

Professional Opera Singers' Voice Disorders In Relation To Voice Type

Pedro Clarós^{1*} MD PhD, Iwona Porebska MD^{1,2,3}, Astrid Clarós-Pujol MSc¹, Carmen Pujol MSc¹, Andrés Clarós MD¹, Konrad Kaczmarek PhD⁴

¹Clarós Otorhinolaryngology Clinic, Barcelona, Spain

²Department of Otorhinolaryngology at Stefan Zeromski Specialist Hospital, Cracow, Poland; ³Scholarship in Clarós Clinic, Barcelona, Spain

⁴Department of Applied Mathematics of the Silesian Technical University, Gliwice, Poland

*Corresponding Author: Pedro Clarós, Clarós Clinic, c./Vergós 31, 08017 Barcelona, Spain.

Received date: August 29, 2019; Accepted date: October 16, 2019; Published date: November 04, 2019

Citation: Clarós P., Porebska L., Astrid C Pujol., Pujol C., Clarós A., Kaczmarek K. (2019) Professional Opera Singers' Voice Disorders In Relation To Voice Type. J.Archives of Medical Case Reports and Case Study. 2(1); DOI:10.31579/2692-9392/004.

Copyright: © 2019 Pedro Clarós, Clarós Clinic, This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Abstract:

Objective: To determine whether there is a relationship between the voice type and the prevalence of voice disorders, and to investigate the frequency of laryngological controls and voice rehabilitation amongst professional opera singers.

Study design: Cohort study, composed of a survey, videolaryngoscopy and videostroboscopy.

Setting: Referral center (Clarós Otorhinolaryngology Clinic)

Subject and methods: Highly professional opera singers performing in the Gran Teatro del Liceo in Barcelona, were divided into 7 study groups based on their voice types. Study was composed of a survey about singing and voice care habits, followed by videolaryngoscopy and videostroboscopy determining the prevalence of voice disorders.

Results: We examined 70 opera singers (30 females, 40 males; aged 19-70), divided into 7 equally numerous study groups based on their voice types. The prevalence of voice disorders was the highest amongst sopranos, i.e. 50% (50%,95%,CI:12-88,SD=.53), in comparison to 20% (20%,95%,CI:10-50,SD=.42) amongst countertenors, tenors and baritones, 10% (10%,95%,CI:13-33,SD=.32) amongst contraltos and mezzo-sopranos, and 0% amongst basses. Statistical significance was confirmed for difference between the group of the highest female and highest male voice (soprano and countertenor), and the group of the lowest female and lowest male voice, i.e. contralto and bass ($Z=2.32, P=.02$). Frequency of attending laryngological appointments and voice rehabilitation was generally very low, although was highest amongst sopranos.

Conclusion: Results supported our hypothesis that the higher voices are at a heightened risk of having voice disorders. It can start the process of evaluating actual risk of vocal fold pathologies that opera singers are exposed to during their careers.

Key Words: opera singers; voice disorders; voice types; vocal fold pathologies; tessitura

Introduction:

For many people, including the authors of this article, music is one of the most important things and one of the strongest experiences in their lives. [1] It can determine mood, create emotions, [2-6] construct memories [4-7] and help in their recall, [6,7] remove barriers between people and help them connect, [1] and even modulate the autonomic nervous system, the hormonal system and the immune system. [6] Beyond the shadow of a doubt, classical music, especially opera which is composed not only by singing but also acting, is a particularly important type of music as it is the most connected to human cultural heritage and, according to many, is especially moving. [2,8,9] Opera performance has always been a magical ritual, emphasized not only by the beautiful buildings characterized by incredible architecture that opera always takes place in, and the *savoir-vivre* that tells us to dress in a particularly elegant way while attending opera performances, but also by the special respect and adoration that

opera singers have always been honored with.

Our clinic has been a widely known consultancy for professional opera singers performing in the Gran Teatro del Liceo in Barcelona and other opera theatres in Europe since 1970. For all of these years we have had the pleasure of sharing many moments of joy with opera singers during their performances, but also many moments of fear and dread when the overuse of voice has caused voice disorders, as there is no doubt that those incredible performances are also superhuman efforts for the voice box, its anatomy as well as physiology. [8] During these years we have noticed a relationship between the type of tessitura that an opera singer is classified to and the prevalence of voice disorders. Therefore we decided to check the presence of this relationship in a cohort study and to make it its objective.

A few words regarding voice disorders warrant mentioning to clarify the subject of our concerns while taking medical care of opera singers. Pathologies caused by trauma, previous intubation and surgery, or

neurogenic and infectious causes are beyond the scope of this text, and they were not present in our research group. Likewise congenital disorders were not present in our patients, which is not surprising taking into consideration how carefully selected opera singers are, and that by definition they are free of voice problems at the beginning of their careers. On the contrary, functional voice disorders (defined as dysphonia without structural or neurological vocal fold pathology [10]), are quite common amongst professional singers. They contain muscle tension dysphonia, vocal fatigue (strictly associated with vocal tiredness after voice overuse or misuse [11]), and psychogenic dysphonia, if the cause of laryngeal tension is psychological, [12] however many authors do not single them out separately. [13-15] The reason for functional voice disorders is a disproportion in the laryngeal and perilaryngeal muscular activity, [10,12-15] and apart from psychological reasons it can be caused by voice overuse, bad adaptation, incorrect voice technique, or increased vocal tone.[12] Typically, functional voice disorders are characterized by a harsh, strained voice of increased effort, decreased volume and unsettled pitch, poor voice control, odynophonia, tenderness in the thyrohyoid space, and tension in neck and shoulders. [11,13,19-26] They are usually treated with voice and behavioral therapy. [10,13, 16-19]

