Lingering Effects of Straw Phonation Exercises on Aerodynamic, Electroglottographic, and Acoustic Parameters

*Jing Kang, *Chao Xue, †David Piotrowski, *Ting Gong, *Yi Zhang, and *Jack J. Jiang, *Shanghai, China, and †Madison, Wisconsin

Summary: Objective. This study aimed to investigate the duration of straw phonation effects using aerodynamic, electroglottographic, and acoustic metrics.

Methods. Twenty-four participants were recruited to perform both a 5-minute and a 10-minute straw phonation exercise. Upon completion of the exercises, phonation threshold pressure (PTP), mean airflow, contact quotient, fundamental frequency, jitter, shimmer, and noise-to-harmonics ratio were measured over a 20-minute time frame. Parameters were measured before the intervention (baseline), immediately after the intervention (m0), 5 minutes (m5), 10 minutes (m10), 15 minutes (m15), and 20 minutes (m20) after the intervention.

Results. PTP significantly decreased immediately after 5 minutes of straw phonation and returned to initial state within 5 minutes. PTP remained decreased over 5 minutes after 10 minutes of straw phonation. Mean airflow increased immediately after both 5 minutes and 10 minutes of straw phonations and remained improved for 20 minutes. No significant changes were obtained for contact quotient and acoustic parameters over the intervention period.

Conclusions. The results extended our knowledge of proper clinical application of straw phonation regarding the duration of exercise. This study confirmed that 10 minutes of straw phonation lead to optimal and relatively continuous effects in PTP and mean airflow. Although straw phonation did show lingering effects in aerodynamics, repeated practices were recommended to obtain optimum and therapeutic effects.

Key Words: Semi-occluded vocal tract−Straw phonation−Contact quotient−Aerodynamics−Acoustics.

INTRODUCTION

Semi-occluded vocal tract exercises (SOVTEs), characterized by a reduction in the cross-sectional area of the distal part of the vocal tract while voicing, have been widely used in voice training and voice rehabilitation.[1] A partial list of SOVTEs presented in descending order of glottal resistance includes straw phonation, lip trill, tongue trill, nasal consonants /m/.[2]

The benefits to the voice from SOVTEs are salient, especially for specific occupations that rely on a worker's healthy voice. Occupations that have a higher risk of voice overuse, including teachers and salesmen, may lead to higher incidences of dysphonia.[3] SOVTEs are methods of voice therapy that have been thoroughly investigated and validated for its positive effect on the voice. In singing voice studies, fatigue resistance can be developed through targeted warm-up or singing activities including SOVTEs.[4] Acoustic metrics, such as jitter, shimmer, and singing power ratio, and self-assessments, such as phonatory comfort and voice quality, have been observed to improve after warm-up using an occluded ventilation mask SOVTEs.[5] Additionally, fundamental frequency has been shown to increase, whereas glottal-to-noise excitation ratio has been found to decrease after phonation through a LaxVox tube.[6] For the speaking voice, improvements in perceptual-auditory evaluation scores were observed after subjects participated in a sounded blowing exercise with semi-occluded vocal tract.[7] Increased open quotient and minimum airflow rates were obtained after the vocal function exercises.[8]

Recent studies suggest that straw phonation is one of the best ways to achieve therapeutic intraoral pressures among all of the other SOVTEs. Straw phonation is surmised to enjoy several outstanding features such as easy accessibility, great efficiency, and controllability when compared with other SOVTEs.[9,10] Furthermore, vocal instruction for straw phonation is relatively simpler than other SOVTE instruction, which may require patients to perform complicated biomechanical routines.[11]

The physical mechanism of straw phonation is explained by increased inertance in the vocal tract during phonation. Inertance is a positive type of impedance, which produces a time-delayed buildup of supraglottal pressure.[12] Time-delayed stimulus and response lead to a negative supraglottal pressure during the closing phase, thus creating suction that pulls the vocal folds apart. This push-pull relationship facilitates self-sustained vibration and decreases phonation threshold pressure (PTP).[13] Inertance is governed by the equation $I = \rho L/A$, where I is inertance, ρ is the density of the oral and laryngeal air column, L is its length, and A is its cross-sectional area.[12] According to the maximum power transfer theorem, optimum power transfer from glottis to lips occurs when source impedance is matched to vocal tract input impedance. It has been validated by computer simulation experiments that SOVTEs result in higher vocal tract impedance, which better matches glottal impedance.[14,15] Moreover, phonation through thin tubes or straws provided resistance best comparable with glottal resistance when comparing 13 semi-occluded vocal tract gestures.[2] Less airflow is expected to dissipate from glottis to lips, which may lead to increased mean airflow during phonation. In addition, increased subglottal pressure and decreased transglottal

