

Effects of Resonance Voice Therapy on Hormone-Related Vocal Disorders in Professional Singers: A Pilot Study

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ABSTRACT

BACKGROUND: Menstruation-related hormonal alteration can be detrimental to the professional singing voice of women. Resonance Voice Therapy (RVT) has been proven to improve vocal production. However, no research to date has been conducted examining the subjective, acoustic, and stroboscopic effects of RVT on professional female singers having premenstrual or postmenopausal voice disorders.

AIM: The aim of this study is to compare the vocal effects of RVT with a control cervical-thoracic intervention in healthy female singers during the premenstrual phase as well as in postmenopausal singers and to evaluate which intervention will allow singers to improve vocal performance regardless of changes in hormonal status.

DESIGN: A randomized study was designed for this research. The research subjects were 20 professional female singers from the Southern California area, USA, with 10 premenstrual subjects in one group and 10 postmenopausal subjects in the other group. Among each group, 5 subjects were randomly selected to receive RVT and the remaining subjects received cervical-thoracic-focused exercises. The therapies consisted of 1 month of daily 15-minute sessions. For premenstrual subjects, voice data were collected at days 25 to 27 of the premenstrual phase during a scheduled initial voice evaluation. Follow-up data were collected during the same phase of the menstrual cycle (days 25-27) after 1 month of exercises. For postmenopausal subjects, voice data were collected at an initial voice evaluation with follow-up after 1 month of the assigned voice treatment. Outcomes were assessed with the singer's voice handicap index (VHI), laryngeal videostroboscopic examination, maximum phonation time (MPT), relative average perturbation (RAP), and pitch range before and following completion of therapies. Alleviation or deterioration percentages were used for statistical analysis. Student *t* test was used for statistical comparison between therapies.

RESULTS: The RVT decreased singer's VHI for both premenstrual and postmenopausal subjects by an average of 67%, compared with 7.8% for the cervical-thoracic therapy. The RVT also effectively decreased RAP by an average of 57% when combining the premenstrual and postmenopausal groups. The RVT increased MPT and pitch range among both premenstrual and postmenopausal subjects. The stroboscopic examination did not detect any significant differences between the 2 interventions.

CONCLUSIONS: The RVT is effective for professional female singers with hormone-related premenstrual and postmenopausal vocal changes. The RVT is suggested as one of the therapeutic approaches for vocal abnormalities in such a population. A larger cohort may be needed for future research.

Level of Evidence: 1b

KEYWORDS: Professional singers, menstruation-related voice disorder, singer's VHI

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Introduction

For female singers, hormonal fluctuations are among the most common and often perplexing causes of voice concerns. For many years, voice specialists have studied the effects of hormones on the voice. Much attention has been given especially to the premenstrual hormonal effects on the singing voice, and the information on menstrual cycle changes is helpful in understanding the effects of menopause. The condition is known as “laryngopathia premenstrualis” and is a result of physiologic,

anatomic, and psychologic alterations secondary to endocrine changes. The physiologic correlations to the perceived voice changes are related to the drop in estrogen levels on or about day 21 in the menstrual cycles.^{1,2}

Estrogen-level alterations cause laryngeal water retention, edema or interstitial tissues, and venous dilation.³ As estrogen levels begin to decrease, laryngeal tissues begin to absorb water, causing mucosal edema, vascular congestion, and increase vocal



fold mass,⁴ which can cause a loss of high notes,^{1,5-9} vocal instability and fatigue,^{2,3,5-9} uncertainty of pitch,^{1,2} decreased vocal efficiency,^{2,3,7-9} and reduced vocal power and flexibility.

