A literature review exploring strategies voice teachers can employ in the online studio to support students with OSA

Caren Perlmutter

Student No. 2335323

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I. Introduction

Impacting as many as one in eight people globally (Malhotra et al, 2021), obstructive sleep apnea (OSA) is a sleep and breathing disorder that is difficult to diagnose, challenging to treat (Chiu et al, 2017), and harmful if left untreated. This literature review evaluates strategies that voice teachers can implement in an online studio to help students alleviate symptoms of OSA.

II. Rationale

In 2014, I observed my wife experience several cessations in breathing while sleeping. Soon after, she was diagnosed with OSA. Several of my voice students have also disclosed an OSA diagnosis. Given that OSA appeared to be a breathing-related affliction, understanding that breath was vital to the act of singing, given that the high proportion of the population living with OSA suggests that many voice practitioners have taught someone with OSA, and learning that Stanford University's sleep center is pursuing research into double-reeded instruments as a potential intervention for OSA, I conducted a review of current research to better understand the potential for singing as an intervention for OSA. This research showed enough promise regarding the anatomical, neurological, and physiological causes of OSA to merit the design of strategies, and enough questions regarding the inflammatory causes of OSA to merit further inquiry.

The following analysis applies the biopsychosocial (BPS) model to evaluating strategies (Engel, 1977). While the BPS model has been criticized for lacking definition of scope, it is now understood that diseases have biological, social, and psychological causes, and therefore can be diagnosed and treated with biological, social, and psychological considerations in mind (Boltin and Gillett, 2019). Especially considering that OSA is partly measured based on a patient's own perception of their behaviors (Senaratna et al, 2017), the benefits of employing an imperfect model outweigh the costs of ignoring social and psychological lenses when evaluating treatment.

III. Literature Inclusions and Exclusions

This review includes five pieces of grey literature. James Nestor's 2020 *Breath* relies on a variety of sources, including dozens of journal articles. Andrew Byrne cites over 100 journal articles in his 2020 *The Singing Athlete.* Dimon's 2018 *Anatomy of the Voice* is a textbook containing anatomy relevant to this review. Alise Ojay's 2024 three-CD exercise collection *Singing for Snorers* was the basis for Hilton et al's 2013 study regarding singing as a treatment for OSA symptoms. In the 26 June 2024 episode of the Be A Singing Teacher Podcast, Dr. Nicholas Perna cites his research regarding nasality. For these reasons all five works are

included. The remaining sources are peer reviewed literature. Other similar texts to *The Singing Athlete* were excluded as they have fewer direct ties to OSA treatment.

IV. OSA Diagnosis, Causes, and Medical Treatments

OSA is a sleep disorder defined by partial or total upper airway obstruction during sleep (Bhatt, St-Laurent, and Graham, 2024), and has been linked to: increased cardiovascular risk (Eckert et al, 2013); hormonal imbalances (Alvarenga et al, 2022); fatigue and depression (Taghizadegan et al, 2021); stroke (Taghizadegan, 2021); and diabetes, neurocognitive dysfunction, and increased risk of traffic accidents (Chiu, 2017). Sleep and breath are vital components of our survival and ability to thrive, and it would logically follow that repetitive, chronic, and involuntary interruptions to sleep and breath would have severe health implications.

The principal metric for diagnosing OSA is the Apnea-Hypopnea Index (AHI). An apnea is a cessation of airflow which lasts at least 10 seconds; a hypopnea is a shallow breathing event causing oxygen desaturation (Malhotra et al, 2021). Questionnaires measuring snoring and daytime sleepiness are also employed during diagnosis (Senaratna et al, 2017).

In their 2013 paper, Eckert et al propose four main causes of OSA: 1) an anatomical predisposition to the closing of the upper airway, which may lessen the responsiveness of the genioglossus muscle; 2) reduced responsiveness of the dilator muscles of the upper airway during sleep; 3) awaking prematurely to the narrowing of the upper airway; and 4) a hypersensitive ventilatory control system. A 2024 literature review by Finke et al showed that out of all craniofacial features identified as a potential source of upper airway obstruction, only three had statistical significance: soft palate or uvula length, soft palate or uvula maximum thickness, and length between the mandibular plane and the hyoid bone. While anatomy may make one predisposed to OSA, OSA develops when at least one of the other causes is present, most notably the decreased responsiveness of the upper airway (Taranto-Montemurro et al, 2019). Each of these four causes may be the key to treating a patient's OSA, and therefore treatment must be tailored to the unique profile of each patient.

