

Singing Voice Handicap and Videostrobolaryngoscopy in Healthy Professional Singers

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Summary: Objectives. This study correlates the Singing Voice Handicap Index (SVHI) scores with videostrobolaryngoscopy in healthy professional singers as a measure of self-perceived vocal health versus actual pathology seen on examination. The objective was to measure the strength of self-assessment among professional singers and determine if there is a benefit of combining SVHI and videostrobolaryngoscopy for routine assessment of singers without an obvious singing voice problem.

Study Design. Prospective cross-sectional study.

Methods. Forty-seven singers were included in the study. Singers produced spoken and sung pitches during videostrobolaryngoscopy. Examinations were blindly rated by two independent fellowship-trained laryngologists who assessed vocal fold appearance and function. The correlation between SVHI scores and total pathologic findings seen on videostrobolaryngoscopy was analyzed using linear regression and serial *t* tests.

Results. SVHI scores (mean of 22.45/144) were as expected for healthy singers. However, although all singers self-identified as healthy, laryngeal abnormalities were relatively common. The interrater reliability of total pathologic findings between two laryngologists was 71% ($P = 0.006$). Linear regression found no significant correlation ($P = 0.9602$) between SVHI scores and videostrobolaryngoscopy findings.

Conclusion. Greater than expected laryngeal pathology was seen in these professional singers, who identified themselves as healthy, which possibly indicates a minimal impact on their singing voice and/or perception of vocal health. These findings demonstrate that laryngeal appearance alone does not dictate nor fully explain the sound or apparent health of a professional singer. Sustaining good vocal health is complex, and even experienced singers may not reliably assess the presence of pathology.

Key Words: Singing–Voice–Voice handicap index–Videostrobolaryngoscopy–Laryngoscopy–Professional singers–Vocal health.

INTRODUCTION

Assessing the vocal health of professional singers requires methods of evaluation that are sensitive to their needs. Professional singers place a unique demand on their larynx, forcing frequent high levels of physical stress. These demands are more than the average person places on her voice through a moderate amount of daily speech, which therefore may make singers more vulnerable to developing vocal problems.¹ Professional singers must maintain good vocal health to consistently perform well, and their ability to self-assess and recognize abnormal changes maximizes their performance capabilities. This study looks at the correlation between two methods of evaluating the vocal health of professional singers: the Singing Voice Handicap Index (SVHI) and videostrobolaryngoscopy.

The SVHI is a questionnaire that was recently developed and validated as a tool to assess voice function and quality, specifically in singers.² It was adapted from the previously existing Voice Handicap Index, which is a questionnaire to assess vocal problems in the general population.^{3,4} Videostrobolaryngoscopy is a specialized tool that has proven valuable in accurately assessing vocal function and allows medical practitioners to directly visualize vocal fold appearance and movement in a slow-motion video format.⁵ This examination is a routine and safe method of evaluating the larynx and is the most accurate method of identifying anatomical and physiological abnormalities of the vocal folds.^{5,6} It has been previously shown that this tool allows reliable analysis of the vocal folds.^{7,8} In this study, we compare the SVHI questionnaire results with videostrobolaryngoscopy findings for a population of healthy professional singers. The objective was to correlate these two assessment tools and determine possible benefits of combining them to accurately assess vocal health in healthy professional singers. We also aim to examine the ability of professional singers to self-assess their vocal health.

MATERIALS AND METHODS

Subjects

The subjects consisted of adult professional singers who identified themselves as being healthy, which we define as having no known current vocal problems. Interested singers were asked three screening questions to determine their eligibility to

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participate: (1) Did you receive or are you currently pursuing an undergraduate or graduate degree in voice? (2) Have you been singing for five or more years? (3) Are you over 18 years old? If they answered “yes” to either question (1) or (2) and “yes” to question (3), then they were scheduled to participate in the study. For the purposes of this study, our definition of a “professional singer” is someone for whom singing is their primary or secondary source of income, is currently or has been in a vocal performance undergraduate or graduate training program, or has been singing in a professional choral group for several years (in which case they would categorize their own singing as “professional entertainment”). An additional criterion is that a professional singer should have received formal voice lessons.