For postmenopausal female singers, their estrogen and progesterone fluctuation diminishes significantly. Unlike the cyclic physiologic changes in female voice that occur in women with active menses, postmenopausal women experience permanent physiologic changes in the vocal folds which are attributed to alterations in hormonal status.^{10,11} After menopause, voices typically drop in fundamental frequency because the ovary secretes little or no estrogen but continues to secrete androgen. The most prominent hormonal change following menopause is a 10-fold to 20-fold drop in estradiol levels.¹² The laryngeal effects seen in the drop in estrogen levels in menopausal women should be consistent with those observed during the premenstrual phase, as similar hormonal changes are occurring. Acoustic analysis of postmenopausal voice shows irreversible modifications leading to decreased vocal quality. Postmenopausal hormone replacement therapy (HRT) does not reverse this decrease in vocal quality.^{13,14}

At present, there are no well-defined therapies designed to aid in stabilizing the healthy female singer's voice prior to menstruation or that can benefit the postmenopausal singing voice, although there is general agreement that good postural alignment is an important element in optimizing voice function.¹⁵⁻¹⁸ Also, in recent years, there has been increased interest among voice professionals in understanding the physiology behind the postural recommendations made to voice students and patients. To date, most of the research regarding length-tension imbalances in the musculature has been undertaken in the physical therapy literature.¹⁹ However, in individuals with pathologic swelling or voice problems due to disease other than physical hormone fluctuation, Resonance Voice Therapy (RVT) has been widely researched and proven to improve voice quality, decrease vocal edema, and promote healing with vocal trauma subjects.²⁰⁻²³ The aim of this study was to use RVT, in comparison with a cervical-thoracic-focused therapy, in healthy female singers during the premenstrual phase and in postmenopausal singers to improve vocal quality and to evaluate which therapy will allow singers to improve vocal performance regardless of changes in hormonal status.

Methods

Subject selection

A total of 20 female singers were recruited for the study from the Southern California area, with 10 women in the premenopausal group and 10 in the postmenopausal group. All subjects were greater than 18 years old, professional singers giving vocal performance more than 3 times per week, and had regular menstrual cycles each month or were postmenopausal, were not pregnant or did not plan to become pregnant during the time period involved in the study, did not report or present

with active voice problems during the study, and had no history of surgery in the neck or larynx region.

Randomization

We designed a randomized controlled trial in which half of the women in each group received RVT and the other half received cervical-thoracic-focused therapy. To determine which subjects received a specific type of therapy, the Statistical Analysis System (SAS) was used to generate values (0 or 1) for simple randomization within each group. Randomization occurred at the time of enrollment. Subjects were interviewed for their age, ethnicity, alcohol and smoking habits, profession, drug allergies, environmental allergies, gastroesophageal reflux, known throat or voice pathology, past throat surgery, menstrual and postmenopausal status, last date of menstruation, dose and frequency of oral contraceptive use, dose and frequency of HRT, and current medications. All subjects received an initial and post voice evaluation and stroboscope. Voice data and the stroboscope results were collected during initial and after therapy evaluation.

Interventions

RVT designed by Katherine Verdolini has been modified for this study. An experienced licensed speech-language pathologist performed voice evaluations and training. For RVT, the subjects engaged in the following stages of exercise 3 times per day (5 minutes each time): for warm-up section, the subjects sat upright with shoulders relaxed, breathed out first, inhaled, and held. While holding the breath, the subjects said "mum-mum-mum-mum" on the top of the breath. They would do slow, slow-fast, and quiet-projected "mum" for 5 times. For the stretching section, the subjects would glide their phonation from the lowest note to the highest note on the word "WHOO" for 5 times. Then they would glide from a comfortable high note to a lowest note on the word "BOOM" for 5 times.

For cervical-thoracic-focused therapy, the subjects were instructed to perform suboccipital stretch, pectoral stretch, neck flexor strength, and neck extender strength exercise in sequence, and each stretch was held for 30 seconds according to the protocols provided by Arboleda and Frederik.¹⁹

All subjects were demonstrated and instructed to perform assigned exercise at home. A follow-up telephone call was made after 1 month to ensure all subjects practicing assigned exercise at home.

Time of evaluation and data collection

For subjects in the premenopausal group, the posttherapy data collection occurred during their consecutive premenstrual phases of the menstrual cycle or days 25 to 27 of the menstrual phase. The first day of the menses is defined as day 1, when the estrogen level decreases and vocal cords have the most severe edema and dysfunction.

