Laryngoscopic and Spectral Analysis of Laryngeal and Pharyngeal Configuration in Non-Classical Singing Styles

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Summary: Purpose. The present study aimed to assess three different singing styles (pop, rock, and jazz) with laryngoscopic, acoustic, and perceptual analysis in healthy singers at different loudness levels. Special emphasis was given to the degree of anterior-posterior (A-P) laryngeal compression, medial laryngeal compression, vertical laryngeal position (VLP), and pharyngeal compression.

Study Design. Prospective study.

Methods. Twelve female trained singers with at least 5 years of voice training and absence of any voice pathology were included. Flexible and rigid laryngeal endoscopic examinations were performed. Voice recording was also carried out. Four blinded judges were asked to assess laryngoscopic and auditory perceptual variables using a visual analog scale.

Results. All laryngoscopic parameters showed significant differences for all singing styles. Rock showed the greatest degree for all of them. Overall A-P laryngeal compression scores demonstrated significantly higher values than overall medial compression and VLP. High loudness level produced the highest degree of A-P compression, medial compression, pharyngeal compression, and the lowest VLP for all singing styles. Additionally, rock demonstrated the highest values for alpha ratio (less steep spectral slope), L1-L0 ratio (more glottal adduction), and Leq (more vocal intensity). Statistically significant differences between the three loudness levels were also found for these acoustic parameters.

Conclusions. Rock singing seems to be the style with the highest degree of both laryngeal and pharyngeal activity in healthy singers. Although, supraglottic activity during singing could be labeled as hyperfunctional vocal behavior, it may not necessarily be harmful, but a strategy to avoid vocal fold damage.

Key Words: Laryngeal hyperfunction–Supraglottic activity–Laryngoscopy–Singing voice–Nonclassical singers.

INTRODUCTION

Earlier studies have suggested that supraglottic activity may not necessarily be a sign of vocal hyperfunction or harmful behavior to vocal folds, but rather a normal and even desirable muscle activity.[1–9] Titze[10] offered an explanation for the possible positive effect of supraglottic compression. The author states that the source-filter interaction and the vocal tract inertance may be increased by narrowing the epilarynx tube in an anterior-posterior (A-P) direction. Inertance is an acoustic property of the accelerating or decelerating supraglottal air mass in the vocal tract which may favorably impact the vocal fold vibration and may allow for an efficient voice production that could possibly be associated with lower effort and a more resonant and stronger sound. Therefore, this A-P narrowing could constitute a benefit for vocal fold oscillation, vocal fold adduction, and subglottic pressures required for phonation.[10–12]

Although there is evidence showing that supraglottic activity could be desirable during singing, most studies have included small sample sizes, and none has assessed specific variables that may have an impact on supraglottic behavior. In a recent work, Mayerhoff et al[13] evaluated the degree of A-P and medial supraglottic laryngeal compression in healthy opera singers of different voice classifications during different pitches, loudness levels, and phonatory tasks. Results demonstrated that A-P compression was greater in males and specifically baritones during loud voice production and with phonation of the vowel /a/. Medial compression was also greater in male subjects and specifically tenors during loud phonation, during high pitch, and while producing the vowel /a/. Moreover, A-P compression was greater than medial compression. Regarding the relationship between A-P compression and loudness, Yanagisawa et al[6] obtained similar results in classical and nonclassical singing styles. Medial compression has also been found in classical singing, and other styles.[14–16]

Considering nonclassical singing styles, belting technique has been associated with relatively closed ventricular spaces, constricted pharyngeal diameters, and epiglottis tilted over the larynx.[5–7] In a recent investigation aimed to vocally assess rock singers who use growl voice and reinforced falsetto, laryngoscopy showed that most of the participants evidenced during singing a high vertical laryngeal position (VLP), pharyngeal compression, A-P laryngeal compression, and medial compression. None of them had any major vocal fold pathology.[17] Interestingly, rock singers did not show any

Accepted for publication May 6, 2014.
There is no financial support and the authors report no conflicts of interest.
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Journal of Voice, Vol. 29, No. 1, pp. 130.e21-130.e28
0892-1997/$36.00

http://dx.doi.org/10.1016/j.jvoice.2014.05.004

significant difference with pop singers (control group) for acoustic, perceptual, and functional assessment of speaking voice. This suggested that although rock singers presented with what appeared to be laryngeal and pharyngeal hyperfunctional, this did not seem to contribute to the presence of any major voice disorder.

