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Managing "Vocal Dose" and the acting voice: how much is too much?

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ABSTRACT

Maintaining vocal health can be challenging for actors and students of acting, given the unique vocal demands placed on the performer's voice including the use of heightened speech, character voices, prolonged speaking at loud volumes, and stage screaming. Vocal fatigue is related to the amount, type, and duration of voice use, and over time, can lead to acute or chronic vocal injury. This article discusses a measurement technique, called vocal dosimetry, which can quantify in real time the vocal fold tissue stresses related to the frequency, intensity, and accumulated duration of vocal fold vibrations. The unique vocal challenges of three different actors (undergraduate student, professional graduate student, and professor of acting) are reviewed in order to examine ways to effectively manage vocal load and optimize vocal health. Ways to monitor, prevent, and recover from vocal fatigue are presented. The actor should adopt the mindset of a vocal athlete, being intentional about training, exercise, self-care, and injury prevention and recovery. Even without access to a vocal dosimeter, actors can benefit from creating and adhering to a plan for managing vocal demands at any stage of a career, and successfully avoid a "vocal overdose."

KEYWORDS

Vocal health; vocal dosimetry; vocal fatigue; semi-occluded vocal tract exercises

Introduction: the challenge of maintaining a healthy acting voice

All professional actors and actors in training must at some point face the reality that their vocal demands present a potential occupational hazard (Lerner et al. 2013). While these demands vary widely across individuals and across the phases of an acting career, understanding these demands and developing effective coping strategies are crucial for all actors. Actors represent a subgroup of what are referred to in the clinical voice literature as occupational voice users. While teachers have traditionally represented the subgroup most likely to present with a voice disorder in a clinical setting (Titze, Lemke, and Montequin 1997), there is sufficient informal observation in the acting community and published evidence to support the notion that actors often face unique vocal challenges (Ferrone, Galgano, and Ramig 2011; Roy, Ryker, and Bless 2000) that can result in frequent or chronic vocal

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complaints, or lead to significant vocal injury (D'haeseleer et al., 2017; Donahue et al. 2014; Kitch and Oates 1994; Lerner et al. 2013; Novak et al. 1991).

Since stage actors typically perform with heightened speech and often for prolonged periods during rehearsals and performances, it stands to reason that they may often experience an abnormally high "vocal dose" (accumulated vibration of the vocal folds that causes mechanical strain on the tissues). Managing vocal dose (or "vocal load" as it is sometimes called) is an important skill for all professional voice users to learn. Voices are capable of prolonged periods of heightened or athletic use, but the vocal folds do require rest and recovery time to repair damage and reduce inflammation at the cellular level. Along with basic voice care or vocal hygiene routines (e.g. drinking enough fluids, warming up and cooling down the voice, and avoiding potential sources of laryngeal irritation such as smoke, allergies, and reflux), learning how to manage periods of vocal work with vocal rest can be vital for a healthy and long career.

There is anecdotal evidence that actors tend to be less knowledgeable or proactive about maintaining vocal health through adherence to common vocal hygiene practices (maintaining adequate hydration, avoidance of tobacco products and other laryngeal irritants, moderation in alcohol use, etc.) than singers. There is also some published evidence of a potential lack of understanding of and adherence to vocal health practices among both acting students and professional actors (Donahue et al. 2014; Zeine and Waltar 2002). While most acting or singing students can easily recite the common "do's and don't's" of vocal hygiene, common experience and at least one published study with student singers (Broaddus-Lawrence et al. 2000), suggests that even focused education and training in vocal hygiene often make little measureable difference in changing day-to-day behavior. Furthermore, there is some evidence that vocal hygiene alone is inadequate for preventing or eliminating voice problems among teachers, and that actively reducing the load on the vocal mechanism is a more effective approach (Roy et al. 2002). Speech-language pathologists specializing in treating voice disorders always include some instruction in vocal hygiene with patients, but clinical practice patterns with this population lean heavily toward direct and active behavioral change by means of vocal exercises or voice retraining, along with thoughtful management of vocal demands.

There is a growing body of clinical and research evidence that careful application of low-impact vocal exercise (with techniques such as lip trills or phonation through a straw) can help improve vocal economy and reduce fatigue (Titze 2006), and perhaps even reduce vocal fold inflammation, which is the first stage of development of vocal fold tissue injury (Abbott et al. 2012). In the latter case, Abbott and colleagues reported that targeted vocal exercise could have a similar effect to the use of corticosteroids in reducing the presence of the biological markers of tissue inflammation. Resonant voice therapy, a long-established and evidence-based method of voice therapy, is in all voice therapists' clinical repertoire in some form, and has been shown to reduce vocal fold tissue impact stress and can prevent and even reverse phonotraumatic vocal fold injury such as vocal nodules (Verdolini et al. 1998).