For women in the postmenopausal group, subjects were examined at the time of voice evaluation without considering their menstruation status. The singer's voice handicap index (VHI), laryngeal videostroboscopy, and acoustic analysis were completed at the same time, both before and after the 1-month therapy interventions as described above.

Singer's VHI

For the premenopausal group, subjects completed the singer's VHI²⁴ during the premenstrual phase (days 25-27). They received instruction how to perform either RVT or cervical-thoracic-focused therapy for a period of 15 minutes during the first visit and were trained to independently perform the therapy at home for 1 month on a daily basis. Following the therapy, subjects completed another singer's VHI questionnaire during the next premenstrual phase. For the postmenopausal group, subjects completed the singer's VHI at the time of voice evaluation and after receiving either RVT or the cervical-thoracic-focused treatment. They completed another singer's VHI after 1 month in-home daily practices.

Stroboscopy

For the subjects in premenopausal group, a KayPentax rigid stroboscope was used, during their premenstrual phase (days 25-27), by a licensed speech-language pathologist with more than 20 years experience in performing the procedure at the Keck Medical Center of University of Southern California to evaluate laryngeal functional parameters including general appearance, arytenoid mobility, supraglottic activity, mucosal wave, symmetry, presence of mucus phonation quality, resonance, and respiratory support. A scoring system was used to quantify the findings of stroboscopy (Table 2). After they received therapy, either RVT or cervical-thoracic-focused treatment, as described above, another laryngeal videostroboscopy was performed during the following premenstrual phase. For subjects in the postmenopausal group, subjects had first stroboscopy at the time of voice evaluation and after learning how to perform assigned exercises. Analysis of the videostroboscopic images was completed by a board-certified laryngologist with more than 20 years of clinical experience.

Acoustic analysis

Acoustic analysis was measured by recording the standardized reading of the "Rainbow Passage" and sustaining a vowel /a/ by the subjects. These recordings were used to determine maximum phonation time (MPT), pitch range, and relative average perturbation (RAP) score using Visi-Pitch IV software.

Both groups (premenopausal and postmenopausal), subjects, acoustic analysis was performed during their initial voice evaluation and after therapy.

Statistical analysis

For data analysis, the Statistical Package for the Social Sciences (SPSS), version 19.0, was used. Due to the significant baseline variations among candidates, improvement or deterioration percentages, on top of baseline measurements, were used to compare the therapeutic effects among groups. The percentages were expressed as mean \pm SD. Improvements or deteriorations were compared using the Student *t* test. A 2-tailed *P* value less than .01 indicated statistically significant differences for all tests, and a 2-tailed *P* value of more than .05 indicated statistical insignificance. Clinicians evaluating the subjective portions of the examinations were blinded to the group which subjects were assigned.

Results

Subjects' age, race, smoking history, alcohol history, allergy, and home medications do not significantly affect the candidates' voice

In our study, 20 professional female singers were included in the study, their ages ranged from 25 to 83 years with average age of 47.9 years. Their ethnic backgrounds included white (85%) and Asian (15%). The racial background did not contribute to any differences in the study results. Smoking, drinking, allergies, and medication history did not significantly contribute to the clinic measurements after statistical analysis of each individual factor (Table 1). The effects of menopausal status and therapy options can be safely analyzed with the planned statistic evaluation.

RVT can decrease singer's VHI for both premenopausal and postmenopausal subjects

As shown in Figure 1, among the premenopausal subjects, RVT decreased the singer's VHI by 60.6%, more than that of the cervical-thoracic-focused therapy, which is only 0.6%. The difference is statistically significant ($*P < .01$). For the postmenopausal subjects, RVT decreased the singer's VHI by 73.4%, and the cervical-thoracic-focused therapy decreased it by only 16.2%. The difference between them is also statistically significant ($**P < .01$).

After the premenopausal and postmenopausal groups were combined, the averaged singer's VHI improvement for all the subjects who received RVT is 67%, and 7.8% for the cervical-thoracic-focused therapy, with statistical difference ($***P < .01$) between these 2 therapies.

RVT can effectively decrease RAP

For the premenopausal group, the RVT improved the candidates' RAP by an average of 60%, the cervical-thoracic-focused therapy only decreased the RAP by 17%, and there is significant statistical differences between these 2 treatments ($*P < .01$).