A total of 47 singers were included in the study. Initially, 60 singers were recruited to participate, but 13 singers were excluded from the final study. One subject was unable to complete the laryngoscopy examination because of discomfort, at which point the examination was stopped without harm to the subject. One subject did not fully complete the SVHI questionnaire. One subject was closely affiliated with the Otolaryngology Department and therefore was excluded to avoid bias. Ten subjects did not fit our definition of a professional singer as outlined previously. Our initial sample size of 60 subjects allowed us to exclude subjects who did not meet our criteria, as previously mentioned, to achieve our desired sample size of 40–50. Recent similar studies involving the Voice Handicap Index questionnaire have enrolled on average of 40 participants or less and achieved reliable results.^{9–12} Compared with previous studies, which recruited a wide variety of subjects who may or may not have included singers, we are focusing our study on just professional singers. Although professional singers are still diverse in style, range, and ability, they represent a population of interest that is comparatively more homogenous than that used in other studies.

Subjects were first asked to read and sign a consent form explaining the risks and benefits to participating. Then, they completed the SVHI and demographics questionnaires according to the instructions and underwent the videostrobolaryngoscopy examination. All subjects were seen at the Otolaryngology Clinic at Boston Medical Center over a 3-month period. None of the study subjects included had any affiliation or experience with the Otolaryngology Department at Boston Medical Center before participation in the study. This study was approved by the Institutional Review Board at Boston University School of Medicine.

Administration of SVHI and demographics questionnaires

The SVHI lists 36 statements pertaining to singing voice quality and the impact it has on the singer’s life. Each statement is rated on a scale of 0–4 (0, never; 1, almost never; 2, sometimes; 3, almost always; and 4, always) according to how strongly the singer agrees with the statement. These ratings are then added up to generate a total SVHI score. A high score is believed to indicate a higher likelihood of having vocal problems, whereas a low score indicates less likelihood of having vocal problems.² The demographics questionnaire includes questions about

singing experience, training, and singing style that may affect vocal health. Both questionnaires were administered on paper to all subjects in the same manner on their arrival to the clinic. Verbal and written instructions were provided. Before the laryngoscopy examination, these were collected, and singers were not permitted to change any answers after undergoing the examination.

Videostrobolaryngoscopy

Flexible videostrobolaryngoscopy was used to examine the appearance and function of the vocal folds in each singer. Each singer received two sprays of topical anesthetic (4% lidocaine mixed 50:50 with neo-synephrine) directly into each side of the nares, which helps numb and decongest the area to minimize any discomfort. The flexible nasolaryngoscope (ENF-V2 VISERA Videoscope; Olympus, Central Valley, PA) was then inserted through the nares until the larynx was visualized. A strobe light at the tip of the laryngoscope was synchronized with the rate of vocal fold vibrations using a microphone placed externally over the larynx.

Singers were asked to perform a series of standardized phonation tasks including spoken and sung pitches (Table 1). First, the vocal folds were inspected at rest without phonation and during sniffing to evaluate for any obvious structural pathology. Singers were asked to produce a sustained pitch in their modal voice (ie, normal pitch and intensity used during conversational speech) without actually singing, then again with increased intensity (loudness), and again but at a higher pitch within the modal voice, to assess baseline vocal fold vibratory activity. A series of spoken staccato vowels were included to assess function without sustaining phonation. Finally, a series of high register sung pitches with and without vibrato and a glissando from low to high were important to include for evaluating subtle

TABLE 1.
Phonation Tasks Protocol

Vocal Task	Vowel or Sound
1. Inspection of vocal folds at rest	
2. Three sniffs	
3. Modal pitch, sustained 10 s	[i] or [m]*
4. Increased intensity of modal pitch above, sustained 10 s	[i] or [m]
5. Higher pitch within modal voice, sustained 10 s	[i] or [m]
6. Alternating staccato vowels	[i-hi-i-hi]
7. Alternating staccato vowel and sniff	[i]-sniff-[i]-sniff
8. High register, sung pitch without vibrato, sustained 10 s	[i]
9. High register, sung pitch with vibrato, sustained 10 s	[i]
10. Glissando (slide between a low pitch and a high pitch)	[i]

Notes: [i] pronounced as in the word “meet”; [m] pronounced with lips closed like a hum; [hi] pronounced “hee.”

