The present study aimed to observe the effect of two types of tubes on vocal tract bidimensional and tridimensional images. Moreover, the total volume of vocal tract modifications of vocal tract configuration during and after phonation of sustained [a:], followed by sustained phonation into a drinking straw, and then repetition of sustained [a:]. A similar procedure was performed with a stirring straw after 15 minutes of vocal rest. Anatomic distances and area measures were obtained from computerized tomography midsagittal and transversal images. Vocal tract total volume was also calculated.

Results. During tube phonation, increases were measured in the vertical length of the vocal tract, oropharyngeal area, hypopharyngeal area, outlet of the epilaryngeal tube, and inlet to the lower pharynx. Also, the larynx was lower, and more closure was noted between the velum and the nasal passage.

Conclusion. Tube phonation causes an increased total vocal tract volume, mostly because of the increased cross-sectional areas in the pharyngeal region. This change is more prominent when the tube offers more airflow resistance (stirring straw) compared with less airflow resistance (drinking straw). Based on our data and previous studies, it seems that vocal tract changes are not dependent on the voice condition (vocally trained, untrained, or disordered voices), but on the exercise itself and the type of instructions given to subjects. Tube phonation is a good option to reach therapeutic goals (eg, wide pharynx and low larynx) without giving biomechanical instructions, but only asking patients to feel easy voice and vibratory sensations.

Key Words: tube phonation--semi-occluded exercises--vocal tract--voice therapy--functional dysphonia.

INTRODUCTION

One aspect considered in voice therapy and training is the modification of vocal tract structures. These changes partially shape the spectral energy distribution, and this in turn, can produce different voice qualities or vocal timbres. It is generally agreed among clinicians and voice trainers that vertical laryngeal position (VLP), pharyngeal width, and laryngeal constrictions are important aspects that shape voice quality in both normal and pathological voices.1–7 A wide variety of voice exercises are used to accomplish modifications in these vocal tract features, one being the semi-occluded vocal tract exercises.

Several effects have been attributed to semi-occluded vocal tract postures. One of the effects that has been explored is the modifications of vocal tract configuration during and after phonation into different types of tubes used in voice therapy. Two earlier investigations have been performed using computerized tomography (CT). Guzman et al.,8 in a single case study, reported that during Finnish glass and stirring straw phonation, hypopharyngeal area widened, the laryngeal position lowered, and more closure was seen between the velum and the nasal passage compared with open vowel phonation. All changes were more prominent during stirring straw phonation than during glass tube phonation in air. In another CT and finite-element modeling single case study, the most dominant change during phonation into the tube was the expansion of the cross-sectional area of the oropharynx and in the oral cavity due to a different tongue position.9 CT images also revealed that the velum rose to seal the nasopharyngeal port during tube phonation and also remained raised after it.10 Moreover, the total volume of vocal tract was considerably larger after phonation into the tube. Laukkonen et al.10 observed similar vocal tract modifications during glass tube phonation in a female subject using magnetic resonance imaging. All of the previously mentioned studies were carried out with vocally trained participants without vocal fold pathology.

Vocal tract changes during eight different semi-occluded exercises were recently studied using flexible laryngeal endoscopy in a group of patients diagnosed with hyperfunctional dysphonia. Findings revealed that all exercises produced a lower VLP, a narrower aryepiglottic opening, and a wider pharynx than resting position.11

To the best of our knowledge, to date, no studies with semi-occluded postures have been performed using CT in patients with voice disorders. The present research aimed to observe the effect on vocal tract bidimensional and tridimensional images of two types of plastic tubes commonly used in voice therapy and training. Based on previous data, we hypothesize that during tube phonation, the vocal tract should experience the following modifications compared with open vowel production: (1) larger total volume of the vocal tract, lower VLP, raised velum, and a wider pharynx; (2) changes should be more prominent during narrow
tube phonation compared with wide tube phonation; and (3) these changes are not expected to remain after exercises.