Organic pathologies include benign lesions like nodules, polyps, cysts and hematomas, as well as vocal edema. Nodules typically apply to the free edge at the border of the anterior and middle thirds of the fold and are caused by initial trauma during contact between opposing surfaces of vocal folds, especially during voice overuse, [12,27-29] and as if in a vicious cycle are aggravated by a following dysphonia causing constant strain and muscle tension and vocal fold weight change, that causes further whip-like trauma. They are structured by fibronectin deposits in superficial lamina propria combined with a relocation of thicker collagen type IV from the basement membrane after its injury. [30] Similar lesions are retention or epidermoid cysts, which are typically unilateral and in contrast to nodules do not improve with vocal therapy.[31] Hematomas, most common in the case of female professional singers,[32-34] are the consequence of vocal abuse or physical trauma, when submucosal blood vessels rupture and bleed into the superficial layer of lamina propria, with the main symptom being dysphonia, [32,35-37] and are normally treated with total voice rest, being directed to surgery only in the case of recurrent hematomas. [32,33,35] The last pathology within the range of interest of this article is vocal edema, caused by over-vibration during voice overuse or misuse that results in the reduction of blood perfusion, intermittent hypoxia and regional inflammation, and is treated with strict voice rest. [38]

Materials and Methods:

The study protocol was acknowledged, reviewed and approved by the internal ethics committee of our medical center, Clarós Otorhinolaryngology Clinic Institutional Review Board. All of the singers were informed about the examination technique and provided written informed consent. The subject of our study were highly professional, international opera singers performing in the Gran Teatro del Liceo in Barcelona, divided into 7 equally numerous study groups based on their voice types: soprano, mezzo-soprano, contralto, countertenor, tenor, baritone and bass. We decided to include countertenor in our study although it is not always singled out as a separate tessitura, as countertenors are usually characterized by tenor, baritone or more rarely bass speaking voices, but underwent a special training to be able to use a falsetto-based vocal technique in order to sing contralto, mezzo-soprano, or soprano parts. [39,40] Exclusion criteria were applied to ensure that no factor other than singing could influence voice, i.e. medications or any

medical condition that might cause edema or paralysis of vocal folds, history of neck trauma, and current allergic reaction or sickness. We also excluded singers with chronic laryngeal reflux disease, although the prevalence of this disease is extremely high in opera singers and is even suggested to be occupation related disease.[41-45] Cases of stage fright (described widely by Spahn and Echternach [9]) and voice problems related to psychological causes were excluded too.

The first limb of the study was completion of a specially constructed survey asking about age and singing experience (i.e. the number of years that they had sung for), to ensure that the differences between the groups were statistically insignificant. The next set of questions related to the presence of any diagnosed voice disorders, and to the frequency at which opera singers attended laryngologist appointments and voice rehabilitation. The second limb of the study was examination of the participants' vocal folds. The most experienced ENT consultant in our Clinic performed a videolaryngoscopy with a rigid endoscope followed by a videostroboscopy (Hopkins II telescope 70 degrees, Karl Storz, Germany) in order to confirm or exclude vocal fold pathologies.

Data was then implemented into Statistica 13.1 (Statsoft Poland, Cracow) software. There were no missing values in our study. The primary hypothesis was that there is a relationship between the voice type and the prevalence of voice disorders. Statistical significance was reported at the alpha level of 0.05. P value below 0.05 was considered significant. While analyzing the data we performed the Kruskal–Wallis H test and the Mann–Whitney U test in order to study distributions of features and to determine if the differences between the distributions are statistically significant. Hypothesis tests were designed as two-tailed. A hypothesis null was formulated as H_0 (the distribution of features in the groups is the same, i.e. there are no differences between opera singers with the different voice types) against the alternative hypothesis H_1 (the distribution of features in the groups is not the same). The confidence intervals (CI) and standard deviations (SD) were established for the obtained values. We created categorized boxes and whisker diagrams with results of ANOVA, analysis of variance, to present our findings.

Results:

We examined 70 highly professional opera singers, aged between 19 to 70 years old, with the average age of 41.77 years old (41.77,95%,CI:38.95-44.60,SD=11.85), divided into 7 study groups of 10 opera singers based on their voice types. From the initial group of 92, 22 singers were excluded, mostly because of chronic laryngeal reflux disease. There were not statistically significant differences in the distribution of age between the groups ($H=2.27,P=.89$) and singing experience, i.e. years of singing ($H=3.07,P=.80$).

The prevalence of voice disorders was the highest in the group of soprano singers, i.e. it was 50% (50%,95%,CI:12-88,SD=.53); they were two hematomas, two cases of voice fatigue and one case of nodules. A much lower prevalence of 20% (20%,95%,CI:10-50,SD=.42) was found for the group of countertenors (one case of voice fatigue and one of nodules), the same for tenors (one polyp and one case of nodules) and baritones (two cases of vocal edema). A prevalence of 10% (10%,95%,CI:13-33,SD=.32) was found for contralto singers as well as for mezzo-soprano singers (in both cases the pathologies were polyps). There were no vocal fold pathologies found amongst bass singers. Statistical significance was confirmed for difference between the group created from the highest female and the highest male voice, i.e. soprano and countertenor, and the group created from the lowest female and the lowest male voice, i.e. contralto and bass ($Z=2.32,P=.02$). Figure 1 shows it graphically.

Legend of figures:

Figure 1. The comparison of the prevalence of voice disorders between the groups of highest and lowest female and male voices.

