

Module 1

Cierra Jordan
2242371

Physiology of the Cricothyroid & Thyroarytenoid Muscles in Voice Production:
Unraveling the Complexity of Pitch Elevation & Mixed Registration

Word Count: 4,623

BMPF7003 — Working and Learning: An Introduction to Work-Based Higher Education

Part 1

Critically evaluate a range of voice-related concepts, theories and models you have recently studied, explaining their relevance to your workplace practice and procedures, and develop a strategy for applying what you have learned to improve your practice and performance.

Research Question: What roles do the thyroarytenoid & cricothyroid muscles play during pitch elevation & mixing registers? What do we know and how do we keep moving forward

Introduction

The concept of “thyroid tilt” has been implemented into much research over the years regarding the role it plays during pitch elevation, as well as mixed voice. As a private Contemporary Commercial Music (CCM) voice teacher, there is a curiosity to fully understand what is really happening within the vocal mechanism and how to effectively, and healthily, guide students as they ascend through the passagio for both Classical & Contemporary styles. This study will assess various viewpoints of the role of “thyroid tilt” during pitch elevation, with expansion on how it could be used as a mixing tool between registers. Fundamental frequencies will not be discussed in this work, as it adds an additional element that would exceed the parameters of this assignment.

Elongation of the Vocal Folds During Ascension

Vocal fold elongation is posed to be the main mechanism needed in order to achieve pitch change (Lam Tang et al, 2008). Some believe elongation happens due to the tilt of the thyroid cartilage (Kayes, 2015). Honda et al agree saying, “the high-pitched voice production can be achieved by thyroid cartilage tilting” (Saldías et al, 2020). Others believe elongation happens as a result of the cricoid tilting, believing that, “cricothyroid muscles elevate the vocal pitch because they lengthen and add to the tension of the

vocal folds by tilting the cricoid plate posteriorly” (Unteregger et al, 2016). Then there are those in the middle who believe both the thyroid and cricoid are tilting, such as Titze and Mathias et al. Titze believes the adjustments are “combined actions of the cricothyroid muscles (CTMs) and thyroarytenoid muscles (TAMs)”, (Titze et al, 1988) and Mathias et al. agrees; “the cricothyroid muscles pull the thyroid cartilage forward and tilt the cricoid cartilage backward thus elongating the vocal ligaments and increasing tension” (Dayme, 2009). There is indeed a unanimous conclusion confirming the elongation of the vocal folds. However, the “how” is what is not agreed upon in the research found.

Laukkanen et al. believe “the activity of both CT and TA has been found to increase simultaneously as pitch is raised” (Laukkanen et al, 2002). In contrast, Kochis-Jennings et al found that TA activity was greater in the middle voice than in head voice (Kochis-Jennings et al, 2014). For this study, we will specify middle voice as a moderate vocal fold closure, whereas head voice will be a thinner vocal fold closure. High-pitched sounds have also been related to a backward cricoid cartilage rotation due to the activation of the cricothyroid muscles. (Saldías et al, 2020) According to Wendler et al. (and supported by recent data by Kochis-Jennings et al.), “the first stage of pitch elevation (M1) is achieved by the CTs, which elongate and tense the vocal folds. Thyroarytenoid muscles perform the fine-tuning. Once CT contraction is exhausted, no (or only minimal) further increase in vocal fold length is possible. Any further pitch elevation, these authors concluded, must be achieved by using the TAMs to change the vocal fold tension or stiffness...Based on electroglottographic measurements, Henrich presented a different hypothesis. Like Wendler et al., Henrich postulated two mechanisms for raising vocal pitch: In the low to mid-part of the frequency range (M1), the activity in the TAs is higher than in the CTMs. In the mid- to high part (M2), the activity in the CTs is higher than in the TA muscle. In short, this hypothesis exactly is the opposite of what Wendler et al. proposed” (Unteregger et al, 2016). More research is needed to clarify further. Nonetheless, we can conclude there is some sort of “tilt” happening within pitch elevation, even as we are not confident which cartilage is tilting and how much.

