and Sataloff (2002) offered possible explanations including the collective effect of unhealthy vocal habits or techniques, the increase in vocal demands, and vocal abuse related to social and recreational activities other than singing. With the increase in vocal demands, CCM singers are subjected to continuous mechanical stress of the vocal folds. This mechanically stressful state is exacerbated with the consumption of external chemical pollutants typically found within this population. Given previous data on the effects of smoking, combined with anecdotal evidence on the voice difficulties experienced by CCM singers, it was hypothesized that those who reported unhealthy lifestyle profiles would display a decreased vocal ability via acoustic analyses as well as lower vital capacity. We also hypothesized that unhealthy singers would be rated as producing a voice with more “deviance from normal” than healthy singers via the CAPE-V.

SPL, SNR, F0, and jitter and shimmer measures were used to analyze the voice signals of both healthy and unhealthy singers. Differences between groups were observed across all dependent measures with statistical significance reported on various *low* and *comfortable* vocal intensities between SNR, F0, jitter, and shimmer results. We also conclude that given the disparity between acoustic measures and auditory perceptual assessment ratings, the early onset of biomechanical changes to the vocal folds are not easily perceivable to the human ear. Moreover, current auditory perceptual assessment scales are clinically created for, and used with, more dysphonic speakers. Future research should focus on construction of a more practical and sensitive assessment tool focused on the intricacies of the singing voice.



						CAPE-V Rater #1			CAPE-V Rater #2		
Participants	Health Profile	Age	Height (inches)	Weight (lbs)	Lung Volume (Liters)	Overall Severity (mm)	Breathiness (mm)	Loudness (mm)	Overall Severity (mm)	Breathiness (mm)	Loudness (mm)
M01	H	21	71.5	178	5.126	0/100	0/100	0/100	0/100	0/100	0/100
M02	U	26	71.3	227	4.786	5/100	5/100	1/100	0/100	5/100	4/100
M03	H	30	71	177	6.23	5/100	4/100	0/100	0/100	2/100	4/100
M04	U	48	68	170	3.835	2/100	0/100	0/100	0/100	8/100	0/100
M05	H	32	70.5	194	6.599	2/100	0/100	0/100	0/100	0/100	0/100
M06	H	26	76.5	243	6.141	3/100	0/100	0/100	0/100	0/100	0/100
M07	H	30	72.25	178	4.603	0/100	0/100	0/100	0/100	3/100	0/100
M08	U	30	76.5	249	5.969	0/100	0/100	0/100	0/100	7/100	0/100
M09	U	33	75	213	4.323	0/100	0/100	0/100	0/100	4/100	0/100
F10	H	23	65	143	3.861	0/100	0/100	0/100	0/100	0/100	0/100
M11	H	28	65.5	121	3.569	0/100	0/100	0/100	0/100	1/100	0/100
M12	U	30	66.5	164	4.107	0/100	0/100	0/100	0/100	0/100	0/100
F13	H	26	66.5	132	3.892	0/100	3/100	0/100	0/100	3/100	0/100

Table 1a. Individual participant (male=M and female=F) descriptive data by health (healthy=H vs. unhealthy=U) profile. Auditory-perceptual ratings using CAPE-V form for three voice parameters, (1) overall severity, (2) breathiness, and (3) loudness. Singers' recorded *comfortable* prolonged /i/ productions in isolation as well as *comfortable* /i/ productions during the "Star-Spangled Banner" were used for analysis.



Participants	Health Profile	Previous Voice Training	Hrs Spent Singing	Tobacco Use?	Frequency	Cannabis Use?	Frequency	Inhalation Device	Freq. of Alcoholic Intake
M01	H	>5 years	6-10 hrs per/wk	Yes	Quit, Feb. 2012	Yes	1-2x a yr	Water Bong	1x a day or 7x a wk
M02	U	3-5 years	6-10 hrs per/wk	Yes	< 1 pack/day	Yes	2-3x a wk	Glass	1x a day or 7x a wk
M03	H	3-5 years	6-10 hrs per/wk	No	Never	Yes	Daily	Various	2x a day or 14x a wk
M04	U	<1 year	>10 per/wk	Yes	< 1 pack/day	No	*n/a*	*n/a*	2x a day or 14x a wk
M05	H	3-5 years	>10 per/wk	No	Never	Yes	Daily	One-hitter	1x a day or 7x a wk
M06	H	None	6-10 hrs per/wk	No	Never	Yes	Rarely	Hookah	<5x per/wk
M07	H	*(Blank)*	6-10 hrs per/wk	No	Never	No	*n/a*	*n/a*	<5x per/wk
M08	U	3-5 years	6-10 hrs per/wk	Yes	< 1 pack/day	Yes	1x per/wk	*(Blank)*	2x a day or 14x a wk
M09	U	>5 years	>10 per/wk	Yes	1-2 packs/day	Yes	1x per/wk	Glass	2x a day or 14x a wk
F10	H	>5 years	6-10 hrs per/wk	No	Never	Yes	Daily	Vaporizer	<5x per/wk
M11	H	None	6-10 hrs per/wk	No	Never	Yes	4-5x a yr	Glass	<5x per/wk
M12	U	1-2 years	6-10 hrs per/wk	Yes	< 1 pack/day	Yes	Daily	Pipe	2x a day or 14x a wk
F13	H	1-2 years	6-10 hrs per/wk	No	Never	Yes	Daily	Water Bong	Does not drink

Table 1b. Individual participant (male=M and female=F) lifestyle descriptive data by health (healthy=H vs. unhealthy=U) profile.