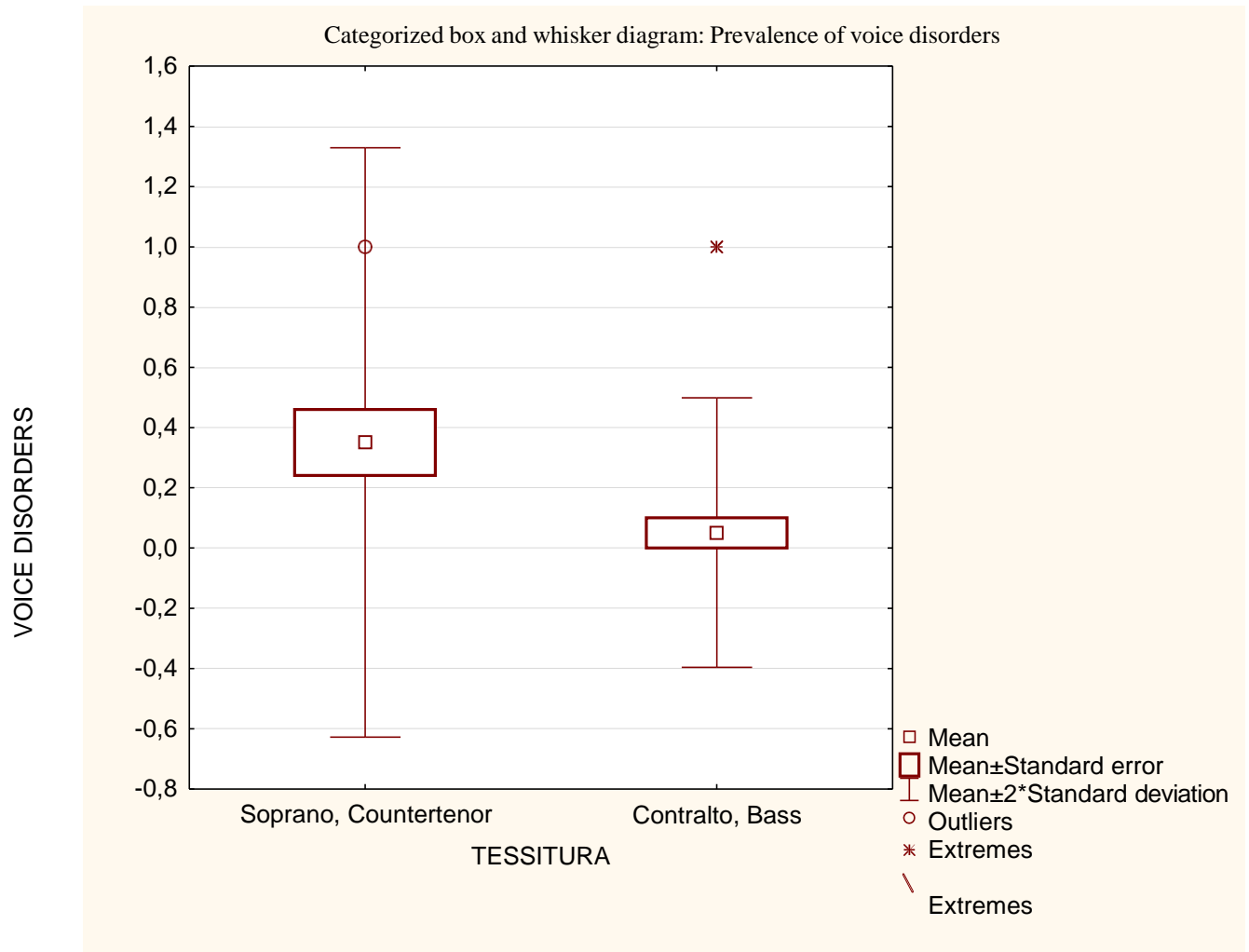


Figure 1. Categorized box and whisker diagram with results of ANOVA, analysis of variance. The graph shows the comparison of mean values with standard error (SE) and standard deviation (SD) for the prevalence of voice disorders between the groups of highest female and male voices and lowest female and male voices.

Legend of figures:

Figure 2. The comparison of the frequency at which opera singers attend laryngological check-ups between the groups of singers with different types of voice (tessitura).