Table 1. A total of 20 professional female singers were included in the study.

GROUPS	TEAMS	NO.	AGE, Y	RACE	SMOKING	ALCOHOL	GERD	ALLERGY	HORMONAL MEDS	VOICE DISEASE HISTORY	
Premenopausal	PR	1	25	W	No	No	No	Yes	No	Yes	
		2	26	W	No	No	Yes	Yes	Yes	No	
		3	42	W	Yes	No	No	No	No	Yes	
		4	29	W	No	No	Yes	No	No	Yes	
		5	21	W	No	No	No	No	No	No	
	PC	6	21	A	No	No	No	No	No	No	No
		7	26	W	No	No	No	No	No	No	No
		8	25	W	No	No	No	No	Yes	No	No
		9	51	W	No	NO	No	No	No	Yes	No
		10	32	W	No	Yes	Yes	No	No	No	Yes
Postmenopausal	MR	11	67	W	No	Yes	Yes	Yes	No	Yes	
		12	56	A	No	No	No	Yes	No	No	
		13	56	W	No	No	Yes	No	Yes	Yes	
		14	61	W	No	No	No	No	No	No	
		15	65	W	No	No	Yes	Yes	No	No	
	MC	16	72	W	Yes	No	No	No	No	No	No
		17	66	W	No	No	Yes	No	Yes	No	No
		18	71	A	No	No	No	No	Yes	No	No
		19	83	W	No	No	No	No	No	No	Yes
		20	63	W	No	No	No	No	No	No	No

Abbreviations: MC, postmenopausal group treated with cervical-thoracic exercises; MR, postmenopausal group treated with RVT; PC, premenopausal group treated with cervical-thoracic exercises; PR, premenopausal group treated with RVT.

Their ages, ethnic backgrounds, smoking and drinking histories, allergies, medication histories and histories of voice disorders were recorded and analyzed. These different variables did not significantly contribute to the clinic voice measurements. Under race, "W" stands for white and "A" for Asian.

The bold terms signify an answer of "Yes".

Similarly, for the postmenopausal group, the RVT decreased the RAP by 54.3%, the cervical-thoracic-focused therapy decreased by 12.0%, and statistical difference was shown between these 2 treatment modalities (** $P < .01$).

When the premenopausal and postmenopausal groups were combined, the RVT still significantly decreased the RAP by 57.2%. But the cervical-thoracic-focused therapy only induced a 15% decline of RAP, with statistical difference between these 2 interventions (** $P < .01$), as shown in Figure 2.

RVT increases MPT

Among the premenopausal subjects, the RVT increased the MPT by 61.8%, the cervical-thoracic-focused therapy only by 3.42%, and the difference between the groups is statistically significant (* $P < .01$). For the postmenopausal subjects, the

RVT increased the MPT by 67.6%, but the cervical-thoracic-focused treatment did not improve the MPT, giving significant statistical difference between these 2 therapies (** $P < .01$).

When the premenopausal and the postmenopausal research subjects were combined, the RVT increased the MPT by 64.7%. On the contrary, the cervical-thoracic-focused therapy did not provide any benefit (-3.46% worsening), resulting in a significant difference between the therapies (** $P < .01$), as shown in Figure 3.

RVT improves pitch range

For the premenopausal group, the RVT increased their pitch range with an average of 9.36% and the cervical-thoracic-focused therapy decreased their pitch range by -12.0%. There is significant statistical therapeutic difference between these 2 groups