Additional Factors At Play

Though the role of the TAs and CTs are the focus of this study, there are other extraneous additives that are said to aid in pitch elevation, such as airflow, larynx height, vertical tension, the hyoid bone, and head and tongue position. According to Unteregger et al., “Vocal pitch is determined by the length, tension, vibrating mass, and stiffness of the vocal folds, as well as sub- and transglottic pressure and airflow. The CTMs, TAMs, and lateral cricoarytenoid muscles (LCAMs) are chiefly responsible for the modification of these parameters, and thus for pitch control” (Unteregger et al, 2016). Larynx height is another item that must be considered. Hirano and Titze et al. reported that “a lowering of the vocal folds within the larynx is accompanied by a pitch elevation” (Unteregger et al, 2016). On the contrary, it is believed that the elevated larynx above resting level “provides a mechanical advantage” for rotation of the CT joint (Hong et al, 2015). Hong et al. encourages that the vertical movement of the larynx is “associated with pitch control. However, the exact effect of laryngeal elevation on pitch control still remains unclear. Because the pitch is mainly affected by major physiological factors, such as tension and length of the vocal folds and subglottal pressure during normal phonation, it is actually very difficult to evaluate the pure effect of laryngeal elevation on pitch control” (Hong et al, 2015). Vocal fold vertical tension is thought to be “the primary contributor to pitch change in the context of unchanging vocal fold length”, according to Lam Tang et al (Lam Tang et al, 2008). Additionally, the hyoid bone. Hong et al says, “the rise in the pitch causes vocalization with an increase in the length of the vocal cords and an increase in the tension. It was found that the increases in vertical movements of the cricoid cartilage, thyroid cartilage, and hyoid bone play an important role in increasing the pitch” (Hong et al, 2015). Lastly, head and tongue position are thought to potentially affect larynx height, especially since the tongue attaches to the larynx, according to Lam Tang et al, however they deem it questionable to say the two directly elongate the vocal folds (Lam Tang et al, 2008).

TA & CT Behavior Within Mixed Registration

Where things start to get even more complex is when studying the behavior of CT vs TA engagement as it pertains to not only pitch elevation, but also mixing registers. “Mix voice as a mix of registers remains a big question mark” (Aaen et al, 2019). Many voice teachers and pedagogues have used the terms “thyroarytenoid (TA) dominant” and “cricothyroid (CT) dominant” when referring to perceived vocal qualities, concluding “head mix and head registers use cricothyroid(CT) muscle dominant voicing, whereas chest and chestmix registers use thyroarytenoid (TA) muscle dominant voicing (Kochis-Jennings et al, 2014). According to Kochis-Jennings, “Little is known about the mechanisms involved in the production of “mixed” registers, such as chestmix and headmix or about how pitch is controlled within these registers. Kochis-Jennings also concluded that “CT activity appeared to be more related to pitch rather than register control” (Kochis-Jennings et al, 2012). Generally speaking, the TAs are “clearly more active in the lower than in the upper range...and the CTs are more active in the upper than in the lower range” (Unteregger et al, 2016). As singers increase in chest voice, Titze believes “they must either gradually separate the vocal processes and/or gradually decrease TA muscle activity as they increase CT muscle activity if an abrupt register transition from chest to falsetto is to be avoided. He theorized that these adjustments might begin around C4 and continue through F4 to avoid an involuntary chest to falsetto register transition” (Kochis-Jennings et al, 2014).

“At higher pitches in singers, a decrease in length was observed, suggesting that change in vocal fold length is pitch range dependent, and that alternative mechanisms for pitch control come into play at higher pitches above the primo passaggio (ie, the transition point between chest voice and head voice) in “head voice” range” (Lam Tang et al, 2008). Kochis-Jennings et al also conclude that their findings “do not support the assumption that all chest and chestmix production has greater TA activity than CT activity or that all headmix and head production require greater CT muscle activity than TA activity. Instead, the data indicate that pitch level may play a greater role in determining TA and CT dominance than register. At this time, too little is known about laryngeal muscle co-contraction and regulation during singing and more data are needed” (Kochis-Jennings et al, 2014). Though not pertaining to pitch elevation, it could

be valuable to note the condition of “reduced density” on same-pitch phonation, with observations of the thyroid cartilage tilting forward, stretching of the mucosa covering the cricoid-arytenoid complex and the posterior cricoid, and an upward posterior, slightly superior, contraction of the middle constrictor muscle in the pharyngeal wall. (Aaen et al, 2019) This notion is also confirmed by various pedagogues amongst available research. So there seems to be tilting happening as singers thin the folds, even on the same pitch, which is very interesting.

