

Aspects of ageing on professional opera singer's voice – preliminary findings

Authors' contribution

A – Study Design
B – Data Collection
C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
G – Funds Collection

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ABSTRACT:

Objectives: The main goals of this study were to assess the most significant morphological changes and acoustic measures for the ageing process of a professional opera singer's voice.

Design: This investigation included 58 healthy professional opera singers, who were compared with 42 young opera singers from the control group.

Methods: All participants underwent a voice assessment protocol: ENT specialist examination and speech therapist evaluation. Acoustic parameters and subjective observations were obtained and analysed.

Results: Fundamental frequency (Fo) level was distinctly decreased in the case of older female singers, but Fo in older male singers had stable levels in comparison to that in younger singers. Older singers were found not to have substantially different values of jitter than younger ones. Maximal phonation time (MPT) was longer in the older women's group when compared to the younger singers, but not relatively different in the men's group. Shimmer value presented no age-related change. Morphological changes seem to correlate with the age of subjects.

Conclusions: The main characteristic of voice change with age was a decreased Fo level among older female professional singers and rather stable Fo levels in male singers. This study gives preliminary results on the ageing of voice in the population of professional opera singers

KEYWORDS:

ageing, fundamental frequency, jitter, opera singers

INTRODUCTION

Voice is one of the most important features of the human being, but unfortunately ageing affects both the function and the anatomy of vocal folds. Several structural changes, such as ossification of the laryngeal cartilage, connective tissue damage, and neurovascular deterioration contribute to presbiphony [1–5]. Vibratory properties of vocal folds are diminished by the thinning of superficial lamina propria. Atrophy of thyroarytenoid muscle can cause bowed vocal folds, prominence of vocal process and a spindle-shaped glottal gap, which are common findings in the senile larynx [9].

Characteristics of ageing voice were widely investigated in the literature. The extent of changes differs significantly according to gender, usually occurring earlier among men [9]. A number of studies showed that in the male population fundamental frequency (F0) decreases over time, until the 5th decade, with a gradual rise afterwards [10]. Furthermore, the gradual decrease of F0 during women's life was found to be the most significant change [3, 7–9].

Voice perturbations are other important elements of voice characteristic. Vocal folds vibrations (jitter) and irregularity of glottic closure (shimmer) are usually used to define them. In the case of jitter, previous studies were inconclusive. Some of them have proven an

increase in jitter with age [21], but others showed no age effect [22]. In her interesting study, Ramig suggested that jitter changes might be related to the general health condition rather than chronological age [5]. Also, for shimmer some inconsistencies were found. Few studies have shown the ageing effect on shimmer in men and women [21], while others only in the male population [22].

A number of studies address the protective aspects of vocal training and singing on voice ageing. The singer's voice was found to be less rough and have better perceptual quality compared to that of non-singers [12]. Furthermore, singing was related to increased maximal phonation time (MPT) and vocal range [13, 14]. The study conducted among professional female singers (between 65–85 years old) proved a significantly higher F0 frequency than in the group of non-singers [15]. Particularly, compared to non-singers in acoustic analysis, male and female singers did not present any age-related changes in the mean speaking fundamental frequency (SFF) [20]. A study conducted by Lortie et al. pointed out the moderating effect of frequent singing on most of the acoustic parameters of ageing voice [16].

Undoubtedly, differences in the ageing voice of male and female singers are also worth attention. Vocal register and voice seem to correlate with the level of sex hormones, similarly to height and fat distribution [17, 18]. Professional female singers were

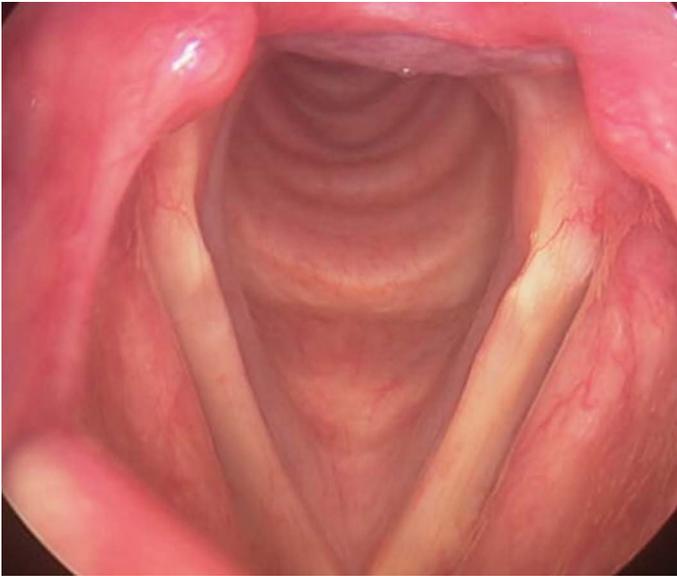


Fig. 1. Vocal folds discoloration in posterior third.