Quantifying vocal demands

Voice research in the last couple of decades has focused heavily on the notion of quantifying the mechanical stresses on the vocal folds and using that knowledge to guide vocal injury prevention and rehabilitation efforts (Berry et al. 2001; Jiang and Titze 1994). These basic

science investigations, while somewhat limited in their direct transfer to clinical voice care, tend to be in harmony with the basic tenets of resonant voice therapy, which has as its primary target the best voice with the least effort by means of barely adducted vocal folds (Verdolini et al. 1998). Berry et al. (2001) defined the notion of an output-cost ratio for phonation (an attempt to quantify the "best voice, least effort" concept), and found that fold vocal fold stresses are minimized and acoustic output is maximized for vocal folds that are indeed barely adducted (compressed together at midline). While these data came from excised canine larynges and caution must be taken in translating these findings directly to the human larynx, some newer research (Gunter et al. 2005) directly measuring vocal fold collision forces in human participants appears to corroborate data from previous studies (Berry et al. 2001; Jiang and Titze, 1994). The authors of these studies also extrapolate to some potential practical advice for reducing mechanical stress on the vocal folds, given that vocal fold shearing and collision forces tend to be highest for not only tighter adduction (the origin of a pressed or tense voice), but for louder and higher voice as well. The duration and frequency of any voice use is also an obvious factor in determining the potential for detrimental consequences. The commonly accepted definition of the term "phonotrauma" (which has replaced the term "vocal abuse" for most voice clinicians) is voice use that is "too much, too loud, and too often." Quantifying the net vocal fold tissue stress incurred by any individual over a particular time interval, given the numerous biological and phonatory behavior variables, has been an essentially impossible task until fairly recently, with the advent of devices that can measure phonation behaviors directly and in real time. These devices, referred to as vocal dosimeters, have allowed clinicians and researchers an unprecedented look at the accumulated cycles of vocal fold vibration, and have helped to begin clarifying the relationship between voice use and its potential negative consequences.

Vocal dosimetry as a tool

Vocal dosimetry is a relatively new voice analysis method that has been used primarily in research and clinical practice to measure voice use in natural settings (Cheyne et al. 2003; Hillman et al. 2006; Mehta et al. 2012; Ohlsson, Brink, and Lofqvist 1989; Švec, Popolo, and Titze 2003; Szabo et al. 2001; Titze, Švec, and Popolo 2003). Most of the research data have been collected regarding the voice usage patterns (or "vocal dose") of school teachers (Halpern et al. 2009; Hunter 2012; Titze and Hunter 2015), who tend to be the profession most often seeking help for voice disorders related to overuse of the voice (Titze, Lemke, and Montequin 1997). Professional singers and singers in training have also been studied (Carroll et al. 2006; Gaskill, Cowgill, and Many 2013; Gaskill, Cowgill, and Tinter 2013), given the known risks created by the heavy vocal demands of singing training and performance. While theatre actors are known to face heavy and unique vocal demands which can cause vocal fatigue and potential injury (Ferrone, Galgano, and Ramig 2011; Kitch and Oates 1994; Novak et al. 1991), little is known about their vocal dose patterns as compared to other professional voice users. While there exists both a clinical and work force impetus to quantify and regulate standards for protecting the vocal health of professional voice users, no universal standards exist at the present time (Titze 1999). For actors, there are currently no published data regarding typical voice use patterns as measured via vocal dosimetry, although vocal habits and typical vocal complaints and voice disorders have been previously described in this population (Donahue et al. 2014; Kitch and Oates 1994; Lerner et al. 2013;

Novak et al. 1991; Zeine and Waltar 2012). Actors have unique performing voice parameters and challenges, especially regarding prolonged voice use at increased loudness and pitch levels. Depending on the role or genre, actors may also face unique demands placed on their speaking voices to create character voices, perform with extremes of emotion, or to create unique vocal effects. Environmental factors can vary widely and create unique vocal challenges (stage combat, stage screams, stage noise, variable performance space acoustics, outdoor performances, presence or absence of body microphones, etc.).

Vocal dosimetry is a tool for making direct, real-time measurements of voice use during any natural activity. Vocal dosimeters are small computerized devices worn on the body and have a sensor attached to the skin directly below the larynx. The dosimeter measures the duration, frequency (pitch), and intensity (loudness) of all voiced sounds made for as long as the device as worn. Most dosimeters are able to collect a full day's worth of data (up to 10–12 h), and are often worn for several days in a row to capture a full picture of voice use patterns, during both professional and personal activities. Once the data are downloaded into accompanying software, calculations of different defined vocal doses are possible.

