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ORIGINAL ARTICLE

Stress Velopharyngeal Incompetence in Collegiate Trombone Players

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Objectives: **Symptoms of stress velopharyngeal incompetence (SVPI) have been reported by many wind instrument players. The current study was designed to determine (1) if symptoms of SVPI were accompanied by aeromechanical signs of SVPI and (2) if signs of SVPI differed across musical tasks.**

Design: **Participants were studied during a single recording session.**

Setting: **The study was conducted in a university laboratory.**

Participants: **Participants were 10 collegiate trombone players. They were separated into two groups: six who reported symptoms of SVPI and four who reported no symptoms.**

Main Outcome Measure: **Nasal pressure recorded during trombone playing was used to determine velopharyngeal status (open or closed).**

Results: **None of the participants exhibited an open velopharynx during trombone playing; however, all participants had positive nasal pressure (indicating an open velopharynx) immediately prior to sound onset on at least some of their breath groups. Two participants had positive nasal pressure prior to the vast majority of their productions and were given biofeedback and instruction to change this behavior.**

Conclusions: **Symptoms of SVPI do not necessarily indicate the presence of a velopharyngeal-nasal leak during wind instrument playing but may reflect awareness of air leaks immediately prior to sound production. Pre-sound velopharyngeal-nasal air leaks may be amenable to behavioral modification by biofeedback and instruction. Nasal pressure measurement (using a nasal cannula) provides a simple, yet powerful, way to identify SVPI.**

KEY WORDS: *SVPI, brass musicians, wind instrument players, nasal air pressure, biofeedback*

The life of a collegiate or professional musician requires countless hours of rehearsing to maintain a high level of performance. For wind instrument players, such rehearsing requires that musicians sustain high levels of oral pressure for long periods (Dibbell et al., 1979). In some cases, the intensity of this rehearsal schedule can impair the ability of the velum to make full closure against the pharyngeal wall, causing air to escape through the velopharynx. This problem is referred to as stress velopharyngeal incompetence (SVPI). The consequences of SVPI are an impaired ability to generate and sustain oral pressure, a sensation of air leaking through the nose, and a less-than-optimal sound quality. These problems are often blamed on ''dead chops'' (i.e., poor embouchure, meaning poor lip seal), causing appropriate evaluation of the velopharynx to be overlooked (Malick et al., 2007).

Musicians who exhibit SVPI during instrument playing seldom exhibit SVPI during speaking. This is probably because the pressures used for speaking are much lower than those used for wind instrument playing. Specifically, pressures for speaking generally range from 5 to 10 cmH_2O (Netsell, 1969; Murry and Brown, 1971), whereas those for wood instrument playing generally range from 10 to 35 cmH_2O on the low end and from 35 to 56 cmH_2O on the high end and can get as high as 193 cmH_2O (Schwab and Shultze-Florey, 2004). Stress velopharyngeal incompetence has most often been observed in musicians at the high school and collegiate levels. This problem is thought to emerge around this age as a consequence of the increase in competition, difficulty of musical pieces, and extended periods of practice time (Schwab and Schultze-Florey, 2004).

The prevalence of SVPI among wind instrument players appears to be surprisingly high. In fact, two recent survey studies indicated that approximately one third of wind instrument players experience symptoms of SVPI (Schwab and Schultze-Florey, 2004; Malick et al., 2007), and that these symptoms tend to be associated with playing for long periods (more than 30 minutes), playing in the middle register, and playing notes of long duration (Malick et al., 2007). Nevertheless, these prevalence figures are based on musician reports, rather than on physiologic observations of velopharyngeal behavior.

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The current study was designed to determine if symptoms of SVPI (that is, the sensation of air leaks through the nose or the perception of nasal sounds while playing) were actually associated with inappropriate opening of the velopharynx in a group of trombone players. This study also sought to determine if the nature of the musical task influenced the frequency of velopharyngeal-nasal air leaks.