Accepted for publication May 8, 2018.
From the *Department of Otolaryngology-Head and Neck Surgery, EENT Hospital of Fudan University, Shanghai, China; and the †Department of Surgery, Division of Otolaryngology-Head and Neck Surgery, School of Medicine and Public Health, University of Wisconsin-Madison, Madison, Wisconsin.
Address correspondence and reprint requests to Jack J. Jiang, Department of Otolaryngology-Head & Neck Surgery, EENT Hospital of Fudan University, 83 Fenyang Road, Shanghai, 200031, China. E-mail: jjjiang@fudan.edu.cn
Journal of Voice, Vol. 33, No. 5, pp. 810.e5−810.e11
0892-1997

https://doi.org/10.1016/j.jvoice.2018.05.002

pressure are acquired when vocal tract is occluded.[16] This aerodynamic alteration, which helps keep the vocal folds slightly abducted, in turn, is expected to produce a lower contact quotient (CQ) of the electroglottograph (EGG).

Although related research suggests that straw phonation benefits voice production, it is still unknown whether straw phonation has a lingering effect or transient response for any amount of time after the exercise. Based on the aforementioned theory of inertance, high inertance can be achieved by lengthening or narrowing vocal tract during SOVTEs, such as when a straw is included in the system during straw phonation. Once the straw is removed from the system, it is expected that any alteration of impedance or pressure in the vocal tract should be indicative of a system without the straw. However, several studies provide evidence suggesting that the effects of straw phonation are sustained for a period of time after the exercise. A decreasing trend in CQ and a significant increase in mean airflow were observed after straw phonation tasks.[17,18] Additionally, a significant decrease in PTP was obtained after completing 10 minutes of straw phonation.[19] Because the measurement of CQ and aerodynamics were taken after the exercise, when the straw is removed, one would expect the measured values to reflect the initial status instead of the improved conditions unless straw phonation had lingering effects after the exercise.

To our knowledge, no other research has evaluated the lingering effects of straw phonation. Such investigations would complete the mechanism of straw phonation and make great progress toward better clinical application. The lingering effects help formulate a dosage schedule in straw phonation. A therapy that has limited lingering effects needs to be given more frequently to build up and maintain a dose high enough to be therapeutically effective. Therefore, this study set out to observe the lingering effects of straw phonation using aerodynamic, CQ, and acoustic parameters within 20 minutes; investigate how long the related effects will last after 5 minutes and 10 minutes of straw phonation; and further determine optimum duration of straw phonation in consideration of the immediate and lingering effects. It was hypothesized that aerodynamic and EGG variables would improve after straw phonation, remain improved for a period of time after the exercise, and then finally return to the initial state that was observed before straw phonation. It was also hypothesized that 10-minute duration straw phonation would result in greater and longer changes than 5-minute straw phonation. However, because the acoustics were found to be less sensitive to reflect precision variation than aerodynamics, no significant changes were expected to be observed in acoustics, including fundamental frequency (F0), jitter, shimmer, and noise-to-harmonics ratio (NHR) after straw phonation.

METHODS

Subjects

A total of 24 subjects (7 males, 17 females) were included in this study, which was approved by the Research Ethics Committee of the Institution of Eye & ENT Hospital of Fudan University (protocol no. 2017031). All volunteered subjects were either undergraduate or graduate medical students from Fudan University, who were given written informed consent to participate. The mean age was 23.71 ± 2.24 years. Inclusion criteria for this study were as follows: (1) above the age of 18; (2) nonsmoking; (3) nonhabitual drinking; (4) no history of diagnosed voice disorders or other laryngeal pathology (polyps, nodules, etc); (5) no acute respiratory infections within 2 weeks of the study participation; and (6) no straw phonation experiences. Participants were required not to have prior straw phonation experience because the experience may impact the influence duration after straw phonation.