METHODS

Participants
Ten participants were included in this study (six women and four men). The average age of the subjects was 26 years, with a range of 21–43 years. Inclusion criteria included (1) age range of 20–45 years, (2) laryngoscopic diagnosis of mild hyperfunctional dysphonia, and (3) no previous voice training or therapy. None of the participants reported previous experience using tube phonation or other semi-occlusions as vocal training or warm-up exercises. Subjects did not report any known voice or hearing pathology at the time of the experiment. Several definitions of laryngeal hyperfunction exist, but a recurrent feature in almost all descriptions includes excessive laryngeal musculoskeletal activity, force, or tension. The basic paradigm for the evaluation of laryngeal hyperfunction is to look for compression of the glottis and supraglottic structures during phonation. In the present study, diagnosis of hyperfunctional dysphonia was made based on the previous description. This study was reviewed and approved by the University of Chile Hospital Review Board. Informed consent was obtained from all participants.

Laryngoscopic assessment
All participants were asked to undergo flexible laryngoscopy (Olympus ENF-P4; Olympus, Center Valley, PA, USA) to confirm the presence of functional dysphonia. Endoscopic laryngeal examinations were performed by two laryngologists who are coauthors of the present study (C.O. and M.L.). Intranasal topical anesthesia was used during trans-nasal endoscopy for all subjects.

CT scanning
CT was carried out at the University of Chile Hospital, Department of Imaging and Radiology. The CT images were acquired using a SOMATOM Sensation 64 (Siemens Healthcare, Erlangen, Germany) CT machine. The CT imaging parameters used to provide images of the vocal tract were voltage of 100 kV, time of the rotation of 0.4 seconds, and slice thickness of 1.2 mm. In supine position inside the CT machine, subjects were asked to produce the following phonatory tasks: (1) to sustain vowel [a:] (baseline, condition pre), (2) to phonate a sustained vowel-like sound into a drinking straw (tube 1) (5 mm of inner diameter and 25.8 cm in length) for 15 minutes, and immediately after that, (3) to produce another sustained vowel [a:] (condition post). After 20 minutes of complete silence (vocal rest), subjects performed phonation into a plastic stirring straw (tube 2) (2.7 mm of inner diameter and 10.7 cm in length) for 15 minutes. Immediately after that, participants were asked to produce another sustained vowel [a:] (post condition). Subjects were allowed to breathe normally during tube phonation. All phonations were carried out at habitual loudness level and speaking pitch. Pitch was kept constant during all phonatory tasks and it was perceptually controlled by one of the experimenters using an electronic keyboard. Participants were required to produce a stable sound with a good closure at the lips; to feel vibratory sensations as strong as possible on the alveolar ridge, face, and head areas; and to produce an easy voice during tube phonation. Each subject was scanned once while producing each phonatory task. No more repetitions were performed because of the maximum allowed amount of radiation. Participants were asked to adopt a relaxed posture in the CT scanner and exactly the same body and head position was kept during the entire CT procedure. The head position was mechanically fixed in a frame during all experiments.

CT image analysis
Most of CT measures included in the present study were based in a previous research. Five CT midsagittal images (five phonatory tasks × one repetition) were chosen from each subject to perform a series of distance measurements (mm). Anatomic distances (Figure 1) of interest included (1) vertical length of the vocal tract (which is indicative of the VLP) measured as the distance between the lowest point of the odontoid process of the atlas and the vocal folds following a vertical line; (2) horizontal length of the vocal tract measured as the distance between the lowest point of the atlas and the narrowest point between the lips, (3) lip opening measured as the distance between the lower edge of the upper lip and the upper edge of the lower lip, (4) jaw opening measured as the distance between the lowermost edge of the jawbone contour and the anterior end of the hard palate, (5) tongue dorsum height measured as the distance between the lowermost edge of the jaw bone and the uppermost point of the tongue dorsum, (6) oropharynx width measured as the distance between the lowest point of the second vertebra and the most posterior part of the tongue contour (to ensure the same angle, we used a straight line from the anterior