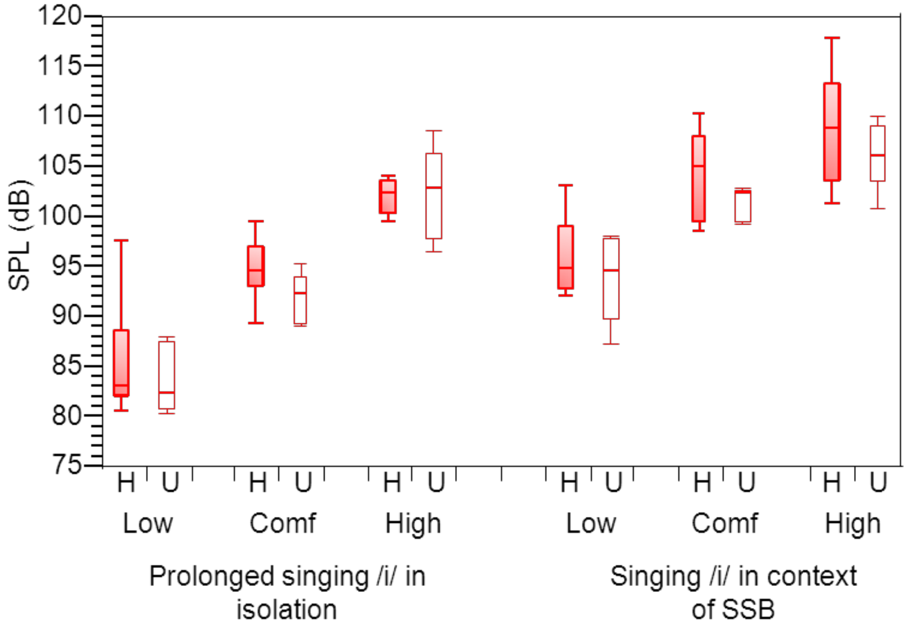


Figure 1. Depiction of sound pressure level (SPL) in decibels (dB) as a function of healthy (H) vs. unhealthy (U) singers as a function of vocal intensity (low, comfortable [comf], and high. Two singing contexts: during an isolation vowel production (prolonged singing /i/ in isolation) and during singing of the Star Spangled Banner (singing /i/ in context of SSB). Median = horizontal line within bar, 1st quartile = lowest horizontal hatch mark to bottom of box, 2nd quartile = bottom of box to median line, 3rd quartile = median line to top of box, 4th quartile = top of box to highest horizontal hatch mark.

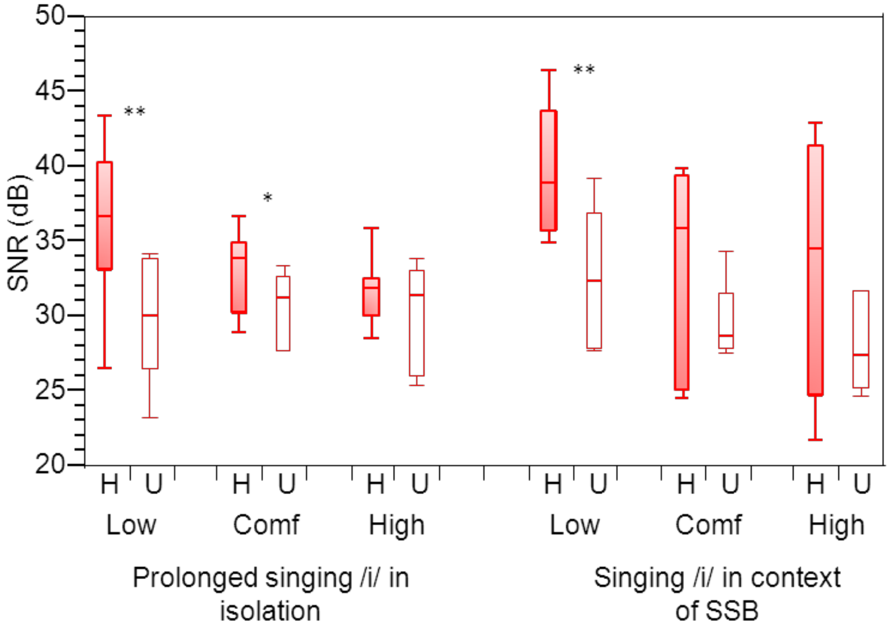


Figure 2. Depiction of signal-to-noise ratio (SNR) in decibels (dB) as a function of healthy (H) vs. unhealthy (U) singers as a function of vocal intensity (low, comfortable [comf], and high. Two singing contexts: during an isolation vowel production (prolonged singing /i/ in isolation) and during singing of the Star Spangled Banner (singing /i/ in context of SSB). Median = horizontal line within bar, 1st quartile = lowest horizontal hatch mark to bottom of box, 2nd quartile = bottom of box to median line, 3rd quartile = median line to top of box, 4th quartile = top of box to highest horizontal hatch mark. *=p<0.10, **=p<0.05