To control for systemic and vocal fold physiological confounders, participants were asked to maintain their typical daily voice use for 24 hours before participation. They were also asked to consume a sufficient amount of water before each session to avoid dehydration. The participants were also asked to refrain from eating 2 hours before testing and to avoid foods that would stimulate gastric reflux, such as carbonated and caffeinated drinks and spicy food. Female subjects were not tested 3 days before or after ovulation and menstruation to avoid confounding effects of sex hormones.

Protocol

Two durations of straw phonation, 5 minutes and 10 minutes, were chosen as test groups based on our previous study, concluding that 5 minutes of straw phonation exposure might be the most cost- and time-effective, whereas 10 minutes may result in the best outcome.[19] All subjects were enrolled in both 5-minute straw phonation exercise and 10-minute straw phonation exercise. The two sessions were completed 24 hours apart, at approximately the same time on two consecutive days. The testing order was randomized to minimize order effects. Each subject practiced the exercises separately with a speech therapist who was guiding the participant. The data were obtained before the intervention (baseline), just after the intervention (m0), at the fifth (m5), the tenth (m10), the fifteenth (m15), and the twentieth (m20) minute after straw phonation. Immediate effects correspond to m0 and lingering effects correspond to any time after m0.

For the straw phonation exercises, subjects were instructed using the video “Ingo Titze's tip for tired voices: Grab a straw!” produced by the National Center for Voice and Speech.[20] Subjects phonated into a 19.5-cm long, 6-mm diameter straw. Each participant practiced forming an airtight seal with his or her lips, then exhaling through the straw comfortably before attempting sound production. Subjects were instructed to phonate with support from expiratory flow and intra-abdominal pressure to maintain relaxed neck muscles. Most importantly, the subjects were required to phonate at a pitch and loudness that was most comfortable through the straw. The exercises began with a prolonged note to verify adequate sound production, and then gradually transitioned to a series of vocal glides. The glides started very low in the subject's phonatory range, ascended to the top of their range, and descended gradually again to the lowest note. Following the glides, the participants added a number of accents using abdominal support, each of which produced a temporary alteration in pitch and volume. Finally, the participants sang specified melodies which were tractable through the straw without neck tension.

Data collection

Aerodynamic parameters were analyzed by the Phonatory Aerodynamic System Model 6600 (KayPENTAX, Montvale, NJ). The measurement of PTP was based on the method of airflow interruption by full-lip occlusion, as described by Sivasankar and Fisher.[21] The subjects wore a face mask with an oral tube inserted 2 cm into the subject's mouth. The subjects were instructed to utter the /pi/ as softly as possible but not whisper at a conversational pitch. Every five /pi/ syllables constituted one trial and every subject produced three trials for a total of 15 /pi/ syllables. Because the first and the last /pi/ syllable were unstable and diverse, the first and the last syllables in every trail were discarded. The mean value of the three middle /pi/ syllables was statically analyzed.

Mean airflow and EGG measures were captured by the Phonatory Aerodynamic System Model 6600 (KayPENTAX). Mean airflow and CQ were collected during this task, with the electrodes on the surface of both sides of the thyroid cartilage and the mask snugly over the nose and mouth to prevent air leakage. Participants were instructed to produce three repetitions of the sustained speaking vowel /a/ at their comfortable pitch and volume. An interval of the airflow and EGG signal (approximately 3 seconds) was selected from the most stable part to compute a mean airflow and EGG value. The mean values were statistically analyzed.

The Multi-Dimensional Voice Program Model 5105 (KayPENTAX) was used to analyze the acoustic parameters, including F0, jitter, shimmer, and NHR, via the same unidirectional moving-coil microphone (Shure, Niles, IL) located diagonally 15 cm from the mouth in an acoustically treated room. Subjects produced the sustained vowels /a/ three times at a comfortable pitch and volume; the mean values of the acoustic parameters were included in the statistics. Subjects were required to take a 5-second break between every two pronunciations to prevent voice fatigue.

Statistical analysis

SPSS 20.0 (IBM Corp., Armonk, NY) was used for the statistical analysis of the data. A two-way analysis of variance with repeated measures were performed to compare the main effects of time, type (5-minute straw phonation or 10-minute straw phonation), and time-type interaction. If the main effects of time and/or type were significant, the within-type and/or between-type comparisons were conducted to further compare the means. For between-type comparisons, a type *t* test was completed and α was set at 0.05. For within-type comparisons, two-tailed paired *t* tests were performed for each coupling of time points to determine where the significant differences took place. A Bonferroni adjustment yielded $\alpha = 0.01$.

