

Laryngeal Tension in Adolescent Choral Singing

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Abstract:

For years there has been speculation about whether singing in varying vocal styles may cause more tension in the voice. The subject of adolescent voice and the consequences of excess tension over a prolonged period have not been thoroughly examined. Examining adolescent vocal folds in motion while singing in varying styles can provide useful information to choral directors, voice teachers, and speech-language pathologists in regard to vocal health at this stage of development. Therefore, we investigated whether adolescent choral singers experienced differences in laryngeal tension in three different singing styles--traditional choral, music theater, and gospel.

Keywords: Vocal health | Singing | Adolescents | Laryngeal tension

Article:

Introduction

For years there has been speculation about whether singing in varying vocal styles may cause more tension in the voice. The subject of adolescent voice and the consequences of excess tension over a prolonged period have not been thoroughly examined. Examining adolescent vocal folds in motion while singing in varying styles can provide useful information to choral directors, voice teachers, and speech-language pathologists in regard to vocal health at this stage of development. Therefore, we investigated whether adolescent choral singers experienced differences in laryngeal tension in three different singing styles--traditional choral, music theater, and gospel.

Various vocal myths have given rise to a number of opposing methodologies in all aspects of singing. (1) Singing requires coordination that goes beyond speech, but the same mechanism used for speaking (and breathing, eating, etc.) is used for singing. A singer's abilities to open the glottis completely and renew the breath silently demands that an acquired high level of coordination is developed between laryngeal action and mechanisms of breathing. Superb coordination is developed between the laryngeal abduction/adduction muscles and the respiratory

muscles. During a complete inspiration, sudden glottal opening results from widely abducted vocal folds. These actions ensure efficient inspiration with sufficient air for easy subsequent voicing. (2) The type of speaking or singing demands placed upon the voice can likely affect these actions.

Adolescents form vocal habits in speaking and singing that can last for a lifetime. Current consensus, however, suggests that childhood voice instruction and performance are safe as long as attention is paid to gradual vocal development and the avoidance of vocal abuse. (3) Diligent avoidance of vocal abuse can help prevent voice disorder in an adolescent singer.

A voice disorder is a result of a combination of physiological activities, including poor respiration, phonation, and resonance. A disorder is present when an individual's pitch, quality, and loudness differ from the majority of similar people or when there is physical evidence of deviance. (4) Common disorders of vocalists may include upper respiratory infections (e.g., colds or laryngitis), overuse (e.g., hoarseness), vocal abuse, allergies, gastroesophageal reflux related voice abnormalities, and medication effects. Vocal misuse tends to be the result of an unconscious habit and is often challenging to treat, particularly when combined with personality factors.

Specific behaviors that are often cited as causal may be divided into activities that occur while speaking (e.g., loud talking or hard glottal attack) and those that occur as a result of non-speech vocal behaviors (e.g., grunting, throat clearing, loud, and hard laughing). (5)

Speaking or singing out of range can cause muscular tension that leads to abnormal voice. Vocal tension results from muscle tension in the area of the larynx. The interarytenoid muscles, those small muscles that control length, tension, and mass of the vocal folds for small changes in pitch, loudness, and quality, can react to stress, talking over music, or general body tension and produce a less than optimal sound. The external arytenoid muscles, the larger muscles surrounding the larynx, or the larger strap muscles of the neck, can also exhibit body tension affecting voice. These muscle fibers join with the interarytenoid muscles comprising the "voice box," and can affect larger changes in vocal pitch, loudness, and quality. The most common recognizable symptom of this type of misuse is speaking in a low-pitched voice or speaking too loudly over time. (6) Singing out of range, performing in a tessitura that is too high or too low for continual vocal performance, can cause vocal fatigue and swelling that may lead to vocal fold nodules. (7)

Certain styles of singing appear to develop vocal nodules in adults and put excessive pressure on vocal fold vibration. (8) These styles include rock, jazz, gospel, and most popular music styles where the singing is similar to shouting. Very few studies have examined the effects of varying singing styles on adolescent voices. (9) The most frequent laryngeal pathology for older school aged children and adolescents is the development of vocal fold nodules. (10) These small, bilateral growths on the external mucosa can result in a breathy and rough voice, and can become chronic over time without reduction of abusive speaking or singing, or without treatment of an underlying medical condition. (11) The most sensitive period for adolescents and vocal development appears to be during the "growth spurt" of puberty, generally occurring between the ages of 10-18 in females and 12-20 in males. (12) Although the vocal folds essentially have reached adult length following pubertal growth spurt, the connective tissues of the vocal folds may continue to increase in size and quantity into adulthood. (13)