Methods

Participants

Ten participants, eight men and two women, were recruited from the University of Arizona trombone studio. They were 20 to 25 years of age and included music and nonmusic majors and undergraduate and graduate students. Participants denied a history of speech therapy, cleft palate or submucous cleft palate, neurological condition, and surgery on the nose, mouth, or velum. All participants reported that they were in good health at the time of the study, and their speech and voice were judged to be normal by a certified speech-language pathologist.

Participants were asked the following question: "Have you ever felt air leaks through your nose or heard nasal sounds while playing your trombone?" The four who replied "No" were placed in the control group, and the six who replied "Yes" or "Maybe" were placed in the experimental group. Those in the experimental group were also asked two additional questions: "When does it occur?" and "Under what conditions does it occur?" Participant responses are summarized in Table 1.

Procedures

The University of Arizona Institutional Review Board approved this study, and informed consent was obtained from all participants. Data were collected in the Speech Research Lab at the University of Arizona. Participants warmed up for a few minutes before data recording began.

TABLE 1 Participant Reports of Feeling Air Leaks Through the Nose or Nasal Sounds While Playing the Trombone

Participant	*Control*	*Experimental*
1	No complaints	
2	No complaints	
3	No complaints	
4	No complaints	
5		Yes; not sure when or under what conditions
6		Yes; maybe when playing from low to high or high to low
7		Yes; playing high registers, loudly, notes of long duration
8		Maybe; playing high registers
9		Yes; as soon as I start playing, high and middle registers, soft and loud, notes of short and long duration
10		Yes; 10 minutes after I start playing, high and middle registers, playing loudly

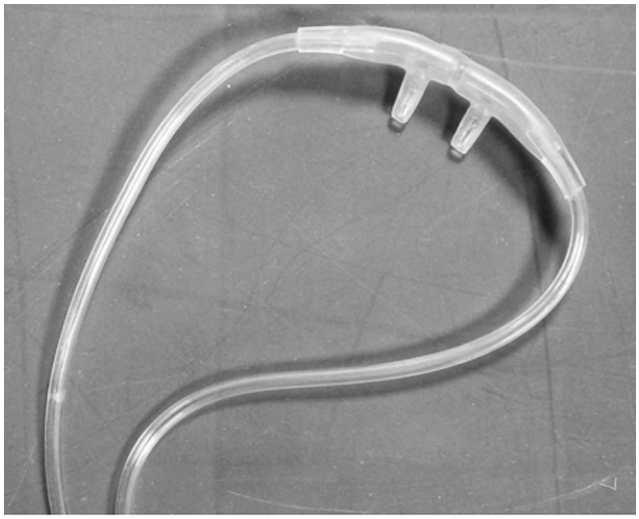

FIGURE 1 A nasal cannula.

The acoustic signal was sensed with an omnidirectional condenser lavalier microphone (Audio-Technica AT 8533, Stow, OH) attached to the participant's right shoulder. This signal was amplified using a Rane MS1 amplifier (Mukilteo, WA). Velopharyngeal orifice status (open or closed) was monitored by sensing nasal ram pressure using a nasal cannula, such as that shown in Figure 1. The cannula was connected to a differential pressure transducer referenced to atmosphere (model P45 with a ± 2 cmH_20 diaphragm, Validyne, Northridge, CA). The pressure delivered to the transducer was the pressure from the anterior nares (not calibrated). This signal was amplified with a CD15 Carrier Demodulator (Validyne) and recorded with an ADInstruments PowerLab 16/30 recorder (Colorado Springs, CO). During the recording session, the acoustic and pressure signals were displayed on a computer monitor using ADInstruments LabChart 7 Pro software. Participants faced away from the computer screen so they would not be distracted or influenced by the data. Each session lasted approximately 30 minutes.

Data were recorded while the participants stood and played their trombones. The musical tasks performed by the participants were selected with assistance of the university trombone professor and were designed to incorporate a variety of different playing conditions. These were the same for all participants and included warm-up exercises (long tones, scales, and articulation patterns) and short musical pieces (varying in tempo, loudness, articulation, and pitch range) from trombone technique books. The tasks are described below.