RESULTS

There was no significant interaction between time and type on PTP ($P = 0.484$), as shown in Table 1. The main effect of time was significant ($P < 0.001$) (Table 1). *t* Tests for the time effects of 5-minute straw phonation revealed a significant decrease between m0 compared with baseline ($d = -0.188 \pm 0.066$, $P = 0.009$) and a significant increase in m5, m15, and m20 compared with m0 ($d = 0.220 \pm 0.066$, $P = 0.003$; $d = 0.296 \pm 0.098$, $P = 0.006$; and $d = 0.301 \pm 0.098$, $P = 0.005$, respectively), as shown in Table 2 and Figure 1. *t* Tests for the time effects of 10-minute straw phonation revealed significant decreases between m0 and m5 compared with baseline ($d = -0.287 \pm 0.063$, $P < 0.001$ and $d = -0.148 \pm 0.050$, $P = 0.007$, respectively). There were significant increases for m10, m15, and m20 compared with m0 ($d = 0.241 \pm 0.060$, $P = 0.001$; $d = 0.354 \pm 0.058$, $P < 0.001$; and $d = 0.350 \pm 0.054$, $P < 0.001$, respectively) and m15 compared with m5 ($d = 0.215 \pm 0.069$, $P = 0.005$) (Table 2). However, no significant differences were obtained in the main effect of type ($P = 0.905$) (Table 1).

For mean airflow, two-way analysis of variance testing revealed no significant interaction effect between time and type ($P = 0.933$) (Table 1). The main effect of time was significant ($P < 0.001$) (Table 1). *t* Tests for the time effects of 5-minute straw phonation revealed an increased trend between m0, m5, m10, m15, and m20 compared with baseline ($d = 0.021 \pm 0.008$, $P = 0.015$; $d = 0.021 \pm 0.008$, $P = 0.011$; $d = 0.021 \pm 0.009$, $P = 0.026$; $d = 0.027 \pm 0.012$, $P = 0.034$; and $d = 0.024 \pm 0.09$, $P = 0.014$, respectively). *t* Tests for the time effects of 10-minute straw phonation revealed an increased trend between m0, m5, m10, m15, and m20 compared with baseline ($d = 0.018 \pm 0.008$, $P = 0.039$; $d = 0.024 \pm 0.010$, $P = 0.022$; $d = 0.027 \pm 0.011$, $P = 0.019$; $d = 0.027 \pm 0.011$, $P = 0.025$; and $d = 0.028 \pm 0.011$, $P = 0.025$, respectively) (Table 2 and Figure 2). However, no significant differences were obtained in the main effect of type ($P = 0.411$) (Table 1).

Results for CQ showed no interaction between time and type ($P = 0.197$), no significant main effect of time ($P = 0.568$), and no significant effect of type ($P = 0.421$) (Table 1).

Concerning sound pressure level, no significant difference was found in interaction between time and type ($P = 0.209$), main effect of time ($P = 0.834$), and main effect of type ($P = 0.780$) (Table 1).

For F0, no significant difference was observed in interaction between time and type ($P = 0.863$), main effect of time ($P = 0.636$), and main effect of type ($P = 0.719$) (Table 1).

Results for jitter showed no interaction between time and type ($P = 0.892$), no significant main effect of time ($P = 0.102$), and no significant effect of type ($P = 0.915$) (Table 1).

For shimmer, our results demonstrated no significant difference in interaction between time and type ($P = 0.415$), main effect of time ($P = 0.540$), and main effect of type ($P = 0.776$) (Table 1).

Concerning NHR, no significant difference was obtained in interaction between time and type ($P = 0.366$), main effect of time ($P = 0.525$), and main effect of type ($P = 0.774$) (Table 1).