Adolescents who invest time and energy in a vocal performance lifestyle need to know whether the style in which they are performing is harmful to their adult careers and how to keep their voices healthy. Performing adolescents are exposed to many aspects of singing that include melodic accuracy, auditory memory, and voice quality. Each of these characteristics of vocal music permits adolescents to be aware that their voice is an integral part of who they are. (14) Adolescents who receive inadequate or no voice training can be at increased risk for vocal problems. As vocal demands are placed on adolescents, they can compensate by using inappropriate techniques that are injurious to the vocal mechanism. Good choral music educators teach appropriate singing techniques to promote healthy speaking and singing voices.

The type or style of music selected by adolescents or their teachers of course plays a role in vocal health. A singer's repertoire should not exceed his or her control of the overall pitch range, points of transition between vocal registers, rhythmic complexity, lengthy phrases, loudness, or tone color. (15) A traditional goal of classically trained singing is the development of a consistent tone color across the range without abrupt shifts of register. (16) Avoiding inadvertent changes of vocal register is historically a problem for the adolescent singer, especially males. Vocal compositions with tessitura within the passaggio, mid-range pitches in a transition area between the chest voice and head voice, are extremely difficult for young singers.

Classical vocal repertoire is assigned by range, (17) tessitura, (18) tone color, (19) or a combination of these. Singers in choral ensembles are assigned to range-based sections (soprano, alto, tenor, bass), but both lyric and dramatic voices form an ensemble of voices. (20) This complex of voices may provoke some students to attempt to match sound levels produced by others in the ensemble that exceed their capability.

Three typical styles of music sung in middle and high schools are Broadway (music theater), gospel music, and classical choral music. The degree to which each can be abusive to the adolescent voice likely depends on the singer and his/her voice teacher. In the case of music theater written for adults (including belting), the adolescent can attempt to imitate a mature adult vocal sound with an immature vocal mechanism and the results may be damaging. (21) The many types/categories of gospel music can include growling, screaming, and increased glottal tension, depending on the style chosen by the singer. (22) Classical choral singing, derived from traditional Italian school bel canto practice, involves techniques that are taught by directors or teachers. (23) Koufman and colleagues found that college level choral singers had much less muscle tension and were more likely to be formally trained. (24) Choral singers who had formal vocal training showed lower muscle tension scores (less vocal/laryngeal work) than those who had none.

Although research with adult singers indicates that trained choral singers perform with less laryngeal tension, no such research had been conducted with adolescent singers. Therefore, the purpose of this study was to determine whether various singing styles are potentially harmful to the adolescent vocal mechanism. Additionally, the investigators obtained a detailed behavioral and acoustic profile of the adolescent speaking voice for comparison to the singing voice (a separate study). (25) Examining adolescent vocal folds in motion while singing in varying styles provides useful information for choral directors, voice teachers, and speech-language pathologists.

Method

The following research questions were addressed in the present study:

1. Did adolescent singers engage in behaviors that are detrimental to good vocal health?
2. Were there significant differences in laryngeal tension in the adolescent voice during the singing of three different styles of music?
3. Were there significant differences in the visual appearance of vocal abduction/adduction of the adolescent voice during the singing of three differing styles of music?
4. Were there significant differences in the degree of tension perceived by trained vocal musicians when listening to adolescents sing in three different vocal styles?

Participants

Participants for this study included 20 middle and high school adolescent students from a public school system in North Carolina. These students had all participated in choir, theater, or band at some point during their school career. Participants consisted of students with singing voices in premutation, during mutation, and postmutation vocal stages. Ages ranged from 11-17 years and included 13 female and 7 male participants.

Procedures

A university Applied Communicative Science Laboratory in was set up as a series of stations. At Station 1, participants completed a vocal health questionnaire with simple questions about their medical histories and about their vocal and music experiences. Students indicated whether they were being treated for allergies, gastroesophageal reflux disorder, asthma, anorexia, or bulimia, and whether they lived in a home with consistent smoke. Other questions related to daily use of the voice, such as cheerleading, screaming most days, extensive talking on the phone during the day, speaking loudly all the time, and singing along with an iPod all the time. The last section of the questionnaire addressed whether students were a part of a choir, theater class, or band; if so, they were asked whether they sang in more than one musical style.

