Acoustic Analysis and Electroglottography in Elite Vocal Performers

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Summary: Background. Acoustic analysis of voice (AAV) and electroglottography (EGG) have been used for assessing vocal quality in patients with voice disorders. The effectiveness of these procedures for detecting mild disturbances in vocal quality in elite vocal performers has been controversial.

Objective. To compare acoustic parameters obtained by AAV and EGG before and after vocal training to determine the effectiveness of these procedures for detecting vocal improvements in elite vocal performers.

Materials and Methods. Thirty-three elite vocal performers were studied. The study group included 14 males and 19 females, ages 18–40 years, without a history of voice disorders. Acoustic parameters were obtained through AAV and EGG before and after vocal training using the Linklater method.

Results. Nonsignificant differences ($P > 0.05$) were found between values of fundamental frequency (F_0), shimmer, and jitter obtained by both procedures before vocal training. Mean F_0 was similar after vocal training. Jitter percentage as measured by AAV showed nonsignificant differences ($P > 0.05$) before and after vocal training. Shimmer percentage as measured by AAV demonstrated a significant reduction ($P < 0.05$) after vocal training. As measured by EGG after vocal training, shimmer and jitter were significantly reduced ($P < 0.05$); open quotient was significantly increased ($P < 0.05$); and irregularity was significantly reduced ($P < 0.05$).

Conclusions. AAV and EGG were effective for detecting improvements in vocal function after vocal training in male and female elite vocal performers undergoing vocal training. EGG demonstrated better efficacy for detecting improvements and provided additional parameters as compared to AAV.

Key Words: Acoustics–Phonation–Voice–Electroglottography–Larynx.

INTRODUCTION

It has been reported that excessive vocal activity and lack of knowledge about techniques and strategies for caring and management of voice can cause trauma to the vocal folds.[1] Also, factors such as inadequate acoustics, background noise, and vocal rest time can indirectly affect voice.[2,3]

In 1991, Koufman[4] described a vocal usage classification system including the following categories: elite vocal performer, level I (actors-singers): This category includes people in whom even a slight aberration in the voice may have dire consequences; most singers and actors are in this group, and the opera singer is the quintessential level I performer; professional voice user, level II (clergy, teachers, etc); nonvocal professional, level III (doctors, lawyers, business, sales, etc); nonvocal-nonprofessional, level IV (factory workers, dancers, and instrumental musicians).

Dysphonia has a prevalence of 3%–9% in the general population[5] and is more common in females (6:4).The most common etiology of dysphonia is vocal misuse or abuse.[6–8] Prevalence in elite vocal performers and professional voice users ranges from 27% to 80%.[9]

Methods of vocal training are techniques for achieving an adequate balance of vocal function, elaboration of mental concepts concerning keeping variations of vocal loudness under control, especially during vocal performances, self-awareness of voice production, and development of vocal performance in a manner suitable and efficient for artistic communication.[10]

Linklater published a vocal training method in 1976.[11] This method has been used in several drama programs in the United States at professional and academic levels. The main purpose of the method is to free the natural voice and to use it as a psychophysical instrument. The method provides tools for avoiding muscle tension during voice production, progressive breathing and relaxation exercises, and body awareness. The goal is to promote proper and efficient vocal use. The benefit of practicing vocal techniques in elite vocal performers and professional voice users can be assessed by subjective evaluations using perceptual examinations. However, several objective methods have been reported including acoustic analysis of voice (AAV), aerodynamic measurements, and electroglottography (EGG), among others.[11]

AAV is an objective measurement of voice, wherein the variability in frequency and amplitude (jitter and shimmer, respectively) can be reliably assessed. Also, the energy ratio of the harmonic components and the number of vibrations of the vocal cords in a cycle (F_0) can be determined.[12–14]

F_0, shimmer, and jitter are considered reliable acoustic parameters for detecting slight variations in voice quality, which can help to differentiate pathological from normal voices.[15] These parameters have been used for estimating the severity of vocal disorders such as vocal nodules, Reinke edema, and other vocal