* International Phonetic Alphabet symbols representing pronunciation of vowels and consonants.

abnormalities related to vocal fold elasticity. All the examination videos were saved on the password-protected clinic computer system (Vaultstream; Image Stream Medical, Littleton, MA) for further review without any identifying information.

Videostrobolaryngoscopy ratings

A focused rating system was determined to be an effective method to evaluate the stroboscopy videos.¹³ Because there is no standardized scale for laryngoscopy, we adapted our own rating criteria based on previous studies.^{5,13-15} Examinations were blindly rated by two independent fellowship-trained laryngologists who each have 7 years of experience in independently performing and analyzing videostroboscopy examinations. After discussing the rating parameters, each laryngologist performed the ratings separately at his own pace using the exact same video recordings. A total of 19 different parameters were used to rate the examinations based on the level of pathology, using a general four-point scale of 0–3 (0, normal; 1, mildly abnormal; 2, moderately abnormal; and 3, severely abnormal). Previous studies have used a similar four-point rating scale with good results.^{5,13} We felt that in our case, a four-point scale was also appropriate, given that we expected the range of pathologies to be narrow in a cohort of healthy singers. We use the term “pathology” throughout this article to refer to any abnormal stroboscopic findings.

We chose to use the most commonly examined parameters of vocal fold function and appearance to determine the presence and level of pathology.^{5,14} In addition to the stroboscopic signs recommended by Hirano and Bless,¹⁵ we look at other structures that participate in vocal production and act as resonators such as the pharynx and tongue. The appearance of these structures is variable in normal healthy singers,¹⁰ and subtle changes can alter voice quality.¹⁶ Laryngopharyngeal mucus is also noted because, although its presence is normal in healthy individuals, its excess may contribute to vocal changes. However, sample sizes of present pathology were relatively small within each parameter. As a result, we combined the numerical values of all the pathologic findings for each subject with simple addition, generating what we are calling a total pathology score (TPS) for each subject. This allows us to account for and compare the varying levels of severity in total pathology among the subjects even if subjects presented with more than one of the pathologies being evaluated. Explanations of the parameters and their rating scales are found in Table 2.

Analysis

Data analysis was performed using *SAS version 9.1* SAS Institute Inc., Cary, NC. An alpha of 0.05 was used for all analyses (before Bonferroni corrections where appropriate, see in the following), and two-tailed tests were used when comparing

TABLE 2.
Stroboscopy Rating Criteria

Parameters	Explanation/Comments
1. Pharyngeal pachydermia	Amount of nodularity seen on the posterior wall of the pharynx
2. Supraglottic constriction	Degree to which the vocal folds are still visible on constriction (0 = completely visible, 1 = more than half still visible, 2 = less than half visible, and 3 = none visible)
3. Arytenoid edema	Amount of visible swelling
4. Arytenoid erythema	Amount of visible redness
5. Vocal fold medial edge straightness	Right and left folds rated separately (0 = straight, 1 = mildly irregular, 2 = moderately irregular/prenodular, and 3 = severely irregular/lesion or nodule)
6. Vocal fold edema	Amount of visible swelling
7. Vocal fold vascularity	Erythema or visible vessels
8. Laryngopharyngeal mucus	Amount of mucus
9. Mucosal wave excursion	Extent of wave propagation across superior surface of right and left folds rated separately
10. Phase symmetry	Degree to which the opening and closing of each fold mirrors or is out of phase with the other (0 = in phase, 1 = mildly out of phase, 2 = moderately out of phase, and 3 = severely out of phase)
11. Periodicity	Regularity of successive vibrations
12. Vocal fold movement	Right and left rated separately
13. Tongue base hypertrophy	Degree to which it protrudes posteriorly into the pharynx (0 = normal, 1 = vallecula obscured, 2 = epiglottis pushed posteriorly, and 3 = tongue base close to touching posterior pharyngeal wall)
14. Amplitude of vocal fold excursion	Lateral distance of movement from midline of right and left folds separately (0 = normal, 1 = mild increase/decrease, 2 = moderate increase/decrease, and 3 = severe increase/decrease)
15. Axis rotation	Rotation of larynx about a vertical axis (degree of anterior commissure moved to the left or right)

Notes: All parameters rated on a 0–3 scale based on the severity with 0 = normal and 3 = severely abnormal; more specifics provided above where necessary.

