INFLUENCE OF HORMONE REPLACEMENT THERAPY ON THE SINGING VOICE TESSITUTRA OF MENOPAUSAL WOMEN
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Abstract: The differences in the functioning of phonatory organs define the divergent aspects between the speaking voice and the singing voice. The human voice represents the most natural and oldest sound source with which music can be reproduced. Physiologically, singing involves the ability to coordinate and control the musculature and structure of the vocal organ. Along life, the human body goes through anatomo-physiological changes, several of them due to the action of sex steroid hormones. The fluctuations of these hormones starting in puberty affect the vocal folds and the larynx. The literature suggests that hormone replacement therapy (HRT) has a beneficial effect on the larynx preventing the voice changes associated with menopause and increasing vocal longevity. The objective of the present study was to compare the vocal tessitura of menopausal female choir singers using HRT or not in order to determine whether hormone replacement interferes with this vocal parameter. The sample consisted of 38 menopausal women divided into four groups in accordance with the hormonal status. No significant difference in singing voice tessitura were detected between female choir singers taking or not HT with estradiol, tibolone and phytohormone.

Keywords: Menopause, Voice, Choral, Singers, Sexual hormones.

I. INTRODUCTION
The human voice represents the most natural and oldest sound source with which music can be reproduced1,2. Physiologically, singing involves the ability to coordinate and control the musculature and structure of the vocal organ in order to produce modulations in the voice, with sounds varying over a wide gamut of frequencies in harmony and melody3,4. The demands made by the singing voice of the organ during singing regarding articulation, respiration and phonation are measurably different from those made by normal speech5. Singing requires refined muscle adjustment, reflecting a greater difficulty, since the singing voice makes more demands on the phonatory mechanism6. Singers represent a unique population in terms of vocal demands, which differ from those of non-singers, being characterized by greater sensitivity to small vocal changes7,8. Along life, the human body goes through anatomo-physiological changes, several of them due to the action of sex steroid hormones. The fluctuations of these hormones starting in puberty affect the vocal folds and the larynx9. During the menopausal period, an earlier alteration occurs in women, and more markedly so in the singing voice10. The literature suggests that hormone replacement therapy (HRT) has a beneficial effect on the larynx11,12 preventing the voice changes associated with menopause and increasing vocal longevity13. The objective of the present study was to compare the vocal tessitura of menopausal female choir singers using HRT or not in order to determine whether hormone replacement interferes with this vocal parameter.

II. METHODS
The sample consisted of 38 menopausal women divided into four groups:
1. Menopausal group with no hormone therapy (GNHT): 22 women aged 45 to 60 years, mean age 56 years, in menopause for at least 2 years and taking no hormone therapy (HT).
2. Menopausal group consisting of women taking estradiol hormone therapy (GHTE): 6 women aged 45 to 60 years, mean age 57 years, in menopause for at least 2 years and taking estradiol HT by the oral route for at least 6 months.
3. Menopausal groups taking tibolone hormone therapy (GHTT): 5 women aged 45 to 60 years, mean age 57
years, in menopause for at least 2 years and taking tibolone therapy by the oral route for at least 6 months.

4. Menopausal group taking phytohormone therapy (GHTP): 5 women aged 45 to 60 years, mean age 57 years, in menopause for at least 2 years and taking phytohormone therapy by the oral route for at least 6 months. All selected volunteers were submitted to otorhinolaryngologic evaluation in order to rule out any lesions in the larynx and/or vocal folds. The vocal tessitura profile was obtained manually using a Roland keyboard tuned in A 2 to 440 Hz, played by a female music teacher and choir conductor with experience in the area. A well-known Brazilian folk song which required variations in frequency from the most grave to the most acute was selected. After explaining the procedure, the conductor started to play the music, guiding the tuning of the volunteer while testing the maximum and minimum frequency achieved. The values of each musical note and their corresponding frequency in Hz were written down manually by the researcher. Data were analyzed statistically by the Mann-Whitney tests using the GraphPad Prism software, with the level of significance set at 5%.