FIGURE 1. Distances (mm) measured in computerized tomography (CT) midsagittal images: (1) vertical length of the vocal tract, (2) horizontal length of the vocal tract, (3) lip opening, (4) jaw opening, (5) tongue dorsum height, (6) oropharynx width, (7) velum elevation, and (8) hypopharynx width.
uppermost edge of the jawbone contour to the anterior lowest point of the second vertebra), (7) velum elevation measured as the distance from the posterior upper edge of the hard palate and the anterior lowest point of the uvula, and (8) hypopharynx width measured as the distance between the lowest point of the pharynx and the internal edge of the epiglottis following a line from the anterior uppermost edge of the jawbone contour to the lower point of the pharynx. All CT distance measurements were performed using OsiriX version 5.0.2 64-bit software.

Moreover, three cross-sectional areas (mm$^2$) were measured from the same five midsagittal CT images (Figure 2). The areas were (1) oral cavity (A1) measured from the lips to the velum (up to the line connecting the lowermost edge of the jawbone contour and a break of declivity on the velum surface), (2) the pharyngeal region (A2) measured from the line ending A1 down to the horizontal line connecting the lower edge of opisthion (occipital bone) and the lowermost edge of the jawbone contour, and (3) the epilaryngeal region (A3) measured from the line ending A2, down to the vocal folds.

Additionally, from the transversal CT images, two areas (mm$^2$) were measured (Figure 3): (1) the inlet to the lower pharynx (Ap) just above the collar of the epiglottis and (2) the outlet of the epilaryngeal tube (Ae) just below the collar of the epiglottis where the epilarynx and the piriform sinuses form three separate tubes. Areas from transversal CT images were chosen taking into account the bending of the vocal tract. A line from backbone to jawbone through the tip of arytenoids in a parallel way to the bottom line of the CT image was used to obtain Ae. A line just above the tip of arytenoids, which was also parallel to the bottom line, was used to obtain Ap.

Furthermore, volumetric measures of total vocal tract were also performed. All volumetric measures were performed using syngo MMWP version 31A software, with the semiautomatic settings. Once the measures were computed, an experienced experimenter (coauthor of the present study) manually corroborated all of the results.

**Statistical analysis**

Descriptive statistics were calculated for the variables, including median and interquartile range. A generalized estimating equation model was fitted to assess differences between pre, during, and post tube use and also to assess the difference between tubes. Spearman rank correlation coefficient was used to assess statistical dependence between distance, area, and volumetric measures. All analyses were made using Stata 12.1 (StataCorp LP, College Station, TX). A $P$ value $<0.05$ was considered statistically significant, and all $P$ values were two sided.

**RESULTS**

Table 1 shows values from distance measures for both sequences (tube 1 and tube 2). In general, it is possible to observe that during use of both tubes there was an increased vertical length, increased tongue dorsum height, a wider oropharynx, higher velum position, and a wider hypopharynx compared with vowel phonation pre and post tube exercise. However, only changes in hypopharynx width were statistically significant for both sequences. Moreover, modifications in tongue dorsum height, oropharynx width, and velum elevation were statistically significant only for tube 2 sequence. Even though vocal tract changes were more prominent for tube 2 than for tube 1,
differences between them were not significant. Figures 4 and 5 show distance changes for tube 1 and tube 2, respectively. Table 2 summarizes the results from area measurements for both sequences (tube 1 and tube 2). In general, outlet of the epilaryngeal tube (Ae), inlet to the lower pharynx (Ap), pharyngeal region (A2), and epilaryngeal region (A3) tended to be greater during phonation into both tubes. However, none of abovementioned changes were statistically significant. Furthermore, comparison of vocal tract area changes between both tubes did not show significant differences. Figures 6 and 7 show area changes during tube 1 and tube 2 for Ap and Ae, respectively.

Results from volumetric measures of vocal tract are displayed in Table 3. During both tube exercises, there was an increased total volume. Nevertheless, statistically significant differences were obtained only for the tube 2 sequence. No significant differences were found when both sequences were compared. Figures 8 and 9 show sagittal and coronal views respectively for volumetric measures for tube 2. From a coronal view (Figure 9), it is possible to observe a clear increase of the piriform sinuses and valleculas.

