Efficacy of Water Resistance Therapy in Subjects Diagnosed With Behavioral Dysphonia: A Randomized Controlled Trial

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Summary: Purpose. The purpose of the present study was to determine the efficacy of water resistance therapy (WRT) in a long-term period of voice treatment in subjects diagnosed with voice disorders.

Methods. Twenty participants, with behavioral dysphonia, were randomly assigned to one of two treatment groups: (1) voice treatment with WRT, and (2) voice treatment with tube phonation with the distal end in air (TPA). Before and after voice therapy, participants underwent aerodynamic, electroglottographic, acoustic, and auditory-perceptual assessments. The Voice Handicap Index and self-assessment of resonant voice quality were also performed. The treatment included eight voice therapy sessions. For the WRT group, the exercises consisted of a sequence of five phonatory tasks performed with a drinking straw submerged 5 cm into water. For the TPA, the exercises consisted of the same phonatory tasks, and all of them were performed into the same straw but the distal end was in air.

Results. Wilcoxon test showed significant improvements for both groups for Voice Handicap Index (decrease), subglottic pressure (decrease), phonation threshold pressure (decrease), and self-perception of resonant voice quality (increase). Improvement in auditory-perceptual assessment was found only for the TPA group. No significant differences were found for any acoustic or electroglottographic variables. No significant differences were found between WRT and TPA groups for any variable.

Conclusions. WRT and TPA may improve voice function and self-perceived voice quality in individuals with behavioral dysphonia. No differences between these therapy protocols should be expected.

Key Words: Tube phonation–Semi-occluded vocal tract–Voice therapy–Subglottic pressure–Phonation threshold pressure.

INTRODUCTION

Physiological approach of voice therapy is commonly used by speech-language pathologists in treating patients with a wide variety of voice disorders. Stemple[1] defined this approach of voice therapy as "programs aimed to modify the physiology of the vocal mechanism." According to Stemple, this approach involves three main components: "1) to improve the balance between the primary voice production sub-systems (respiration, phonation, and resonance), simultaneously, as opposed to working on each component individually (as symptomatic approach does), 2) to improve the strength, balance, tone, and stamina of laryngeal muscles, and 3) to develop a healthy mucosal covering of vocal folds."[2] Examples of physiological voice therapy programs include resonant voice therapy (RVT),[3] the accent method of voice therapy (AM),[4] and vocal function exercises (VFE).[1]

Semi-occluded vocal tract exercises

A common aspect in physiological voice therapy programs mentioned above is that all of them take advantage of semi-occluded vocal tract exercises (SOVTE). This group of exercises includes phonation on voiced fricatives, nasals, lip and tongue trills, hand over mouth, and phonation into different tubes with the distal end either freely in the air or submerged into a recipient filled with water.

Several studies have been carried out to investigate the physiological aspects of SOVTE. Some of them have focused on the glottal source,[5–24] others on vocal tract configuration,[22,25–29] and also an important number of investigations have explored aerodynamic variables.[29–33] Some effects regarding the glottal source, related to the increased inertive reactance in the vocal tract, have been reported in modeling studies.[9,34,35] Specifically, earlier modeling investigations support the idea that this increment positively affects the vocal fold vibration,[5,8,34,35] changing the glottal flow amplitude and pulse shape.[6,7,35,36] According to Titze, strengthening of the higher harmonics and an increase in the overall sound pressure level are caused by an increased skewing of the glottal flow waveform (faster cessation of the flow) when inertive reactance is increased.[5–8] Additionally, the phonation threshold pressure (PTP) (the minimum subglottal pressure required to initiate and sustain phonation) is reduced by increased vocal tract inertance.[8,35,36] Low values of this variable suggest an easy phonation (low phonatory effort).

A considerable number of studies have explored the possible effect of SOVTE on vocal fold adduction through electroglottographic contact quotient (CQ_{EGG}).[10–19] Andrade et al[18] as well as Guzman et al[19] compared the CQ_{EGG} among different SOVTEs. The latter found that different SOVTEs differentially affect vocal fold adduction in both subjects with dysphonia and subjects with normal voice. Lip and tongue trills produced

Accepted for publication September 8, 2016.

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Journal of Voice, Vol. ■■, No. ■■, pp. ■■-■■
0892-1997

http://dx.doi.org/10.1016/j.jvoice.2016.09.005

the lowest CQ_{EGG} values, whereas straw submerged 10 cm below water presented the greatest CQ_{EGG}.[19] Low CQ_{EGG} values during tongue and lip trills have also been reported by Andrade et al[18] and Gaskill and Erickson.[10]

The impact of SOVTE on vocal fold vibration and glottal area variables has also been observed by high speed digital imaging during tube phonation.[20–22] Additionally, an investigation (a double-case study) using computerized tomography (CT) was carried out to observe whether there are systematic changes in the vocal fold adjustment during and after tube phonation.[23] Muscle activity has also been assessed using electromyography.[24] Findings from electromyography showed that the ratio of thyroarytenoid muscle activity versus cricothyroid muscle activity increased during phonation into a tube.[24]