Expansion of Various Styles

Many studies were conducted to draw conclusions about muscle engagement in classical vs commercial singers. Pedagogues have also noticed “significant differences” between trained and untrained voice users (Lam Tang et al, 2008). Vocal training and vocal use “may influence the manner in which laryngeal and supralaryngeal mechanisms are used for pitch control” (Lam Tang et al, 2008). “Hirano measured TA and CT muscle activity during production of same pitch phonation produced in chest, middle, and head in one trained female classical singer. He found TA muscle activity was greater for middle voice than for head voice but less than for chest. He also reported little change in CT muscle activity by register. (Kochis-Jennings et al, 2012) Studies have shown that “singers with primarily classical training showed smaller ranges of TA muscle activity (25–38% of maximum), whereas those with commercial training showed a greater range of TA muscle activity (5–75% of maximum). This was particularly true for high pitch phonation” (Kochis-Jennings et al, 2012).

For commercial singers, Titze speculated that “the trained singer may separate the VPs as pitch is increased in chest to offset increased TA activity and then gradually decrease TA while CT activity increases, thus ensuring a smooth register transition from chest to head. However, the actual mechanisms by which female commercial singers maintain chest or chest mix as they traverse the upper middle and upper pitches are not currently known. Although there is evidence that register control is dependent on adjustments made at the level of the larynx, there has not been a systematic study of these adjustments across different registers and singing styles” (Kochis-Jennings et al, 2012).

When looking at the effects of added twang, which is said to be related to a greater forward tilt of the thyroid cartilage (Titze, 1988), it is said that there is decreased TA activity in the upper register while having more in the lower register, whereas a backward tilt of the cricoid muscle was evident regardless of range (Saldías et al, 2020). In regard to belting, Popeil unpacks the original Estill teaching that the larynx remains stable as the cricoid cartilage tilts upward and in turn proposes that the two cartilages are tilting toward each other in belt production. An endoscopy within her study confirms her assumption in belt quality. She also includes soft belting as an option, but states it “includes the definite sensation of ‘the lean’” (Popeil, 1999). Therefore, “commercial singers are able to maintain chestmix while producing pitches in the upper-mid and upper part of their frequency range by maintaining or increasing vocal fold adduction and by engaging the TA muscle to a greater extent than they would to produce the headmix and head registers (Kochis-Jennings et al, 2012). Furthermore, an understanding of how chestmix is produced will help singing teachers better instruct students who wish to produce this register and help us to understand how it may be produced in a healthy manner” (Kochis-Jennings et al, 2012).

Conclusion

There is still ample room for exploration. Unteregger poses the following questions: “Do untrained singers use only one technique or both, but do so less effectively than trained singers? Second, do trained singers exhaust the first mechanism before they transition to the second, or do they transition at a lower pitch? Third, at what pitch is arytenoid rotation/rocking exhausted? Finally, is there a correlation between cricothyroid joint type and vocal range?” (Unteregger et al, 2016). “Aaen et al. says, “Future studies should include multiple methods allowing the documentation of both laryngeal, oral, nasal, and facial adjustments that may impact timbral percepts” (Aaen et al, 2021).

Kochis-Jennings et al. desire a systematic study that explores the framework that “TA muscle activity and vocal fold adduction are measured during a variety of singing tasks produced in the pitch range of interest (F4–E5)” (Kochis-Jennings et al, 2012). They add that there aren’t studies that compare classical and contemporary singers. What I have found throughout this study confirms this idea, as each study hones in on one or the

other, not both. Another item of question is how much control we have over our vibratory depth of the vocal folds (Titze et al, 1988) and how that affects the amount of engagement within the other muscles.

Exploration of Additional Approaches

In spite of what we don't know, there is opportunity for application within the studio based on what we do know. With what I found in this study, I have a few takeaways:

- Accessing thyroid tilt and cricothyroid engagement is worth navigating and can be approached with curiosity, even if there isn't finalized research on what is occurring. As students explore the sensations of these adjustments, feel and ease will remain top priority.
- Effective training tools can be implemented within the studio:
 - Specific Semi-Occluded Vocal Tract Exercises (SOVTs) through a straw into water are easily understood by students and are effective in teaching blend between registers. (Burdett et al, 2011). They lower the collision force of the vocal folds, as well as the Phonation Threshold Pressure (PTP) (Titze, 2018) and provide much opportunity for efficiency.
 - Pitch glides, isolating the thyroid tilt, including hand gestures to provide a visual representation during execution.
 - Implementing the idea of "crying" or "whining" in order to access increased thyroid tilt, therefore thinning the vocal folds during ascension.
- Playing with the mixing of registers while also remaining curious about the role of twang may be able to unlock greater options for students as they approach contemporary styles.
- I'd be interested in further developing the concept of chest mix vs head mix in order to access various tones and colors of the voice, all within the confines of efficiency and health.