Vocal dose definitions

The vocal doses that have been of primary interest in the research and clinical literature thus far are time dose, cycle dose, and distance dose (Švec, Popolo, and Titze 2003; Titze, Švec, and Popolo 2003). The time or duration dose can be expressed as either a total accumulated voice time (all of the moments of vocal fold vibration summed together for the analysis period) or a percent phonation time (the percentage of time during the analysis period during which the vocal folds were vibrating). Cycle dose is calculated from the total voice duration and the mean fundamental frequency of vibration of the vocal folds for the analysis period. For example, if the total accumulated voicing duration was 2 h (7200 s) and the mean fundamental frequency during voicing was 220 cycles per second (typical adult female fundamental frequency for speaking voice), then the accumulated cycle dose is estimated as 1,584,000 cycles (7200 s × 220 cycles per second). That means that the vocal folds vibrated back and forth over 1.58 million times for those 2 h of accumulated phonation. Distance dose is also an estimated calculation that uses duration and frequency data, but also the mean intensity (loudness) of voice during the analysis period. We know that louder voice requires a larger excursion of the vocal fold tissue during each cycle. Based on estimates of typical vocal fold tissue excursion distances for different levels of loudness, the cycle dose (number of vocal "trips") can be multiplied by the typical distance (amplitude) taken during each trip (opening and closing of the vocal fold tissue). For example, for the above cycle analysis period, if the mean distance traveled by the tissue was 2 mm, then the distance dose would be 3168 km. So, it is not unheard of for heavy voice users to have vocal fold tissues that run the equivalent of a 5K race! Distance dose is believed to be a particularly important measurement for analyzing voice use and risk of vocal injury, since both the collision forces (hitting of the vocal folds at midline) and shearing forces (horizontal deformation of the tissue as it travels back and forth) are much greater for loud phonation.

Ttize and Hunter (2015) review and expand on the concept of vocal dose measurement, introducing the concept of an energy dissipation dose, which is also an estimated quantity that can either include or exclude the effect of vocal fold collision forces. This dose is more conceptual and rather impractical with current measurement devices and the degree

of estimation involved, but it can account for the energy that is dissipated into the tissue due to frictional forces as the vocal fold tissues move rapidly in their phonatory pathway, and the collision forces between the two vibrating vocal folds (for modes of phonation where there is full contact between the vocal folds). While impractical in some ways, the authors contend that this is potentially the most meaningful vocal dose as far as predicting vocal fold tissue fatigue or injury. Combined with the previous findings regarding how the degree of adduction, loudness, and pitch influence the output-cost ratio (Berry et al. 2001), Ttize and Hunter (2015) introduce the idea of making intentional trade-offs between degree of adduction (the continuum of breathy to pressed phonation), loudness, pitch, and phonation duration.

Ttize and Hunter (2015) present data from dosimetry with schoolteachers in terms of an equal-energy-dissipation dose (EED) as a means of managing the risk of vocal fold injury. For example, someone speaking at an average fundamental frequency of 230 Hz (typical female speaking pitch) without vocal fold collision (using a barely adducted configuration and presumably a more efficient, resonant voice) could speak for 4 h at 90 dB, 8 h at 80 dB, or 20 h at 70 dB with equivalent energy dissipation (which can be read here as accumulated vocal tissue stress). If collision of the vocal folds is accounted for (using a more pressed voice), then the above phonation times at these three loudness levels reduce to 1 h, 2.5 h, and 6 h, respectively (Ttize and Hunter (2015), 1434). Applying this concept of trading off voice quality (pressed vs. resonant voice), loudness and duration could be very enlightening for actors and other professional voice users needing to create and stick to a "vocal budget" in the pursuit of voice conservation both for the short term (planning how to get through a week of technical rehearsals) and for the long term (training the voice for efficient vocal technique, choosing roles, and establishing lifelong healthy habits for social voice use).

Vocal dosimetry concepts as a guiding principle in voice conservation

As of now, most vocal dosimeters are being used by voice scientists and speech-language pathologists for research or monitoring of voice therapy patients. However, new technologies are being developed to make vocal dosimetry much more accessible. A smartphone version of the first commercial vocal dosimeter is in development (Mehta et al. 2012), so more and more professional voice users will have potential access to this type of vocal monitoring. The concept of wearable technologies for monitoring health states and physical performance is now familiar to most people, given the availability of smartphone applications and wrist monitors that can track sleep patterns, vital signs, and steps taken for fitness goals. Even if theatre actors and pedagogues do not have access to this technology, more and more university-based speech-language pathologists and voice scientists are using this technology on campuses across the country. Partnering with these individuals could be a valuable learning experience. One study has been published examining the vocal dose of graduate opera majors and how this information was incorporated into their vocal pedagogy course to help them learn how to manage their own vocal dose and encourage future students to do so as well (Gaskill, Cowgill, and Tinter 2013).