Fig. 2. Spindle-shaped glottal gap.

reported to lose the ability to reach high registers, their voice lost brilliance and vocal intensity after menopause [23]. In her report that, Boulet stated that among surveyed professional singers, female vocalists experienced physiological changes at a stronger level around the 5th decade which may, in turn, affect their singing ability [23].

There is lack of research which aims to predetermine changes due to physiological ageing of professional singers.

The idea behind this paper is to compare the vocal findings among groups of opera singers (of ages between 65 and 80, female and male), and younger singers. We attempted to assess the morphological changes and acoustic measures most significant for the ageing of a professional voice.

We asked the following questions:

- What are the morphological changes in the senile larynx of a professional opera singer?
- Which acoustic measure changes with the age of professional singers?

MATERIALS AND METHODS

The subjects analyzed in this study were 58 healthy professional opera singers (30 women and 28 men). All participants had been professional opera singers for at least 10 years, 65–80 years old (a mean age of 69 years). The group was divided according to the type (tessitura) of voice (21 sopranos, 7 mezzos, 2 contraltos, 17 tenors, 7 baritones and 6 basses).

The control group consisted of 42 professional opera singers (25 women and 17 men). They were 30–45 years old (a mean age of 41 years).

None of the singers reported any vocal fatigue, alcohol, or tobacco use. During examinations, no vocal pathology was discovered,

and neither were any symptoms of inflammatory disease of the larynx. Patients did not use any medications, which could alter voice emission, for example medication for thyroid function, hormones, hypertension treatment, diabetes and antipsychotic drugs. No history of Parkinson disease was reported.

All patients underwent a voice assessment protocol. In detail, each subject participated in the evaluation, as follows:

- ENT specialist examinations: videostroboscopy (VLS) was performed with a 90-degree Karl Storz R rigid endoscope and a HD camera with recording system during articulation of /i/a and singing of low- and high-pitched sounds. VLS allowed the examination of vibration and undulation of vocal folds.
- A speech therapist examined AERODYNAMIC MEASURES such as: fundamental frequency (F0), maximal phonation time (MPT), jitter and shimmer.

Vocal recording was performed in a silent room, with a microphone placed 10–15cm away from the lips. All voice recordings were obtained in equal conditions. We measured fundamental frequency (F0), which corresponds with the number of vibrations per seconds of vibrant mass of vocal folds, expressed in Hz. We used jitter and shimmer measures to assess the stability of acoustic signal. In order to make results more reliable, we checked the maximal phonation time on the sustained vowel (measured after deep inspiration). Software system: PRAAT (version 6.0.20) was used for acoustic analysis.

RESULTS

Endoscopic evaluation results are given in Tab. I., and acoustic measures in Tab. II. We decided to present percentage results for videolaryngoscopy findings, and mean values for acoustic parameters. During endoscopic examination of the singer's glottis, we found a yellowish and greyish discoloration of vocal folds in 39% of

women, and 29% of men, especially on the posterior third (Fig. 1.). When it comes to morphological changes, we observed mild vocal folds oedema in 59% of women, and 43% of men. Signs of atrophy of vocal folds were found in 20% of women, and 51% of men. We stated that due to the presence of a thinner appearance of vocal folds, which is associated with reduction of muscle, and mucosal covering (Fig. 2.). We also searched for prominence of the contour of vocal process or bowing of the vocal folds.

In 35% of cases, we noted the signs of diminished tension of vocal folds and a thinning of the superficial vibratory tissue.

Moreover, we noticed insufficient glottis closure in 47% of women, and 51% of men. We used a 3-stage scale to describe insufficient glottis closure (stage 1 – vocal fold bowing, stage 2 – spindle-shaped glottal gap, stage 3 – partial glottal gap). In our study group, vocal fold bowing was present among 20% of men but rarely in women. A spindle-shaped type of glottal gap was found in 19% of men.

A partial glottal gap was present in 15% of men. Yet in women, it was only present in the anterior part of the glottis. According to the procedure, VLS evaluation was performed in every patient. In 86% of cases, we observed an incomplete closure of the glottis in vibration. Other common findings were: vocal folds aperiodicity during vibration in 81% of cases, asymmetry of vocal folds in 12% of cases, and reduced amplitude of vibration in 45% of cases.