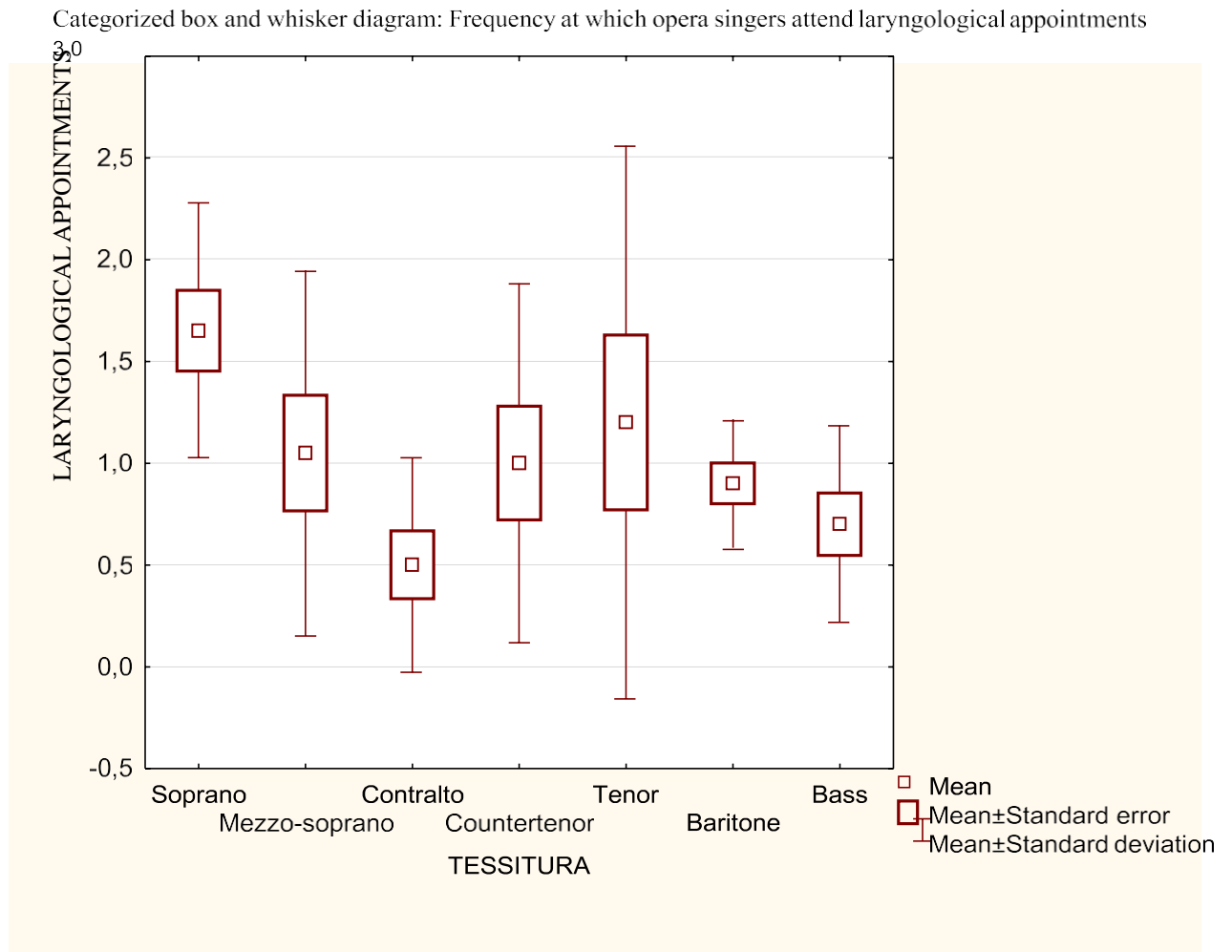


Figure 2. Categorized box and whisker diagram with results of ANOVA, analysis of variance. The graph shows the mean values with standard error (SE) and standard deviation (SD) for the frequency at which opera singers attend laryngological check-ups between the groups of singers with different types of voice (tessitura).

Legend of figures:

Figure 3. The comparison of the frequency at which opera singers attend voice rehabilitation between the groups of high voices (soprano, mezzo-soprano, countertenor, contralto and tenor) and low voices (baritone and bass).