<table>
<thead>
<tr>
<th></th>
<th>F2</th>
<th>F1</th>
<th>F2-F1</th>
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<tbody>
<tr>
<td>GNHT</td>
<td>387.52 Hz</td>
<td>175.43 Hz</td>
<td>212.09 Hz</td>
</tr>
<tr>
<td></td>
<td>(±116.48)</td>
<td>(±33.54)</td>
<td>(±116.64)</td>
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<tr>
<td></td>
<td>349.23 Hz</td>
<td>174.61 Hz</td>
<td>196.00 Hz</td>
</tr>
<tr>
<td>GHTP</td>
<td>426.78 Hz</td>
<td>138.61 Hz</td>
<td>288.17 Hz</td>
</tr>
<tr>
<td></td>
<td>(±154.90)</td>
<td>(±52.45)</td>
<td>(±139.08)</td>
</tr>
<tr>
<td></td>
<td>397.90 Hz</td>
<td>156.61 Hz</td>
<td>285.28 Hz</td>
</tr>
<tr>
<td>GHTT</td>
<td>367.40 Hz</td>
<td>187.00 Hz</td>
<td>180.40 Hz</td>
</tr>
<tr>
<td></td>
<td>(±100.78)</td>
<td>(±40.89)</td>
<td>(±140.86)</td>
</tr>
<tr>
<td></td>
<td>311.13 Hz</td>
<td>207.65 Hz</td>
<td>91.13 Hz</td>
</tr>
<tr>
<td>GHTP</td>
<td>413.42 Hz</td>
<td>197.84 Hz</td>
<td>208.96 Hz</td>
</tr>
<tr>
<td></td>
<td>(±55.27)</td>
<td>(±22.73)</td>
<td>(±58.45)</td>
</tr>
<tr>
<td></td>
<td>392.00 Hz</td>
<td>200.00 Hz</td>
<td>171.39 Hz</td>
</tr>
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III. RESULTS

No significant difference in F2 values were observed when GNHT was compared to GHTE (p=0.5566), GHTT (p=0.9751) and GHTP (p=0.4727). Again, no significant difference in F1 values were observed between GNHT and GHTE (p=0.2510), GHTT (p=0.3991) and GHTP (p=0.0751). When the F2-F1 values were compared between GNHT and GHTE (p=0.1702), GHTT (p=0.3995) and GHTP (p=0.9751), no significant differences were observed. Table 1 presents tessitura based on the mean, standard deviation (SD) and median values of each maximum and minimum musical note in Hz.

Table 1 – Mean (± SD) and median tessitura of the maximum (F2) and minimum (F1) frequencies in Hertz and difference between the F2 and F1 frequencies of the groups taking no hormone therapy (GNHT), taking hormone therapy with estradiol (GHTE), hormone therapy with tibolone (GHTT), and hormone therapy with phytohormone (GHTP).

IV. DISCUSSION

The relationship between voice and circulating sex steroid hormone levels has been previously established. Several studies have attempted to prove a correlation between menopause and voice using perceptive and acoustic evaluations. Some of these studies have proven this correlation, while others have not. The methodology used in the cited studies was perceptive and/or acoustic analysis of the phonation of a sustained vowel or sentence and therefore the measurements were not made during singing or the emission of different musical notes.

Some studies have stated that HT has a beneficial effect on the larynx, preventing the changes of voice associated with menopause and increasing vocal longevity. The data of the present investigation agree with other studies that evaluated various vocal parameters and did not detect a significant difference between menopausal women using HT or not. In the present study, the tessitura of the singing voice of the group taking no HT did not differ significantly from that of HT users. There are no studies in the literature on the normal tessitura values of singing voice in menopausal women, nor any comparisons of tessitura between menopausal women taking HT or not. Thus, the present study contributed to the literature by providing the tessitura values of singing voice of menopausal women taking HT or not.
V. CONCLUSION
No significant difference in singing voice tessitura were detected between female choir singers taking or not HT with estradiol, tibolone and phytohormone.

REFERENCES
[27] Stoicheff ML. Speaking fundamental frequency characteristics of nonsmoking female adults. J