means. Our primary outcome was the correlation between the SVHI and TPS. Potential correlation between TPSs and SVHI was examined using Pearson correlation. We used linear regression of TPS on SVHI to determine if total pathology predicted SVHI as a dependent variable. We also regressed each individual pathology as an independent variable on SVHI. Because singing experience in the cohort was overall high with most singers having been classically trained, we did not find it necessary to control for level of experience or training. To further compare the individual pathology categories to SVHI, we compared the SVHI scores of subjects with pathology versus subjects without pathology for each parameter using serial *t* tests. We used a Bonferroni correction to adjust for the use of serial tests. The interrater reliability was calculated using a conservative and simple approach. We measured the percentage difference between the TPSs from the two raters, standardized to the average, as a measure of unreliability. We also used a Pearson correlation as a measure of strength in correlation between the two raters.

RESULTS

The subjects ranged in ages from 19 to 62 years with a mean age of 31 years. The mean SVHI score for the 47 professional singers was 22.4 of a possible 144, which was as expected for healthy singers.² The SVHI scores ranged from 0 to 72 of a possible range of 0–144. The standard deviation in the SVHI total scores (by individual) was 16.33. According to the SVHI, 89.4% of the singers reported singing as their primary or secondary source of income. The remaining singers were deemed professional based on the inclusion criteria outlined previously. The majority of singers specialized in the genres of classical solo (95.7%), choral (89.4%), and opera solo (80.9%). Singing experience in the cohort was overall high with the majority having 6–20 years of experience or more. A total of 85.1% had at least an undergraduate degree in vocal performance, and almost all were classically trained (95.7%) (Table 3).

On videostroboscopy, the frequency of laryngeal pathology seen was unexpectedly high. Most notable was a higher than expected presence of supraglottic constriction, vocal fold vascularity, phase asymmetry, and excessive mucus. No significant correlation was found between SVHI and videostroboscopy in linear regression analysis ($P = 0.9602$) comparing SVHI and TPS (Figures 1 and 2). In the *t* test analyses, using the individual pathologic findings and SVHI, none of the pathologies were found to be significant predictors after Bonferroni adjustment. A potentially useful result would be the recovery of a combination of objective parameters that correlate to the SVHI. However, we did not recover any such combination of parameters. Multivariate regression indicated that even including all objective parameters at once only explained a minority of the variance in SVHI. The inclusion of interaction terms did not improve the model beyond a small (and expected) inflation in the product moment coefficient.

Interrater reliability of total pathologic findings between the two laryngologists was overall 71% ($P = 0.006$). There was a strong positive correlation in TPSs between the two raters

TABLE 3.
SVHI and Demographics: Characteristics of Singer Cohort

Characteristics	n	%
Income		
Primary source of income	15	31.9
Secondary source of income	27	57.4
Not a source of income	5	10.6
Singing style*		
Classical solo	45	95.7
Opera solo	38	80.9
Musical theater	25	53.2
Choral	42	89.4
Early music	27	57.4
Pop	11	23.4
Singing status*		
Professional entertainment	34	72.3
Voice teacher	22	46.8
Singing student	20	42.6
Choir/singing group	4	8.5
Years singing		
1–5	2	4.3
6–10	17	36.2
11–20	16	34.0
21–30	5	10.6
30+	7	14.9
Training*		
Classically trained	45	95.7
Undergraduate degree	40	85.1
Graduate degree	25	53.2
Voice lessons	47	100

* Singers may have more than one singing style, status, and training modality.

(Pearson product moment coefficient of 0.74), indicating strong covariance between the raters even when their specific scores differed slightly. Despite the difficulty in standardizing a rating system and lack of correlation between the SVHI and pathologies, the interrater reliability for our data set is relatively high. Additionally, although the interrater reliability calculated individually for each subject ranged from 15 to 100%, the raters did achieve an interrater reliability of greater than 80% in most subjects with a mode of 100%.