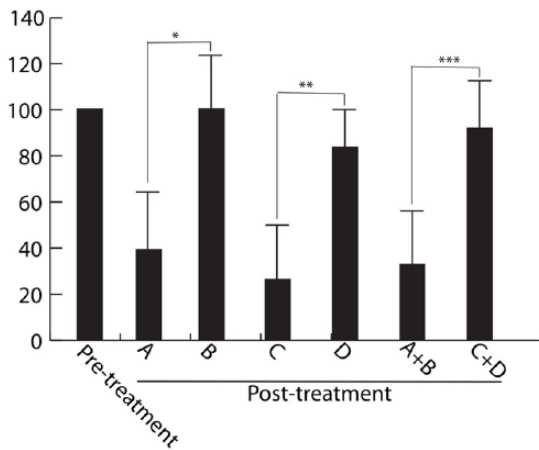


Figure 1. By standardizing the pretreatment singer's VHI to 100, the posttreatment score was scaled to get a standard score, which was used to compare the outcome of different therapies. The RVT decreased the singer's VHI by 60.6% for premenopausal subjects, more than that of the cervical-thoracic-focused therapy (0.6%), with statistical significance ($*P < .01$). Similar results were obtained for the postmenopausal groups ($**P < .01$) and the groups after combination ($***P < .01$). RVT indicates Resonance Voice Therapy; VHI, voice handicap index.

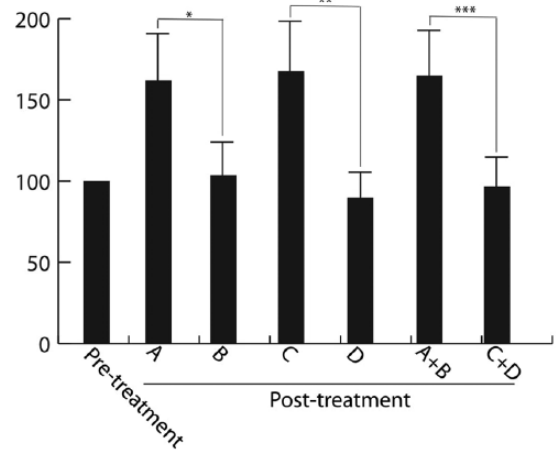


Figure 3. By standardizing all the measurements for statistical comparison, the candidates' MPT was compared after different therapies. For the premenopausal subjects, RVT increased the MPT by 61.8%, higher than that of the cervical-thoracic-focused therapy (3.42%), and the difference is statistically significant ($*P < .01$). Similar results achieved for the postmenopausal candidates (67.6% vs -5.00%, $**P < .01$) and the mixed candidates (64.7% vs -3.46%, $***P < .01$). MPT indicates maximum phonation time; RVT, Resonance Voice Therapy.

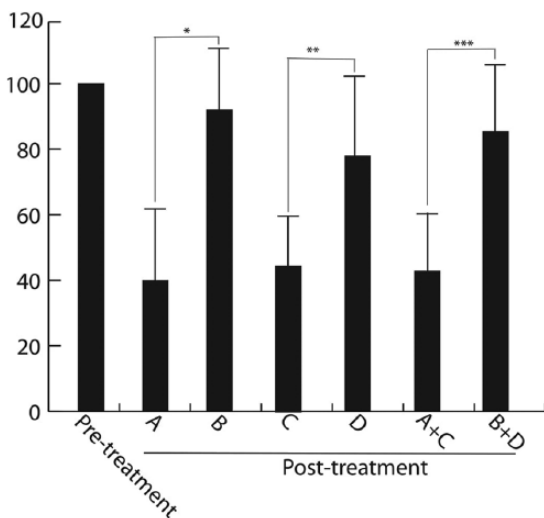


Figure 2. Similar standardized statistical comparison and calculation was for RAP. RVT improved the premenopausal candidates' RAP by 60%, compared to the 17% improvement by the cervical-thoracic-focused therapy with significant statistical difference ($*P < .01$). Similar results were achieved for the postmenopausal groups (54.3% vs 12%, $**P < .01$) and the combined groups ($***P < .01$). RAP indicates relative average perturbation; RVT, Resonance Voice Therapy.