1. Sustained tones on whole notes with pitch jumps
2. Longer series of sustained tones on whole notes with pitch jumps down to low range

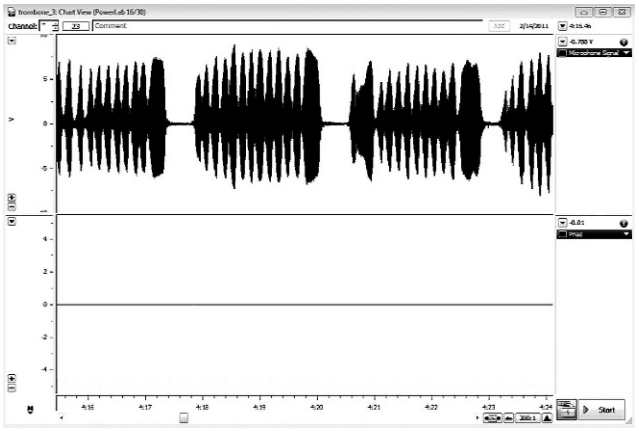

FIGURE 2 Acoustic (top) and nasal pressure (P_{nas}) waveforms. P_{nas} is zero during trombone playing.

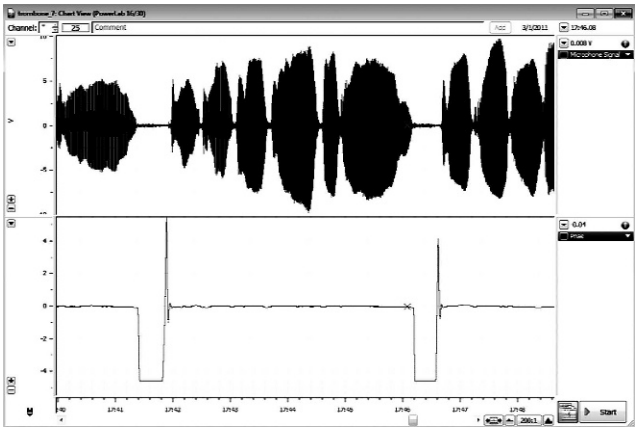

FIGURE 3 Acoustic and P_{nas} waveforms. P_{nas} is essentially zero during trombone playing and negative during inspiration. Note the positive spike in P_{nas} immediately prior to sound onset.

3. Articulation exercise using legato tonguing (smooth and connected)
4. Repeat of task 3 with staccato tonguing (short and separated)
5. Two octaves of the C major scale, ascending and descending pitch
6. Five-note segment pattern in C major (16th note harmonic patterns)
7. Chromatic scale (ascending and descending sequence of pitches by semitones) from participant's lowest to highest pitch
8. Allegretto (moderately quick) tempo piece in common time incorporating several loudness changes and variety of note durations and articulation patterns
9. Moderato tempo piece in three-quarter time played at piano loudness with legato tonguing
10. Allegro (quick, lively) tempo piece in common time consisting of slurred 16th note harmonic series patterns played at forte loudness
11. Andante (moderately slow) tempo piece in three-quarter time consisting of lip slur patterns on quarter notes and eighth notes played at mezzo-forte loudness

Data Analysis

The nasal pressure data reflected changes in ram pressure at the anterior nares. A pressure of zero during production of sound (musical tones) was interpreted to indicate a closed velopharynx, whereas a positive nasal pressure was interpreted to indicate an open velopharynx (velopharyngeal-nasal air leak). Data analysis consisted of manually tabulating instances of positive pressure during sound production and immediately prior to the onset of sound production. The percentage of breath groups (defined as expirations accompanied by sound production, bounded by inspirations identified by a brief period of negative nasal pressure and/or inspiratory noise from the audio recording) containing positive pressure (and therefore velopharyngeal-nasal air leaks) during sound production and immediately prior to the onset of sound production was calculated manually for each task for each participant.

Results

Velopharyngeal-Nasal Air Leaks During Sound Production

There were no instances of velopharyngeal-nasal air leaks during sound production. This was true for both the control and experimental participants across all tasks. An example of a typical set of data tracings is shown in Figure 2.