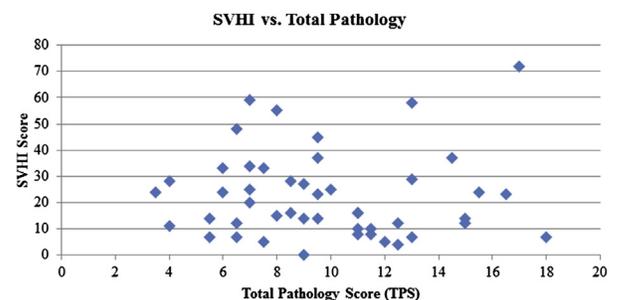


FIGURE 1. Plot of the SVHI scores and TPS for each of 47 singers. Average TPS between the two raters was used for each subject. Serial *t* test analyses found no significant correlation.

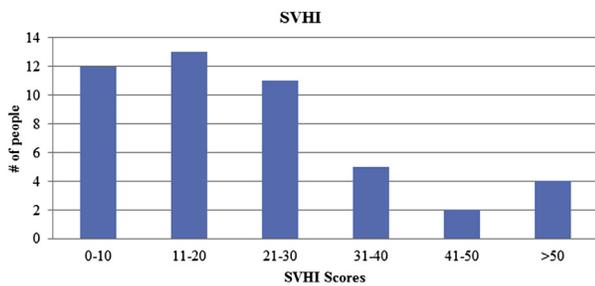


FIGURE 2. Distribution of SVHI scores. Singing voice handicap and videostrobolaryngoscopy in healthy professional singers.

Both raters found more pathology than expected despite any differences in rating. The stroboscopy rating criteria with the highest mean scores were laryngopharyngeal mucus and arytenoid erythema followed by vocal fold vascularity, arytenoid edema, supraglottic constriction, and pharyngeal pachydermia (Table 4). The most common pathologies among the singers were arytenoid erythema (93.6%) and laryngopharyngeal mucus (95.7%) followed by arytenoid edema (74.5%) and vocal fold vascularity (74.5%). Only one singer was found to have very small vocal fold nodules.

DISCUSSION

Professional singers depend daily on their vocal health to succeed in their careers. Singers carry their instrument with them at all times, and it is necessary for them to be aware of how they are using or misusing their voices in every aspect of their lives. Thus, the ability to self-assess potential vocal problems becomes a relevant issue.

TABLE 4.
Videostrobolaryngoscopy Mean Scores (Scale of 0–3)

Parameters	Rater 1	Rater 2
Pharyngeal pachydermia (nodularity)	0.85	0.68
Supraglottic constriction	0.87	0.74
Arytenoid edema	0.89	0.26
Arytenoid erythema	1.17	0.45
Vocal fold medial edge straightness		
Right vocal fold	0.45	0.67
Left vocal fold	0.47	0.83
Vocal fold edema	0.60	0.68
Vocal fold vascularity (erythema)	0.91	0.66
Laryngopharyngeal mucus	1.53	1.32
Mucosal wave excursion		
Right vocal fold	0.23	0.34
Left vocal fold	0.32	0.51
Phase symmetry	0.43	0.34
Periodicity	0.43	0
Vocal fold movement		
Right vocal fold	0.13	0.02
Left vocal fold	0.06	0
Tongue base (hypertrophy)	0.64	0.57
Amplitude of vocal fold excursion		
Right vocal fold	0.30	0.19
Left vocal fold	0.34	0.36
Axis rotation	0.30	0.02

A singer's vocal health is complex and the way in which a singer cares for and uses her voice and body on a daily basis encompasses many subjective aspects of good vocal health. This includes proper hydration, avoiding sources of irritation such as smoking or drugs, avoiding misuse or overuse of the voice, and avoiding excessive struggle to produce a clear sound. Good vocal health assessed by a medical examination means the actual appearance and function of the larynx on stroboscopy examination and includes the absence of chronic inflammation, gross obstructive pathologies, excessive supraglottic constriction, and vocal fold contour irregularities. Additionally, an experienced individual with an expertise in the singing voice should be consulted to determine if the singer is producing a healthy sound.

This study is not the first to find more pathology than expected in professional singers who identified themselves as being healthy.¹⁰ Perhaps, these pathologies do not affect their singing or they have learned to accommodate them. What may be “normal” for one singer may be “abnormal” for another; so, it is difficult to compare the health status of individuals based on these data alone. Given the vigorous use of their voices, this level of increased arytenoid erythema and edema, for example, may not be unusual. It is not surprising, however, that only one singer was found to have a benign vocal fold lesion because our cohort was specifically composed of healthy singers without reported vocal problems.