- I plan to navigate understanding and mastering thyroid tilt for myself in order to be an effective teacher to those in my studio, while still remaining curious about what we do not yet know.

Part 2: (approx 1800 words)

- a) Reflect on your recent learning experience and the value of learning you have acquired. Assess your current competencies and identify future development needs in the context of your workplace/voice studio/classroom.**
- b) Devise a detailed personal development plan which incorporates identified areas for development, objectives, activities to be undertaken, methods, resources review periods and timescales.**

In an effort to reflect on the information presented above, I decided to utilize Gibbs' model, which includes 6 steps: description, feelings, evaluation, analysis, conclusion, and action plan (Gibbs, 1998). Other reflective models seemed too general and simplified, leaving much room for generalizations. I particularly liked the increased number of sections, due to the thorough nature of the process, as well as the opportunity to not only use this model for an individual event or assignment, but also within a group setting. I see it helpful to have such a tangible guide to assess and reflect on my current understanding, what I have learned, and how to make adjustments as I move forward.

As a voice teacher, I desire to be thorough and effective in the studio, therefore demanding clarity and ownership of current, available research within myself. I believe this makes me a greater asset to my students as they navigate the vocal journey. Additionally, having been injured previously due to incorrect teaching and approach in the upper register, my goal in researching the role of thyroid tilt during pitch elevation is to further grasp the mechanics of the vocal mechanism during ascension in order to better guide students into their process of mastery; in an efficient and sustainable way.

It is often that students come to me hoping to expand their range and strengthen the transition between their lower and upper registers, aka their mixed voice. The problem is, with so many videos and posts from various voice teachers across the world at my disposal, it is difficult to discern what is correct and most accurate. That is why I have decided to dive into this topic; to assess our current understanding from a scientific approach.

Description

Upon choosing my topic, I utilized the UWTSD Library to find anything and everything about thyroid tilt and pitch ascension. I downloaded the applicable files and spent hours highlighting and sorting. From there, I split chosen content into related sections in order to digest effectively. Each section was numbered in correspondence with the appropriate article/reference. Being a visual learner, I sought out visual diagrams that helped bring concepts to life and support various viewpoints. I also took time to play within my own voice, making myself aware of what I was feeling and noticing. I personally noticed the benefits of implementing the concept of “tilt” while both mixing my registers and ascending, but I do still question what is actually happening; perception vs. reality.

Feelings

It was a daunting task weaving through all current research, however, I was surprised to find so many resources on this topic. I had not realized how many others had been actively pursuing answers in these areas for so long. As I worked my way through the process, overwhelm arose due to the fact that so many scientific results have been published but vocal pedagogues across the world, and yet, do not come to a more unanimous conclusion across the board. This leaves me more unresolved than I had hoped to be, making it a little more challenging to confidently move forward in a confirmed direction. Until there are more consistent findings across the board, I imagine it could be difficult for others to be confident in this area as well. More research is needed.

Evaluation

The amount of resources available during this process made for effective collection of information and provided ample findings. I would have however, loved to have other forms of access, such as videos of vocal scopes or MRIs. This would have aided in further understanding and visualization of the discussions at hand.

There is a consistent theme that pedagogues agree about the active engagement of the TA and CT muscles, which is good. In contrast, the lack of tangible, applicable tools in regard to the how, when, and how much make it difficult. I particularly enjoyed the intentionality behind researching across varied styles. I believe this provided some interesting concepts worth pondering and keeping in mind as I move forward.

Analysis

The academic literature has been extremely helpful in understanding what options are proposed to be at play. I was unaware of the potential forward rocking of the cricoid as a way of elongating the vocal folds instead of thyroid tilt. I also wonder how this then

would affect other vocal qualities such as belt. It may be helpful to focus on one aspect at a time and dissect accordingly, such as chestmix only or behaviors of ascension only. There are just too many variables at play. Simplifying the process where possible would be helpful.

Conclusion

This study was very informative and allowed me to expand upon my current knowledge base regarding behavior of the vocal mechanism during ascension. I would love to see a more solidified and unified consensus amongst vocal pedagogues in the coming years. This will enable me to better understand and therefore serve my students well. I also believe this information will allow me to access further mastery of my own instrument.

Action Plan

See the chart below to view the plan moving forward.