Even without access to this type of vocal monitoring technology, actors, acting students, and acting teachers can apply some of the concepts and knowledge from the vocal dosimetry and vocal health research to both the daily and career-long challenges of caring for the acting voice. First, we will describe the range of acting voice demands that are often encountered and place them in a potential hierarchy of vocal dose demands, in light of

the voicing parameter trade-offs discussed above. Then, we will describe the experiences of three typical individuals in the acting community: an undergraduate musical theatre major, a graduate acting student, and a professor of acting. These descriptions are somewhat hypothetical but based on real observations of the second author, who is a trained actor and teaches acting and voice at a large public university. Taking a closer look at acting vocal demands, both in terms of vocal dose (or to use another analogy, "vocal cost"), and also in terms of the typical "day-in-the-life" physical and vocal demands of actors, can be helpful in making informed choices that insure both short-term and long-term vocal health. Finally, we will return to some of the voice science research regarding mechanisms of monitoring and recovering from vocal fatigue. There are simple tools and techniques available to all professional voice users that can be implemented in order to lower the risk of both chronic vocal complaints and acute vocal injury.

Managing vocal output cost for the actor

Since vocal fold tissue stress is directly related to both the amount and type of vibration the vocal folds are exposed to, we can use the information discussed above about the trade-offs between duration, loudness, relative pitch, and degree of adduction to at least estimate the severity of the vocal demands required by different types of acting voice use. For example, we could consider two extremes on the continuum of acting voice demands: brief, intermittent, soft-spoken dialogue vs. a prolonged monologue at the level of a shout. The soft-spoken dialogue is of low duration, and pitch and loudness levels are at or below typical speech, while adduction is likely to be reduced for softer, breathier phonation. The loud monologue could be considered the polar opposite, given the increased duration and loudness, along with higher-than-normal pitch and most likely a much more pressed form of phonation. Even without being able to quantify how long each of these behaviors could be maintained before incurring an unwanted "vocal cost," it is clear that the latter form of voice use would have to be offset with better vocal preparation and warm-up/cool-down practices, more intentional vocal rest before and after shows, and impeccable use of vocal technique (e.g. the vocal cost could be reduced by employing use of resonance and forward placement instead of a tight, pressed voice in order to achieve the requisite vocal power). This same thoughtful analysis of different types of acting voice use could be applied to any performance scenario along the vocal demand continuum, considering each of the overall vocal dose contributions: phonation duration, loudness, pitch, and vocal fold adduction. In doing so, an actor or acting teacher could perhaps make proactive adjustments when needed (or possible, given the artistic demands of the material) in order to maximize vocal longevity for the purposes of getting through initial and technical rehearsals, and the entire run of a show. For a long-running engagement, it stands to reason that even a modest adjustment in execution (e.g. reducing vocal loudness slightly in all or part of a demanding monologue) over the time spent in the role could add up as "deposits" instead of "withdrawals" in the overall "vocal budget," to continue the financial metaphor for accumulated vocal dose.

Managing vocal dose and maintaining vocal health: three different actor scenarios

Next, we will consider the unique programmatic and environmental challenges faced by three actors in different phases of a stage career. As mentioned above, these descriptions are drawn from personal experience and observations of the second author who has taught acting and voice for 11 years at both the undergraduate and graduate level, and still performs roles on a regular basis.

The setting is a vibrant theater program at a large public university that produces eight shows in the academic school year (two musicals and six plays). There are other performances that include student projects, showcases, and a small-scale summer musical that happens off campus. Degrees offered are a BA in Theatre and students may also audition for the Musical Theatre track. There are currently 150 majors and 10 graduate actors in the MFA program with a concentration in acting. The program offers rigorous training and getting cast to perform in productions is competitive. Rehearsals are typically four hours in length, six days a week, followed by a run of six or seven shows depending on the project.

The undergraduate musical theatre student

First, we consider a typical busy day for an undergraduate musical theatre student who is often cast in plays and musicals. A heavy voice use day often consists of the following: two fifty-minute acting classes, one thirty-minute voice lesson for singing, performance of one song in the departmental convocation for the musical theatre department for feedback and criticism, then after a short dinner break, the student will head into a four-hour rehearsal. This is the most demanding day the student has vocally each week, and fortunately this student does have a healthy voice mindset. He stays hydrated and does not smoke. He does drink beverages containing caffeine and alcohol to some degree, but is aware of how excessive consumption can negatively affect the hydration and vibratory function of vocal fold tissues. The student does deal with seasonal allergies and his upper respiratory system is sensitive to shifts in the weather. In order to manage these environmental vocal irritants, he works to find an appropriate minimum dose of his allergy medication to avoid its drying effects on the vocal tract and vocal folds. The student does steam inhalation regularly for vocal and throat irritation, and tries to stay rested, eat a healthy diet, and maintain overall adequate systemic hydration. This student is quite professional for his age, as well as a dynamic performer. In spite of the vocal demands and typical undergraduate social and lifestyle demands he faces, he has managed to maintain a healthy voice and avoid any major vocal issues.