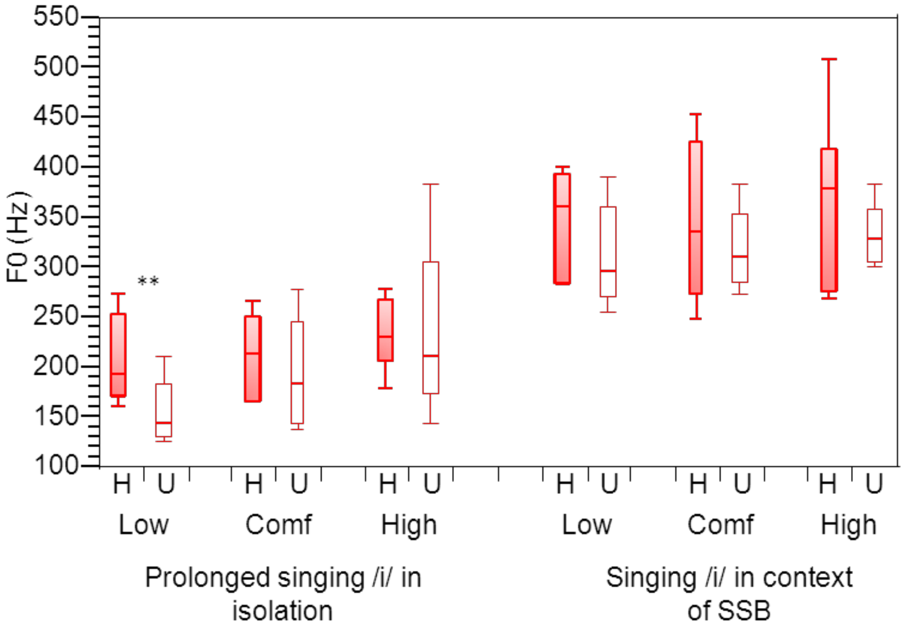


Figure 3. Depiction of fundamental frequency (F0) in hertz (Hz) as a function of healthy (H) vs. unhealthy (U) singers as a function of vocal intensity (low, comfortable [comf], and high. Two singing contexts: during an isolation vowel production (prolonged singing /i/ in isolation) and during singing of the Star Spangled Banner (singing /i/ in context of SSB). Median = horizontal line within bar, 1st quartile = lowest horizontal hatch mark to bottom of box, 2nd quartile = bottom of box to median line, 3rd quartile = median line to top of box, 4th quartile = top of box to highest horizontal hatch mark. *=p<0.10, **=p<0.05

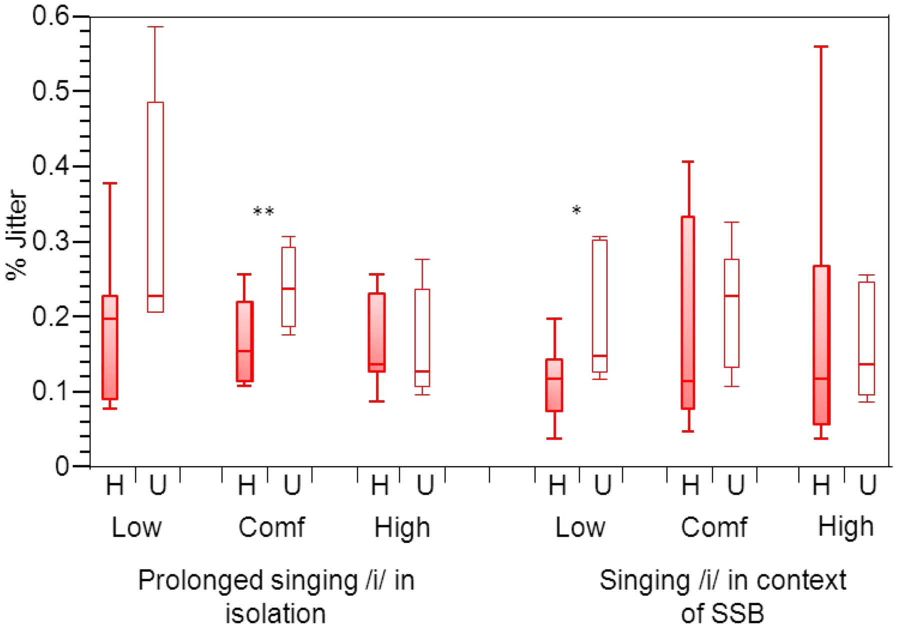


Figure 4. Depiction of cycle-to-cycle frequency variation (jitter) in percent (%) as a function of healthy (H) vs. unhealthy (U) singers as a function of vocal intensity (low, comfortable [comf], and high. Two singing contexts: during an isolation vowel production (prolonged singing /i/ in isolation) and during singing of the Star Spangled Banner (singing /i/ in context of SSB). Median = horizontal line within bar, 1st quartile = lowest horizontal hatch mark to bottom of box, 2nd quartile = bottom of box to median line, 3rd quartile = median line to top of box, 4th quartile = top of box to highest horizontal hatch mark. *=p<0.10, **=p<0.05