Correlation analysis for tube 1 demonstrated strong linear relation between Ap and A3 (rho = 0.904; P = 0.000), Ae and Ap (rho = 0.948; P = 0.000), Ae and A3 (rho = 0.805; P = 0.005), hypopharyngeal width and Ae (rho = 0.799; P = 0.006), hypopharyngeal width and Ap (rho = 0.726; P = 0.017), hypopharyngeal width and A3 (rho = 0.662; P = 0.037), oropharyngeal width and Ae (rho = 0.652; P = 0.041), tongue dorsum height and oropharyngeal width (rho = 0.704; P = 0.023), tongue dorsum height and A1 (rho = −0.908; P = 0.025), and total volume and A3 (rho = 0.732; P = 0.016).

Correlation analysis for tube 2 demonstrated strong linear relation between Ap and A3 (rho = 0.881; P = 0.001), Ae and Ap (rho = 0.903; P = 0.000), Ae and A3 (rho = 0.710; P = 0.021), hypopharyngeal width and Ae (rho = 0.778; P = 0.008),

**TABLE 1.**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Pre During Tube 1</th>
<th>Post Tube 1</th>
<th>During Tube 2</th>
<th>Post Tube 2</th>
<th>Intratube 1 (P Value)</th>
<th>Intratube 2 (P Value)</th>
<th>Tube 1 Versus Tube 2 (P Value)</th>
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<td>Vertical length</td>
<td>61.89</td>
<td>70.56</td>
<td>60.59</td>
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<td>27.12</td>
<td>17.41</td>
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<td>Lip opening</td>
<td>93.59</td>
<td>97.73</td>
<td>93.73</td>
<td>94.44</td>
<td>94.41</td>
<td>0.36931</td>
<td>0.69948 0.3863</td>
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<tr>
<td>Tongue dorsum height</td>
<td>10.04</td>
<td>3.48</td>
<td>9.32</td>
<td>2.73</td>
<td>9.37</td>
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<td>0.0001 0.0745</td>
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<td>Oropharynx width</td>
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<td>1.02</td>
<td>8.50</td>
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<td></td>
</tr>
<tr>
<td>Velum elevation</td>
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<td>81.85</td>
<td>81.16</td>
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<td>0.71592 0.2411</td>
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<tr>
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<td>3.39</td>
<td>11.42</td>
<td>7.32</td>
<td>11.89</td>
<td>6.28</td>
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<tr>
<td>Lip opening</td>
<td>10.34</td>
<td>16.29</td>
<td>10.33</td>
<td>17.32</td>
<td>10.39</td>
<td>0.20584</td>
<td>0.01116 0.1141</td>
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<tr>
<td>Jaw opening</td>
<td>5.42</td>
<td>7.85</td>
<td>5.35</td>
<td>6.63</td>
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<tr>
<td>Tongue dorsum height</td>
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<tr>
<td>Oropharynx width</td>
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<td>4.90</td>
<td>5.51</td>
<td>4.90</td>
<td>5.04</td>
<td></td>
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</tr>
<tr>
<td>Velum elevation</td>
<td>20.71</td>
<td>24.81</td>
<td>22.19</td>
<td>26.02</td>
<td>22.32</td>
<td>0.03957</td>
<td>0.02771 0.0745</td>
</tr>
<tr>
<td>Hypopharynx width</td>
<td>3.11</td>
<td>5.93</td>
<td>2.10</td>
<td>5.93</td>
<td>3.79</td>
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<td></td>
</tr>
</tbody>
</table>

CT, computerized tomography.

**FIGURE 4.** Midsagittal images of the vocal tract. Before (left), during (middle), and after tube drinking straw (right) phonations. The two most evident changes are the higher velum, the lower laryngeal position, and wider pharynx during straw phonation.
hypopharyngeal width and Ap (rho = 0.713; P = 0.021), oropharyngeal width and volume (rho = 0.633; P = 0.049), jaw opening and tongue dorsum height (rho = 0.834; P = 0.003), total volume and A3 (rho = 0.807; P = 0.005), and total volume and Ap (rho = 0.62; P = 0.05).