TABLE 1.
Effects of Time and Type of Exercise, as Well as Time-Type Interaction on Aerodynamic and Acoustic Variables, Determined by Two-way ANOVA (N = 24 Subjects)

Effect	PTP		Mean Airflow		CQ		SPL		F0		Jitter		Shimmer		NHR	
	F	*P*	F	*P*	F	*P*	F	*P*	F	*P*	F	*P*	F	*P*	F	*P*
Time	12.873	<0.001*	6.056	<0.001*	0.695	0.568	0.312	0.834	0.580	0.636	1.970	0.102	0.815	0.540	0.794	0.525
Type	0.014	0.905	0.690	0.411	0.659	0.421	0.079	0.780	0.131	0.719	0.011	0.915	0.082	0.776	0.084	0.774
Time × type	0.856	0.484	0.158	0.933	1.563	0.197	1.517	0.209	0.258	0.863	0.275	0.892	1.006	0.415	1.082	0.366

* $P < 0.01$.
Abbreviations: ANOVA, analysis of variance; PTP, phonation threshold pressure, CQ, contact quotient, SPL, sound pressure level, F0, fundamental frequency, NHR, noise-to-harmonics ratio.

DISCUSSION

In this study, aerodynamic, EGG, and acoustic measurements were monitored over 20 minutes after straw phonation exercises in normal-voiced subjects. Our results presented and validated the immediate and lingering effects using aerodynamic parameters; however, no significant immediate and lingering effects were obtained in EGG and acoustic measurement. Comparisons across measurement conditions showed a significant decrease in PTP and a significant increase in mean airflow immediately after completing both types of straw phonation. Increased mean airflow was found to last 20 minutes after both types of straw phonation exercises, whereas PTP could only remain decreased for 5 minutes after 10 minutes of straw phonation.

Significant differences were observed in aerodynamic parameters after straw phonation. As one can volitionally modify their vocal output through compensatory mechanisms that result in a voice of approximately normal acoustic quality, even though the aerodynamics used to produce that voice may be quite effortful.[22] Aerodynamic parameters of phonation, sensitively reflecting vocal fold geometry, and biomechanical properties of the vocal fold, have been the focus of numerous theoretical and experimental studies in the past decade.[23] In particular, PTP is an index of the minimum pressure required to produce tissue oscillation, which provides an objective indication of such subjective sensations as vocal effort and the "ease of phonation."[12] The improvement in aerodynamics after straw phonation exercises demonstrated that straw phonation targeted improvements in vocal efficiency and fatigue resistance, which could play an important role in clinical application.

Recent studies confirmed that straw phonation exercise improved aerodynamics of the vocal tract by increasing inertance; however, the mechanisms in which increased inertance was sustained remain to be investigated. A few hypotheses were generated to explain the sustained inertance, including sustained improved vocal tract configuration and motor learning of improved phonation technique.

Sustained improved configuration of the vocal tract may be the reason why the improvement of aerodynamics could be acquired after completing straw phonation exercises. According to the computerized tomography results in both of Guzman et al's studies,[11,24] a larger ratio between the inlet of the lower pharynx and the outlet of the epilaryngeal tube was obtained during and after straw phonation, which has been reported as a contributing factor for increased vocal tract inertance.[25,26]

Furthermore, motor learning may play a role in the phenomenon for sustainability of an increased inertance. With practice, the neural connections that represent the task become relatively permanent (motor learning) and can be used to accomplish similar tasks (generalizability).[27] The longer the exercises and learning process last, the stronger motor learning stays. Therefore, our results indicate that participants practiced the adjusted configuration of the vocal tract during straw phonation and maintain the improved status, with higher inertance even after completing the exercises.[9] This hypothesis

TABLE 2.
Intragroup Comparison of PTP and Mean Airflow Between Different Time Points (N = 24 Subjects)