Personal Development Plan

Why am I taking this course?	I am hoping to gain insight into the complexities of thyroid tilt, as well as mixed voice, in order to further mastery, understanding, and teaching styles within CCM. I am additionally curious about how these findings could in turn impact further topics, such as riffing and belting.
How does this benefit me?	If I am able to understand what triggers the engagement and the “why” behind it, I believe I will have better tools when approaching the other topics listed above.
Area of Development	Action Plan
1. Further investigate thyroid tilt and its impact on pitch elevation.	Utilize the MA Library to stay to date on all research regarding the topic, with an understanding that we are always discovering more. ● Deadline: June 2024
2. Personally test the current research with curiosity.	Find and test current vocal exercises that isolate the movement of the thyroid and cricoid cartilages in order to grow personally in not only information, but personal application.

	• Deadline: June 2024 Attend an Estill course. • Deadline: July 2024
3. Research belt to see how it pertains to thyroid tilt.	Though I have found studies on the belt quality previously, I would love to dive more into the degree at which thyroid tilt or cricoid may play a role. • Deadline: August 2024
4. Investigate twang as a means of elevating pitch.	Research the role of twang in regard to pitch elevation. • Deadline: August 2024
5. Develop a teaching strategy to implement in the studio for students.	I plan to develop a tangible teaching strategy including sounds, prompts, and exercises that teach students how to access their upper register, as well as strengthen their mix. • Deadline: November 2024

Reference list

Aaen, M., McGlashan, J., Christoph, N. and Sadolin, C. (2021). Deconstructing Timbre into 5 Physiological Parameters: Vocal Mode, Amount of Metal, Degree of Density, Size of Larynx, and Sound Coloring. *Journal of Voice*. doi:<https://doi.org/10.1016/j.jvoice.2021.11.013>.

Aaen, M., McGlashan, J. and Sadolin, C. (2019). Investigating Laryngeal 'Tilt' on Same-pitch Phonation—Preliminary Findings of Vocal Mode Metal and Density Parameters as Alternatives to Cricothyroid-Thyroarytenoid 'Mix'. *Journal of Voice*, 33(5), pp.806.e9–806.e21. doi:<https://doi.org/10.1016/j.jvoice.2018.02.023>.

Burdett, E. and Mitchell, V. (2011). Anatomy of the larynx, trachea and bronchi. *Anaesthesia & Intensive Care Medicine*, 12(8), pp.335–339. doi:<https://doi.org/10.1016/j.mpaic.2011.05.002>.

Echternach, M., Sundberg, J., Arndt, S., Markl, M., Schumacher, M. and Richter, B. (2010). Vocal Tract in Female Registers—A Dynamic Real-Time MRI Study. *Journal of Voice*, 24(2), pp.133–139. doi:<https://doi.org/10.1016/j.jvoice.2008.06.004>.

Edmondson, J.A. and Esling, J.H. (2006). The valves of the throat and their functioning in tone, vocal register and stress: laryngoscopic case studies. *Phonology*, 23(02), pp.157–191. doi:<https://doi.org/10.1017/s095267570600087x>.

Gibbs, G. (1998) *Learning by Doing: A Guide to Teaching and Learning Methods*. Oxford: Further Education Unit, Oxford Polytechnic.

Gillyanne Kayes (2015). *Singing and the actor*. London: Bloomsbury.

Greene, M.C.L. and Mathieson, L. (1997). *The voice and its disorders*. London: Whurr.

Harris, T. and Howard, D.M. (2018). *The voice clinic handbook*. Oxford, Uk Compton Publishing.

Herbst, C.T. (2020). Registers - The Snake Pit of Voice Pedagogy. *Journal of Voice*, 77(2), pp.175–190.

Hong, Y.T., Hong, K.H., Jun, J.-P. and Hwang, P.H. (2015). The effects of dynamic laryngeal movements on pitch control. *American Journal of Otolaryngology*, 36(5), pp.660–665. doi:<https://doi.org/10.1016/j.amjoto.2015.05.002>.

Johan Sundberg (1987). *The science of the singing voice*. Dekalb, Ill: Northern Illinois University Press.

Juan Carlos Casado-Morente, Felipe Luis Benjumea-Flores, Bárbara Romero-Gómez, María Soledad Angulo-Serrano, O'Connor-Reina, C., Carlos Casado Alba, Antonio José Galeas-López and Carricondo, F. (2022). Comparison Between two Surgical Techniques for Increasing Vocal Pitch by Endoscopic Shortening of the Vocal Folds. *Journal of Voice*. doi:<https://doi.org/10.1016/j.jvoice.2022.06.012>.