**DISCUSSION**

Voice exercises to produce an open throat have been commonly used to reduce muscle tension in the pharyngeal and laryngeal areas, in both normal and pathological voices.\(^3\)\(^2\)\(^1\) Moreover, Titze,\(^1\)\(^4\) and Titze and Story\(^1\)\(^5\) stated that the “wide pharynx”...
configuration is an acoustic way to enhance the first formant and this increases the overall sound level. The present study found statistically significant measures of increase in the hypopharyngeal width during phonation with both tubes, which simultaneously increased measures of the inlet to the lower pharynx (Ap) and the epilaryngeal region (A3).

Correlations were found between Ap and A3 for both tubes, hypopharyngeal width and Ap for both tubes, and hypopharyngeal width and A3 for tube 2. Additionally, an increased oropharyngeal width was observed for both tubes (only stirring straw was significant) compared with baseline vowel phonation. A similar study was previously performed (using trans-nasal laryngeal endoscopy) in participants with voice disorders. Authors reported that the eight assessed semi-occluded postures increased pharyngeal width differently throughout, with more prominent changes during phonation into stirring straw and tube submerged into the water (so-called water resistance therapy). Earlier research has demonstrated similar results with normal subjects and trained participants. Guzman et al found that during stirring straw phonation (similar to tube 2 in the present study), the hypopharynx became 38% wider compared with its size before tube phonation. Ap area increased both during Finnish glass tube phonation.

**TABLE 3.** Median and interquartile range for volumetric measures (mm\(^3\)) obtained from the CT samples performed before, during, and after tube 1 and tube 2 phonations

<table>
<thead>
<tr>
<th>Variables</th>
<th>Pre</th>
<th>During Tube 1</th>
<th>Post Tube 1</th>
<th>During Tube 2</th>
<th>Post Tube 2</th>
<th>Intratube 1 (P Value)</th>
<th>Intratube 2 (P Value)</th>
<th>Tube 1 Versus Tube 2 (P Value)</th>
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</thead>
<tbody>
<tr>
<td>Total volume vocal tract</td>
<td>57.94</td>
<td>68.21</td>
<td>58.31</td>
<td>76.91</td>
<td>56.41</td>
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<td>18.86</td>
<td>18.98</td>
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</tr>
</tbody>
</table>

CT, computerized tomography.

**FIGURE 7.** Transversal images of the vocal tract. Before drinking/stirring straw (left), during drinking straw (middle), and during stirring straw (right) phonations. Ae increased during both drinking straw and stirring straw phonations compared with open vowel phonation.

**FIGURE 8.** Volumetric images from a sagittal view. Before drinking/stirring straw (left), during stirring straw (middle), and after stirring straw phonation (right).
(9%) and stirring straw phonations (91%), and the epilaryngeal region (A3) became larger during both glass tube (13%) and stirring straw (73%) phonations compared with vowel phonation before exercise. Laukkanen et al in a case study observed a greater cross-sectional area (67%) in the pharyngeal region during phonation into a tube compared with vowel phonation before using the tube.

Although, no significant differences were detected, vertical length of the vocal tract tended to be larger during phonation into both tubes. This change is likely caused by two observed modifications: the lowering of the larynx and the elevation of velum during exercises. In the present study, all participants demonstrated an important modification in the velum position, which rose to seal the nasopharyngeal port during the tube and stirring straw phonations. Larger changes were observed during the latter. However, after tube phonations, the velum was not as high as during tube phonations. This change has been previously reported in three studies.