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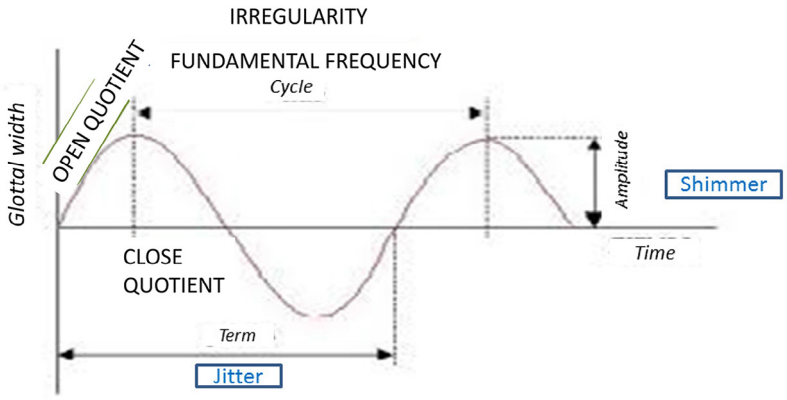

FIGURE 1. Graphic representation of the opening (abduction) and closing (adduction) motions of the vocal cords during voice production. The vertical axis or the glottal width represents the lateral excursion of one vocal cord and the horizontal axis indicates the time. The horizontal arrows on top are delimiting the cycle. The horizontal arrows at the bottom indicate the term. The vertical arrows indicate amplitude. The acoustic parameters provided by acoustic analysis of voice (fundamental frequency, shimmer, and jitter) and electroglottography (open quotient, closing quotient, irregularity, and also fundamental frequency, shimmer, and jitter) are shown in relation to the features of the cycle.

pathologies associated with vocal abuse and also for monitoring the outcome of different voice therapies.[12–15]

Recent reports have questioned the reliability of these acoustic measurements. Brockmann-Bauser and Drinnan[16] analyzed the relationship between jitter and shimmer and severity of dysphonia as perceptually evaluated and did not find a significant association between these parameters in pathological voices. Moreover, these authors reported that most of the voices affected by mild to moderate dysphonia showed values of shimmer and jitter within normal limits.

In contrast, vibrational patterns of the vocal folds can be monitored indirectly by EGG in which the improvement of certain parameters returning to normal ranges can be taken as an evidence of a positive therapeutic response in cases of vocal disorders.[17] EGG has the advantage of assessing the glottal wave without interference of the supraglottal activity or background noise because it captures vibrations directly above the thyroid cartilage.

Electroglottographic analysis is focused on the glottic cycle. Open quotient (OQ) is defined as the relation between the duration of the opening phase in a complete glottis cycle and the contact quotient, which is an indicator of the vocal fold's closing phase.[18,19] A decrease in mean contact quotient suggests a glottal insufficiency, whereas an increase in this quotient suggests a hyperfunctional glottis. Other parameters such as shimmer and jitter are related to vocal stability, and they can also be obtained by EGG (see Figure 1).

Recently, EGG has been used for analyzing the behavior of the vocal folds during phonation in normal voice, especially in singers of various musical genres.[20] Differences in OQ and F_0 parameters have been reported depending on the musical genre and the singer's vocal range. Moreover, EEG has been reported as a reliable tool for detecting vocal disturbances and following up the clinical course during vocal treatment.[21–24]

The purpose of the present study is to compare acoustic parameters obtained by AAV and EGG before and after a period of vocal training in elite vocal performers to assess the effectiveness of these procedures for detecting mild improvements in phonatory or vocal control, which can be described as the ability to keep variations of vocal loudness under control during vocal performances.

MATERIALS AND METHODS

A prospective cohort study was carried out from August 2014 to July 2016 at the Instituto Nacional de Rehabilitación in Mexico City. The protocol was approved by the internal review board of the institute.

Elite vocal performers attending a 3-month vocal training course following the Linklater method at the Center for Studies on the Use of Voice in Mexico City were invited to participate in the study. The Center for Studies on the Use of Voice is certified by the Institute of Fine Arts of Mexico and has provided vocal training for elite vocal performers for over 10 years. The protocol and the procedures involved were carefully explained to all potential participants. Thirty-eight subjects agreed to be included in the study group and signed an informed consent. All subjects underwent a clinical evaluation of voice and a videonasolaryngoscopy before being included in the definitive study group. Four subjects were excluded because they had a history of voice disorder. One more subject was eliminated because he did not finish the evaluations. A total of 33 subjects were finally included in the study group. Gender was distributed as follows: 19 females and 14 males. Age range was 18–40 years old. The median age was 30 years in the female group and 25 years in the male group. All subjects were elite voice performers, either singers or actors or both. All subjects had been professional elite voice performers for less than a year.

All subjects underwent a flexible videonasolaryngoscopy, which was performed by the same experienced phoniatrist (first author of this paper). None of the subjects demonstrated laryngeal pathology. The study group underwent AAV and EGG assessments before the initiation of the vocal training period and at the end of it.