Although earlier studies have demonstrated that supraglottic activity may not be pathologic during classical and nonclassical singing, they have not compared different singing styles produced by the same subjects. In addition, most of them have only evaluated laryngeal compression, not other features such as VLP or pharyngeal compression. The present study aimed to assess three different singing styles (pop, rock, and jazz) with laryngoscopic, acoustic, and perceptual analysis in healthy singers at different loudness levels. Special emphasis was given to the degree of A-P laryngeal compression, medial laryngeal compression, VLP, and pharyngeal compression. This work is a continuation of the recent investigation conducted by Mayerhoff et al.[13]

METHODS

Participants

Informed consent was obtained from 20 female pop singers. The average age of this subject set was 27 years, with a range of 25–31 years old. Inclusion criteria for this study included: (1) no history of voice problems in the past year, (2) no vocal fold pathology at the time of examination, and (3) at least 5 years of formal nonclassical singing training. None of the participants reported a hearing impairment. Although 20 subjects were recruited, eight of them did not meet the inclusion criteria because of vocal fold pathology found at the time of laryngeal endoscopy. Therefore, only 12 were included in the analysis. The average length of voice training was 8 years, with a range of 5–10 years. Participants were recruited from various vocal bands and conservatories. All were asked to undergo rigid videostroboscopy (Digital videostroboscopy system RLS 9100-B; KayPENTAX, Lincoln Park, NJ) to confirm the absence of laryngeal pathology. Flexible laryngoscopy (Olympus ENF type p4; Olympus, Center Valley, PA) with specific voice singing tasks (see below) was also performed to assess supraglottic activity during singing. Endoscopic laryngeal examinations were performed by three laryngologists who are coauthors of the present study (A.L., C.O., and P.C.). Intranasal topical anesthesia was used during transnasal endoscopy for all subjects. Topical anesthesia was used during rigid laryngeal endoscopy procedure only when needed because of gag reflex. This study was reviewed and approved by the University of Chile, School of Communication Sciences and Disorders Review Board.

Singing phonatory tasks

During the transnasal endoscopic examination, each participant was instructed to sing the song “Happy Birthday” in three different styles (pop, rock, and jazz). Participants were asked to produce each singing task at three loudness levels (medium, high, and low). Loudness was subjectively controlled by the singers and experimenters. The musical key of “Happy Birthday” was adapted to each singer’s vocal comfort. Participants were required to keep the same musical key during all singing phonatory tasks. This was also perceptually controlled by experimenters. All subjects were also strongly instructed to make vocal differences between singing styles and loudness levels. The flexible endoscope was placed near the tip of the uvula during singing. This position allowed a full view of the pharynx and larynx. The placement was set by securing the fiberscope against the alar cartilage of the nose with the laryngologist’s finger. A steady placement of the fiberscope is crucial because observation of laryngeal height adjustments and other laryngeal configurations can be affected by movement of the endoscope.

Visual evaluation of laryngoscopic samples

Four blinded judges (speech-language pathology graduate students with experience in singing voice and laryngeal endoscopic assessment), were asked to review the laryngoscopic examinations and rate the degree of A-P laryngeal compression, medial laryngeal compression, pharyngeal compression, and VLP on a 100 mm visual analog scale. To standardize the rating parameters and rating scales, the four judges participated in a 1-hour training session in videolaryngocopy examinations. For VLP, 1 = very low, 100 = very high; for pharyngeal compression, 1 = very wide, 100 = very narrow; for medial laryngeal compression, 1 = very open, 100 = very narrow; and for A-P laryngeal compression, 1 = very open, 100 = very narrow. All sound was removed from video recordings. Each laryngoscopic examination could be reviewed as many times as desired. A total number of 108 video samples (12 subjects × three singing styles × three loudness levels) were obtained. Additionally, 20% of samples were randomly repeated to determine whether judges were consistent in their perceptions (intrarater reliability analysis).

Audio recordings

All participants were recorded when performing the same singing phonatory tasks as during laryngoscopy (to sing “Happy Birthday” with three different styles at three different loudness levels). The duration of each recording session was approximately 15 minutes. A Focusrite Scarlett 8i-6 USB audio interphase (Focusrite Audio Engineering, High Wycombe, UK) and a Rode condenser microphone, model NT2-A (Rode, Long Beach, CA) were used to capture the voice samples. This microphone was selected on the basis that the manufacturer’s specifications include a flat frequency response from 20 to 20 000 Hz. The microphone was positioned 30 cm from the mouth of the participants who remained standing. Recording took place in an acoustically treated room and samples were recorded digitally at a sampling rate of 44 kHz and 16 bit. The capture and recording of voice signals were made using the software *Protools 9.0* (Avid Corporation, Burbank, CA). Audio signal was calibrated using a sustained vowel for further sound level measurements. The equivalent level (Leq) of this reference sound was measured with a sound level meter (Brüel & Kjær, model 2250; Brüel & Kjær Sound & Vibration