Most participants (eight) evidenced a lower VLP during use of both tubes in our study. Variable results have been previously reported regarding VLP during different semi-occluded exercises. Most studies have encountered a lower VLP during semi-occluded tasks, whereas others have reported the opposite. Considering that people diagnosed with hyperfunctional voice disorders (as subjects in the present study) commonly present a high VLP, semi-occluded vocal tract exercises may be a useful therapeutic tool. Sovijärvi et al and Simberg and Laine stated that one of the positive effects of phonation into a tube submerged in water (another commonly used semi-occluded exercise) is the lowering of the larynx. Sovijärvi stated that the length of the tube and depth into the water should be chosen so that a clear lowering of the larynx would occur during the exercise. Nevertheless, the goal after the exercise is to have a normal voice production with the larynx in a neutral position.

Constriction of the outlet of the epilaryngeal tube (Ae) (ie, anterior-posterior laryngeal compression or aryepiglottic compression) has been an important topic in the laryngology field, especially when it is assessed as a sign of laryngeal hyperfunction. This supra-glottic laryngeal activity is often considered a sign of abuse or misuse of the vocal mechanism. It is commonly reported in patients presenting with voice disorders, particularly nonorganic voice disorders, such as muscle tension dysphonia. Although anterior-posterior compression has been accepted as an endoscopic sign of vocal dysfunction, some studies have demonstrated that it may be present in normal speaking and during voice production. Our data showed that during both tube exercises, Ae tended to increase compared with vowel production before tube phonation (although no significant differences were found). Similar findings were reported in a single case study performed with CT. The Ae area became larger during stirring straw phonation (65%). Vampola et al showed no changes of the epilaryngeal tube diameter during tube phonation. Differently, Guzman et al in a study designed for laryngoscopic observation of supraglottic activity, showed that all semi-occluded exercises produced a narrowing of the outlet of the epilaryngeal tube. This modification was more prominent during semi-occlusions that have the highest degree of airflow resistance (tube into water 3 and 10 cm and stirring straw into air). The same three phonatory tasks caused the widest pharynx and the lowest laryngeal position. In fact, a high correlation between all these variables was found. Correlation analysis from our data demonstrated a strong positive correlation between Ae and the other pharyngeal areas (Ap, A3, and hypopharynx width) for both tube exercises.

Because semi-occluded exercises have been demonstrated to increase vocal tract reactance, narrowing of the epilaryngeal tube has been reported as the most contributing factor for the raised vocal tract reactance, one may expect that tube phonation.
plus narrowing of epilaryngeal tube would be a good combination during and after exercise. Most previous investigations have not demonstrated this combination. Nevertheless, it has also been stated that wider vocal tract (increased diameter) could have the same effect of a narrowed diameter of epilaryngeal tube. In this regard, the Vampola et al study showed that the subject was able to increase the vocal tract input reactance and makes the vocal tract more inertive by expanding the space of oropharyngeal and oral cavities rather than narrowing the epilaryngeal tube. The ratio between these two areas (epilaryngeal tube diameter and pharyngeal width) has been suggested to be an important factor for the singer’s formant cluster production (a prominent spectrum envelope peak near 3 kHz associated with the “ringing” voice quality). Sundberg stated that when the cross-sectional area in the pharynx is at least six times wider than that of the laryngeal tube opening, the epilaryngeal tube is acoustically unlinked from the rest of the vocal tract acting as a separate resonator. Therefore, an extra formant would be added to the vocal tract transfer function. Guzman et al found a greater Ap/ Ae ratio after stirring straw phonation (5.5) compared with vowel phonation before straw phonation. This value is close to the value suggested by Sundberg (6). Interestingly, acoustic results from the same data showed the largest increase in the energy of the speaker/singer’s formant cluster region after straw phonation.

In the present study, the total volume of the vocal tract was larger during both tube exercises compared with baseline, but it was significantly different only during use of the stirring straw. This change did not remain after tube phonation. Only one earlier study has explored changes in vocal tract volume during tube phonation. Contrary to our data, authors revealed that the total volume increased 38.5% after phonation into the tube when compared with vowel phonation before tube phonation. According to Vampola et al, the increase in volume was mostly due to transversal expansion of the vocal tract. From our results, similar modifications could be the main cause for the increased total volume during tube phonation. In fact, total volume obtained a good correlation with A3 and Ap during both tube exercises. Therefore, it seems that changes in vertical length of the vocal tract are not the main cause of increased total volume, but changes in cross sectional areas.

