The Vocal Athlete

Second Edition

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Contents

Foreword

In my first publication on voice, I noted that "singing is an athletic activity and requires good conditioning and coordinated interaction of numerous physical functions" (Sataloff, 1981). At that time, care of voice patients and training of voice students was not particularly scientific or sophisticated. That changed rapidly, and a decade later it was clear that "improvements were made possible by interdisciplinary collaborations among professionals, who, at first, barely spoke the same language" (Sataloff, 1992). When the concept of a "singing voice specialist" was introduced (Carroll & Sataloff, 1981), it was not only novel but also somewhat controversial. By 2014, when Plural Publishing produced the first edition of *The Vocal Athlete* by Wendy LeBorgne and Marci Rosenberg, substantial advances in knowledge and interdisciplinary teamwork had revolutionized the state-of-the-art in laryngology, speech-language pathology, and voice teaching. Their classic book was directed toward singing teachers of all genres; and it synthesized in accessible language core knowledge in anatomy and physiology, vocal health and fitness, voice pedagogy, and practical voice research.

The second edition of *The Vocal Athlete* is updated and expanded including two new chapters on vocal pathology and registration. It is admirably successful in filling a gap in traditional academic voice pedagogy. *The Vocal Athlete, Second Edition* is grounded in solid science and practical experience. It will be an invaluable addition to the libraries of all singing teachers, speech-language pathologists who work with voice patients, singing voice specialists, and acting voice specialists; and its information is equally valuable for laryngology fellows and laryngologists. Like the first edition, the second edition will become a classic.

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Preface

Meeting Industry Demands of the Twenty-first Century Vocal Athlete

Through our years of professional singing training and performance (resulting in an evolution to become voice pathologists and singing voice specialists), we have encountered a transition in the industry demands and injuries of the twenty-first century vocal athlete. Today's commercial music industry demands versatility of vocal athletes, who are now expected to be skilled in multiple styles of singing. Not only are these singers asked to perform vocal gymnastics on an eight-show per week schedule, these vocal athletes must also possess excellent acting skills and strong dancing ability to be competitive. These demands on the voice, body, and psyche necessitate a physically, vocally, and mentally fit singer who is agile and adaptable.

In a time when major opera companies are closing their doors, the commercial music industry boasts millions of viewers on a weekly basis through mainstream media outlets (e.g., *The Voice*, *American Idol*, *X-Factor*). According to Playbill.com, Broadway shows continue to generate record ticket sales, with newer shows like *Hamilton* grossing up to $4 million per week and other hit shows, including older favorites, still grossing $2 to 3 million per week. When you consider that there are typically more than 25 shows on Broadway at any given time, in addition to another $1.4 billion spent on years of national tours, the money spent by consumers on this genre is staggering and continues to grow. In the pop music market in 2012 alone, physical albums, digital albums, and digital songs surpassed 1.65 billion units, indicating a strong public desire and potentially lucrative business for commercial music singers. Yet, there are only a very small handful of vocal pedagogy training programs for contemporary commercial music (CCM) singing in the United States. Therefore, these vocal athletes learn their craft by relying on god-given talent, they make their way by imitation, or they study with a voice teacher who may or may not have experience or training in the commercial music genre. Some of these choices may unfortunately lead to vocal problems if they cannot withstand demands of the profession. By no means do we suggest that classical voice pedagogy is not a valid and proven effective method of vocal training, as it has hundreds of years of history and successes in the classical genre. However, even though running is part of a gymnastics floor routine, it would be unlikely that an Olympic gymnast would train exclusively with a running coach when he/she is required to perform backflips on a balance beam. This has become even more relevant as newer musicals continue to push the boundaries with shows like *Hamilton* and other pop/rock musicals. With CCM vocal styles continuing to dominate and evolve, the need for teachers trained in this type of pedagogy continues to grow.

