VOCAL DOSIMETRY (APM) IN OPERA AND MUSICAL SOLOIST SINGERS DURING LIVE PERFORMANCES IN THEATRES: A PILOT STUDY

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Abstract: In clinical management of singers it’s important to identify risk components of vocal fatigue and glottic damage, predicting and assessing the vocal cost of the various vocal performances to avoid any risk. Despite many difficulties, we made dosimetry on singers (9 opera and 9 musical) during live theatre performances. Our aim was to evaluate phonatory behaviors before, during and after performances to determine the actual amount of vocal load and the possibility of assessing vocal fatigue and performative potential risks through the identification of a vocal recovery index (VRI). Since the analysis of numerical data from APM (Fo, SPL, vocal doses) doesn’t immediately highlight the extent of vocal load, we decided to elaborate data in order to propose a new index: VRI. We found that a lower VRI corresponds to difficult or fatiguing moments, while the opposite happens in moments of vocal rest or recovery. We suppose that there are different threshold ranges between males and females and between different vocal classes, therefore it would be desirable to establish VRI thresholds for references in evaluation of data from dosimetry.

In this study we also show differences between opera and musical soloist singers and describe Fo histogram like a real vocal score profile, SPL histogram like an on stage relative dynamic agility and phonation density graph like an on stage phonetogram to point out many vocal features. Finally, through this method, it could be possible to adapt technical and behavioural measures to avoid and reduce the risk of vocal fatigue or damage. Keywords: vocal dosimetry, vocal recovery index, vocal effort, vocal doses.

I. INTRODUCTION

In the clinical management of the artistic voice it’s important to identify all the risk components of vocal fatigue or glottic damage. The choice of repertoires unsuited to technical and vocal features, inadequate work planning, phonatory behaviours tending to hyperkinesis with very high total phonation times, due to amount of voicing during rehearsals, performances, breaks, teaching, private life, a lifestyle that does not include a regular diet, regular sleep-wake cycles, use of drugs or doping substances, the environment in which it takes place the voice activity are all factors that increase the risk of performing complications. For this reason it is essential to predict and to assess the vocal cost of the various vocal performances to avoid any risk of glottic damage.

II. METHODS

Initially we conducted preliminary clinical assessments (anamnesis, tonal audiometry and videolaringostroboscopy to assess singers’ vocal health) and interviews to describe singers’ feelings about sung roles, by examining different points of the vocal score, to identify difficult or fatiguing moments and rest times. Later we started to make dosimetries on opera and musical singers during live performances in theatres, using the APM model 3200 on 19 singers, 10 opera and 9 musical singers. The Ambulatory Phonation Monitor (APM) is a portable, wearable device for objectively documenting the key phonatory behaviors of a client over a full day of normal vocal activity. Specifically, APM measures the amount of time a client phonated, when the phonation occurred, and estimates the client’s vocal intensity (dB SPL) and fundamental frequency (F0) during all phonatory activity. This data can be viewed graphically and quantitatively through APM software. The data essentially provides a “profile” of a client’s “typical” phonatory behaviors. During the period of monitoring, APM does not record the client’s speaking or singing, it only extracts phonation related parameters. [1,2]. The main parameters are: Phonation Time (total duration of phonation expressed as the total cumulated time and the percentage of time spent phonating for the time period of the displayed), Fundamental frequency, mode (values at which most phonation occurred in displayed data) and average [2], Sound Pressure Level and Vocal Doses (derived from mathematical processing of previous parameters).[1] These are the Total Cycles of Vibrations (Dc: total number of glottal cycles detected in displayed data) and the Total Distance Dose (Dd: estimate of “how far” vocal folds traveled in displayed data in meters).[3] Analyzing numerical data of frequency, amplitude and vocal dose we don’t immediately point out the extent of vocal load. It was therefore decided to assess the ratio between cycles of vibration dose (Dc) and total distance dose (Dd) in order to determine the average vibration...
cycles made for each meter of distance traveled in the displayed examination.[4]

III. RESULTS
In this paper it’s shown the example of two experienced tenors who have performed at Teatro alla Scala in Milan two different roles in two operas by Giuseppe Verdi (“Aida” and Jacopo in “I due Foscari”) and the example of two female musical singers performing different roles in the musical Cats by Andrew Lloyd Webber. The first example shows the examination of Radames tenor: the total length of the representation in 3 hours and 36 minutes for a PT about 44 min. For the total duration of the opera the ratio between the two parameters (Dc/Dd) is 54 cycles per meter, i.e. 1.54 cm for a cycle. (Fig.1)

During the interview, the singer has revealed that the most difficult moment of the entire opera is the beginning of the first act, corresponding to the aria “Celeste Aida”. By analyzing the parameters regarding only the execution of the aria, we get the result of a ratio Dc/Dd down to 30.2 cycles per meter, that is 3.3 cm cycle: a clear reduction in this ratio; moreover the values of F0 and average amplitude are much higher. (Fig.2).