It is worth noting here that, as many have seen or experienced, this student is probably not typical. Whether or not they ultimately experience a serious vocal injury, many student actors do not adhere to patterns of self-care and vocal hygiene that promote overall vocal wellness and reduce their risk of voice problems. Donahue et al. (2014) present rather eye-opening data from 188 freshman musical theatre majors collected over a 10-year period at a major music conservatory. Over half of the respondents to their survey reported currently experiencing a negative vocal symptom, and most had a least one vocal risk factor or area of poor vocal hygiene which could potentially lead to a more serious voice problem. While almost all the students reported regular use of some form of voice warm-up, most

did not perform any cool-down routine following heavy voice use. While not heavily studied, the authors point to emerging evidence of the benefits of vocal cool-down techniques for improving vocal function and reducing the perception of vocal fold effort. The authors conclude that this population was at particular risk for significant vocal injury as a group, and that increased effort for training students how to care for their voices early in their performing careers was warranted.

In another study comparing a group of professional actors, amateur actors, and acting students, general vocal hygiene knowledge was lowest among the students (Zeine and Waltar 2002). Even though, as mentioned previously here, there is clinical and anecdotal evidence to support the need for voice care beyond vocal hygiene alone, physicians and clinicians who manage voice disorders operate from a body of evidence that supports maintaining the health of the vocal fold cover. Basic voice care should be considered an essential prerequisite for maintaining vocal health and preventing voice problems. The goal of this paper is to point out the vital "next step" in this process, which is a thoughtful and proactive approach to vocal dose management. This process must indeed occur in the context of a sound and well-implemented vocal hygiene routine.

The professional graduate student actor

Next, we consider another acting student, but with a much different set of experiences and current vocal demands. Consider a day in the life of one of a graduate student in the same theatre department. Unlike the undergraduate student in his twenties, he is 50 years old, with years of professional experience, and has returned to school for a graduate degree. This student also happens to be a compelling singer and actor and is often cast in two major productions a semester. Graduate actors in this program receive actor training and also have the opportunity to teach during the three years of study for the MFA degree. On a vocally demanding day, he will have three performance classes that require moderate vocal use, and also teach one class that meets twice-a-week for an hour and fifteen minutes. He also has a history of being cast in vocally demanding roles in plays and substantial singing roles in musicals. He faces some unique additional pressures given his stage of life compared to most traditional students. The financial burden of being a student again, finding time to focus on his commuter marriage, assisting his aging parents, on top of maintaining his health and well-being while in graduate school have been taxing on him. When his schedule is hectic he admittedly does not take care of his voice as he knows he should. This performer has had years of vocal training and is aware of the benefits of proper vocal hygiene; however, the demands of his graduate work result in stress which is often manifested in his voice. In his favor, his experience and level of training help him maintain sufficient body-mind awareness to create balance in his demanding work an actor. He is also gifted with a naturally commanding and effective acting voice, so he does not need to rely solely on his vocal technique as an actor. He represents a class of actors with a unique blend of robustness from both natural gifts and a refined craft, and vulnerability due to an unusually high vocal demand in the context of numerous other personal challenges.

The discussion of this graduate student's vocal demands brings up another important issue that should be considered when implementing vocal hygiene and vocal dose management plans: the changes of the human voice associated with aging. This is a much-studied phenomenon and is relevant to the performer and non-performer alike. While more

pronounced in the general population over the age of 65, there are fairly predictable changes in the voices of both men and women that begin to occur as early as age 30, and include changes in muscle structure and function, elasticity and hydration of the vocal fold cover, and mobility of the laryngeal cartilages (Ramig et al. 2001). All of these changes can affect vocal performance (pitch and loudness control, vocal stamina, vocal agility, etc.), especially under high-demand conditions. Individuals vary widely in the onset, severity, and functional handicap of vocal aging, but all professional voice users would benefit from awareness of these potential changes. Fortunately, emerging clinical voice research strongly suggests that the detrimental effects of many of these age-related voice changes can be offset with targeted vocal exercise (Ziegler et al. 2014).

The acting pedagogue and performer

The final day-in-the-life profile comes from the personal experience of the second author.

I (Prof. Hetzel) am an Associate Professor of Voice and Acting and have been in my current position at a major university since 2006, teaching acting, voice, and speech classes at both the undergraduate and graduate level. I hold an MFA in Voice and Acting Pedagogy and have experience both as an actor and workshop leader throughout the U.S. and abroad. I am also an Associate Teacher of Fitzmaurice Voicework and an active member of VASTA. Now in my forties, I am very aware of the need for mindful adherence to vocal hygiene (especially adequate hydration) and to carefully manage vocal "deposits" and "withdrawals" on a daily basis. A typical day in the academic year is full of meetings, teaching classes, vocal coaching, rehearsals, as well as speaking to students and colleagues in addition to other scheduled commitments. If my day begins with a faculty meeting I work to only speak as needed and sip water to I can stay consistent with my hydration efforts. If I have a break between my meeting and first class I use that time to check in with my voice with some simple humming and pitch glide exercises (employing the low impact, resonant voice concept) as well as connecting to my breathing with Fitzmaurice Voicework. This allows my breath to drop in to release tension and I find and feel a full rib-swing on my inhale. This allows me to achieve proper breath management by using abdominal support, which is a key element for a healthy day of voice use, especially when I must address a class or have rehearsal. When I am connected to my breath I can support my voice easily and minimize fatigue on a typical day with a variety of vocal demands.