			5-Minute Straw Phonation		10-Minute Straw Phonation	
Variables	Time (a)	Time (b)	d (b − a)	*P*	d (b − a)	*P*
PTP	Baseline	m0	−0.188 ± 0.066	0.009**	−0.287 ± 0.063	<0.001**
	Baseline	m5	0.033 ± 0.088	0.714	−0.148 ± 0.050	0.007**
	Baseline	m10	0.014 ± 0.073	0.854	−0.045 ± 0.045	0.323
	Baseline	m15	0.109 ± 0.067	0.121	0.067 ± 0.069	0.341
	Baseline	m20	0.113 ± 0.072	0.130	0.063 ± 0.058	0.292
	m0	m5	0.220 ± 0.066	0.003**	0.139 ± 0.066	0.045*
	m0	m10	0.201 ± 0.081	0.021*	0.241 ± 0.060	0.001**
	m0	m15	0.296 ± 0.098	0.006**	0.354 ± 0.058	<0.001**
	m0	m20	0.301 ± 0.098	0.005**	0.350 ± 0.054	<0.001**
	m5	m10	−0.019 ± 0.069	0.784	0.102 ± 0.043	0.026*
	m5	m15	0.076 ± 0.086	0.387	0.215 ± 0.069	0.005**
	m5	m20	0.081 ± 0.077	0.302	0.211 ± 0.076	0.01*
	m10	m15	0.095 ± 0.055	0.097	0.112 ± 0.055	0.053
	m10	m20	0.100 ± 0.057	0.092	0.108 ± 0.057	0.069
	m15	m20	0.005 ± 0.046	0.918	−0.004 ± 0.042	0.924
Mean airflow	Baseline	m0	0.021 ± 0.008	0.015*	0.018 ± 0.008	0.039*
	Baseline	m5	0.021 ± 0.008	0.011*	0.024 ± 0.010	0.022*
	Baseline	m10	0.021 ± 0.009	0.026*	0.027 ± 0.011	0.019*
	Baseline	m15	0.027 ± 0.012	0.034*	0.027 ± 0.011	0.025*
	Baseline	m20	0.024 ± 0.09	0.014*	0.028 ± 0.011	0.025*
	m0	m5	0.000 ± 0.005	1.000	0.005 ± 0.005	0.272
	m0	m10	0.000 ± 0.007	0.954	0.009 ± 0.007	0.252
	m0	m15	0.006 ± 0.010	0.565	0.008 ± 0.004	0.059
	m0	m20	0.003 ± 0.011	0.787	0.009 ± 0.006	0.153
	m5	m10	0.000 ± 0.005	0.937	0.003 ± 0.009	0.713
	m5	m15	0.006 ± 0.008	0.484	0.003 ± 0.006	0.643
	m5	m20	0.003 ± 0.008	0.725	0.004 ± 0.008	0.637
	m10	m15	0.006 ± 0.007	0.357	0.000 ± 0.007	0.953
	m10	m20	0.003 ± 0.007	0.647	0.000 ± 0.007	0.950
	m15	m20	−0.003 ± 0.007	0.674	0.001 ± 0.005	0.877

* $P < 0.05$;
** $P < 0.01$.
Abbreviation: PTP, phonation threshold pressure.

could also explain why the lingering effects of PTP were longer in 10 minutes of straw phonation exercises than in 5 minutes of exercises. Because all the subjects took the exercises for the first time, 10 minutes of straw phonation could maintain improved PTP for only 5 minutes. Improved configuration and decreased PTP are expected to remain longer with increased practice frequency.

Another important factor should be taken into account when considering mean airflow apart from increased inertance. As the supraglottal impedance increases, more subglottal pressure is required to initiate and maintain the vibration of the vocal folds. Thus, more breath support should be provided. In the process of straw phonation, repeated utilization of the corresponding organs and the surrounding structures can not only coordinate the subsystems but also exercise the respiratory muscles, leading to improved respiratory function.[28] Increased mean airflow values that lasted for 20 minutes indicated that the enthusiasm mobilization of respiratory system

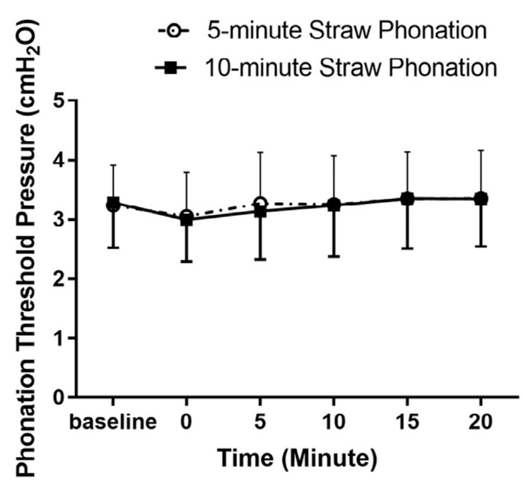

FIGURE 1. Comparison of PTP in 5-minute straw phonation and 10-minute straw phonation before and after intervention.