TABLE 1. Results of Vocal Health Habits Survey.

Question	N (Yes Response)	% (Yes Response)
Warm-up before singing	20	100
Listen to music daily	20	100
Sing with your iPod daily	19	95
Currently exercise daily	16	80
Currently sing in choir	15	75
Yell frequently	15	75
Continuously clear throat	14	70
Eating late frequently	13	65
Currently under stress	10	50
Participate in musicals	6	30
Currently live in a smoky environment	5	25

Whisper frequently	5	25
Hoarse frequently	5	25
Participate in cheerleading	4	20
Experiencing vocal fatigue	4	20
Currently take antacids	4	20
Currently have a sore throat	4	15
Currently having vocal difficulty	3	15
Warm down after singing	3	15
Currently dehydrated	2	10
Currently taking medications	2	10
Currently taking voice lessons	2	10
GERD currently	0	0
Anorexia currently	0	0
Bulimia currently	0	0

At lab Station 2, each student's vocal acoustic parameters were tested for another study. (26) At lab Station 3, visual imaging of vocal fold vibrations were recorded via nasendoscopy while students sang. The actual images of the students' moving vocal folds were acquired using a Welch Allen flexible rhinolaryngoscope, Model RL-25 as part of the KayPentax Digital Video Stroboscopy System (LVES), Model 9295. A microcamera on the nasal endoscope recorded the images.

Students were seated in a comfortable chair in a living room type setting and given a mist of saline solution in the nasal area. The saline solution was a safe topical spray used for lubrication during the procedure. The spray moistened the nasal cavity and throat to allow the fiberoptic scope to be placed above the vocal folds and avoid the "gag" reflex. The procedure was carefully explained to each student to ensure that s/he was calm and relaxed before singing. After the scope was in place, each student sang three short examples of music: a choral composition ("Pueri concinite" by Von Herbeck), Broadway musical composition ("Tomorrow" from Annie by Stoupe, Charmin, and Mecehan), and a gospel music composition ("He never failed me yet" by Robert Ray).

TABLE 2. Supraglottic Activity Rating and Assessment.

Style	N	No Tension (rated 0)	Slight Tension (rated 1)	Increasing Tension (rated 2)	Higher Tension (rated 3)	Mean*	SD	<1.00*
CL	19	9	10	0	0	0.53	.51	100.0
Gos.	19	2	12	5	0	1.16	.60	73.7
MT	19	0	11	5	3	1.58	.77	57.9

CL = classical, Gos. = gospel, MT = music theater.

* Assessments under 1.00 indicate a lack of tension in the vocal folds.

The LVES recorded vocal fold movements in slow motion to allow detection of abnormalities in the movement of the vocal folds. Movement characteristics examined were glottal closure patterns, mucosal wave, tissue patterns, and asynchronous vibration. Each singer's stroboscopy

session was video and audio recorded digitally for later analysis by two speech-language pathologists.

The stroboscopic videos were analyzed using a procedure common in speech-language pathology and otolaryngology protocols. (27) The investigators were trained to rate the vocal fold movement using the Wisconsin LVES rating protocol via a KayPentax training video recording. Nine characteristics of vocal fold activities were rated during speaking and singing.

- 1) Supraglottic activity was rated on a five-point scale, ranging from 0 (normal) to 5 (dysphonic-folds were not visible).
- 2) Vertical level of vocal fold approximation was rated on a five-point scale, ranging from 0 (on glottic plane) to 5 (off plane).
- 3) Amplitude was rated on the following five-point scale: 0 = normal, 1 = slightly decreased, 2 = moderately decreased, 3 = severely decreased, 4 = barely perceptible, and 5 = no visible movement.
- 4) Vocal fold edge was rated on a five-point scale, ranging from 0 (smooth/straight) to 5 (rough/irregular).
- 5) Mucosal wave was rated on the following five-point scale: 0 = normal, 1 = slightly decreased, 2 = moderately decreased, 3 = severely decreased, 4 = barely perceptible, and 5 = absent.
- 6) The nonvibrating portion of the vocal folds was rated on the following five-point scale: 0 = none, 1 = 20%, 2 = 40%, 3 = 60%, 4 = 80%, and 5 = 100%.
- 7) Phase symmetry was rated on the following five-point scale: 0 = regular, 1 = irregular during and/or beginning tasks, 2 = irregular during extremes of pitch or loudness, 3 = irregular during 50%, 4 = generally irregular 75%, and 5 = always irregular.
- 8) Phase closure was rated on the following -5 to 5 scale: -5 = open phase predominates (whisper dysphonia), 0 = normal, and 5 = closed phase predominates (hyperadduction).
- 9) Each student's glottic closure was assigned one of seven available types, including complete, posterior, irregular, spindle, anterior, hourglass, and incomplete.