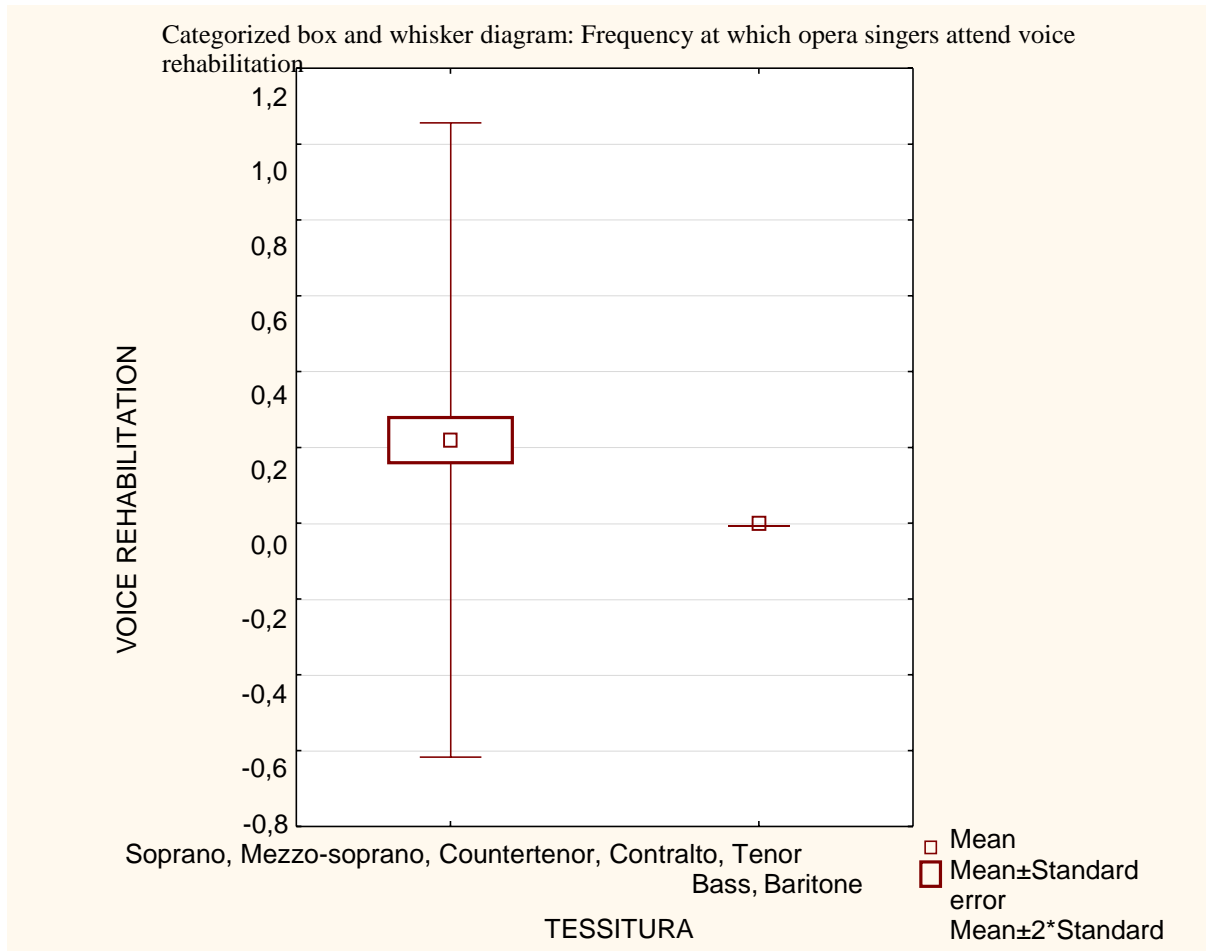


Figure 3. Categorized box and whisker diagram with results of ANOVA, analysis of variance. The graph shows the comparison of mean values with standard error (SE) and standard deviation (SD) for the frequency at which opera singers attend voice rehabilitation between the groups of high voices (soprano, mezzo-soprano, countertenor, contralto and tenor singers) and low voices (baritone and bass singers).

Legend of figures:

Figure 4. The comparison of the frequency at which opera singers attend voice rehabilitation between the groups of two highest (soprano, mezzo-soprano) and two lowest (bass, baritone) voices.

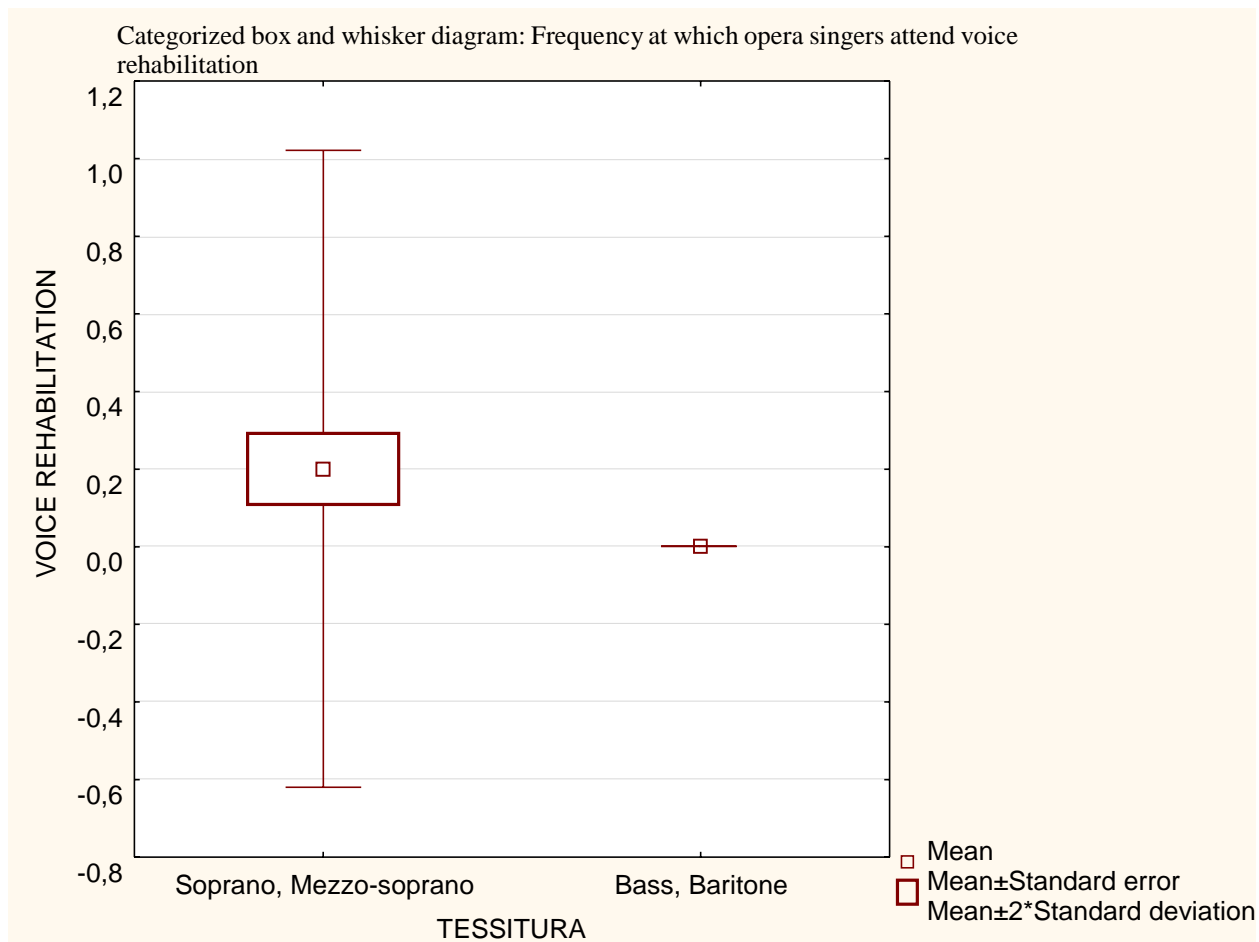


Figure 4. Categorized box and whisker diagram with results of ANOVA, analysis of variance. The graph shows the comparison of mean values with standard error (SE) and standard deviation (SD) for the frequency at which opera singers attend voice rehabilitation between the groups of two highest (soprano, mezzo-soprano) and two lowest (bass, baritone) voices.

