Position of the larynx during lyrical singing in professional and amateur female singers: Preliminary results

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The aim of this study was to analyze the position of the larynx of professional and amateur singers during singing using measurements of the longitudinal distance between vocal folds and the hard palate. In the study 36 female singers were analyzed; 18 of them were professional singers and 18 were amateur, classified as soprano or mezzo-soprano. In order to obtain anatomical images, each participant underwent video-fluoroscopy, being instructed to sing vocalizations in do, re, and mi major with an extension of one octave with the vowels “A,” “I,” and “U” sustaining the superior note. Descriptive statistics were adopted. There was no difference in the longitudinal distance between the vocal folds and the hard palate between sopranos and mezzo-sopranos in either the amateur or the professional group, and when the two groups were compared, identical values were detected. Amateur singers showed, while in rest, they had a shorter distance in the vowels “A” and “U” in tones re and mi and in the vowel “I” in tones do, re, and mi. Professional singers had the largest distance between the vocal folds and palate compared to the rest in all images, demonstrating the domination of extrinsic muscle adjustments for the production of singing voice.

Keywords: voice quality; voice training; position of the larynx; professional singers; amateur singers

The characteristics of the singing voice depend on the anatomofunctional interaction between the components of the larynx and of the vocal tract, influenced by the morphophysiological particularities of each individual associated with acquired factors such as vocal well-being and the phonoarticulatory adjustments, and the adjustments of the extrinsic musculature of the larynx.
achieved with speech therapy and singing work for voice enhancement (Lovetri et al. 1999).

The physiological bases of singing and the mechanisms of the singing voice can be investigated by various methods in order to permit the analysis of vocal production (Shipp and Izdebski 1975, Sundberg 1974, Morozov 2002, Dmitriev 2004). Over the last few decades, computerized programs have been used in order to obtain normative data, a better acoustic comprehension, documentation and monitoring of the efficacy of training, and an instrument for the early detection of vocal and laryngeal problems of the singing voice (Sundberg 1977, Titze 2001). Analysis of radiological images of singers during singing has confirmed that each voice type has a determined length of the vocal tract, showing conformity between vocal classification and position of the larynx (Dmitriev 2004). After a certain time of training, singers, often unconsciously, maintain their larynx in a determined position in their neck, leading to a shorter or longer vocal tract. The dimensions of the vocal tract are influenced by individual morphology and by articulatory adjustments and are thought to be relevant for the characteristics of the singing voice and possibly for vocal classification (Roers et al. 2009a, 2009b).

In addition to the individual morphophysiological differences, voice tests used for the analysis of the source and filter, time, and type of training of the singing voice, as well as being a professional or amateur singer, among other aspects, seem to influence the mode of utilization of the phonoarticular structures for sound production (Pehlivan and Denizoglu 2009, Iwarsson and Sundberg 1998).

Despite the very large number of aspects that act on the production of the different qualities of the singing voice, it is necessary to identify and standardize the more relevant ones for a better understanding of the cause and effect factors related to the singing voice, providing guidance for the work of voice enhancement, also taking into consideration the individual morphophysiological limits. Based on the hypothesis that movement of the larynx differs among singers with distinct vocal experience, the aim of the present study was to analyze the position of the larynx of professional and amateur singers during singing, using measurements of the longitudinal distance between vocal folds and the hard palate.

**METHOD**

**Participants**

Participants were 36 female singers from choirs and soloists from the region; 18 of them were professional singers and 18 were amateur singers. There
were 9 sopranos and 9 mezzo-sopranos in each group. The average age was 33, with a minimum of 18 and a maximum of 45 years old. All of the selected participants were in the phase of vocal efficiency (after voice change and before menopause), were nonsmokers, and did not show any laryngeal and/or hormonal change (Boulet and Oddens 1996).

**Materials**

*Philips*-BV equipment was used for the research (Pulsera, Amsterdam, The Netherlands), linked to the image recording apparatus *Philips* MDVDR-100- Medical DVD Recorder (Amsterdam, The Netherlands).

**Procedure**

All singers were submitted to evaluation of the dynamic physiological image of the larynx by videofluoroscopy. During examination, each participant remained sitting comfortably in a chair in a profile position in relation to the radiation ampoule. A five-cent real coin was fixed on a tiara placed on the singer’s head to serve as a fixed point which was used as a parameter for the measurements. Each participant was first instructed to remain silent during the videofluoroscopy procedure. Next, each one was asked to sing the vocalization, which involves an extension of one octave, with the vowels “A,” “I,” and “U,” in the do, re, and mi tones, sustaining each time the higher note (see Figure 1).

Ten images of each singer were selected using the *Vegas* software, one of them obtained at rest and nine obtained during the execution of vocalization, one for each vowel in do, re, and mi. The longitudinal distance between the vocal folds and the horizontal lamina of the hard palate was measured in each image and recorded in millimeters with the *ImageJ* software always by the same examiner, who was trained for this analysis. For data analysis, we adopted descriptive statistics.