Vocal tract shape changes during SOVTE have been investigated through CT,[17,25,29] magnetic resonance imaging,[26] and with flexible laryngeal endoscopy as it comes to hypopharyngeal and laryngeal changes.[27] In a single case CT study with a vocally normal subject, Vampola et al[25] found that the most dominant modification during tube phonation was the expansion of the cross-sectional area of the oropharynx and oral cavity. A higher velum position was also reported. When comparing the pre- and posttube phonation, the authors showed that the total volume of the vocal tract was considerably larger after phonation into the tube. The volume of the valleculae and piriform sinuses also increased.[25] Similar results have been demonstrated by Laukkanen et al[26] and Guzman et al[17] in vocally normal subjects. The latter also showed that the vertical laryngeal position was lower during phonation into a tube compared with vowel phonation, and that the changes were more prominent during phonation into a narrow straw (stirring straw) compared with phonation into the traditional Finnish glass tube. Wistbacka et al[28] showed in a recent investigation with a dual-channel electroglottograph that phonation into a tube submerged into water caused a lower vertical laryngeal position, whereas it rose during phonation with the distal tube end in air. Moreover, in a recent investigation with CT on voice patients, the total volume of the vocal tract increased during tube phonation compared with the conditions pre- and postexercises.[29]

Various earlier studies have addressed the effect of different SOVTEs on air pressure measures.[17,30–33,37] Maxfield et al[32] measured the intraoral pressure (Poral) produced by 13 semi-occlusions. The highest values of oral pressure were evidenced for a straw submerged in water, for lip trills, and for a stirring straw with the free end in air. Radolf et al[30] showed that compared with vowel phonation, the Poral increased in phonation into a resonance tube and stirring straw, most when the resonance tube was 10 cm in water. Subglottic pressure (Psub) also tended to increase relatively more than Poral, and thus transglottic pressure (Ptrans) was higher during tube and straw phonation compared with vowel phonation. In a recent investigation, it was found that all exercises with phonation into tubes in air and submerged in water had a significant effect on Psub, Poral, and Ptrans.[37] Phonation into a flexible silicon tube (LaxVox-like tube) submerged 10 cm in water and phonation into a stirring straw in air resulted in the highest values of Psub and Poral compared with baseline. Moreover, most variables behaved in a similar way regardless of the vocal status of the participants (functional dysphonia, normal without voice training, normal with voice training, and vocal fold paralysis).[37]

Evidence about efficacy of physiological approach of voice therapy

Multiple earlier studies have demonstrated the efficacy of physiological approach of voice rehabilitation programs.[38–63] VFEs have been examined with both normal and voice disordered populations,[38–56] as well as RVT[57–59] and AM.[60–63] However, there are few studies exploring the efficacy of alternative voice rehabilitation programs based on SOVTE, such as phonation into different tubes with the distal end either freely in the air or submerged into a recipient with water. An investigation on the effect of drinking straw phonation in air plus bilabial consonant /ß:/ in a group of acting students diagnosed with muscle tension dysphonia showed that after a 6-week therapeutic period, significant positive changes were observed by spectral analysis and laryngoscopic assessment.[64] In a recent randomized controlled trial, Kapsner-Smith et al[65] demonstrated that a 6-week therapeutic program, based on flow-resistant tube exercises (stirring straw phonation), caused significantly more improvement in Voice Handicap Index (VHI) scores than in the scores of the control condition (no-treatment group).[65] Furthermore, flow-resistant tube therapy resulted in significant decrease in roughness (from the Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V) scale) relative to the control group. To the best of our knowledge, only two longitudinal studies have been carried out using phonation into tubes submerged in water (water resistance therapy [WRT]) in subjects with behavioral dysphonia.[66,67] In a controlled study conducted by Simberg et al,[66] participants from experimental group underwent a 7-week therapy period with WRT. Perceptual assessment and results from a questionnaire of the occurrence of vocal symptoms revealed significant positive changes in the treatment group compared with the control group.[67]

Tube in air versus tube into water

From the physical point of view, one of the main differences between tube phonation with the free end in air and tube submerged into water is the degree of resistance that they offer to the airflow, being greater when tube is placed in water. Andrade et al[33] showed that when tubes are submerged into water, back pressure (analogous to Poral) needs to overcome the pressure generated by the water depth before flow can start.[33] Another difference between tube phonation in air and into water is due to the water bubbles produced during the latter (WRT). Therefore, tube phonation in water generates a pulsating oral pressure at the frequency of 15–40 Hz,[30,31] which may cause a massage-like effect on the laryngeal and pharyngeal tissues.

Although the two physical differences between tube in air and tube in water are well supported by evidence, there is no evidence on the possible long-term effects of these two therapeutic approaches and the possible differences in the effects. It seems important to investigate whether these approaches would result in different therapeutic outcomes. The investigation is motivated by the fact that these two approaches are practical and easy to use in voice therapy, and therefore they have become increasingly popular worldwide. Therefore, the present study aimed to