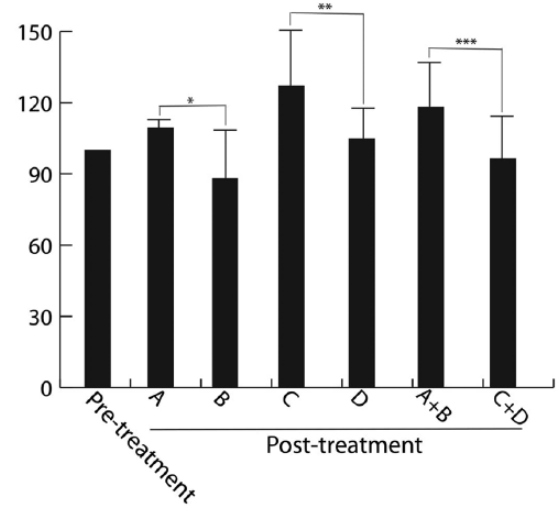


Figure 4. RVT, rather than cervical-thoracic-focused therapy, can significantly improve candidates' pitch ranges. There is significant statistical therapeutic difference between 2 different posttreatment teams for premenopausal candidates (9.36% vs -12%, $*P < .01$), but there is no statistical therapeutic difference for the postmenopausal candidates (27% vs 4.7%, $**P > .05$). However, when we mixed the premenopausal and postmenopausal candidates together, the difference is significant again (18.2% vs 3.6% with $***P < .01$). RVT indicates Resonance Voice Therapy.

($*P < .01$). In the postmenopausal group, the RVT increased the pitch range by 27.0%, the cervical-thoracic-focused treatment increased by 4.7%, but there was no statistical difference between them ($**P > .05$). When the premenopausal and postmenopausal groups were combined, the RVT extended the pitch ranges by 18.2%, and the cervical-thoracic-focused therapy worsened by -3.6%, and there is a significant statistical difference ($***P < .01$), as shown in Figure 4.

RVT does not significantly improve the appearance of vocal folds when evaluated with laryngeal videostroboscopy

Using our videostroboscopy scoring system, we developed a way to quantify the appearance and functional status of vocal cords for comparison across different candidates and different chronologic points of same candidates, as shown in Table 2.

Table 2. A simple videostroboscopic scoring system, which was designed and used quantify clinic findings on stroboscopy.

VIDEO STROBOSCOPY SCORING SYSTEM		
CATEGORIES	STROBOSCOPIC APPEARANCE	SCORES
a	Asymmetry	1
b	Incomplete glottic closure	1
c	Low resonance quality	1
d	Hyperactivity and compression	1
e	Breath support	1
f	Appearance of mucous	1
g	Low phonation quality	1
h	Edema of larynx	1
i	Erythema of larynx	1
j	Abnormal mucosal wave	1
Total		10

These laryngeal functional parameters include general appearance, arytenoid mobility, supraglottic activity, vibration, mucosal wave, symmetry, presence of mucus stranding, phonation quality, resonance and respiratory support, with 1 score assigned to each parameter. The higher the score is, the more severe the abnormality is.

A simple videostroboscopic scoring system was designed and used to quantify clinical findings on stroboscopy. A higher score corresponds to increased abnormality.

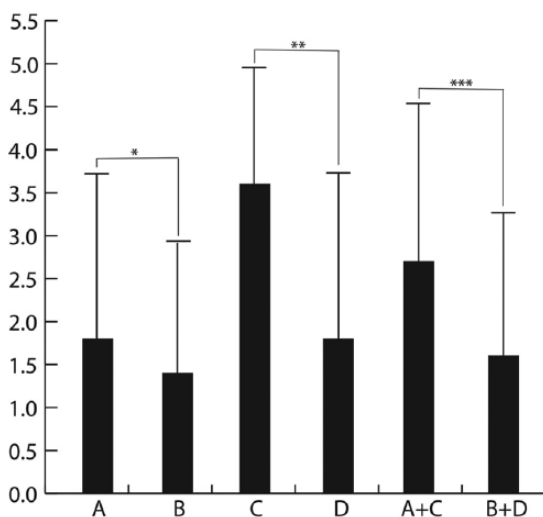


Figure 5. RVT does not significantly improve the stroboscopic appearance of vocal folds. Using our videostroboscopy scoring system, the averaged stroboscopic improvement was 39.2% with RVT, and it is 30% for the cervical-thoracic-focused therapy, with no significant difference between them ($*P > .05$). There is no statistical differences for the postmenopausal groups (50.7% vs 29.8%, $**P > .05$) or combined groups (44.9% vs 29.9%, $***P > .05$) either. RVT indicates Resonance Voice Therapy.