The most common medical intervention is a continuous positive airway pressure (CPAP) machine, but adherence to treatment is low (Saconi et al, 2020). Surgical interventions have also been employed, but the success rate of these surgeries is only 56%, almost all patients still experienced apneas after surgery (Thaler et al, 2016), and surgeries have both severe risks (Woodson and Laohasiriwong, 2012) and impact to the singing voice (Bertino et al, 2006).

V. Strategies to Treat OSA in the Online Voice Studio

Orofacial Myofunctional Applications

One promising treatment for OSA is Myofunctional Therapy (MFT), originally developed to treat speech and swallowing disorders and improve oral growth through exercises targeting the tongue, lip seal, and nasal breathing (Carrasco-Llatas, O'Connor-Reina, and Calvo-Henríquez, 2021). Limitations of MFT include a lack of clarity on which exercises are the most successful, a dearth of standardized diagnostic tools, and a lack of coverage by insurance (Carrasco-Llatas, O'Connor-Reina, and Calvo-Henríquez, 2021).

However, orofacial myofunctional therapy (OMT) — a form of MFT targeted at optimizing tongue placement and improving oropharyngeal tone — has been observed to reduce AHI, subjective sleepiness, and snoring frequency, and improve minimum oxygen saturation and perceived quality of life (Saba et al, 2023). In 2023, The Sleep Centre at Sengkang General Hospital in Singapore produced a series of videos demonstrating OMT exercises that one can implement at home to improve sleep. Furthermore, in his 2020 book *Breath,* James Nestor asserts that chewing, sucking, and other facial muscle strengthening exercises support not only stem cell growth but also expansion of the airways, leading to greater ease of nasal breathing and healthier breathing overall.

Considering that singing involves both the recruitment of the upper airway muscles and breath management (Fleming, Titze, and Fleming, 2021), it follows that singing strategies could be employed to treat OSA symptoms. A 2000 study by Ojay and Ernst found a decrease in snoring among participants following 20 minutes of daily singing exercises, and a 2013 study by Hilton et al found that after three months of singing exercises, participants exhibited decreased snoring and daytime somnolescence. Neither of these studies note an impact on AHI, though it is critical to note that AHI was not one of the data points measured by the authors.

The 2008 study by Guimaraes et al confirmed that a suite of exercises focused on the soft palate, tongue, facial muscles, and stomatognathic functions, including both isotonic and isometric movements, were successful at reducing AHI in those suffering from mild to moderate OSA. The following is an analysis of how these muscles and structures can be recruited through singing exercises to reduce OSA symptoms.

Soft Palate

In their 2008 study, Guimaraes targeted the soft palate depressor muscles (palatopharyngeus and palatoglossus) and elevator/tensor muscles (tensor veli palatini and levator veli palatini) by having participants speak an oral vowel both continuously and intermittently. Vowel

pronunciation was also suggested by Vik Veer, ENT Consultant with the Royal National ENT Hospital London, in Hospital's 2023 Video series.

A singing exercise that may leverage the soft palate elevator and depressor muscles even more extensively might be to add a nasal consonant — an m, n, or ng, to the beginning of small phrases to strengthen the soft palate depressor muscles, then a vowel afterwards to strengthen the soft palate elevation muscles (Byrne, 2023).

Tongue

A 2013 study by Kezirian et al found that increased stimulation to the hypoglossal nerve reduced OSA symptoms. The hypoglossal nerve enervates the tongue's intrinsic muscles as well as the genioglossus, hyoglossus, chondroglossus, and styloglosssus extrinsic muscles (Maxfield, 2019). In a 2004 study, Randerath et al observed that tongue muscle training reduced snoring, but did not alter AHI in participants. However, tongue exercises were included in the suite of exercises employed by Guimaraes et al, and therefore should be included in the suite of exercises employed to treat OSA.