Acoustic evaluation revealed that maximal phonation time (MPT) showed no substantial difference between groups. Alike for older vs. younger singers and between both genders, no distinction was observed. The results for F0 level showed relevant change with age between younger singers and older female singers, but no difference in the male population.

Results showed a slight tendency in the reduction of jitter levels with age, but no significant difference between younger and older singers was found. Shimmer levels showed no meaningful difference with age.

DISCUSSION

The unavoidable ageing process affects the entire body. Recognition of the different aspects of senile age can be useful in the perspective of understanding the changes which may occur. The progression of ageing may differ from one individual to another of the same chronological age. Thus, a better comprehension of physiological ageing may help to develop successful physical training programmes and interventions, which can, in turn, help to prevent and cope with age-related deterioration.

Opera singers are unique individuals with years of advanced voice training. Therefore, it is very important to explore vocal ageing within this group. Authors were able to find only a few researches comparing groups of professional vocalists, and usually very specific ones, such as Carnatic singers in India. Yet, the number of studies comparing professional and amateur singers to non-singers showed very interesting and promising results. Thus, this field

of research needs further development to recognise the influence of advanced vocal training on ageing. In this study we wanted to assess the morphological changes of glottis which appear over a long-term singing career, which is usually associated with over 20 years of intensive and excessive voice use. We decided to look for symptoms of presbylarynx in our study group. We managed to compare laryngeal findings in a group of 100 professional singers. We divided the group into subgroups of younger and older vocalists to compare the results of laryngeal evaluation.

Typically, presbylarynx is a diagnosis of exclusion made in the absence of other laryngeal diseases in elderly patients [2, 9, 14]. In his study on adults without vocal complaint, Pontes et al. observed that certain signs were frequent enough to distinguish a geriatric larynx from a younger one [9]. In particular, he pointed out specific symptoms such as: vocal folds bowing in male subjects, prominence of the vocal process among females, an increased glottis proportion in both genders. Also noticeable among the females were phase and amplitude asymmetry of the mucosal wave [9].

One of the characteristic signs of senile larynx is vocal folds discolouration. This can arise due to fat degeneration or keratosis of mucous membrane [1]. In our group, this sign was present in 39% of women, and 29% of men, which seemed to be less frequent than that reported in literature [1]. It may be consistent with the hypothesis which implies that senile changes of vocal folds developed more slowly among trained singers [15]. As often stated in literature the presence of vocal folds oedema was also prevalent among the older female singers in our study group [9, 14]. Oedema can increase the mass of the vocal folds, which contributes to changes of the vocal pitch level. Previous research pointed out a relation between the tendency to oedema among women and hormonal changes during menopause [23].

Another common finding among elderly subjects is insufficient glottal closure. In one of his studies, Pontes analyzed the glottis closure among the younger and older population [9]. He noted a higher prevalence of triangular chink type glottal gap in young subjects, especially in women. The presence of a spindle-shaped gap was more characteristic for older women in this group. This type of glottal gap was absent in the younger population. In our study, we observed similar prevalence of insufficient glottal closure between genders, but a slightly higher percentage among male singers. Vocal fold bowing was more frequent in male opera singers in comparison to females, which is consistent with previous findings in the general population [9, 14, 22].

Prevalence of a spindle-shaped glottal gap was a less common observation among female opera singers, than in the group of elderly women reported in literature [1]. Additionally, a partial gap in anterior part of glottis was a characteristic image for female subjects. Among one fifth of our male population, we observed a spindle-shaped gap, and a partial glottal gap in 15%. Our study may suggest that insufficient glottal closure is less frequent among older opera singers, than in the general population [1, 22].

As another step, we decided to evaluate VLS findings among singers in different age groups. This method is considered to be

a golden standard in the phoniatic evaluation of professional voice users and allows for proper assessment of laryngeal dynamics during phonation [17]. Although VLS can provide a lot of important information, a high prevalence of abnormal findings (58–90%) in asymptomatic singers has been reported in previous studies [24]. It must be noted that they concerned only young individuals, therefore it would be difficult to compare results with elderly singers.

Incomplete glottic closure in vibration was found in almost 90% of our subjects. Irregularities of vocal folds movement (aperiodicity – 81%, asymmetry of vocal folds – 12%) were less frequent. A reduced amplitude of vibration was present in 45% of the cases. In a large study, Myint et al. reported 90% of abnormal voice pathologies in asymptomatic young singers [11]. Yet, particular findings like incomplete glottic closure (49% of cases) and amplitude asymmetry (44%) were less frequent than in our cases. In our opinion, a comparison of VLS findings with previous research is not desirable, in view of different characteristic of prior study groups. That is the reason way VLS evaluation in elderly singers needs further research.