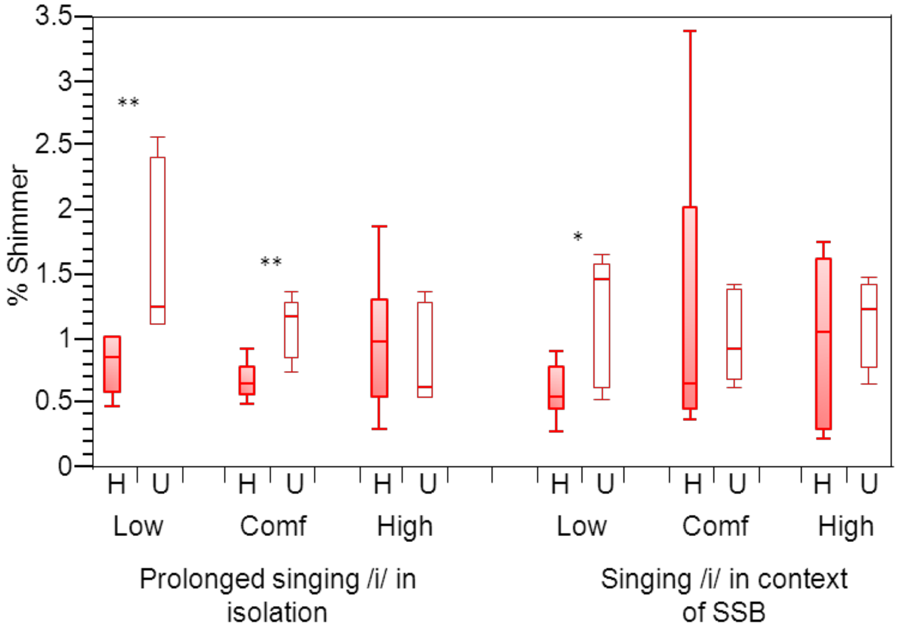


Figure 5. Depiction of cycle-to-cycle amplitude variation (shimmer) in percent (%) as a function of healthy (H) vs. unhealthy (U) singers as a function of vocal intensity (low, comfortable [comf], and high. Two singing contexts: during an isolation vowel production (prolonged singing /i/ in isolation) and during singing of the Star Spangled Banner (singing /i/ in context of SSB). Median = horizontal line within bar, 1st quartile = lowest horizontal hatch mark to bottom of box, 2nd quartile = bottom of box to median line, 3rd quartile = median line to top of box, 4th quartile = top of box to highest horizontal hatch mark. *=p<0.10, **=p<0.05

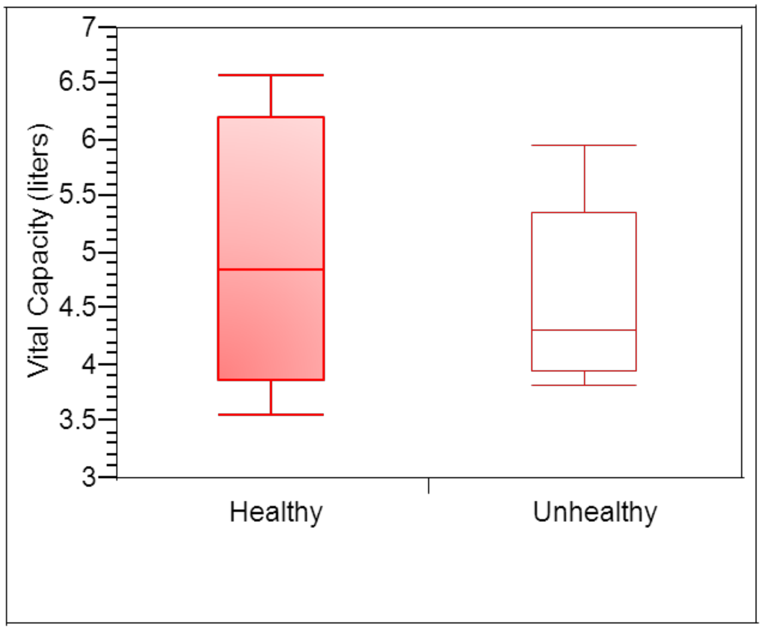


Figure 6. Depiction of vital capacity in liters (L) as a function of healthy vs. unhealthy singers profiles. Median = horizontal line within bar, 1st quartile = lowest horizontal hatch mark to bottom of box, 2nd quartile = bottom of box to median line, 3rd quartile = median line to top of box, 4th quartile = top of box to highest horizontal hatch mark.

APPENDIX I

Lifestyle Research Questionnaire

Voice & Performance – Singers of Contemporary Commercial Music

Alexander Foote, Elaine Stathopoulos, Jeff Higginbotham, Joan Sussman
A Research Project of the University at Buffalo

PLEASE ONLY COMPLETE THIS QUESTOINNAIRE IF YOU ARE CURRENTLY PERFORMING FOR *6 OR MORE HOURS PER WEEK*

Musical Background

1) How long have you been singing professionally?
- ☐ Less than 1 year
- ☐ 1-2 years
- ☐ 3-4 years
- ☐ 5-10 years
- ☐ More than 10 years

2) How much of your income is gained from your singing career?
- ☐ 100%
- ☐ About 75%
- ☐ About 50%
- ☐ About 25%
- ☐ Less than 25%

3) List the style(s) of music you sing and circle your primary style.

____
____
____
____
____
____

4) If you had voice training, where did you get it? Check all that apply.
- ☐ No training
- ☐ Private lessons
- ☐ Church choir
- ☐ Peer mentor (friend/family member)
- ☐ Self-study
- ☐ College-level courses
- ☐ Other

____

5) Which type of training have you had? Classical training, or contemporary? Please complete:
_____ yrs classical, and _____ yrs contemporary
If Contemporary, please specify style (ie. musical theatre, pop, rock, blues, r & b, ect.)

