Resonance Tube or Lax Vox?

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Summary: Objective. This study compares the *flow resistance* of Resonance tube (RT) and Lax Vox tube (LVT) when submerged 2 cm and 10 cm in water, as well as *phonation into the tubes* in these conditions.

Methods. In the *in vitro* experiment, the air pressure for flow rates of 60–600 mL/s was measured at the tube inlet, when the outer end of the tube was submerged 2 cm and 10 cm below water surface in 30°, 45°, and 90° angle. In the *in vivo* experiment, 14 subjects phonated in habitual loudness and loudly into both tubes, with the outer end 2 cm and 10 cm in water. RT was immersed in a 45° angle and LVT in a 90° angle in water. Oral pressure, contact quotient from electroglottographic signal, and sound pressure level were studied. Sensations during phonation were reported in an interview.

Results. Flow resistance was slightly lower with LVT than with RT, and slightly lower for smaller immersion angles. In habitual loudness, transglottic pressure and frequency of oral pressure variation were lower for LVT phonation and amplitude of oral pressure variation was higher for LVT 2 cm in water. Some subjects preferred RT, whereas others preferred LVT or reported no differences between them.

Conclusions. The tubes differed slightly in flow resistance. Higher oral pressure oscillation with LVT 2 cm in water may offer stronger massage effect on vocal folds.

Key Words: Flow resistance–EGG–Voice therapy–Water resistance therapy–Air pressure in phonation.

INTRODUCTION

Voice training and therapy utilize phonation into tubes to improve voice quality. Phonation into a tube that artificially lengthens and narrows the vocal tract increases flow resistance (mean air pressure divided by mean airflow). Phonation into tubes is performed so that the outer end is either free in the air or immersed in water.[1] The latter is called "water resistance therapy." In Finnish tradition, glass Resonance tubes (24–28 cm in length, 8–9 mm in inner diameter), lanced by Sovijärvi,[2] are used. The depth of immersion in water in a bowl is 2–10 cm (sometimes even 15 cm). Shallow immersion depth, which offers lower flow resistance, is used for hyperfunctional voice disorder, whereas deep immersion with high flow resistance is used for hypofunctional voice disorder, in order to increase compensatory adductory activity.[2,3] For children, Sovijärvi recommended tubes of 24 cm in length and 8 mm in inner diameter. For adults, the recommended length of tubes depended on voice category: For altos and basses, longer tubes (28 cm) were recommended, whereas for sopranos and tenors shorter tubes (26 cm) were regarded best. In addition to glass Resonance tubes, flexible silicon tubes, called Lax Vox tubes (length of 35 cm, inner diameter of 9–12 mm), are nowadays used for water resistance therapy.[4,5] The recommended immersion depth for a Lax Vox tube is 2–7 cm, and typically a bottle is used instead of a bowl.

Various beneficial effects have been reported after undergoing water resistance therapy. Simberg et al[6] reported improved perceptual voice quality and fewer vocal symptoms after 7 weeks of Resonance tube treatment of students with mild dysphonia. Paes et al[7] found increased phonatory comfort, improved perceptual voice quality, and decreased instability, subharmonics, and noise in dysphonic patients' voices immediately after water resistance exercising with Resonance tube. Mailänder et al[4] reported improved perceptual voice quality and self-evaluation of voice and increased sound level in voice range profile in healthy teachers after 3 weeks of Lax Vox training.

So far, few studies exist on the effect on phonation of the length and diameter of Resonance tube. Laukkanen compared phonation into three glass tubes (26 cm, 27 cm, and 28 cm in length, and 9 mm in inner diameter) of two female subjects.[8] The outer end of the tubes was free in the air. No systematic differences in the effects of the tubes were found. A recent study[9] investigated the effect of phonation into Resonance tubes of 26 cm and 28 cm in length on vertical position of the larynx and oral pressure in two subjects. The distal end of the tube was in water. Tube length did not seem to have a systematic effect on the results.

In general, it is known that the length and diameter of a tube affect the impedance of the tube,[10,11] with the diameter having a stronger effect than the length. Furthermore, flow resistance (mean pressure divided by mean airflow) is naturally higher when a tube is in water than when it is free in the air,[12,13] and higher when the immersion is deeper. It is plausible that the immersion angle also affects the flow resistance of the tube.

Among clinicians, there has been an ongoing discussion whether one should use glass Resonance tube or Lax Vox tube for water resistance therapy. Some speech therapists prefer a glass Resonance tube as it seems to give stronger sensations of resonance vibrations on the lips and because it is easier to clean.[3] Other therapists prefer Lax Vox tube because it is more practical and non-breakable, and offers the possibility of inserting it in a straight angle into a bottle to avoid splashing of water from a bowl and to help in keeping the head position natural, that is not bent down. It has also been mentioned that a Lax Vox tube ensures a better jaw position due to its slightly wider diameter.[5]

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To the best of our knowledge, no systematic study exists so far on the differences between Resonance tube and Lax Vox tube, neither as it comes to the flow resistance properties of the tubes as such nor as it comes to the effect the tubes have on phonation. Hence, this study compares (1) the flow resistance of *Resonance tube* and *Lax Vox tube in vitro* as the tubes are submerged 2 cm and 10 cm in water, and (2) the characteristics of phonation into *Resonance tube* and *Lax Vox tube* with the outer end immersed 2 cm and 10 cm in water in a bowl. The immersion depths of 2 cm and 10 cm were chosen as they represent shallow and deep immersion and are most often used in clinical practice.