The LVES video recordings were evaluated on all features. Any tension or abnormality in the vocal fold configuration was identified and noted. The video recordings were rated by the research team, which consisted of the researcher, an experienced speech-language pathologist, and a speech-language pathology graduate student. All raters were trained by the experienced speech-language pathologist. Each rater looked at 57 combinations of vocal fold motion independently. There was disagreement only four times out of 57 instances (0.7%). Each of these disagreements was on different students. After reviewing the video, researchers reached an evaluation consensus for all of the combinations of vocal fold motion.

Singing voices were recorded using a Shure, Model 5121 microphone and a high bias Sony audio recorder. A microphone was placed one foot from each student. The students sang the composition with an accompaniment that had been digitally recorded on a CD to obtain consistency among subjects. Students were audio recorded for future evaluation.

Two judges, trained musicians with extensive experience in working with adolescents' voices, evaluated the recorded performances in terms of aurally detected vocal tension. Correlations between the two judges' ratings ranged from $r = .84$ for perceptual ratings of classical choral singing, $r = .92$ for gospel music singing, and $r = .78$ for music theater singing.

Results

1. Did adolescent singers engage in behaviors that are detrimental to good vocal health?

Results of the Vocal Health Habits Survey are shown in Table 1. The highest ranking deleterious behaviors are yelling frequently (75%), continuously throat clearing (70%), eating late frequently (65%), and currently under stress (50%). Other damaging behaviors include living in a smoky environment (25%), whispering frequently (25%), experiencing hoarseness (25%), and sore throat (15%). Four students also participated in cheerleading.

2. Were there significant differences in laryngeal tension in the adolescent voice during the singing of three different styles of music?

This question was answered with a qualified yes as the results of the stroboscopy (LVES) indicated that more tension was found in the singing of the music theater style. Of the nine vocal fold motion characteristics examined, only assessments of supraglottic activity revealed significant differences. Assessment of glottic closure did not reveal any significant differences; however, some aspects were atypical. All of the aspects of the remaining vocal fold assessments were normal in every subject for each of the types of singing categories. This included vertical level of vocal fold approximations, amplitude, vocal fold edge (1 irregular, 18 normal), mucosal wave, nonvibrating portion, phase symmetry, and phase closure.

Supraglottic activity was assessed to examine excessive ventricular fold movement during phonation. It was rated on a scale of 0-5 where 0 was considered normal. As can be seen in Table 2, 100% of the subjects sang in the classical style with little tension. Only 73.7% sang in gospel style with a small amount of tension and 57.9% sang in music theater style with little tension. Singing in classical style produced the least amount of stress on the vocal mechanisms.

A Friedman Analysis of Variance by Ranks indicated that there was a significant difference in the amount of supraglottic activity ($X^2 = 18.11$, $p = 0.0001$). To further determine where significant differences occurred, a posthoc Wilcoxon Signed-Rank Test was computed on all pairs. Classical and gospel ($p = .0024$) and classical and music theater ($p = .0005$) styles were significantly different from each other; gospel and music theater were not. Thus, there was significantly more vocal tension in both gospel and music theater styles compared to singing in classical singing style.

3. Were there significant differences in the visual appearance of vocal abduction/adduction of the adolescent voice during the singing of three differing styles of music?

It appeared that vocal fold abduction/adduction was within normal limits, but often laryngeal tension was so severe it was not possible to view the folds. The glottis muscle contracted much tighter when singing in music theater style as opposed to classical choral. The suggestion that singers "sit" or "press" on their vocal folds while belting was indeed shown in the video. The arytenoids were definitely covering the folds in a far more severe way during the music theater and gospel styles than during the classical style. For some students the false vocal folds were pulled into use on the music theater and gospel styles of singing but not on the classical style. The classical choral style was seen to have a much more relaxed musculature.

4. Were there significant differences in the degree of tension perceived by trained vocal musicians when listening to adolescents sing in three different vocal styles? The scores from the two judges were averaged and analyzed by a Friedman Analysis of Variance by Ranks. There were no statistically significant differences in the perceived vocal tension among the three styles, although slightly more tension was perceived during gospel performances. Data from only 15 participants were available because the remaining student voices were too soft to be heard on the recording.