Velopharyngeal-Nasal Air Leaks Prior to Sound Production

Velopharyngeal-nasal air leaks occurred immediately prior to the onset of sound production at least occasionally in all participants, an example of which is displayed in Figure 3. Figure 4 shows the percentage of velopharyngeal-nasal air leaks prior to onset of sound production for each participant (all tasks combined). Eight of the participants (1 through 8) exhibited velopharyngeal-nasal air leaks prior

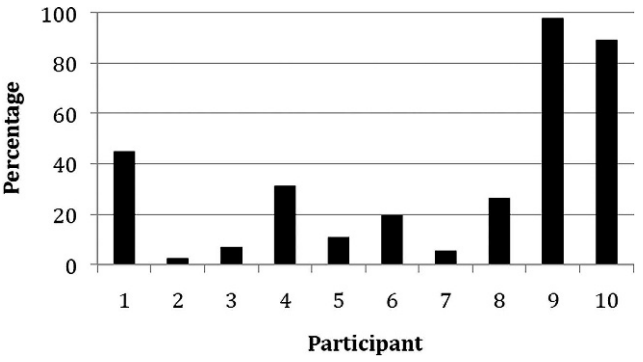

FIGURE 4 Percentage of breath groups with pre-sound velopharyngeal-nasal air leaks for each trombone player (1–4 = control participants; 5–10 = experimental participants).

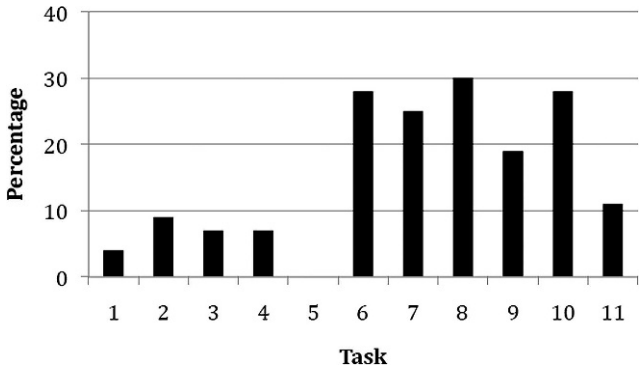

FIGURE 5 Percentage of breath groups with pre-sound velopharyngeal-nasal air leaks for each of the musical tasks (data for participants 1–8 combined). Tasks 1–5 = simpler tasks; tasks 6–10 = more demanding tasks.

to less than half (3% to 45%) of their breath groups, with no apparent difference between the control (1 though 4) and experimental participants (5 through 8). By contrast, experimental participants 9 and 10 exhibited velopharyngeal-nasal air leaks prior to the vast majority (98% and 89%, respectively) of their breath groups.

The influence of task on the occurrence of velopharyngeal-nasal air leaks prior to the onset of sound production was examined by tabulating the percentage of occurrences for participants 1 through 8, as shown in Figure 5 (data for participants 9 and 10 were excluded because they exhibited velopharyngeal-nasal air leaks prior to nearly all their productions). As can be seen in the figure, tasks 1 through 5 (the simpler tasks) were associated with fewer pre-sound velopharyngeal-nasal air leaks than were tasks 6 through 11 (the more demanding tasks).

Biofeedback and Instruction

Participants 9 and 10 differed from the other participants in that they exhibited pre-sound velopharyngeal-nasal air leaks on the vast majority of their breath groups. To determine if biofeedback and instruction could reduce their air leaks, they were each invited to a follow-up session.

The session began by allowing the participant to monitor the nasal pressure signal as it was being recorded while being instructed to "minimize or eliminate the spike in the tracing" (referring to the rapid rise and fall in nasal pressure immediately following the end of inspiration and immediately preceding the onset of the tone). After a few minutes of such biofeedback, participant 9 reduced the frequency of velopharyngeal-nasal air leaks, but participant 10 did not.