METHODS

Measurement of flow resistance of the tubes

The flow resistance of a glass Resonance tube (27 cm, 9 mm) and a silicon Lax Vox tube (35 cm, 10 mm) was measured as follows. The inlet of the tube was attached to a flow source (Figure 1). The air pressure (backpressure, P(back)) for various steady flow rates was measured at the tube inlet (1 cm upstream of the tube), when the outer end of the tube was submerged 2 cm and 10 cm below water surface in an aquarium. Compressed air (1 atm) was used as the flow source. The airflow rate, as the manually controlled parameter, was measured by a floating flowmeter (EMKO DF3 09K5, EMKOMETER s.r.o., Ledec nad Sazavou, Czech Republic). The air pressure on the inner wall of the upstream tube was measured with a digital manometer (GDH 07 AN, with the measurement accuracy of 1 mm H_2O, GHM Messtechnik GmbH Standort Greisinger, Regenstauf, Germany). The signal was registered by a PC-controlled measurement system Brüel & Kjaer PULSE 10 (Brüel & Kjær Sound & Vibration Measurement A/S, Nærum, Denmark) using a 32.8 kHz sampling frequency and a 16 bit A/D convertor. Flow values ranging from 60 to 600 mL/s were used, as they comprise the most typical range measured from humans.[14] Three different immersion angles were tested: 30°, 45°, and 90°. These angles were chosen because 90° is recommended for vocal exercising with the Lax Vox tube and 45° for the Resonance tube, and 30° was considered as the lowest degree that is practical to use when phonating through a tube in water. A movable laboratory support was used for ensuring the exact tube position in the water (Figure 1).

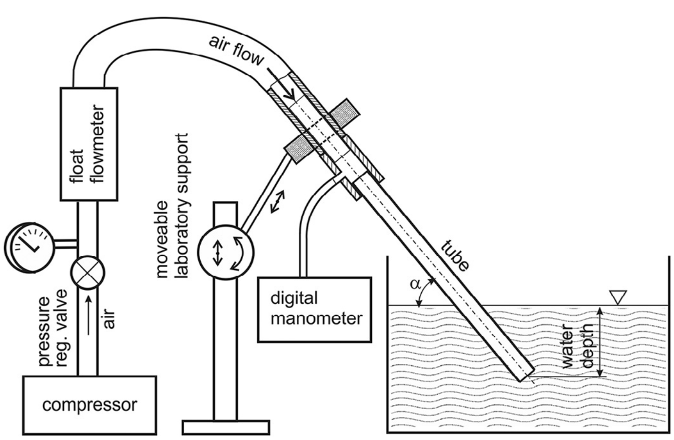

FIGURE 1. The experimental setup for measurement of flow resistance of the tubes.

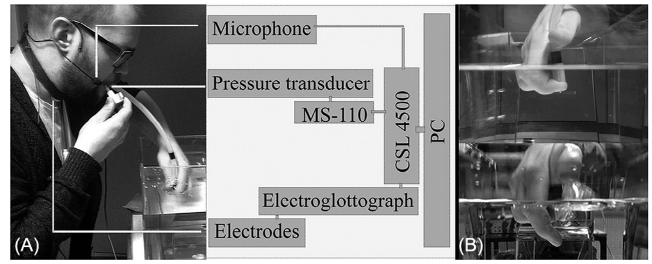

FIGURE 2. **A.** The experimental setup for studying phonation into the tubes. Photo published with permission of the person. **B.** Shuttering of the distal end of the tube under water at random intervals with finger.

Recording of the subjects

Fourteen volunteers with no known pathology of the larynx or voice (6 males, 8 females, mean age of 43 years) were recorded. Six subjects (4 females, 2 males) had taken at least their bachelor's degree in vocology and were familiar with Resonance tube and Lax Vox exercising. The other subjects (4 males, 4 females) were not familiar with vocal exercising. Trained and untrained subjects were compared in order to get a representative sample of both types of potential users of tube exercises, and to find out whether possible differences in phonation into the two tubes would be related to the tubes as such or to compensatory strategies that have been learned. The subjects were instructed to phonate into the tube a vowel-like sound between [u:] and [o:], which are the most natural alternatives with lip rounding (lips around the tube). They phonated three times in comfortable pitch and loudness and three times loudly into a Resonance tube (27 cm) and Lax Vox tube, with the outer end submerged first 2 cm and then 10 cm in water (Figure 2). Each sustained phonation lasted approximately 5 seconds. Half of the subjects started with Resonance tube and the other half with Lax Vox tube. The Resonance tube was immersed in 45° angle in water and Lax Vox tube in 90° angle, as these angles allow the best body posture during the task. Recordings were made for oral pressure (MS-110 transducer electronics unit by Glottal Enterprises, Syracuse, NY; and transducer PT-75, which enables registering pressures of up to 75 cm H_2O), electroglottographic signal (dual-channel Electroglottograph (EGG), Glottal Enterprises), and acoustic signal (AKG head-mounted microphone C5441 at 6 cm from the lips; AKG, Vienna, Austria). Computerized Speech Laboratory (CSL 4500, KayPENTAX, Lincoln Park, NJ) was used in the recording (44.1 kHz, 16 bits). Acoustic signals were calibrated with a standard sound source to enable measurement of sound pressure level (SPL). Sensations during tube phonation were reported in an interview. The questions posed were the following: (1) Did you feel any differences between the tubes? (2) If yes, which tube you preferred and why?

Analyses of the signals

The peak oral pressure P(oral) during manual shuttering of the distal tube end was measured for an estimate of subglottic pressure P(sub), and the mean P(oral) was measured when the tube was open (Figure 3). These measurements enabled the calculation of the mean transglottic pressure: P(trans) = P(sub) – P(oral).