____
____

6) How much voice training have you had?
- ☐ None
- ☐ Less than 1 year
- ☐ 1-2 years
- ☐ 3-5 years
- ☐ More than 5 years

7) How old are you?
- ☐ Under 20 years
- ☐ 20-24
- ☐ 25-29
- ☐ 30-34
- ☐ 35-39
- ☐ 40-44
- ☐ 45-49
- ☐ Above 50 years

8) Are you signed with a record label or represented in anyway?
- ☐ Yes
- ☐ No

If yes, please explain:
____
____
____
____
____

9) Are you? ☐ Male ☐ Female

Performance & Lifestyle Demands

10) On average, how many performances do you give each week?
- ☐ 0-2
- ☐ 3-5
- ☐ 6-10
- ☐ Over 10

11) On average, how many hours weekly are you involved in the **act of singing**? (ie. gigging/rehearsing)
- ☐ 0-2
- ☐ 3-5
- ☐ 6-10
- ☐ Over 10

12) Approximately low long does a typical performance last?
- ☐ Less than 1 hour
- ☐ About 1 hour
- ☐ About 1 ½ hours
- ☐ About 2 hours
- ☐ About 2 ½ hours
- ☐ About 3 hours
- ☐ More than 3 hours

13) At what level do you perform?
- ☐ Locally
- ☐ Regionally
- ☐ Nationally
- ☐ Internationally

14) Are you employed in work other than singing? ☐ Yes ☐ No

*If yes, please explain:*____

Please list # of hrs you work this job per week: ______________________________

	Never	Almost Never	Sometimes	Almost Always	Always
15) Do you play small outdoor venues? *i.e. neighborhood/street festivals*	☐	☐	☐	☐	☐
16) Do you play large outdoor venues? *i.e. outdoor amphitheaters*	☐	☐	☐	☐	☐
17) Do you play small indoor venues? *i.e. pubs, bars, restaurants*	☐	☐	☐	☐	☐
18) Do you play large indoor venues? *i.e. convention centres*	☐	☐	☐	☐	☐
19) Do you play smoky venues?	☐	☐	☐	☐	☐

Vocal Characteristic

20) What vocal category best describes your voice?
- ☐ Bass
- ☐ Baritone
- ☐ Tenor
- ☐ Alto
- Other:__________
- ☐ Mezzo-soprano
- ☐ Soprano
- ☐ Not Sure
- ☐

21) Which nationally known singer, past or present, do you believe has the most desirable vocal quality for the type of music you sing?

____

22) Are you happy with your vocal quality?

☐ Yes ☐ Sometimes ☐ No

23) Do you deliberately alter/change your natural singing voice to replicate your favorite singer(s) vocal qualities?

☐ Yes ☐ No

	Very light	Moderately light	In between	Moderately heavy	Very heavy
24) Is your typical singing voice light or heavy?	☐	☐	☐	☐	☐

	Very bright	Moderately bright	In between	Moderately warm	Very warm
25) Is your typical singing voice bright or warm?	☐	☐	☐	☐	☐

	Very Weak	Moderately weak	In between	Moderately strong	Very strong
26) Is your typical singing voice weak or strong?	☐	☐	☐	☐	☐

	Not Breathy	Slightly breathy	Moderately breathy	Very breathy	Extremely breathy
27) Is your typical singing voice breathy?	☐	☐	☐	☐	☐

	Not Rough	Slightly rough	Moderately rough	Very rough	Extremely rough
28) Is your typical singing voice rough?	☐	☐	☐	☐	☐

Vocal Performance

29) What voice parts do you typically sing?
- ☐ Lead only
- ☐ Mostly lead with some harmony
- ☐ Lead and harmony equally
- ☐ Most harmony with some lead
- ☐ Harmony only

30) How much singing do you do in a performance?
- ☐ Sing in most every song
- ☐ Sing in about 75% of the songs
- ☐ Sing in about 50% of the songs
- ☐ Sing in about 25% of the songs
- ☐ Sing in a few songs

	Almost Never	Never	Sometimes	Almost Always	Always
31) Do you rest your voice between or after performance sets?	☐	☐	☐	☐	☐
32) During a performance, do you ever have to sing above a comfortable volume to be heard?	☐	☐	☐	☐	☐
33) During a performance, do you ever have to sing in a range that is too high or too low for you to sing comfortably?	☐	☐	☐	☐	☐
34) After a performance, have you ever felt vocally tired?	☐	☐	☐	☐	☐
35) After a performance, has your voice ever sounded hoarse?	☐	☐	☐	☐	☐

Vocal Health

36) Check any vocal problems you believe you have had because of singing your primary style of music?

- ☐ No problems
- ☐ Medical voice disorder diagnosed by a physician
- ☐ Loss of voice
- ☐ Tired voice
- ☐ Singing flat
- ☐ Loss of top end of singing range
- ☐ Other______________________

37) Have you seen any of the following for a problem with your singing voice?

- ☐ Have not seen anyone
- ☐ Physician
- ☐ Licensed speech-language pathologist
- ☐ Singing teacher
- ☐ Singing coach
- ☐ Other ________________________

38) Would you seek help from a physician or licensed speech-language pathologist if you had a voice problem?