The high prevalence of arytenoid erythema and excessive laryngopharyngeal mucus seen on examination suggests that most healthy singers are functioning in a state of at least mild laryngeal irritation. Professional singers use their singing voice almost every day whether it is in practice or performance, so we suggest that the appearance of their larynx is because of chronic changes from frequent use. Despite these apparent abnormalities, singers seem to function adequately in their careers without medical intervention. This highlights our conclusion that the definitions of normal and abnormal may be different for every individual within a healthy cohort, especially when there is a narrow range of laryngeal findings. Additionally, a possible selection bias exists among the healthy appearing singers who volunteered for the study leading to higher than expected visualized pathology on stroboscopy. It is possible that of those who volunteered, although all reported no frank vocal issues, some may have felt a small change in their voice and had concern that pathology existed.

There was no statistically significant correlation between the SVHI scores and the amount of pathology seen on examination. This indicates that although the SVHI may be an adequate means of assessing the self-perceived impact of known vocal problems,² it is unable to accurately assess or correlate with the presence of pathology at least in healthy singers with no previously known vocal issues. The SVHI has been shown to have the ability to differentiate between singers with and without vocal problems and different levels of self-perceived vocal problems.² Because our cohort of singers were all healthy professionals, no serious vocal anatomic pathology was found. It is difficult for the SVHI to differentiate between subtle levels of self-perceived voice handicap when the scores fall within a

limited range. The lack of correlation between SVHI and laryngoscopic findings also indicates that the SVHI may uncover the impact of a subtle singing voice problem not seen on laryngoscopy, and conversely, laryngoscopy may uncover an abnormality not apparent with SVHI because it is not having a significant impact. Singers' perspectives on their own singing vary daily based on their general health, success in their careers, execution of particular performances, and many other factors. Because their voice is an integral part of who they are, singers may subjectively reflect on their overall performance capabilities when answering the SVHI rather than focusing on vocal health.

Professional singers have an increased concern and sensitivity to changes in their voice, which may lead to detection of problems earlier. Although this may be true for some, others may ignore small vocal changes hoping that it is nothing serious. Yet another cohort of singers may ignore symptoms of an underlying problem because of perhaps an overly confident attitude, which is common in the performance industry, leading them to delay seeking medical attention.

Videostrobolaryngoscopy certainly allows us to assess the appearance and function of the larynx in more detail.¹⁷ Although stroboscopy remains a subjective measure dependent on the expertise of the laryngologist, when evaluated by a trained individual, it gives us valuable insight into the laryngopharyngeal state in which the average healthy singer operates. Furthermore, the subjectivity of stroboscopy is reduced, and the reliability increases with the use of more than one rater. The lack in correlation between assessment modalities leads us to believe that neither tool can stand alone in definitively categorizing the level of vocal health of a professional singer. Rather, a more comprehensive approach is necessary in which SVHI and stroboscopy together may give a more complete picture of vocal health in the average singer. There needs to be an ongoing dialogue between the singer and her otolaryngologist to help identify subtle changes that may need attention or assurance that they are not out of the ordinary for a professional singer.

CONCLUSIONS

Our findings imply that the appearance of the larynx alone does not necessarily explain the apparent health or self-perceived vocal health of a professional singer. Although all singers self-identified as healthy, laryngeal pathology was relatively common, which possibly indicates a minimal impact on their singing voice and/or perception of vocal health. Most healthy singers appear to function normally, despite evidence of chronic irritation. Sustaining good vocal health is complex and that for which every singer strives. However, it is difficult for even professional singers, who are supposedly more aware of their vocal health, to reliably assess how their voice is functioning. Professional singers do not appear to have a strong

ability to evaluate their vocal health as defined by their assessment of vocal function using the SVHI and are unaware of the presence of pathology. This may be because of a difference in sensitivity in self-assessing vocal changes. Consequently, it is important for professional singers to obtain a comprehensive vocal examination while healthy to serve as a baseline and have a low threshold for seeking medical advice. Whether SVHI or laryngeal examination correlates better to true vocal health remains undetermined. Further research may explore the issue of vocal hygiene and its relation to perceived vocal health.

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