Bass and baritone singers were rarely (not more often than once per year) attending laryngological check-ups, and they were not attending any voice rehabilitation (nobody in both groups). In the other groups the frequencies of ENT appointments and voice rehabilitations were also low (mostly more rarely than once per year for ENT examinations with no habit of attending voice rehabilitations at all). In the group of tenors just one singer suffering from nodules reported attending laryngological appointments 4-5 times per year, as well as voice rehabilitation; one tenor suffering from polyp reported attending laryngological appointments 2 times per year, as well as voice rehabilitation; and two tenors with no vocal fold pathologies reported seeing laryngologists 1-2 times per year, however only one of them attends voice rehabilitation in order to improve singing technique. In the group of countertenors just one singer suffering from voice fatigue reported seeing a laryngologist 3 times per year and attends voice rehabilitation as well; and two countertenors see ENT doctors 1-2 times per year, however only one of them attends voice rehabilitation because of suffering from nodules.

The situation is quite similar in the case of female opera singers. In the

group of contralto singers just one singer suffering from polyp claimed to see an ENT doctor 1-2 times per year and to attend voice rehabilitation. In the group of mezzo-soprano singers two persons declared seeing a laryngologist more often than once per year (2-3 times per year), despite a lack of voice disorders, and one singer declared attending voice rehabilitation because of suffering from polyp. The prevalence of regular laryngological visits was again the highest in the group of soprano singers: four of them claimed to see laryngologists 2 times per year despite a lack of voice disorders, one singer 3 times per year because of vocal fatigue, one 2 times per year, as well as attending voice rehabilitation, because of suffering from nodules, and two other singers claimed to attend voice rehabilitation because of suffering from hematoma and voice fatigue. Statistical significance of differences between all the groups was confirmed for attending laryngological appointments ($H=15.73, P=.02$), as well as for attending voice rehabilitation for comparisons between high and low voices, i.e. soprano and mezzo-soprano singers contra baritone and bass singers ($Z=2.06, P=.04$), and soprano, mezzo-soprano, countertenor, contralto and tenor singers contra baritone and bass singers ($Z=2.26, P=.02$). Figures 2-4 show it graphically.

Interestingly, a lot of opera singers claim to never attend laryngological check-ups, despite reporting high level of fear about their voices. As many as 20% (14 out of 70, 20%,95%,CI:18.88-21.12) opera singers in our study claim to never attend laryngological appointments (0 sopranos, 1 mezzo-soprano, 4 contraltos, 2 countertenors, 3 tenors, 1 baritone, 3 basses). The answer “rarely” or “very rarely” also appeared relatively often, in nearly 13% of our study group (9 out of 70, 13%,95%,CI:12.06-13.94) – once in the group of soprano, six times in the group of baritone, and two times in the group of bass. If we summarize these two findings, we can conclude that as many as nearly 33% of opera singers (23 out of 70, 33%,95%,CI:31.68-34.32) claim to never, very rarely or rarely attend laryngological appointments.

Discussion:

Our results confirmed the hypothesis, that there is a relationship between the type of voice that an opera singer has and the prevalence of vocal fold pathologies, i.e. in our study the prevalence of voice disorders was distinctly highest in the group of soprano singers and it dropped with the fundamental frequency of the singers’ tessitura (it was the lowest for the lowest voice, i.e. bass). There can be couple of reasons of this observation. Firstly, as we confirmed before in our different study, soprano singers’ vocal folds are the shortest, [40] and while singing they are being extended the most. At the same time they are also the most exposed to incredible strain while singing the highest frequencies. Finally, we are tempted to claim, that soprano parts play a special role in operas, and usually soprano arias are the longest and the most demanding, therefore affect vocal folds the most.

Our findings are in agreement with what we have observed during our years of providing medical support for the opera singers; however, several doubts warrant discussion. Firstly, there are differences between the singers that are difficult to evaluate, however might have affected their vocal folds. For example: lifestyle, addictions, living environment, individual differences between physiology and anatomy of the larynx, or performance technique and lack or presence of voice training. [8] Another doubt warrant discussion is the difficulty in comparing all types of voices, as they vary between the genders not only in pitch and vocal range, but also voice box anatomy. We decided the best way to evaluate prevalence of voice disorders in relation to voice type is to compare the group of singers with the highest female and the highest male voice with the group of singers with the lowest female and the lowest male voice. Statistical significance was confirmed for this difference. However, there is room left for further investigation and exploring this relationship for all the possible combinations of voice types.

From another point of view, we find the results related to the frequency of voice rehabilitation and laryngologists appointments very interesting. As we can see again, the higher the fundamental frequency of opera singers’ tessitura, the more frequent laryngological appointments and voice rehabilitations are. Presumably that might be connected to our first finding, i.e. the higher prevalence of voice disorders in the high voice group, however in future another study establishing the difference in consciousness about importance of voice care between the singers might be interesting. Nevertheless, what is the most surprising is the generally low frequency of laryngological appointments and voice rehabilitation in the group of opera singers, which is opposite to what has been described before.[32,46-48] Surprisingly, as many as 33% opera singers claim to never, very rarely or rarely see ENT specialists, despite the fact that it has become well accepted that they highly cherish their voices and worry about their condition a lot.[26,28] Expectedly, it raises the question of the reason of this outcome. We agree with Kwak et al. that the research about the effect of professional singing on the vocal folds is still very limited and the subject is still not exhausted. [8] This might be one reason why professional singers are unaware of the importance of regular laryngological examinations. Presumably, although they know the risk factors, they do not have specific knowledge about the actual significance of them (e.g. there is a high rate of opera singers who drink alcohol and smoke), as well as about which group of opera singers is more vulnerable