Next, the participant was instructed to modify his breathing (while continuing to visually monitor the nasal pressure tracing) as follows: "Take in a breath and hold it with your breathing muscles, then play the tone immediately without allowing any air to escape first." The goal of this instruction was to prohibit loss of air before the onset of sound production. The combination of biofeedback and breathing instruction reduced the frequency of the pre-sound air leaks in both participants. An additional instruction to "breathe in and out only through the mouth (and not the nose)" seemed to further reduce the occurrence of pre-sound velopharygneal-nasal air leaks.

Discussion

The present participants did not exhibit velopharyngeal-nasal air leaks during trombone playing; however, such leaks occurred frequently just prior to the onset of sound production. Does this mean that these trombone players had SVPI? The following discussion examines the definition of SVPI and speculates on its prevalence, describes the benefits of monitoring velopharyngeal status using a nasal pressure technique, and explores pedagogical implications of the present findings.

Definition and Prevalence of SVPI

Although an early report characterized SVPI as being associated with the production of high oral pressure for long periods (Weber and Chase, 1970), subsequent research has shown that it can also be associated with low-pressure sound production. This broader view is reflected in a recent definition of SVPI as "the unwanted coupling of the oral and nasal cavities while brass and woodwind musicians play their instruments" (Malick et al., 2007, p. 424).

In cases of documented SVPI, sound production during wind instrument playing has been accompanied by velopharyngeal opening or some other form of oral-nasal coupling (Weber and Chase, 1970; Massengill and Quinn, 1974; Dibbell et al., 1979; Peterson-Falzone, 1985; Gordon et al., 1994; Conley et al., 1995; Klotz et al., 2001). The musicians in the present study maintained a closed velopharynx during sound production and thus did not exhibit SVPI as it is typically described. Nevertheless, they often exhibited velopharyngeal-nasal air leaks (and therefore an open velopharynx) at the beginning of expiration before the onset of sound. These pre-sound velopharygneal-nasal air leaks were observed at least occasionally in all of the present participants, and two (participants 9 and 10) began the vast majority of their pre-sound expirations with an open velopharynx. Is this a sign of SVPI? If SVPI is defined as "unwanted coupling of the oral and nasal cavities," pre-sound velopharyngeal opening may, indeed, be a sign of SVPI.

Whether or not pre-sound velopharyngeal opening is included in the definition of SVPI, it is interesting to consider the symptoms reported by the musicians who comprised the present experimental group. These six musicians reported that they experienced air leaks through the nose and/or heard nasal sounds while playing the trombone. It seems that these perceptions may have been associated with the pre-sound velopharyngeal-nasal air leaks that we observed in their data. However, there was

not a one-to-one correspondence between the presence of pre-sound velopharyngeal-nasal air leaks and the perception of leaks. This was evidenced by the fact that the four musicians from the control group denied experiencing air leaks when, in fact, they exhibited pre-sound leaks during our data recording. This is best illustrated by the data of control participants 1 and 4 who had pre-sound velopharyngeal-nasal air leaks on 45% and 31% of their breath groups, respectively.

This apparent mismatch between musician report and velopharyngeal status is relevant to the interpretation of some of the prevalence data available on SVPI. In a study of oral pressure during wind instrument playing, Schwab and Schultze-Florey (2004) began by asking their participants the following questions: "Are you aware of the problem of involuntary air exhalation from the nose when playing your instrument? If so, do you have any personal experience of this?" Of the 148 musicians they asked, most (56%) stated that they were aware of this problem, and nearly one third (31%) indicated that they had experienced it personally. In a subsequent survey conducted by Malick et al. (2007), questionnaires were sent to college wind instrument players to obtain information regarding symptoms of SVPI. Specifically, they asked respondents to confirm or deny the following statements: "I have had air leak through my nose while playing my instrument: now; in the past; never; don't know" and "I have heard nasal sounds while playing my instrument: now; in the past; never; don't know." Approximately one third of their respondents (53/156 = 34%) reported that they experienced nasal air leaks or heard nasal sounds while playing.