The higher the score is, the more severe are the appearance and dysfunction.

Among the premenopausal group, the average stroboscopic score decreased by 39.2% with RVT and the cervical-thoracic-focused therapy decreased by 30%. There was no significant difference between them ($*P > .05$). For the postmenopausal subjects, there was 50.7% improvement from RVT. There was only 29.8% improvement from the cervical-thoracic-focused therapy, and there was no statistical difference between the 2 interventions ($**P > .05$). When all the subjects were combined, the RVT resulted in 44.9% stroboscopic improvement, the cervical-thoracic-focused therapy resulted in 29.9%, with no statistical difference between them ($***P > .05$), as shown in Figure 5.

Discussion

Resonance Voice Therapy is proven to be an effective voice treatment method for voice disorders. This method is identified to be learnable and is likely to be used outside clinics.²⁵ Several researchers reported that RVT can reduce voice handicap index, self-reporting severity, phonation effort, voice quality severity, and vocal fold abnormality for voice-disordered patients.²⁵⁻²⁷ The results of this study suggest that RVT had positive effects on female singers' voice quality, speaking flexibility, phonation effort, and functional communication. These results were consistent with other researchers' findings in which reduction in voice quality severity was reported after RVT.²⁵⁻²⁷ To our knowledge, this research is the first study exclusive to professional female singers, whose vocational performances were affected by hormonal changes associated with menstruation.

Researches indicated that menstruation and menopause²⁸ affect variations in female vocal production and they all coincide with marked hormonal changes. Especially, estrogen cause similar epithelial changes of both larynx and vagina.²⁹ Histologic laryngeal changes during the menstrual cycle also mimic endometrium.¹⁰ Progesterone decreases in volume causing vocal fold edema by increasing viscosity and acidity levels of glandular laryngeal cells, whereas estrogen increases glandular cell secretion and has a hypertrophic effect on laryngeal mucus.^{10,30} So, both these steroids fluctuate during menstrual cycle and have effect on vocal characteristics throughout the cycle.³¹ These changes during the premenstrual phase cause an increase in mass of the vocal folds, which affect the vibratory characteristics of the vocal folds, lower fundamental frequency, and/or cause hoarseness. Our study results show that RVT is effective for professional female singers with premenstrual and postmenopausal voice concerns without significant changes in vocal fold appearance under videostroboscopy, and RVT is suggested as one of the effective therapy approaches in clinics for this population which has high demands for vocal quality.

During the past decade, or so, emphasis has been paid to the association between posture control and voice function (both

for normal speech and for professional artistic performance).³²⁻³⁴ In fact, because the larynx is suspended from the hyoid bone, it can vary its position according to how the hyoid bone itself moves, or, indirectly, when the head, jaws (and thus temporomandibular articulation), cervical spine, and scapular girdle move.³⁵ If one considers the muscle-tendon and ligament connections of the hyoid bone with these parts of the skeleton, the anatomical-functional relationship between the larynx and posture becomes clear. But the skeletomuscular components do not affect the inner structure of the larynx. In our study, no improvements were observed with the singer's VHI, RAP, MPT, or pitch range following cervical-thoracic-focused therapy.

As discussed above, this study focuses exclusively on female singers, without recruiting any female nonsingers, which makes this study unique in its design and result application. The limitation of this study is mainly its sample size, which is difficult to enlarge in real life.

Further research is needed to include larger sampling to make the statistical analysis more powerful. In our study, we noticed that both the RVT and the cervical-thoracic-focused therapy can improve the laryngeal findings under stroboscopy without statistically significant difference, but the singers voice functions are significantly different. This finding prompts our interest in further research on the relationship between stroboscopic findings and the functional status of larynx, especially under the influence of hormones.

Author Contributions

LO: Study design, subject recruitment, data analysis. BV: Study design, subject recruitment, data analysis. CL: Data analysis, manuscript drafting. GT: Data analysis, manuscript drafting. US: Study design, subject recruitment, data analysis, principal investigator.

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