to the voice disorders. Although the subject of professional singing seems to have received a reasonable amount of attention in scientific investigation, it is wide enough to still have some areas in which exploration is lacking. Kwak et al. explored changes in acoustic parameters before and after opera performances, however without evaluating long-term effects and without distinguishing singers’ voice types. [8] Phylant et al. checked the prevalence of voice disorders in singing groups in comparison to non-singing ones, and compared the groups singing in opera, musical theatre and “contemporary-other-than-rock” singing group, however did not compare the groups of singers with different tessitura. [28] Chernobelsky evaluated the results of voice therapy amongst professional classical singers with vocal fold nodules, but without dividing them by tessitura, and without evaluating the prevalence of this disorder. [27] Pacheco and Behlau investigated the immediate impact of vocal demand, but distinction according to tessitura was also beyond the scope of the research. [26] Mayerhoff et al. studied different types of tessitura, but only in the context of the presence of supraglottic hyperfunction not voice disorders, however they suggested the correlation between one and another. [49] Thus, we are tempted to claim that our research explores aspects not addressed before.

Conclusion:

The beautiful voice which opera singers are characterized by is an amazing gift and instrument to make lots of people happy and fulfilled, including opera singers themselves while they follow their great passion of singing. However it is also a blessing that is easy to lose, simply because of following this passion. It is therefore also the subject of instant worry. However, because of the dearth of general knowledge in the subject, they are unaware of the actual risk for their vocal folds and the possible benefits of counteractions, and they don’t attend laryngologist appointments or voice rehabilitation enough. We believe it is therefore important for the population of opera singers to evaluate the actual risk that they are exposed to over the years of their career, which might encourage them to control their vocal folds more often and comfort them with regular voice rehabilitation. Our study attempted to start the process of this evaluation and to emphasize the importance of this subject.

Acknowledgement

The authors report no conflicts of interest. The authors report no financial and material support for the research and the work reported in the manuscript.

References:

1. Clarke E, DeNora T, Vuoskoski J. (2015) Music, empathy and cultural understanding. *Phys Life Rev.* 15:61-88.
2. Balteş FR, Avram J, Miclea M, Miu AC. (2011) Emotions induced by operatic music: psychophysiological effects of music, plot, and acting: a scientist's tribute to Maria Callas. *Brain Cogn.* 76(1):146-157.
3. Juslin PN, Västfjäll D. (2008) Emotional responses to music: the need to consider underlying mechanisms. *Behav Brain Sci.* 31(5):559-575.
4. Juslin PN, Liljeström S, Västfjäll D, Barradas G, Silva A. (2008) An experience sampling study of emotional reactions to music: listener, music, and situation. *Emotion.* 8(5):668-683.
5. Koelsch S. (2011) Toward a neural basis of music perception - a review and updated model. *Front Psychol.* 2:110.
6. Proverbio AM, Lozano Nasi V, Alessandra Arcari L, et al. (2015) The effect of background music on episodic memory and autonomic responses: listening to emotionally touching music enhances facial memory capacity. *Sci Rep.* 5:15219.
7. Simmons-Stern NR, Deason RG, Brandler BJ, Frustace BS, O'Connor MK, Ally BA, Budson AE. (2012) Music-based