The studies by Schwab and Schultze-Florey (2004) and Malick and colleagues (2007) indicate that about one third of otherwise healthy wind instrument players have a history of SVPI symptoms. The question arises, however, as to whether SVPI symptoms actually predict SVPI. In the present study, they did not. The lack of correspondence between SVPI symptoms and SVPI found in this study suggests that substantially fewer musicians who report SVPI symptoms actually have SVPI. The present study also suggests that such symptoms may be associated with pre-sound velopharyngeal-nasal air leaks in the context of a fully functional velopharynx.

These pre-sound velopharyngeal-nasal air leaks tended to occur more frequently during the more demanding musical tasks (tasks 6 through 11 in the current study). Although it is possible that fatigue may have influenced these findings (the tasks were always performed in the same order), this seems highly unlikely as the sessions lasted approximately 30 minutes, a much shorter period than their usual practice sessions. Our data suggest that the more up-tempo, musically complex, and in some cases louder tasks led to a greater frequency of velopharyngeal-nasal air leaks. While these tasks did not lead to SVPI during sound production, it is possible that the relatively great temporal and pressure demands of these tasks may have resulted in unwanted coupling of the oral and nasal cavities prior to sound production.

Using Nasal Pressure to Identify SVPI

The nasal air pressure technique used in this study has been applied successfully to monitoring the status of the velopharynx during vocalization and speech production in infants, children, and adults (Thom et al., 2006; Bunton et al., 2011) and was applied to wind instrument playing for the first time in the present study. This technique is noninvasive and comfortable (requiring only a nasal cannula on the face and a small microphone taped to the shoulder), involves simple recording procedures (requiring only a pressure transducer, amplifier, and computer and no need for calibration), and yields data that are easy to interpret (requiring only a judgment as to whether the pressure is zero, positive, or negative).[1] The present musicians were able to play their trombones with minimal interference from the instrumentation, so that performance during nasal pressure measurement may be more natural than performance during more cumbersome forms of measurement (e.g., videofluoroscopy and nasoendoscopy). This nasal pressure technique offers an excellent way to monitor velopharyngeal status in cases where SVPI is suspected. If positive nasal air pressure is detected during wind instrument playing, a more extensive evaluation should be then undertaken to diagnose or rule out SVPI.

Pedagogical Implications

As described in previous studies (Dibbell et al., 1979; Gordon et al., 1994; Conley et al., 1995; Klotz et al., 2001), SVPI can have a detrimental impact on musicians' ability to play their instruments. In some cases, medical interventions have been effective in alleviating SVPI. Thus, early detection of SVPI may be critical to the success of intervention and to maintaining high-quality performance levels and successful careers. The simple yet powerful nasal pressure technique described in this study provides an excellent way to determine if SVPI is present.

An important and unique observation made in this study was that velopharyngeal-nasal air leaks are relatively common immediately before the onset of sound production. As discussed above, this may or may not be categorized as a sign of SVPI (depending on the definition of SVPI that is adopted). Nevertheless, the act of moving

[1]During the present study, minor alternating fluctuations of the nasal pressure tracing were noted during some tasks, particularly those with high-pressure demands. These fluctuations, which alternated from positive to negative, were likely due to movements of the velum in response to high oral pressure rather than actual velopharyngeal openings. Similar air pressure or flow fluctuations around zero have been described previously (Lubker and Moll, 1965; Thompson and Hixon, 1979; Hoit et al., 1994; Thom et al., 2006) and have also been ascribed to velar movements.

from an open to a closed velopharynx so near to the generation of the tone may degrade the quality of the tone onset. Specifically, this could cause the onset of the tone to sound "unfocused" or "dampened" and the "attacks to be inconsistent," as has been suggested by a trombone teacher (Paiewonsky, personal communication, May 2011). Instructing the musician to breathe in and out of the mouth (only) when playing the trombone may alleviate this problem. The presence of these pre-sound velopharyngeal-nasal air leaks also indicates that there is loss of lung volume at the beginning of the breath group. This could reduce the duration of sound that can be played and/or cause a musician to continue playing to a smaller lung volume where recoil is less positive or even negative and thereby lead to respiratory fatigue. It appears that a combination of biofeedback and instruction may be helpful in reducing or eliminating pre-sound velopharyngeal-nasal air leaks. Thus, although pre-sound velopharyngeal-nasal air leaks may not be a sign of impairment of velopharyngeal function in healthy trombone players, their elimination may improve the quality of the playing.