Discussion

Screaming is a very destructive vocal activity, and seventy-five percent of the students indicated that they yell frequently. In particular, cheerleading requires extensive screaming under the worst possible physical and environmental circumstances. It is interesting to note that three subjects, who were cheerleaders, were given a letter of referral to an ear, nose, and throat specialist for the appearance of incipient nodules. Subsequent studies should be conducted to follow up on students who continue that activity without any vocal training in breath management. It would be wise to expose cheerleading coaches to good vocal management skills to understand what is abusive to the voice during practices and games.

Seventy percent of the students continuously clear their throat. Throat clearing becomes a habit that can contribute to the swelling of the vocal folds. As the folds swell, the individual feels the need to cough or clear the throat even more, aggravating the situation further. Throat clearing is a problem that should be addressed on an individual basis.

Sixty-five percent of the students admitted to eating late on a frequent basis. This can lead to gastrointestinal problems. Although none of the participants in this study indicated they suffered from gastroesophageal reflux (GERD), anorexia, or bulimia, such problems can develop. Gastric reflux can cause respiratory infections, asthma, or apnea. (28) There is a marked increase in digestive problems among adolescents that also include anorexia and bulimia. (29) All of these problems involve stomach acid eroding the throat lining and causing damage to the vocal folds. Issues of GERD and any other physical or emotional problems experienced by the young singer should be considered when determining vocal difficulties.

Survey responses indicated that fifty percent of the students said they were under stress. We know that stress can affect the entire body in many damaging ways. Stress is a psychological experience that manifests in physiological systems. Students at this age undergo many hormonal changes that can add to the stress level and directly affect the voice. This study was conducted just prior to the December holiday season, and therefore perhaps additional stress was added to normal school and performing schedules.

Twenty-five percent of the students live in smoke-filled homes and the damaging effects of tobacco smoke are indisputable. Smoke exposure can cause mild edema and generalized inflammation through the entire vocal tract. The students have no choice but to live in the environment provided to them by their parents; this adds some additional problems to students who are allergic to smoke and have to remain in that environment on a continuous basis.

LVES imaging results indicated more tension in the music theater style of singing. This contradicts findings of the study of adults done by Koufman and colleagues, which concluded that gospel singing resulted in higher degrees of muscular tension. (30) In that study, adults were asked to sing in one style and were rated against each other. In this study, the students sang four measures of three styles of music. This may not have allowed them enough time to sing in a true gospel singing style, which may have led to slightly different results. Additionally, they were not in a performance hall or religious setting, both of which may lead to more tension.

The vocal perception judges did not hear significant differences in the degree of tension perceived by listening to adolescents sing in three different musical styles, although they did hear slightly more tension in the gospel performances. It was very difficult to hear some of the subjects due to the buzz of the strobe light, but the listeners did not report this as a problem. Several participants sang too softly to be heard. When LVES is used for diagnosis of a voice disorder, topical anesthesia is sometimes used for patient comfort, but it was not used in this study of normal singers, and that may have caused some discomfort. It is likely that any singer not used to an endoscope in the mouth/pharynx might alter his/her normal positioning for singing.

In future studies, the students should sing in slightly longer segments. This would enable them to become more comfortable in allowing them to express themselves well in each style. A larger and even more diverse group of singers would provide more data. Also, future research could examine acoustic and physiologic measures of tension, in addition to behavioral/listener ratings of tension. This would provide a clearer indication of the tension involved in the three styles. Although further studies are necessary to understand the adolescent voice, choral teachers should practice caution when teaching music theater and gospel pieces of music to the adolescent age group. That does not suggest that these styles should not be taught or that they can not be sung in a healthier vocal manner, (31) but since laryngeal growth is taking place one should not teach exclusively in this style, particularly for prolonged periods of time. As with any singing, vocal warm up is essential.

Choral teachers are responsible for the vocal health of young singers and should do their best to teach them how to sing in a healthy manner. They should help adolescents take care of their voices in order to have them in good working condition for the rest of their lives. This would include knowledge of the development of the human voice over time and the awareness of the rapid changes of the adolescent voice over a short period. It is important as vocal music educators to remember that children's vocal mechanisms are still developing and students should not push or stress their voices in an attempt to emulate the adult sound.

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