- memory enhancement in Alzheimer's disease: promise and limitations. *Neuropsychologia*. 50(14):3295-3303.
8. Kwak PE, Stasney CR, Hathway JR, Guffey D, Minard CG, Ongkasuwan J. (2017) Physiologic and Acoustic Effects of Opera Performance. *J Voice*. 31(1):117.e11-117.e16.
 9. Spahn C, Echternach M, Zander MF, Voltmer E, Richter B. (2010) Music performance anxiety in opera singers. *Logoped Phoniatr Vocol*. 35(4):175-182.
 10. Roy N. (2003) Functional dysphonia. *Curr Opin Otolaryng Head Neck Surg*. 11:144-148.
 11. Paolillo NP, Pantaleo G. (2015) Development and validation of the voice fatigue handicap questionnaire (VFHQ): clinical, psychometric, and psychosocial facets. *J Voice*. 29(1):91-100.
 12. Morrison MD, Rammage L. (1993) Muscle misuse voice disorders: description and classification. *Acta Otolaryngol*. 113:428-434.
 13. Roy N, Bless DM, Heisey D, Ford CN. (1997) Manual circumlaryngeal therapy for functional dysphonia: an evaluation of short- and long-term treatment outcomes. *J Voice*. 11:321-331.
 14. Koufman JA, Blalock PD. (1988) Vocal fatigue and dysphonia in the professional voice user: Bogart-Bacall syndrome. *Laryngoscope*. 98:493-499.
 15. [15] Belafsky PC, Postma GN, Reulbach TR, et al. (2002) Muscle tension dysphonia as a sign of underlying glottal insufficiency. *Otolaryngol Head Neck Surg*. 127:448-451.
 16. Houtz DR, Roy N, Merrill RM, Smith ME. (2010) Differential diagnosis of muscle tension dysphonia and adductor spasmodic dysphonia using spectral moments of the long-term average spectrum. *Laryngoscope*. 120(4):749-757.
 17. Roy N, Whitchurch M, Merrill RM, Houtz D, Smith ME. (2008) Differential diagnosis of adductor spasmodic dysphonia and muscle tension dysphonia using phonatory break analysis. *Laryngoscope*. 118(12):2245-2253.
 18. Roy N, Mazin A, Awan SN. (2014) Automated acoustic analysis of task dependency in adductor spasmodic dysphonia versus muscle tension dysphonia. *Laryngoscope*. 124(3):718-724.
 19. Pacheco PC, Karatayli-Ozgursoy S, Best S, Hillel A, Akst L. (2015) False vocal cord botulinum toxin injection for refractory muscle tension dysphonia: Our experience with seven patients. *Clin Otolaryngol*. 40(1):60-64.
 20. Watts CR, Hamilton A, Toles L, Childs L, Mau T. (2015) A randomized controlled trial of stretch-and-flow voice therapy for muscle tension dysphonia. *Laryngoscope*. 125(6):1420-1425.
 21. Welham NV, Maclagan MA. (2003) Vocal fatigue: current knowledge and future directions. *J Voice*. 17:21-30.
 22. Gotaas C, Starr CD. (1993) Vocal fatigue among teachers. *Folia Phoniatr (Basel)*. 45:120-129.
 23. Colton RH, Casper JK, Leonard RL. *Understanding Voice Problems: A Physiological Perspective for Diagnosis and Treatment*. 3rd ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2006.
 24. Kitch JA, Oates J. (1994) The perceptual features of vocal fatigue as self-reported by a group of actors and singers. *J Voice*. 8:207-214.
 25. Kostyk BE, Putnam Rochet A. (1998) Laryngeal airway resistance in teachers with vocal fatigue: a preliminary study. *J Voice*. 12:287-299.
 26. Pacheco C, Behlau M. (2018) Immediate Impact of Vocal Demand on Musical Theater Singers in Brazil. *J Voice*. 30(18):30020-30021.
 27. Chernobelsky SI. (2007) The treatment and results of voice therapy amongst professional classical singers with vocal fold nodules. *Logoped Phoniatr Vocol*. 32(4):178-184.
 28. Phyland DJ, Oates J, Greenwood KM. (1999) Self-reported voice problems among three groups of professional singers. *J Voice*. 13(4):602-611.
 29. Karkos PD, McCormick M. (2009) The etiology of vocal fold nodules in adults. *Curr Opin Otolaryngol Head Neck Surg*. 17:420-423.
 30. Gray SD, Hammond E, Hanson DF. (1995) Benign pathologic responses of the larynx. *Ann Otol Rhinol Laryngol*. 104:13-18.
 31. Milutinović Z, Vasiljević J. (1992) Contribution to the understanding of the etiology of vocal fold cysts: a functional and histologic study. *Laryngoscope*. 102(5):568-571.
 32. Novakovic D, D'Elia J, Branski RC, Blitzer A. (2014) The effect of different angiolytic lasers on resolution of subepithelial mucosal hematoma in an animal model. *Ann Otol Rhinol Laryngol*. 123(6):387-394.
 33. Postma GN, Courey MS, (1998) Ossoff RH. Microvascular lesions of the true vocal fold. *Ann Otol Rhinol Laryngol*. 107:472-476.
 34. Hochman I, Sataloff RT, Hillman RE, Zeitels SM. (1999) Ectasias and varices of the vocal fold: clearing the striking zone. *Ann Otol Rhinol Laryngol*. 108:10-16.
 35. Lennon CJ, Murry T, Sulica L. (2014) Vocal fold hemorrhage: factors predicting recurrence. *Laryngoscope*. 124(1):227-232.
 36. Spiegel JR, Sataloff RT, Hawkshaw M, Rosen DC. (1996) Vocal fold hemorrhage. *Ear Nose Throat J*. 75:784-789.
 37. Abitbol J. (1998) Vocal cord hemorrhages in voice professionals. *J Voice*. 2:261-266.
 38. Wang J, Devine E, Fang R, Jiang JJ. (2017) Over-vibration induced blood perfusion and vascular permeability changes may lead to vocal edema. *Laryngoscope*. 127(1):148-152.
 39. Tom K, Titze IR. (2001) Vocal intensity in falsetto phonation of a countertenor: an analysis by synthesis approach. *J Acoust Soc Am*. 110(3 Pt 1):1667-1676.
 40. Clarós P, Sobolewska AZ, Doménech-Clarós A, Clarós-Pujol A, Pujol C, Clarós A. (2018) CT-based Morphometric Analysis of Professional Opera Singers' Vocal Folds. *J Voice*. 21(17):30614-30618.
 41. Pregon I, Bakucz T, Banai J, et al. (2009) Gastroesophageal reflux disease: work-related disease? *Dig Dis*. 27(1):38-44.
 42. Heman-Ackay YD, Dean CM, Sataloff RT. (2002) Stroboscopy findings in singing teachers. *J Voice*. 16:81-86.
 43. Sliwiska-Kowalska M, Niebudek-Bogus E, Fiszer M, et al. (2006) The prevalence and risk factors for occupational voice disorders in teachers. *Folia Phoniatr Logop*. 58:85-101.
 44. Cammarota G, Elia F, Cianci R, et al. (2003) Worsening of gastroesophageal reflux symptoms in professional singers during performances. *J Clin Gastroenterol*. 36:403-404.
 45. Cammarota G, Masala G, Cianci R, et al. (2007) Reflux symptoms in professional opera choristers. *Gastroenterology*. 132:890-898.
 46. Sataloff RT. (1987) Common diagnoses and treatments in professional singers. *Ear Nose Throat J*. 66:28-46.
 47. Punt NA. (1983) Laryngology applied to singers. *J Laryngol Otol*. 6(suppl):1-24.
 48. Sataloff RT. *Professional Voice: The Science and Art of Clinical Care*. New York NY: Raven Press; 1991.
 49. Mayerhoff RM, Guzman M, Jackson-Menaldi C. (2014) Analysis of supraglottic activity during vocalization in healthy singers. *Laryngoscope*. 124(2):504-509.