In his Online Studio, Andrew Byrne includes a series of isometric and isotonic tongue exercises, called *Release Your Tongue,* intended to activate the extrinsic genioglossus, palatoglossus, styloglossus, and hyoglossus muscles, as well as the intrinsic vertical, superior longitudinal, inferior longitudinal, and transverse muscles (Byrne, 2023). To apply tongue movement to singing, Ojay includes five exercises targeting movement of the back, middle, and front of the tongue (Ojay, 2024).

Facial Muscles

Facial muscles recruited in the 2008 Guimaraes et al study include the orbicularis oris (lip movement), buccinator (cheek muscle), major zygomaticus (raises the upper lip), minor zygomaticus (used for expression — smiling), levator labii superioris (raises the upper lip - smiling), levator anguli oris (lifts the corners of the mouth), lateral pterygoid (lowers the mandible and opens the mouth), and medial pterygoid (closes the mouth) muscles (Dimon, 2018).

> <u>Orbicularis oris and buccinator:</u> As a puffed cheeks hold without phonation is one of the exercises included in Sengkang General Health's 2023 OMT video series, a puffy cheeks SOVT exercise involving phonation may recruit the orbicularis oris and buccinator muscles. It is worth noting that in the 2006 Puhan trial which showed a significant decrease in AHI among participants who practiced the didgeridoo, the

embouchure specified was 3mm in width, so straw phonation with a 3mm straw may also serve to recruit similar facial muscles.

Major zygomaticus, minor zygomaticus, levator labii superioris, levator anguli oris muscles: A 'meow', exaggerated and sung on a melody of the voice coach's choosing, may serve to exercise this combination of muscles as well as other facial muscles, as the 'ee' leads the lips to a smile and the 'ooh' rounds the lips.

Stomatognathic Exercises

During the processes of chewing and deglutition, many muscles of the palate, tongue, cheek, and lips are employed (Dimon, 2018). Other chewing muscles include the masseter and temporalis muscles of the jaw; the larynx also plays a key role in swallowing (Dimon, 2018).

Masseter and Temporalis: Andre Byrne's Online Studio also features a series of videos named Release Your Jaw that target stretching and strengthening the masseter and temporalis muscles (Byrne, 2023).

Larynx: In their 2017 study, Stegemoller et al found that singing could serve as an early treatment for those diagnosed with Parkinson's Disease (PD), a neurodegenerative disease impacting motor control and functioning (Postuma, 2012). Stegemoller et al note that PD patients exhibit decreased hyoid movement, observe that maintaining laryngeal elevation is critical for a safe swallow, and propose that by targeting the muscles in and around the larynx, singing may help PD patients maintain laryngeal elevation when swallowing. As a depressed soft palate invites a higher larynx (Perna, 2024), the aforementioned exercises may provide sufficient laryngeal stimulation. However, laryngeal position is an important component in singing a variety of repertoire (Ikavalko, 2024), and if the teacher plans to work on a song with the student, the coach might consider including an exercise that aids laryngeal flexibility.

Breathing Applications

In their 2020 literature review, Courtney identifies breathing strategies that may help OSA, including Buteyko breathing and inspiratory resistance training. While the 2016 Vranish et al inspiratory resistance training study did not show a relationship to AHI, and the Buteyko breathing trials were case studies with extremely small sample sizes, both Courtney and Nestor assert that breathing exercises that help increase CO2 tolerance may treat the oversensitivity of the ventilatory control system common in OSA patients. As hyperventilation from oversensitivity to CO2 is associated with OSA (Saba et al, 2023), slowing inhalation and exhalation could help alleviate this symptom. Voice coaches can employ longer scales for straw phonation and other

exercises suggested above to encourage a longer exhale, a component of Buteyko breathing (Nestor, 2020). In his 2020 book *The Singing Athlete*, Andrew Byrne includes two videos with accompanying songs which help students extend the functional inhale and exhale, aptly named "Inhale Slowly" and "Exhale Slowly".

Several limitations arise when considering breathing in the online voice studio. First, much evidence shows that nasal inhalation helps to raise CO2 tolerance and prevent hyperventilation (Nestor, 2020), but mouth breathing is common and even often recommended in singing (Gates, Forest, Obert, 2013). To mitigate this, students can practice "Inhale Slowly" using nasal breathing. It is also important to note that nasal breathing was the placebo treatment in the 2008 Guimaraes study, so nasal breathing alone is not a panacea for OSA.