I have firsthand experience with the potentially detrimental effects of heavy vocal dose along with an overall physically and mentally demanding schedule. In the three shows that I have done over the past 10 years during the busy and demanding school year, I have had some form of vocal difficulty to overcome. However, the performing projects that I have undertaken over the summer terms have been free of any vocal obstacles, since they did not also require the long days of voice use in teaching classes, meetings, and student advising sessions. Vocal hygiene and maintaining upper respiratory health has been challenging since moving to Alabama 11 years ago, when I developed seasonal allergies and frequent sinusitis. During each of the academic-year shows in which I performed, I developed an upper respiratory infection requiring medication (steroids and antibiotics). Each time, I visited a trusted otolaryngologist to help me recover quickly and prevent vocal damage. For the first show, I had sinusitis and developed vocal fatigue, but was able to perform without losing my voice. The second show was a near disaster; I ultimately developed viral laryngitis and

was only able to perform in two of the seven performances (opening and closing nights). The role was demanding to begin with, involving an abnormally high vocal dose including scenes requiring shouting and crying. In the run up to opening night, I could tell my voice was suffering, and in spite of judicious use of voice rest and gentle vocal warm-ups, my upper register disappeared. After opening night, I experienced complete voice loss. After I received the diagnosis, I was forced to rest my voice and gently ease back into voice use as the severe swelling abated. This was a frightening but valuable lesson as a performer and an acting teacher. The third and most recent event had a much more positive outcome. I developed an ear infection and the onset of vocal strain and mild hoarseness in preparing for a very vocally demanding show. The role required shouting, a stage fight, and long emotionally charged monologues at extremes of pitch, loudness, and pressed phonation. I was able to be much more proactive this time with my use of technique, warm-ups and a pre-emptive strike of medications from my otolaryngologist.

These firsthand experiences can provide an empathetic perspective for helping the young actor navigate the social and performance demands of a university student. Many of these students see themselves as rather invincible, and often push themselves vocally in and out of rehearsals. Late nights with heavy social voice use in loud environments (often involving alcohol and either first- or secondhand smoke) are all too commonplace. Students are often not self-aware when it comes to their own level of vocal dose. An anecdote is reported by Gaskill, Cowgill, and Many (2013) in which a freshman musical theatre major participating in a week of daily vocal dosimetry mistakenly thought that his vocal dose during a long rehearsal was likely to be very high. In fact, his vocal dose in the hour of social time following the rehearsal was much higher in terms of accumulated phonation duration and loudness. It is likely that this misperception of vocal demands is frequent among young college-age vocal performers. Even when a star student loses their voice, they may seem unconcerned, and usually the voice does return. By incorporating evidence-based information about the risks of vocal overdose in terms of basic hygiene, vocal dose management, and fatigue prevention and recovery (to be discussed in the next section), acting pedagogues can provide at least some insurance for actors-in-training against chronic vocal fatigue or even career-ending vocal injury.

Managing vocal fatigue

Even if vocal hygiene is impeccable, and an actor is able to proactively manage their individual vocal dose by evaluating and modifying vocal demands in terms of overall impact on the vocal tissue, bouts of acute vocal fatigue are inevitable for the performer. While it is generally accepted that severe and chronic vocal fatigue should be avoided and is a warning sign for potential vocal damage, both laryngeal muscle and vocal fold tissue fatigue are a natural consequence for the professional voice user (see Welham and Maclagan 2003 for a discussion of vocal fatigue). Fatigue frequency and severity can likely be reduced via the use of healthy technique, vocal hygiene, and vocal warm-up/cool-down, but what can an actor do to evaluate fatigue levels subjectively and/or objectively for managing vocal risk? And what are some ways to promote effective and rapid recovery from fatigue? We will now address these two questions.