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**Figure 1.** Vocalization used during the exam.
RESULTS

The results of the measurements showed that, at rest, the mean longitudinal distance from the vocal folds to the hard palate in amateur singers was 70.97 mm for the sopranos and 68.08 mm for the mezzo-sopranos. During singing, the mean ranged from 65.75 to 71.69 mm for the sopranos and from 63.24 to 69.83 mm for the mezzo-sopranos (see Table 1).

In the professionals, the distance from the vocal folds to the hard palate at rest was 63.95 mm for the sopranos and 65.75 mm for the mezzo-sopranos. During vocalization, the mean ranged from 70.47 to 72.8 mm for the sopranos and from 70.68 to 75.56 mm for the mezzo-sopranos (see Table 2).

Comparing the overall means of the amateur singers to the professional singer groups, at rest, in each of the top notes vocalized, we can see that the amateur singers presented a shorter distance in the vowel “A” and “U” in re and mi and in the vowel “I” in all tones. The professional singers showed a greater distance in all images (see Table 3).

Table 1. Means of length of the vocal tract of amateur singers.

<table>
<thead>
<tr>
<th>Voice classification</th>
<th>Mean of length of the vocal tract (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rest “A”do “A”re “A”mi “I”do “I”re “I”mi “U”do “U”re “U”mi</td>
</tr>
<tr>
<td>Soprano</td>
<td>70.97 71.69 71.07 70.79 66.69 66.44 65.75 69.87 69.45 67.81</td>
</tr>
<tr>
<td>Mezzo-soprano</td>
<td>68.08 69.83 66.11 68.05 67.74 67.52 63.24 69.34 67.00 65.66</td>
</tr>
</tbody>
</table>

Table 2. Means of length of the vocal tract of professional singers.

<table>
<thead>
<tr>
<th>Voice classification</th>
<th>Mean of length of the vocal tract (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rest “A”do “A”re “A”mi “I”do “I”re “I”mi “U”do “U”re “U”mi</td>
</tr>
<tr>
<td>Soprano</td>
<td>63.95 70.99 72.80 72.33 71.43 71.38 70.47 72.48 72.42 70.50</td>
</tr>
<tr>
<td>Mezzo-soprano</td>
<td>65.75 72.04 73.37 73.04 71.29 72.03 71.02 75.58 75.56 70.68</td>
</tr>
</tbody>
</table>

Table 3. General means of length of the vocal tract of amateur and professional singers.

<table>
<thead>
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<th>Voice classification</th>
<th>General mean of length of the vocal tract (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rest “A”do “A”re “A”mi “I”do “I”re “I”mi “U”do “U”re “U”mi</td>
</tr>
<tr>
<td>Amateur singers</td>
<td>69.52 70.76 68.59 69.42 67.21 66.98 64.49 69.61 68.22 66.73</td>
</tr>
<tr>
<td>Professional singers</td>
<td>64.85 71.56 73.09 72.69 71.36 71.71 70.75 74.03 74.04 70.59</td>
</tr>
</tbody>
</table>
DISCUSSION

Improvement of joint work between speech therapists and singing teachers is necessary to refine the quality of the singing voice, considering the methods of evaluation and the respective vocal training. Within this context, we emphasize the need for singing teachers to understand the anatomophysiological basis of the production of determined sounds in order to facilitate students’ learning, which is often limited to auditory perception and to trial and error attempts (Lovetri et al. 1999).

Complementing the perceptive-auditory evaluation with visual and quantitative analysis of vocal production by means of laryngeal images (Roers et al. 2009a, 2009b, Lovetri et al. 1999) it tends to favor the learning and refinement of singing voice and may contribute to the scientific sphere, allowing methodological reproduction and the establishment of normative and reference values for this population.

The professional singers maintained the larynx below the rest position during vocalization for all vowels and tones, with a significant difference for the vowel “U” in the do and mi tones. According to the vocal classification, the soprano professionals had shorter vocal tract during the singing voice when compared to mezzo-sopranos in the same condition, in agreement with the study of Roers et al. (2009a, 2009b) in which such significant difference was attributed mainly to the length of the pharyngeal cavity. However, the professional singers, both sopranos as mezzo-sopranos, presented the greatest distance between the vocal folds and the hard palate compared to the rest moment in all images, inferring that the technique of singing and training time promoted the field of extrinsic adjustments for a long-term feature associated with more serious tone and vowels employed, reflecting the lower position of the larynx and stretching the vocal tract during the singing.

On the other hand, the amateur singers did not present the same pattern as observed in the professionals; sopranos had a shorter distance compared to the rest in the vowel “A” in mi and the vowels “I” and “U” in all tones. The mezzo-sopranos had a shorter distance in the vowels “A” and “U” in re and mi and vowel “I” in all tones. These results may be related to the more acute pitch and to the articulatory nature of the vowel “I,” whose production involves anteriorization of the tongue accompanied by laryngeal elevation.

Considering the importance of improving the methods for evaluation and the teaching-learning methods, more studies are needed in the area, including the recruitment of a control group consisting of non-singers in order to compare the morphophysiological findings involved in vocal production and
to establish normative values that might be associated with perceptive-auditory evaluation.

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References