Inflammation and Psychological Applications

Improvements in OSA have also been linked to the status of the autonomic nervous system, metabolism, and levels of inflammation (Courtney, 2020). The intermittent hypoxia episodes of OSA have been shown to cause chronic inflammation in those diagnosed with OSA (Flores et al, 2020). Nasal obstruction and inflammation have also been found to be common in patients with OSA (Wallace et al, 2022). It is therefore worth considering strategies in the voice studio that may decrease inflammation.

As anxiety may be linked with inflammation (Won and Kim, 2020), and can also be a psychological symptom associated with OSA (Chua et al, 2022), one treatment path to consider in an online voice studio is strategies a voice coach can employ to reduce anxiety during a lesson. Options include incorporating peripheral vision exercises, as anxiety has been linked with a lack of peripheral vision (DeCouto et al, 2023) or exercises that improve interoception, as anxiety has ben linked with impaired interoception (Brewer, Murphy, Bird, 2021). Though the bounds of this paper will not permit this exploration, given the application of the BPS model, it would also be worth investigating strategies to treat other common psychological consequences of OSA, including shame, hostility, depression, and guilt (Chua, 2022).

Additionally, a 2019 study by Hesselbacher also showed that about one in every five patients with OSA also exhibited symptoms of ADHD. Given that those with ADHD respond better to smaller rewards sooner rather than larger rewards later (Marco et al, 2009), applying the exercises to a song of choice may help a student appreciate gains sooner than the three months it may take to show advances in AHI and sleep quality.

VI. Implementation Considerations

CPAP Use

Several studies have shown that patients with OSA who use a humidified CPAP machine nightly experience a decrease in laryngeal side effects (Roy et al, 2019) and a positive impact on the voice (Karaoğullarından and Erkan, 2022). Singing treatment should thus ideally take place alongside CPAP use.

Exclusions

Though the 2013 Hilton study excluded participants who had severe OSA or a BMI above 40, the 2021 Carrasco-Llatas, O'Connor-Reina, and Calvo-Henríquez literature review confirms that these exclusions are unnecessary. One exclusion worth considering is alcohol consumption during the trial, as alcohol consumption can increase the likelihood of snoring and impact AHI (Foroughi et al, 2018). Further investigation should be made into other substances that may cause similar upper airway muscle relaxation.

Treatment Duration & Frequency

The 2021 literature review by Carrasco-Llatas, O'Connor-Reina, and Calvo-Henríquez suggest that treatment should last for three months to impact AHI, though there is no clear answer on whether treatment needs to be continual after that point. Similarly, there is a lack of uniformity regarding duration and frequency of treatment over those three months. The literature suggests a range of 15-25 minutes of exercises 5-6 days a week, either throughout the day or in one practice session (Guimaraes, 2009; Puhan, 2006; Hilton, 2013; Sengkang General Hospital, 2023). While Ojay's 2024 work includes audio exercises, a video format such as Byrne's Online Studio videos or Sengkang General Hospital's 2023 OMT videos may improve accuracy while performing the exercises at home; it should be noted that Guimaraes et al 2008 trial led patients through exercises in-person. During the 2006 Puhan study, patients were contacted halfway through the study, but as this treatment would occur in the context of a voice studio, more frequent connection may be both possible and beneficial.

Measuring Success and Limitations

As AHI is the gold standard for measuring OSA (Malhotra et al, 2021), patients should undergo a baseline polysomnography prior to treatment to assess AHI, along with a sleep quality questionnaire (Senaratna et al, 2017) at the onset of treatment, and a reassessment of both after three months. There is, however, a lack of clarity regarding whether the treatment must be ongoing to maintain benefits — a limitation that requires more research to clarify. It should also be mentioned that one barrier of OSA diagnosis is the difficulty in obtaining a polysomnography

(Chiu et al, 2017); it may therefore behoove the voice coach to partner with a sleep center professional to gain access to this important measurement tool. A final limitation is the degree of regular adherence to the exercises, though the opt-in approach to treatment and songwork applications may mitigate this.