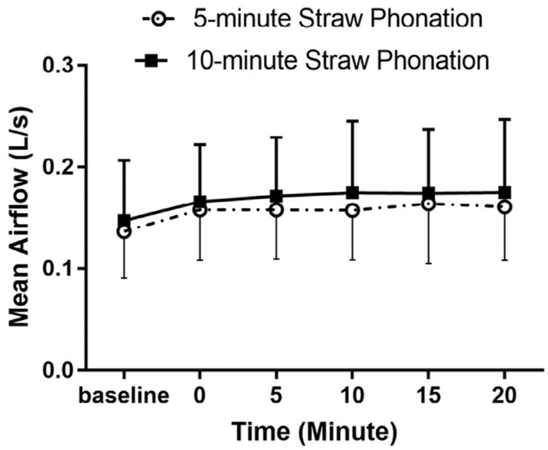

FIGURE 2. Comparison of mean airflow in 5-minute straw phonation and 10-minute straw phonation before and after intervention.

was easier to arouse and sustain compared with adjustive configuration.

Surprisingly, no significant trend in CQ was acquired during and after straw phonation. Diverse consequences were obtained in CQ after straw phonation in different studies. Thirty subjects were asked to perform a 15-minute session of straw phonation by Portillo et al and no significant changes were found when before and after conditions in CQ were compared.[29] Andrade et al recruited 23 healthy volunteers to assess EGG measures during straw phonation.[30] No significant changes were found in CQ when straw phonation and comfortable phonation were compared. No significant change during and after 5 minutes of straw phonation for vocally healthy subjects was found, whereas a significant increase in CQ was obtained during exercise for participants with hyperfunctional dysphonia in Guzman et al's study.[31] A classically trained singer was recruited in another Guzman et al's study, and decreased CQ was obtained after straw phonation exercises.[24] There is little doubt that the experience of phonation into the straw lead to a change in glottal behavior for all the participants, but the mechanism or mechanisms for variance in CQ between individuals remains unknown. It seems possible that this discrepancy could be attributed to vocal training status, which would impact individual compensatory reactions when supraglottal pressure increases.[31] Trained singers tend to adjust laryngeal pattern in a more proper way in response to an unfamiliar task, whereas participants without enough voice and laryngeal control may provide more or less laryngeal muscle tension when encountering resistance from the straw phonation exercises. The participants without enough voice and laryngeal control and their improper response to an unfamiliar task could explain the wide intrasubject variability in the data.[32] The issues of training in adaptation and insufficient or excessive impedance provided by the straw have also been raised.[33]

All acoustic parameters did not achieve any significant differences after straw phonation exercises, which was consistent with our previous work.[19] No significant changes were also obtained in jitter, shimmer, and F0 in Ramos et al's study.[34] There are several possible explanations for the results. Straw phonation tasks restrict jaw and lip motion, and the velum and the tongue would be relatively more rigid than talking.[35] Therefore, they do not translate well to natural talking and significantly impact voice perturbation. On the other hand, the acoustics were found to be less sensitive to reflect precision variation than aerodynamics, especially when all participants were from a healthy population without voice disorders. It was harder to obtain significant changes in acoustic variables within normal range.[22]

A limitation of this study was that participants performed straw phonation exercises for the first time, which might have led to a transient or immediate effect. It can be thus suggested that after repeated training of straw phonation, aerodynamic parameters could stay improved for a longer period, deriving from the motor learning acquirement. Another limitation of this study is the absence of the control group. Future studies on the current topic are still recommended. There is abundant room for further progress in determining whether the required duration and frequency of straw phonation will change with the degree of familiarity and vocal training of exercises.

CONCLUSIONS

Our present study detected aerodynamic, EGG, and acoustic measures before and within 20 minutes after straw phonation. Increased mean airflow was found to last 20 minutes after both types of straw phonation exercises, whereas PTP could only remain decreased for 5 minutes after 10 minutes of straw phonation. Owing to the limited lingering effects of straw phonation, repeated exercises are needed to build up and maintain therapeutic effects. This study has not only confirmed that 10 minutes of straw phonation lead to optimal and relatively continuous effects, but has also extended our knowledge of proper clinical applications of straw phonation.

Acknowledgments

This study was supported by the NSFC (81329001).

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