The vocal fatigue index (VFI) and swelling tests

A relatively new clinical voice instrument, the Vocal Fatigue Index, has been published and has proven to be a valid and reliable measure of the various aspects of vocal fatigue (Nanjundeswaran et al. 2015). The VFI is a simple survey with statements about vocal fatigue symptoms (in the categories of vocal tiredness, laryngeal pain or discomfort, and ease of recovery) that are rated on a 5-point scale from "never" to "always." This would be a useful and very simple means for actors, acting students, and their teachers to monitor and dialogue about vocal fatigue symptoms. It would be enlightening to have new students complete the VFI and have them retake the survey at crucial points during their training, and especially if vocal complaints emerge. Patterns could emerge if these data are interpreted in the context of level of training, severity of current vocal demands, and adherence to voice care and vocal dose management plans. Of particular interest and relevance to the performer trying to avoid vocal injury would be the VFI questions regarding ease of recovery from vocal fatigue. Clearly, in times of heavy voice use some degree of fatigue (even to subjectively extreme levels) can be expected, but if these times of fatigue are followed by a consistent and timely return to levels of vocal comfort and baseline function, then it is likely that the overall vocal risk is minimal.

Vocal performers should adopt the mindset of a "vocal athlete", which is a common term applied to the elite professional voice user. Just like an elite athlete experiences inevitable fatigue, their risk of injury is managed by careful application of proper technique, targeted exercise (e.g. strength or endurance training), rigorous self-care, watchfulness for warning signs of potential injury, rest, and post-workout or post-game routines that aid in rapid recovery. All of these concepts have direct analogues for the vocal performer. The VFI can aid in the "watchfulness" domain, along with another more direct technique, which is monitoring for the inability to produce soft voice (IPSV). This has been studied almost exclusively with singers and teachers (Carroll et al. 2006; Halpern et al. 2009) but the concept and technique are applicable for the monitoring of vocal fold tissue fatigue for any heavy voice user. The technique is simple to use; someone wanting to monitor vocal fold tissue changes related to vocal fatigue would check themselves periodically for the ease of producing very soft voice at high pitches. This is usually accomplished through producing short, staccato syllables ("hee hee hee"), gliding up in pitch on a vowel, and singing a familiar song (e.g. "Happy Birthday"). If this procedure is done consistently, the vocalist will develop a keen sense of his or her own ease of phonation for high, soft voice and be able to monitor how it varies in correlation with voice use. That way, when there is a sudden loss of the ability to produce high, soft voice, it can serve as a signal that vocal fold tissue fatigue is present and that voice use should be curtailed or even cease to allow for recovery. The underlying physiology of this technique is that there is a minimum amount of pressure (phonation threshold pressure or PTP) required to set the vocal folds in motion for voicing, and changes in PTP are most obvious at high, soft voice where only the outermost layer of vocal fold tissue is vibrating. A sudden loss of easy phonation at this combination of pitch and loudness is thought to indicate the onset of vocal fold swelling and a subsequent increase in PTP. In fact, these IPSV tasks are often referred to as vocal fold swelling tests (Bastian, Keidar, and Verdolini-Marston 1990). Clinical voice research suggests that vocal fold swelling is the first (and easily reversible) stage of developing and actual vocal fold would or injury to the tissue (Abbott et al. 2012; Hunter and Titze 2009). Clearly, a primary goal of professional

voice care is preventing, or at least consistently recovering from, vocal fold inflammation following periods of heavy voice use.

Vocal fatigue recovery

A brief discussion of what is currently understood about the typical trajectory of vocal fold tissue fatigue onset and recovery is in order here. There are accounts in the clinical voice science literature regarding the measured effects of what is often referred to as vocal loading (usually an imposed task of prolonged, loud reading) (Chang and Karnell 2004; Gelfer, Andrews, and Schmidt 1991). Significant vocal changes have usually been measured after vocal loading in terms of perceived symptoms of vocal fatigue and increased vocal effort, along with perceptual measurement of vocal quality and acoustic analysis of voice recordings pre- and post-vocal loading. More recently, Hunter and Titze (2009) sought to further quantify the typical pattern of vocal fold response to a large vocal dose, and refine our understanding of symptom onset, progression, and resolution. Hunter and Titze (2009) have coined the phrase "vocal recovery trajectory" in their study where they tracked 86 adult participants for two days following a vocal loading task of reading in a loud voice for 2 h. Their data for these participants recovering from the effects of an intense and concentrated vocal dose indicate that 90% of the recovery (i.e. a return to baseline vocal function) occurred within 4–6 h and full vocal recovery was complete within 12–18 h. They mention that their data are in line with other medical data for wound healing. Even having this bit of information regarding how vocal folds respond to and recover from a heavy vocal dose could be very helpful for an actor navigating the demands of training and/or performance schedules. Most successful performers have likely determined their own typical recovery trajectory empirically and work within it in order to remain vocally healthy.