Ethical Considerations

As this suite of exercises comprises the treatment of a medical disease, several ethical considerations arise. The first is the consideration of privacy of health information - how, can, and should students disclose an OSA diagnosis? One potential mitigation to this limitation is to ask students to opt into a trial, then allow the associated sleep center to manage OSA-related data. Second, what are the responsibilities of the voice coach during treatment? This is where King's VOCAL model may be employed — as a way to ensure boundaried, responsible care (Van Looy and King, 2023). Third, as breathing can be linked to trauma (Gilbert, 1998), voice coaches may wish to explore training in trauma-informed teaching.

VII. Conclusions

A combination of strategies, inspired by MFT therapies and inclusive of psychological considerations, may help patients with OSA sing their way to better sleep. Further investigation is warranted into the duration and frequency of care and the securing of proper baseline procedures, and further preparation is needed for the voice coach to be able to administer treatment.

VIII. Critical Reflection

Rationale

In reviewing models for my reflection, two stood out — the Kolb Model, and the DEBRIEF Model. I was drawn to the Kolb model for several reasons. One is that Kolb names and defines the four roles that I have often found myself in while in the midst of a lesson — coach, facilitator, evaluator, and subject expert — and maps each of these to a component of the Learning Cycle, helping me not only own and integrate each of these roles, but also clarify how and when to apply them (Kolb and Kolb, 2018). In their 2023 article, Choi et al also describe how the Kolb model was applied to improve clinical reasoning skill and cognitive bias awareness of first-year medical students in New York City. As the process of a vocal coach might be described as diagnostic — i.e. the voice coach is solving for a perceived problem or area of growth as identified by either the coach or the student — the use of Kolb in a clinical reasoning process also seemed quite apt.

It should be noted that the Kolb model does have its limitations. First, the model assumes that the context of the experience is apolitical, i.e., that there are no social power dynamics at play and everyone feels psychologically safe reflecting critically on themselves or others (Russ, 1998). To mitigate this in my studio, I hope to apply King's VOCAL model with my students to co-create a boundaried place for learning, and investigate other tools for supporting psychological safety in the online voice studio (Van Looy and King, 2023). To mitigate this in my coursework, I plan to engage in meditative practices before initiating my own learning or teaching that will help me reflect authentically. Russ also notes that Kolb's model does not acknowledge that bias may interfere with the perception of an experience. Choi et al's 2023 study layers the investigation of bias onto the Kolb model. The DEBRIEF model goes one step further by explicitly asking the learner to draw out and examine how any biases might impact engagement in and reflection on experiences (Allan, 2011).

For my own reflection, I chose to use the Kolb model and its iterative cycles to track and reflect my continuous learning, and also added Choi's layering of bias. I have chosen to apply components of the DEBRIEF model to provide a more holistic overview of my learning in Module 1 thus far.

Describe

I deepened my examination of the same topic addressed in my Formative Assessment — Singing as a Strategy for Treating Obstructive Sleep Apnea (OSA), this time assessing

strategies for treating OSA in the online voice studio. I applied the Kolb model to track my learning experiences, log my time, ask questions, and dig more deeply into the material.

Evaluate

Weekly meetings with my tutor helped me realize and examine held assumptions, broadened my ideas of what strategies could fall under the umbrella of my chosen field, and gave me weekly accountability and deliverables to work toward. Tracking my time also helped me appreciate my weekly accomplishments and measure if I achieved my average weekly target goal of 8 hours of schoolwork. Applying the Kolb model deepened my inquiry, sending me into grey literature more so than during the Formative.

I also found that the Formative Assessment helped me evaluate sources more critically while I was engaging with them, as opposed to applying a critical lens after-the-fact.

I think that because the topic was the same, I mistakenly assumed that I could use much of my work from the Formative on this module, causing me to get a slower start. I also uncovered anatomy as an area for development, as I am spending much time better understanding which muscles I should target in the design of my strategies. I was also (over) excited about one particular source only to find that it was less applicable in the online studio than I had imagined.

Bias

Meetings with my tutor also helped me uncover biases. One is a bias surrounding weight - I have experienced both periods of being overweight and underweight in my life and I imagine that might color the subject for me. Another is a bias around using grey literature in an academic program. Additionally, I uncovered a bias regarding the author of sources; during the pandemic I was moved to apply exclusion criteria around the consumption of media, and consume from sources that were for the most part *not* white heterosexual men, and I have found that my preference for these sources may be impacting my criticality in this Module— for example, I am much more excited to read a peer-reviewed paper authored by a female scientist, and more apt to be critical of a work authored by a white, heterosexual man.