Conclusions

SVPI can seriously impair the career of a wind instrument player; thus, early identification and treatment of SVPI are critical to a musician's success and quality of life. The results of the present study indicate that SVPI may be difficult to identify through perception alone (i.e., merely by feeling air or sound through the nose) and that an instrumental approach is a much more accurate way to identify SVPI. The measurement of nasal ram air pressure using a nasal cannula offers an easy yet powerful method for monitoring velopharnygeal status during wind instrument playing and may be useful for both evaluation and behavioral management (e.g., biofeedback). The present study suggests that much more common than velopharyngeal-nasal air leaks during the production of tones are velopharyngeal-nasal air leaks just prior to the onset of tones. Whether or not this should be considered SVPI is open to interpretation. Nevertheless, trombone players and their teachers may view pre-sound velopharyngeal-nasal air leaks as undesirable and believe that they impair the quality of the musical product.

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References

Bunton K, Hoit JD, Gallagher K. A simple technique for determining velopharyngeal status during speech production. *Sem Speech Lang*. 2011;32:69–79.

Conley SF, Beecher RB, Marks S. Stress velopharyngeal incompetence in an adolescent trumpet player. *Ann Otol Rhinol Laryngol*. 1995;104:715–717.

Dibbell DG, Ewanowski S, Carter WL. Successful correction of velopharyngeal stress incompetence in musicians playing wind instruments. *Plast Reconstr Surg*. 1979;64:662–664.

Gordon NA, Astrachan D, Yanagisawa E. Videoendoscopic diagnosis and correction of velopharyngeal stress incompetence in a bassoonist. *Ann Otol Rhinol Laryngol*. 1994;103:595–600.

Hoit JD, Watson PJ, Hixon KE, McMahon P, Johnson CL. Age and velopharyngeal function during speech production. *J Speech Hear Res*. 1994;37:295–302.

Klotz DA, Howard J, Hengerer AS, Slupchynskj O. Lipoinjection augmentation of the soft palate for velopharyngeal stress incompetence. *Laryngoscope*. 2001;111:2157–2161.

Lubker J, Moll K. Simultaneous oral-nasal air flow measurements and cinefluorographic observations during speech production. *Cleft Palate J*. 1965;2:257–272.

Malick D, Moon J, Canady J. Stress velopharyngeal incompetence: prevalence, treatment, and management practices. *Cleft Palate J*. 2007;44:424–433.

Massengill R, Quinn G. Adenoidal atrophy, velopharyngeal incompetence and sucking exercises: a two-year follow-up case report. *Cleft Palate J*. 1974;11:196–199.

Murry T, Brown WS. Subglottal air pressure during two types of vocal activity: vocal fry and modal phonation. *Folia Phoniatrica*. 1971;23:440–449.

Netsell R. Subglottal and intraoral air pressures during the intervocalic contrast of /t/ and /d/. *Phonetica*. 1969;20:68–73.

Peterson-Falzone SJ. Velopharyngeal inadequacy in the absence of overt cleft palate. *J Craniofac Genet Dev Biol Suppl*. 1985;1:97–124.

Schwab B, Schultze-Florey A. Velopharyngeal insufficiency in woodwind and brass players. *Med Problems Performing Artists*. 2004;19:21–25.

Thom S, Hoit J, Hixon T, Smith A. Velopharyngeal development in infants. *Cleft Palate Craniofac J*. 2006;43:539–546.

Thompson AE, Hixon TJ. Nasal air flow during normal speech production. *Cleft Palate J*. 1979;16:412–420.

Weber J, Chase RA. Stress velopharyngeal incompetence in an oboe player. *Cleft Palate J*. 1970;7:858–886.