☐ Yes ☐ No

39) Do you have access to information about maintaining a healthy singing voice? Check all that apply.

- ☐ No
- ☐ Yes, from my record label
- ☐ Yes, from my voice teacher
- ☐ Yes, from my vocal coach
- ☐ Yes, from my doctor
- ☐ Yes, from my speech pathologist
- ☐ Yes, from my fellow musicians
- ☐ Yes, Other
  ____

Vocal Preservation

This section asks questions about the use of substances that are known to affect vocal quality. All responses are **strictly confidential.**

40) Do you smoke cigarettes? (Check one)

- ☐ No, I have *never* smoked
- ☐ No, I used to smoke, but quit on __________________ (year/month)
- ☐ Yes, less than 1 pack/day
- ☐ Yes, 1-2 packs/day
- ☐ Yes, greater than 2 packs per day

41) Do you smoke substances other than tobacco?

☐ Yes ☐ No

If yes, how often: ____________________

What kind of smoking device do you use?

____

42) During time periods when you are performing regularly, do you drink caffeine each day?

- ☐ No
- ☐ Yes, less than 1 cup of coffee or 2 colas
- ☐ Yes, 2-3 cups of coffee or 4-6 colas
- ☐ Yes, over 3 cups of coffee or 6 colas

43) During time periods when you are performing regularly, do you drink water each day?

- ☐ No
- ☐ Yes, less than 2 eight-ounce glasses
- ☐ Yes, 2-4 eight-ounce glasses
- ☐ Yes, 5-6 eight ounce glasses
- ☐ Yes, 7-8 eight-ounce glasses
- ☐ Yes, over 8 eight-ounce glasses

44) On average, how often do you consume alcoholic beverages?

- ☐ *Do not* drink or *rarely*
- ☐ Consume *less* than 5 *beverages a week*
- ☐ Consume *1 beverage a day or on average 7 beverages a week*
- ☐ Consume *2 beverages a day or on average 14 beverages a week*
- ☐ Consume *3 or more beverages a day or more than 14 beverages a week*

45) Do you exercise? ☐ Yes ☐ No

If yes, what type of exercise? ___________________________________

How frequent? (i.e. days per week) ____________________________

	Almost Never	Never	Sometimes	Almost Always	Always
46) Do you ever have vocal problems after social use of alcohol?	☐	☐	☐	☐	☐
47) Do you ever have vocal problems due cigarette smoking?	☐	☐	☐	☐	☐
48) Do you ever have vocal problems due to smoking substances other than tobacco?	☐	☐	☐	☐	☐

APPENDIX II

Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V)

The following parameters of voice quality will be rated upon completion of the following tasks:

1. Sustained vowels, /a/ and /i/ for 3-5 seconds duration each.
2. Sentence production:

a.	The blue spot is on the key again.	d.	We eat eggs every Easter.
b.	How hard did he hit him?	e.	My mama makes lemon muffins.
c.	We were away a year ago.	f.	Peter will keep at the peak.

3. Spontaneous speech in response to: "Tell me about your voice problem." or "Tell me how your voice is functioning."

Legend: C = Consistent I = Intermittent
MI = Mildly Deviant MO =Moderately Deviant SE = Severely Deviant

SCORE

Overall Severity ______________________________ C I ____/100
MI MO SE

Roughness ______________________________ C I ____/100
MI MO SE

Breathiness ______________________________ C I ____/100
MI MO SE

Strain ______________________________ C I ____/100
MI MO SE

Pitch (Indicate the nature of the abnormality): ______________

______________________________ C I ____/100
MI MO SE

Loudness (Indicate the nature of the abnormality): ______________

______________________________ C I ____/100
MI MO SE

__________ ______________________________ C I ____/100
MI MO SE

__________ ______________________________ C I ____/100
MI MO SE

COMMENTS ABOUT RESONANCE: NORMAL OTHER (Provide description):______________

ADDITIONAL FEATURES (for example, diplophonia, fry, falsetto, asthenia, aphonia, pitch instability, tremor, wet/gurgly, or other relevant terms):

Clinician:______________

REFERENCES

American Association for Teachers of Singing (2008). In support of contemporary commercial music (nonclassical) voice pedagogy. *Journal of Singing.* 65(1), 7–10.

Awan, S. N., & Alphonso, V. A. (2007). Effects of smoking on respiratory capacity and control. *Clinical Linguistics & Phonetics*, 21(8), 623-636.

Bartlett I. (2011). *Sing out loud, sing out long – A profile of professional contemporary gig singers in the Australian context.* (Doctoral dissertation). Retrieved from http://research-hub.griffith.edu.au/display/n63dfcf9068cb1ca72c2a905db6bc185b

Behlau, M. (2003). Consensus auditory-perceptual evaluation of voice (CAPE-V). *ASHA*, 187-9.

Benninger, M. S., Alessi, D., Archer, S., Bastian, R., Ford, C., Koufman, J., ... & Woo, P. (1996). Vocal fold scarring: current concepts and management. *Otolaryngology-Head and Neck Surgery,* 115(5), 474-482.

Bhuta, T., Patrick, L., & Garnett, J. D. (2004). Perceptual evaluation of voice quality and its correlation with acoustic measurements. *Journal of Voice,* 18(3), 299-304.