Interestingly, among the voice parameters measured among older female opera singers, only F0 seemed to significantly decrease with age, but changed only slightly in older male singers. The fundamental frequency is the quality of voice which changes with age in the general population, but there is lack of evidence comparing it among professional singers. F0 is mainly determined by biomechanics of vocal folds, so it is reasonable to assume that vocal changes are related to the anatomical and histological deterioration of senile larynx [21]. In general, a decreased tension of vocal folds is associated with lower F0 levels [21].

These observations seem to disagree with previous research which stated that singers' F0 levels seem not to match the men-women coalescence pattern but were statistically significant only for younger and older female singers, and middle-aged men [20]. Furthermore, in statistical analysis, no changes in SFF levels as a function of ageing were significantly relevant [20]. On the other hand, Berghs found a strong negative correlation between age and the highest F0 in older singers, and age and F0 range in female singers [6]. Also, in male singers, a positive correlation was found between age and the lowest F0, and the highest and lowest voice intensity.

It could benefit men in reaching lower notes, and having the ability to sing more loudly, but softly. Finally, a decreased F0 level was identified as the main characteristic change over the years in this group of singers. It is important to notice that, in his study, Berghs evaluated a large group of professional choir singers, who usually also participate in vocal activities outside work. Professional opera singers are quite different in that matter since they usually stick to an agreement not to participate in any other singing activities, and they follow a special rest protocol to avoid vocal fatigue.

Rising age was also related to increased jitter and shimmer in the general population [12, 20]. A couple of researches conducted

Tab. I. Videolaryngoscopy findings.

ENDOSCOPIC EVALUATION	OLDER SINGERS	
	MEN (N = 28)	WOMEN (N = 30)
Oedema	43%	59%
Vocal folds discolouration	29%	39%
Atrophy of vocal folds	51%	20%
Insufficient glottis closure - general	51%	47%
Stage 1 – Vocal folds bowing	20%	14%
Stage 2 – Spindle-shaped glottal gap	19%	40%
Stage 3 – Partial glottal gap	15%	10%

Tab. II. Results of acoustic evaluation.

SINGERS	ACOUSTIC MEASURES			
	MAXIMAL PHONATION TIME – MPT (S)	FUNDAMENTAL FREQUENCY – F0 (HZ)	JITTER (%)	SHIMMER (%)
Young (n = 42)	20.46	203.2	0.97	1.94
Older Male (n = 28)	20.50	135.7	0.85	1.45
Older Female (n = 30)	20.57	190.3	0.89	1.92

among singers showed significantly less jitter, greater intensity levels, and a wider phonation range when compared to non-singers [12, 15, 20]. Only one study conducted by Maruthy compared jitter among singers of different age and showed significantly higher mean jitter values in the younger participants [13]. Our study showed relatively similar results. Mean jitter values were higher, but not substantially different in younger opera singers in comparison to older ones. Shimmer values were quite similar in both groups.

Findings regarding the age effect on maximal phonation time (MPT) remain inconsistent. MPT values were found to be longer in older females in comparison to young ones in the general population [19]. Yet, in another research, MPT had significantly longer values in younger Carnatic singers than in the older group [13]. The results of MPT in our study showed higher levels in the older female singer group when compared to younger subjects, but no changes in the male group were found. MPT is used to express the coordination between phonation and breathing [13]. Thus, regular voice training and improved respiratory performance in singers may be the reason for relatively stable MPT levels. In particular, this aspect of vocal analysis needs further research.

It should be emphasised that our rather small study gives preliminary results in the population of professional opera singers. We are aware of the fact that, when a sample like ours is divided into subgroups, the data is limited for generalisation. Nevertheless, we hope to start a discussion on that matter, and we would like to expand this subject. In the future, we hope to enlarge the study population, and we would like to study patterns of ageing in singers with different types of voice, other lifestyle habits, and general health condition. Good comprehension of age-related voice changes is a key to develop methods which may protect against the negative aspects of voice senility.

CONCLUSIONS

Fundamental frequency level was significantly decreased in the case of older female singers, but F0 in older males had stable levels in comparison to younger singers. Older singers were found not to have substantially different values of jitter than younger ones. MPPT was longer in the older female group when compared to younger singers, but not significantly different in the male group. Shimmer

presented no age-related change. Morphological changes seem to correlate with the age of the subjects.

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