Keltz, A. and McHenry, M. (2020). Steam and/or Semi-occluded Vocal Tract Exercise as Morning Vocal Warm-up Strategy. *Journal of Voice*, 36(5), pp.734.e7–734.e13. doi:<https://doi.org/10.1016/j.jvoice.2020.08.037>.

Kochis-Jennings, K.A., Finnegan, E.M., Hoffman, H.T. and Jaiswal, S. (2012). Laryngeal Muscle Activity and Vocal Fold Adduction During Chest, Chestmix, Headmix, and Head Registers in Females. *Journal of Voice*, 26(2), pp.182–193. doi:<https://doi.org/10.1016/j.jvoice.2010.11.002>.

Kochis-Jennings, K.A., Finnegan, E.M., Hoffman, H.T., Jaiswal, S. and Hull, D. (2014). Cricothyroid Muscle and Thyroarytenoid Muscle Dominance in Vocal Register Control: Preliminary Results. *Journal of Voice*, 28(5), pp.652.e21–652.e29. doi:<https://doi.org/10.1016/j.jvoice.2014.01.017>.

Lam Tang, J.A., Boliek, C.A. and Rieger, J.M. (2008). Laryngeal and Respiratory Behavior During Pitch Change in Professional Singers. *Journal of Voice*, 22(6), pp.622–633. doi:<https://doi.org/10.1016/j.jvoice.2007.04.002>.

Laukkanen, A.-M., Takalo, R., Arvonen, M. and Vilkman, E. (2002). Pitch-Synchronous Changes in the Anterior Cricothyroid Space During Singing. *Journal of Voice*, 16(2), pp.182–194. doi:[https://doi.org/10.1016/s0892-1997\(02\)00088-7](https://doi.org/10.1016/s0892-1997(02)00088-7).

Meribeth Bunch Dayme (2009). *Dynamics of the Singing Voice*. Vienna: Springer Vienna.

Popeil, L.S. (1999). Comparing Belt and Classical Techniques Using MRI and Video-Fluoroscopy. *Journal of Singing*, 56(2), pp.27–29.

Saldías, M., Laukkanen, A.-M., Guzmán, M., Miranda, G., Stoney, J., Alku, P. and Sundberg, J. (2020). The Vocal Tract in Loud Twang-Like Singing While Producing High and Low Pitches. *Journal of Voice*, 35(5). doi:<https://doi.org/10.1016/j.jvoice.2020.02.005>.

Sundberg, J., Maddalena Bitelli, Holmberg, A. and Laaksonen, V. (2017). The ‘Overdrive’ Mode in the ‘Complete Vocal Technique’: A Preliminary Study. *Journal of Voice*, 31(5). doi:<https://doi.org/10.1016/j.jvoice.2017.02.009>.

Titze, I. (2018). Major Benefits of Semi-Occluded Vocal Tract Exercises. *Journal of Singing*, 74(3), p.311.

Titze, I.R. (2000). *Principles of voice production*. Iowa City, Ia: National Center For Voice And Speech.

Titze, I.R. ed., (2011). Vocal Fold Mass Is Not A Useful Quantity for Describing F₀ in Vocalization. *Journal of Speech, Language, and Hearing Research*, 54(2), pp.520–522. doi:[https://doi.org/10.1044/1092-4388\(2010/09-0284\)](https://doi.org/10.1044/1092-4388(2010/09-0284)).

Titze, I.R., Jiang, J. and Drucker, D.G. (1988). Preliminaries to the body-cover theory of pitch control. *Journal of Voice*, [online] 1(4), pp.314–319. doi:[https://doi.org/10.1016/S0892-1997\(88\)80004-3](https://doi.org/10.1016/S0892-1997(88)80004-3).

Traser, L., Burdumy, M., Richter, B., Vicari, M. and Echternach, M. (2013). The Effect of Supine and Upright Position on Vocal Tract Configurations During Singing—A

Comparative Study in Professional Tenors. *Journal of Voice*, 27(2), pp.141–148.
doi:<https://doi.org/10.1016/j.jvoice.2012.11.002>.

Unteregger, F., Honegger, F., Potthast, S., Zwicky, S., Schiwowa, J. and Storck, C.
(2016). 3D analysis of the movements of the laryngeal cartilages during singing. *The Laryngoscope*, 127(7), pp.1639–1643. doi:<https://doi.org/10.1002/lary.26430>.