Analyzing the time of the break between 2nd and 3rd Act and non singing part during beginning of 3rd Act, when it is assumed that there is no phonatory fatigue, but tendency to vocal recovery, we note a marked reduction of Average F0 and amplitude and a ratio Dc / Dd of 208 cycles per meter, id est 0.48 cm cycle. From phonation density graph we can point out speech and soft phonation trend. (Fig.3)

In summary we see that the moments considered the most difficult and fatiguing by the singer are characterized by a lower ratio Dc/Dd and a higher distance in centimeters travelled for each cycle; the opposite happens in moments of vocal rest or recovery. (Tab.1). Similar results for the second tenor: warming up value of ratio Dc/Dd 107 c/m and most difficult and fatiguing moment, the aria in first act, 60.5 c/m. We also analyze the examples of two female musical singers, doing the same considerations.

The role of Grizabella in the musical Cats, a non-danced role, and the role of Jennytutt-a-poys, a danced role. In the first role we conducted the recordings of double performance and of one night stands. (Tab.2) Dosimetry
in the second singer, instead, shows a value of VRI higher than the previous, sign of probably less vocal fatigue, despite the dance.

### Table 2

<table>
<thead>
<tr>
<th>VRI (Dc/Dd) in different moments of the performance (female musical singer)</th>
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<tbody>
<tr>
<td>• RI double performance → 129 c/m → 0.77 cm/cycle</td>
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<tr>
<td>• RI 1st performance → 123 c/m → 0.8 cm/cycle</td>
</tr>
<tr>
<td>• RI 2nd performance → 123 c/m → 0.8 cm/cycle</td>
</tr>
<tr>
<td>• RI break → 220 c/m → 0.45 cm/cycle</td>
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<tr>
<td>• RI one night stand → 110 c/m → 0.9 cm/cycle</td>
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### IV. DISCUSSION

Making comparisons between the two tenors we found that the phonation time profile of the warm-up and first act shows that the profile of the first tenor is broken, a sign that he tends to rest and needs less warming-up than the latter, that instead works more with increased risks of voice fatigue. (Fig.4)

The Fundamental frequency histogram could be considered such as a real vocal score profile. Here we see a substantial equality between the two tenors, a sign that the roles of the two operas have the same musical characteristics in the first act [5,6] (Fig.5) as also evidenced by the histogram of the vocal score profile. [8,9] (Fig.6). The SPL histogram, however, could be considered as such as an on stage relative dynamic agility. In this case the first tenor has a wider range of SPL compared to the second tenor, which uses high SPL for longer, a sign of higher vocal fatigue. [1,6] (Fig.7) The phonation density graph is like a phonetogram and can point out the vocal, technical and behavioral features. The first tenor has a wider phonetographic range in all vocal sectors and a wider range in speech and soft phonation sector than the latter. A 2006 study [7] shows that inability to produce soft phonation increases when vocal effort is present. In this case the chart can show a very small range of speech and soft phonation in the second tenor, even this sign of an increased vocal effort. (Fig.8)
net increase of VRI in times of less fatigue or vocal rest, while there is a reduction in the most challenging moments, especially in one-night stands than in double performance, perhaps because of awareness to face many hours of work in double performance; this would induce the singer to save energy in order to not tire herself in two consecutive performances.

In the second musical singer we found a VRI higher than the previous, sign of probably less vocal fatigue, despite the dance, due to the use of a classical singing technique that allows to sing in a lower average glottic SPL, enhancing use of vocal tract resonators. According to these data it’s possible to make comparisons between musical and classical singers. Opera soloist singers make 2-3 performances a week and rehearsals with a total sung phonation time less than 5 hours a week. This would allow us to say that there is a greater likelihood of damage from acute fatigue. Musical soloist singer make 8-9 performances a week, rehearsals and often hard bodily fatigue in dancing with a total sung phonation time more 10 hours a week. In this case there would be a greater likelihood of damage from chronic fatigue.

V. CONCLUSION

The literature is still poor and so there are not many references. In the future it would be desirable to establish vocal fatigue or vocal recovery thresholds for a reference in the evaluation of data from the dosimetrías. We had some difficulties: the size of APM is too large and cause discomfort to the dance and stage movements. The costumes are often too tight and it’s impossible to hide the tool. The singers often don’t feel safe to go on stage with discomfort and then refuse to wear it. We must clarify how to perform initial calibration in case of those singers who use both classical and modern way to sing during the same performance. Through this method it could be possible to adapt technical and behavioral measures to avoid or reduce the risk of vocal fatigue or damage.

We must still understand whether the technique and voice features influence vocal dose parameters; for this would be useful to implement the dosimetry for the same role in different singers. We need more studies to establish standard fatigue and recovery thresholds and ranges and to assess the possible differences between males and females and between different vocal classes.

REFERENCES