This book was developed to aid singing teachers (of all genres), voice pathologists who work with singers, and the singers themselves in their understanding of the vocal mechanism, specific care of the body and instrument, and the science behind how we learn and how we can maximize performance for longevity in a commercial music market. The second edition has been updated with numerous new references and two entirely new chapters on vocal pathology and registration, making this book a truly comprehensive source for classical and contemporary teaching. Section I introduces the Structure and Function of the Voice as it applies to vocal athletes. Chapter 1 presents the mechanics, structure, and function of the singer's body, incorporating anatomy of body framework and the integration of movement and movement strategies for active performers. The next two chapters (Chapters 2 and 3) go beyond typical anatomy and physiology of the respiratory and laryngeal mechanisms. These chapters incorporate relevant research and functional utility of breath and sound production in the commercial music performer including topics on how dancers who sing use different breathing strategies and information on vocal fold vibration patterns in high-demand voice users. Chapter 4 details the central command center (neurologic control) of the voice, from both a physical and an emotional perspective. Included in Chapter 4 is information relevant to performance anxiety in vocal athletes. Chapter 5 in Section I sets up a basic understanding of vocal acoustics and resonance, providing singers and teachers with a user-friendly chapter on these often challenging topics using relevant singing illustrations. Finally, Chapter 6 provides a wonderful overview on perception, aesthetics, and registration in the contemporary vocal athlete.

As vocal health and fitness are paramount for amateur and elite vocal athletes for long-term careers, Section II is devoted to providing a unique perspective on relevant topics for vocal athletes. Section II includes invited expert authors on the topics of: the impact of reflux on the singer (Chapter 10, Adam D. Rubin, MD, and Cristina Jackson-Menaldi, PhD); what singers need to know when undergoing anesthesia (Chapter 11, Sam A. Schechtman, MD, and Andrew Rosenberg, MD); and team members' roles on a multidisciplinary voice care team (Chapter 9, Leda Scearce, MM, MS). Chapter 7 details the how and why of phonotrauma on the vocal folds and provides insight into wound healing and injury prevention, followed by a comprehensive review of common pathologies found in vocal athletes (Robbi Kupfer, MD). The Life Cycle of the Voice (Chapter 12) provides an overview of the changes that happen to the singing voice throughout the lifespan, with specific attention to the under 40 singers who populate the commercial music scene. Chapter 13 (Medicines, Myths, and Truths) confirms and dispels many of the common old wives' tales related to vocal health and hygiene, including tradition and alternative medical therapies.

The final section of this text (Section III) includes six unique chapters. These chapters span a review of both classical and belting pedagogy (Chapters 14 and 15) and the scientific studies on the how and why of belting in elite and student performers (Chapter 16). There is no book that incorporates this information into one text. The assumption that traditional classical pedagogy can support any style of singing is inconsistent with what singing science research is now showing about physiologic differences between classical and CCM styles of singing. Chapter 17 and Chapter 18 are based on how we learn and acquire new skills, providing singing teachers (regardless of style) with invaluable information on maximizing teaching and learner outcomes. The book concludes with an invited chapter on audio technology (Chapter 19, Matthew Edwards, DMA) and the understanding and use of current technology (e.g., microphones, sound boards, monitors) by every teacher and singer who sings in a commercial style.

We would be remiss without including functional exercises to develop and train the concepts discussed in this text. Therefore, over 60 exercises, from expert teachers all over the world, to accompany and parallel the concepts presented in this textbook are included in the sister workbook: *The Vocal Athlete: Application and Technique for the Hybrid Singer, Second Edition* (Rosenberg & LeBorgne, 2021).