Branski, R. C., Verdolini, K., Sandulache, V., Rosen, C. A., & Hebda, P. A. (2006). Vocal fold wound healing: a review for clinicians. *Journal of Voice,* 20(3), 432-442.

Brockmann, M., Storck, C., Carding, P. N., & Drinnan, M. J. (2008). Voice loudness and gender effects on jitter and shimmer in healthy adults. *Journal of Speech, Language, and Hearing Research,* 51(5), 1152-1160.

Brockmann, M., Drinnan, M. J., Storck, C., & Carding, P. N. (2011). Reliable jitter and shimmer measurements in voice clinics: the relevance of vowel, gender, vocal intensity, and fundamental frequency effects in a typical clinical task. *Journal of Voice*, 25(1), 44-53.

Carding, P. N., Wilson, J. A., MacKenzie, K., & Deary, I. J. (2009). Measuring voice outcomes: state of the science review. *The Journal of Laryngology & Otology*, 123(08), 823-829.

Chai, L., Sprecher, A. J., Zhang, Y., Liang, Y., Chen, H., & Jiang, J. J. (2011). Perturbation and nonlinear dynamic analysis of adult male smokers. *Journal of Voice,* 25(3), 342-347.

Damborenea, T. J., Fernández, L. R., Llorente, A. E., Naya, G. M., Marín, G. C., Rueda, G. P., & Ortiz, G. A. (1999). The effect of tobacco consumption on acoustic voice analysis. *Acta Otorrinolaringologica Espanola*, 50(6), 448-452.

Dworkin, J. P. (2008). Laryngitis: types, causes, and treatments. *Otolaryngologic Clinics of North America,* 41(2), 419-436.

Dykema, Peter, Earhart E, McConathy O, & Dann H. (1917). *I hear America singing; 55 songs and choruses for community singing.* Bonston, MA: C.C. Birchard & Company.

Eadie, T. L., & Doyle, P. C. (2005). Classification of dysphonic voice: acoustic and auditory-perceptual measures. *Journal of Voice,* 19(1), 1-14.

Erickson-Levendoski, E., & Sivasankar, M. (2011). Investigating the effects of caffeine on phonation. *Journal of Voice*, 25(5), e215-e219.

Erickson, M. L. (2012). The traditional/acoustic music project: A study of vocal demands and vocal health. *Journal of Voice,* 26(5), 664-e7.

Finnegan, E. M., Luschei, E. S., & Hoffman, H. T. (2000). Modulations in respiratory and laryngeal activity associated with changes in vocal intensity during speech. *Journal of Speech, Language, and Hearing Research*, 43(4), 934-950.

Fitzpatrick, T. M., & Blair, E. A. (2000). Upper airway complications of smoking. *Clinics in Chest Medicine,* 21(1), 147-157.

Gelfer, M. P. (1995). Fundamental frequency, intensity, and vowel selection: Effects on measures of phonatory stability. *Journal of Speech, Language, and Hearing Research,* 38(6), 1189-1198.

Gelzinis, A., Verikas, A., & Bacauskiene, M. (2008). Automated speech analysis applied to laryngeal disease categorization. *Computer Methods and Programs in Biomedicine,* 91(1), 36-47.

Gilman, M., Merati, A. L., Klein, A. M., Hapner, E. R., & Johns, M. M. (2009). Performer's attitudes toward seeking health care for voice issues: understanding the barriers. *Journal of Voice*, 23(2), 225-228.

Gold, D. R., Wang, X., Wypij, D., Speizer, F. E., Ware, J. H., & Dockery, D. W. (1996). Effects of cigarette smoking on lung function in adolescent boys and girls. *New England Journal of Medicine*, 335(13), 931-937.

Gonzalez, J., & Carpi, A. (2004). Early effects of smoking on the voice: A multidimensional study. *Medical Science Monitor*, 10(12), 649-656.

Guimarães, I., & Abberton, E. (2005). Health and voice quality in smokers: an exploratory investigation. *Logopedics Phonatrics Vocology*, 30(3-4), 185-191.

Huber, J. E. (2007). Effect of cues to increase sound pressure level on respiratory kinematic patterns during connected speech. *Journal of Speech, Language, and Hearing Research,* 50(3), 621-634.

Keskinen AK. (2013). *Vocal pedagogy and contemporary commercial music: Reflections on higher education non-classical vocal pedagogy in the United States and Finland* (Master's thesis, Sibelius Academy: University of the Arts Helsinki, Finland) Retrieved from http://ethesis.siba.fi/files/nbnfife201306103898.pdf

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

Lã, F. M. B., & Sundberg, J. (2012). Pregnancy and the singing voice: Reports from a case study. *Journal of Voice,* 26(4), 431-439.

Linville, S. E. (2002). Source characteristics of aged voice assessed from long-term average spectra. *Journal of Voice*, 16(4), 472-479.

LoVetri, J. (2008). Contemporary commercial music. *Journal of Voice*, 22(3), 260-262.

Mazzoni D. (1999). Audacity®. Pittsburg, PA: Carnegie Mellon University.

Meline, T., & Wang, B. (2004). Effect-size reporting practices in AJSLP and other ASHA journals, 1999–2003. *American Journal of Speech-Language Pathology*, 13(3), 202-207.

Milenkovic, P. (1987). Least mean square measures of voice perturbation. *Journal of Speech, Language, and Hearing Research,* 30(4), 529-538.