Promoting recovery with low-impact vocal exercise

Regarding the athletic concept of preparation and post-workout or post-game routines, actors and other professional voice users are already familiar with the vocal warm-up, but the vocal cool-down (the post-game procedure) is less commonly used. It is believed that "cooling down" the voice can both relax muscles and reduce the severity of sensations of vocal tiredness or throat pain, as well as aid in reducing or perhaps even preventing the latent onset of vocal fold swelling following heavy voice use. Many singers and voice clinicians can attest to this effect anecdotally (including personal experience of the first author), and there is at least some emerging evidence of the effects of low-impact vocal exercise to reduce vocal fold inflammation following a vocal loading task (Abbott et al. 2012). Using the already well-established techniques from resonant voice therapy (Verdolini et al. 1998), the authors have presented preliminary data that gentle vocal exercise with a barely-adducted vocal fold configuration as studied previously (with pitch glides and a forward-focused, resonant voice—which can be achieved through humming, lip trills, straw phonation, etc.) has a similar anti-inflammatory effect as the application of corticosteroids. While these data are considered preliminary, they are quite compelling and seem to line up well with the common experience of voice patients and vocal performers, as well as with the medical literature that has begun to favor carefully applied exercises instead of rest for post-surgical recovery and wound-healing (Abbott et al. 2012). The basic science research regarding vocal fold tissue

injury and mechanisms of recovery are ongoing, but these data represent an encouraging trend in modern voice care that is directly applicable to the elite vocal performer.

As mentioned previously, both vocal performers and clinicians have increasingly employed techniques such as lip trills and straw phonation for voice training and rehabilitation. These fall under the umbrella of semi-occluded vocal tract (SOVT) exercises, which have received much attention in both voice science literature and vocal pedagogy literature (see Titze 2006 for a basic scientific rationale and review). While seemingly novel, they have a long history in voice training and rehabilitation in parts of Europe, and are actually right in line with the concepts already mentioned here of promoting resonant voice that maximizes vocal output while minimizing vocal fold tissue stress (Berry et al. 2001; Verdolini et al. 1998). In fact, much of the current practice of resonant voice therapy and SOVT bears a strong resemblance to and owes a great deal of thanks to the work of the legendary voice practitioner Arthur Lessac. His technique of the "y-buzz" (Lessac 1997) and training "the call" technique for efficient vocal projection heavily influenced the development of resonant voice therapy (Verdolini et al. 1998). Verdolini has codified her particular voice training technique and has named it Leassc-Madsen Resonant Voice Therapy (LMRVT), after Lessac and another clinician who inspired certain aspects of the technique (Abbott 2008). Resonant voice then, has both a performance implication for producing an efficient performing voice, and a vocal health implication, for preventing and recovering from vocal fold tissue fatigue.

Conclusion: adopting a vocal athlete's mindset

Actors, like all professional voice users, must see themselves as vocal athletes. The concept of managing vocal dose, even without access to this emerging technology, can be a valuable addition to the overall voice care and injury prevention plan. All acting students and professional actors can learn to apply the athlete analogy to voice care: proper training for the sport (vocal technique), basic physical training (vocal exercises), physical warm-ups and cool-downs (low-impact vocal techniques such as SOVT exercises and other resonant voice techniques), strategic scheduling of work-outs and games (managing rehearsal and performance demands), minimizing body strain and monitoring for fatigue (finding trade-offs of pitch, loudness, vocal adduction, and using tools like the VFI or IPSV tasks), and self-care and recovery (vocal hygiene and scheduled vocal rest). All actors will experience vocal challenges at some point in their training or professional career. It would appear that the preparation for and the response to these challenges are what make the difference between successful and unsuccessful outcomes. Also in keeping with the mindset of a vocal athlete, actors would do well to remember that fatigue is indeed part of the game. No one would expect an elite athlete to never feel tired or have any unpleasant physical symptoms associated with training or playing a sport at a professional level. Athletes do get injured sometimes, but the majority do not. Most have sufficient training and support to develop the physical and mental skills needed to sustain a career and maintain their physical health and remain injury-free. If an injury does occur, there is an established process to evaluate, treat, and recover from the injury. Professional voice users need to have this same mindset.

Finally, with all this discussion of vocal vulnerability, it is healthy and important to remember that the human larynx and vocal folds are well-suited to take on both the normal daily doses of vibrational strain, but also the strain from athletic vocal use. Broadway singers and actors survive their 8 shows a week, sometimes month after month or year after year,

and most remain vocally healthy. They have learned how to both apply their vocal craft and also to "stay in the game" with an athlete's single-minded focus on optimum performance and minimizing the potential for injury. Ferrone, Galgano, and Ramig (2011) provide some clear evidence that even what most experts would consider potentially harmful levels of vocal dose can be managed successfully. In their investigation of actors in the La MaMa Experimental Theater Club, the authors fully expected to find evidence of vocal problems among this group, but failed to do so. While it is unclear what it is exactly that allows these actors to perform in the way that they do and remain vocally healthy, the role of proper technique and voice care in the context of frequent and extreme vocal doses cannot be underestimated. This should help actors arrive at a livable balance between a feeling of vulnerability and invincibility; the vocal instrument is both delicate and mighty. With proper training and proactive care, even the most demanding vocal career can be managed with an athlete's determination and focus.

Disclosure statement

No potential conflict of interest was reported by the authors.

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