Review

On reflection, I realize that I have a tendency towards assuming, and going with my first thought. I am aware that assumption may block curiosity and listening, and thus assuming

might prevent me from seeing the truth of a matter, considering more than one opinion, and including grey literature.

Regarding anatomy, I have also experienced a lack of confidence in my knowledge of anatomy while teaching lessons.

Lessons Learned

One lesson learned is to identify ways to mitigate my tendency towards assumption — in life, not just in school! Two ideas come to mind. The first is to more proactively set aside reflecting time in my log as opposed to five minutes after-the-fact before rushing off to the next source. Simply put — to take more time in the learning process and resist the urge to feel rushed. I think reengaging in a meditative practice may also help assuage this tendency. I'd also like to strengthen my anatomy knowledge in the hopes of making the reading of anatomical papers more efficient. Finally, I'd like to find a resource to help me address any conscious or unconscious bias regarding weight and sex.

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X. PDP

Goal 1	Action Plan	Measuring Success	Timeline
Objective	Measure and address potential biases regarding weight and sex/gender	1) Greater awareness of how my biases might inform my behavior 2) Ultimately, if possible, a noticeable decrease in favoritism towards any population based on weight and sex/ gender	Dec 1 2024
Activity 1	Investigate and take quizzes/assessments to help me understand the extent of my biases	Completion of quizzes; greater awareness about potential biases	Complete by Nov 1 2024
Activity 2	If a bias is uncovered, find a resource (course, etc.) that will help me address and mitigate biases	Complete course or other resource	Complete by Dec 1 2024

Goal 2	Action Plan	Measuring Success	Timeline
Objective	Continue and deepen learning in anatomy of the voice	Confidently apply anatomical concepts snd knowledge in voice lessons and Module 3 paper	Complete by Dec 15 2024
Activity 1	Read ‘Anatomy of the Voice’ (Dimon, 2018)	Able to name each anatomical component and explain its use in singing	Complete by Nov 15 2024
Activity 2	Review VSC Anatomy Module	Fill in any gaps left by Dimon text	Complete by Dec 15 2024

Goal 3	Action Plan	Measuring Success	Timeline
Objective	Deepen learning on trauma-informed care in the online voice studio	Exhibit greater care and sensitivity around interoception and breathing tools in the studio as these are both tools related to treating OSA and can be triggering (Byrne, 2020; Gilbert, 1998).	Complete by Jan 15 2025
Activity 1	Review VSC lecturers — Emily Foulkes, Dr. Geneva Mayne, Megan Durham, Elisa Monti	Apply at least one tool from lectures to studio	Complete by Dec 1 2024
Activity 2	Research other resources suggested by VSC lecturers	Apply at least one tool/ concept from resources into lesson and understand how it applies to OSA treatment	Complete by Jan 15 2025

Goal 4	Action Plan	Measuring Success	Timeline
Objective	Enrich understanding of tools to treat anxiety in the online voice studio	Consistently apply tools to online lessons	Complete by Feb 15 2025
Activity 1	Visit and review VSC resources	Apply one tool to lessons	Complete by Jan 15 2025
Activity 2	Research other sources and choose 1-3 to pursue in more detail	Apply a tool from each source into lessons	Complete by Feb 15 2025

Goal 5	Action Plan	Measuring Success	Timeline
Objective	Deepen immersion in broader Singing & Health community	Greater sense of connectedness with Singing & Health peers	Complete by March 1 2025
Activity 1	Connect with other Singing & Health focused students in VSC and look into Singing for Health network	Find several few peers interested in similar subjects and willing to answer questions	Complete by Feb 1 2025

Goal 5	Action Plan	Measuring Success	Timeline
Activity 2	Research other media (podcasts, conferences etc) on the subject	Sign up for a conference or find a podcast/other resource	Complete by March 1 2025

Goal 6	Action Plan	Measuring Success	Timeline
Objective	Re-ignite meditation practice	Noticing more of a beginner's mind in lessons and in life :)	Ongoing practice
Activity 1	Sharon Salzberg 8-day Kindness meditation course	Completion of course	Complete by Oct 31 2024
Activity 2	Meditate before starting Module-related work	Noticing differences in reflection log	Commence October 11 2024