Milenkovic P. (2001). TF32. Madison, WI: University of Wisconsin-Madison.

Milenkovic P. (2001). TF32 user's manual. Madison, WI. University of Wisconsin-Madison.

Monson B. (2011). *High-frequency energy in singing and speech*. (Doctoral dissertation). Retrieved from http://search.proquest.com/docview/888204027

Muckala, J. C. (2013). Commercial Music: What Every SLP Should Know. *SIG 3 Perspectives on Voice and Voice Disorders,* 23(1), 28-35.

Murray, C. J., & Lopez, A. D. (1997). Alternative projections of mortality and disability by cause 1990–2020: Global Burden of Disease Study. *The Lancet*, 349(9064), 1498-1504.

Nagai, H., Ota, F., Konopacki, R., & Connor, N. P. (2005). Discoordination of laryngeal and respiratory movements in aged rats. *American Journal of Otolaryngology,* 26(6), 377-382.

Ortega, J., Cassinello, N., Dorcaratto, D., & Leopaldi, E. (2009). Computerized acoustic voice analysis and subjective scaled evaluation of the voice can avoid the need for laryngoscopy after thyroid surgery. *Surgery*, 145(3), 265-271.

Parsa, V., & Jamieson, D. G. (2000). Identification of pathological voices using glottal noise measures. *Journal of Speech, Language, and Hearing Research*, 43(2), 469-485.

Rabinov, C. R., Kreiman, J., Gerratt, B. R., & Bielamowicz, S. (1995). Comparing reliability of perceptual ratings of roughness and acoustic measures of jitter. *Journal of Speech, Language, and Hearing Research*, 38(1), 26-32.

Rosenberg, M., & LeBorgne, W. (2014). *The vocal athlete: Application and technique for the hybrid singer*. San Diego, Calif: Plural Publishing.

Sodersten, M., & Lindestad, P. A. (1990). Glottal closure and perceived breathiness during phonation in normally speaking subjects. *Journal of Speech, Language, and Hearing Research,* 33(3), 601-611.

Spira, A., Beane, J., Shah, V., Liu, G., Schembri, F., Yang, X., Palma J., & Brody, J. S. (2004). Effects of cigarette smoke on the human airway epithelial cell transcriptome. *Proceedings of the National Academy of Sciences of the United States of America*, 101(27), 10143-10148.

Sorensen, D., & Horii, Y. (1982). Cigarette smoking and voice fundamental frequency. *Journal of Communication Disorders*, 15(2), 135-144.

Stathopoulos, E. T., & Sapienza, C. (1993). Respiratory and laryngeal function of women and men during vocal intensity variation. *Journal of Speech, Language, and Hearing Research*, 36(1), 64-75.

Stathopoulos, E. T., Huber, J. E., Richardson, K., Kamphaus, J., DeCicco, D., Darling, M., Fulcher, K., & Sussman, J. E. (2014). Increased vocal intensity due to the Lombard effect in speakers with Parkinson's disease: Simultaneous laryngeal and respiratory strategies. *Journal of Communication Disorders*, 48, 1-17.

Stathopoulos, E. T., Huber, J. E., & Sussman, J. E. (2011). Changes in acoustic characteristics of the voice across the life span: Measures from individuals 4–93 years of age. *Journal of Speech, Language, and Hearing Research*, 54(4), 1011-1021.

Tepe, E. S., Deutsch, E. S., Sampson, Q., Lawless, S., Reilly, J. S., & Sataloff, R. T. (2002). A pilot survey of vocal health in young singers. *Journal of Voice,* 16(2), 244-250.

Titze, I. R., Horii, Y., & Scherer, R. C. (1987). Some technical considerations in voice perturbation measurements. *Journal of Speech, Language, and Hearing Research*, 30(2), 252-260.

Titze, I. R. (1988). The physics of small ‐ amplitude oscillation of the vocal folds. *The Journal of the Acoustical Society of America*, 83(4), 1536-1552.

U.S. Department of Agriculture and U.S. Department of Health and Human Services (2010). In: Dietary Guidelines for Americans. Chapter 3 – Foods and Food Components to Reduce. 7th Edition, Washington, DC: U.S. Government Printing Office. 30-32

Van der Vaart, H., Postma, D. S., Timens, W., & Ten Hacken, N. H. T. (2004). Acute effects of cigarette smoke on inflammation and oxidative stress: a review. *Thorax*, 59(8), 713-721.

Volic, S. V., Kirincic, N., & Markov, D. (1996). Some morphological, histological, cytological and histochemical aspects of Reinke's oedema. *Acta Oto-laryngologica,* 116(2), 322-324.

Wan, P., & Huang, Z. (2008). The effect of smoke and alcohol abuse to voice. *Journal of Clinical Otorhinolaryngology, Head, and Neck Surgery,* 22(15), 686-687.

LoVetri, J., & Woodruff, N. W. (2011). On the voice: Contemporary commercial voice pedagogy applied to the choral ensemble: An interview with Jeannette LoVetri. *The Choral Journal,* 39-53.

Zeitels, S. M., Bunting, G. W., Hillman, R. E., & Vaughn, T. (1997). Reinke's edema: Phonatory mechanisms and management strategies. *Annals of Otology, Rhinology & Laryngology,* 106(7), 533-543.