Vocal tract changes such as wider pharynx, lower larynx, and raised velum are likely due to the increased oral air pressure (Poral) during tube phonation. Several earlier studies have reported that during occlusion at the lip and or artificial lengthening of the vocal tract, oral pressure increased compared with open vowel production. Titze et al stated that when airflow resistance is increased because of occlusion, the intraoral (supraglottal) pressure is positive, and this in turn would reduce the transglottal pressure (difference between subglottic and oral pressure), unless the subglottic pressure is raised. A recent investigation aimed to assess the static back pressure (oral pressure) and airflow for different tubes commonly used for voice therapy, reported that changes in the diameter of straws affect Poral considerably more compared with the same amount of relative change in length. Radolf et al found that the mean Poral increased (compared with vowel phonation) during voice production into a resonance tube submerged 10 cm below the water surface. Maxfield et al created a rank ordering by measuring the intrathoracic pressure produced by 13 semi-occlusion exercises commonly used in voice therapy. The highest values of Poral were found in straw submerged in water, raspberries, and stirring straw with the free end in air. Guzman et al, in a study performed using subjects with different voice conditions (normal trained, normal untrained, with functional dysphonia, and with vocal fold paralysis) using five different semi-occluded exercises, reported that all exercises had a significant increase in oral pressure, with phonation into a silicon tube submerged 10 cm in water and phonation into a stirring straw as the exercises having the highest values of Poral compared with baseline (repetition of syllable [pa:] for all vocal status. In the present study, vocal tract changes were more prominent during tube 2 phonation (stirring straw) than during tube 1 (drinking straw) phonation, likely because of the higher airflow resistance that stirring straw offers compared with drinking straw. This in turn should have produced greater Poral during the former.

The most observed changes in our present study are also the common goals in voice therapy. It is generally accepted that a low VLP, a raised velum, and a widened pharynx (A1, A2, A3, and Ap) are important goals during voice therapy for pathological voices. These desired changes in our study were attained without giving any biomechanical instructions to the participants (eg, “raise your velum,” “lower your larynx,” or “open your throat”). Participants were simply asked to feel vibratory sensation as strong as possible on the alveolar ridge, face, and head areas, and to produce an easy voice during tube phonation. Voice therapy and singing training in many institutions and practices tend to focus on a conscious, mechanical control of voice production (eg, “move your tongue,” “open your mouth,” or “relax your shoulders”). To be sure, some patients improve performance with instructions like these, but recent studies in perceptual motor learning have shown that subjects who receive instructions about the biomechanics (internal focus of attention) of vocal control showed poorer learning than those who were given no instruction at all. According to Titze and Verdolini, verbal instructions about the biomechanics of a task are inadequate descriptors of action and often exceed a patient’s processing capability. Perceptual-motor learning principles suggest that an external focus, especially oriented to effect an action, is better for motor learning than an internal focus on the mechanics of actions. Our current study may confirm this learning principle and supports earlier findings. Even though no verbal biomechanical instructions were given to our subjects, they all showed the desired anatomical vocal tract changes when using tube phonation. Hence, it is reasonable to state that semi-occluded vocal exercises using an external focus of attention are appropriate, reproducible, and valuable therapeutic tools in the treatment of dysphonic voice.

CONCLUSION

Tube phonation causes an increased total vocal tract volume, mostly due to the increased cross-sectional areas in the pharyngeal region. This change is more prominent when a tube offers more airflow resistance (stirring straw) than when a tube offers less airflow resistance (wider drinking straw). Based on our data
and earlier studies, it appears that vocal tract changes during voice therapy are not dependent on the voice condition (vocally trained, untrained, or disordered voices), but on the exercise itself and the type of instructions given to subjects. Tube phonation is a good option to reach therapeutic goals (eg, wide pharynx and low larynx) without giving biomechanical instructions, but only asking to feel easy voice and vibratory sensations during phonation. Changes obtained during tube phonation will not necessarily remain after it.

REFERENCES