Whether at the professional or novice level or somewhere in between, there are limited resources for training commercial vocal styles relative to the number of singers who desire to sing them. This book aims to provide scientifically based information without usurping the art of singing pedagogy to provide twenty-first century hybrid singers with a guide toward their goal of becoming proficient and healthy CCM vocalists. This brings us back to the necessity for sound vocal instruction and technique to allow these singers to use their voices as safely as possible in order to promote vocal health in this group of singers who may already be at high risk for encountering vocal problems. This is now more important than ever, as in reality musical theater and other CCM styles will continue to raise the bar. Composers will continue to be commissioned to write shows that will make money, especially during current economic strains when there is less willingness to finance works that aren't going to ensure financial payoff. Therefore singers will continue to be asked to "defy gravity" and generate more complex vocal acrobatics in order to stay employed. Ultimately, the CCM vocal athlete and teachers are charged with the task of providing voice students with a sound pedagogical technique that will (1) serve them well in their chosen vocal style, (2) allow the singer to cross over to varied vocal styles as demanded, and (3) promote vocal longevity and health.

> hy•brid sing•er – (n). Refers to the vocal athlete who is highly skilled performing in multiple vocal styles possessing a solid vocal technique that is responsive, adaptable, and agile in order to meet demands of current and ever-evolving vocal music industry genres.

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—Wendy D. LeBorgne

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—Marci Daniels Rosenberg

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17

Exercise Physiology Principles for Training the Vocal Athlete

Introduction

As with all physical actions, voice production requires a combination of muscular strength and coordination of multiple body systems even for the most basic phonatory tasks. Consider the complex mental, physical, and vocal actions necessary for high-level singing regardless of style. Although there are physiologic differences in how these styles are produced, all genres of singing require stable, strong musculature functioning in a balanced, efficient manner for optimal output. The concept of applying the principles of motor learning and exercise physiology to voice training is not new for the speech-language pathologist specializing in rehabilitation of the voice. These concepts and principles have also been adopted by some vocal pedagogues who use a physiologic approach to voice training in their studios.

The following chapter highlights some of the key principles of how muscles work, the exercise science behind movement, and how these philosophies might be applied when training high-level singers. The subsequent chapter provides an overview of basic motor learning principles with emphasis on how the teacher/clinician/singer can maximize practice patterns, cueing, and modeling to facilitate permanent carryover of new vocal skill sets. For further reading on these topics, the reader is encouraged to explore the references provided in this chapter for books and papers on exercise science and motor learning.

Muscle Fibers and Laryngeal Function

In recent years, the understanding and development of exercise physiology as it may be applied to voice production and optimization have been integrated into voice therapy and rehabilitation protocols (Patel, Bless, & Thibeault, 2010; Sandage & Pascoe, 2010; Saxon & Schneider, 1995; Stathopoulos & Duncan, 2006; Stemple, Lee, D'Amico, & Pickup, 1994). Similarly, vocal pedagogues have begun to work to incorporate a physiologic and functional approach to artistic singing and speaking voice training in recent years. Physiological studies regarding specifically exercise physiology principles and voice provide the basis for consideration of possible modalities to improve the muscle strength of both the respiratory and the laryngeal muscles as well as detraining effects (Baker, Davenport, & Sapienza, 2005; Illi, Held, Frank, & Spengler, 2012; Sabol, Lee, & Stemple, 1995; Sapienza, 2008; Sapienza, Troche, Pitts, & Davenport, 2011; Tay, Phyland, & Oates, 2011; Wingate, Brown, Shrivastav, Davenport, & Sapienza, 2007).

A basic knowledge of what a muscle is and how it works provides the voice pedagogue and singer with the building blocks for functional understanding. There are three types of muscle in the human body: (1) smooth muscle, (2) cardiac muscle, and (3) striated muscle. Smooth muscle is regulated by the autonomic nervous system. Examples of smooth muscle structures include the uterus, stomach, and esophagus. For these structures, involuntary peristalsis (propelling contraction) is the primary pattern of muscle contraction. Cardiac muscle is a striated muscle that is also involuntary. The heart is composed of cardiac muscle. Skeletal limb muscles and muscles of the larynx are striated muscles under voluntary motor control and will be the focus of this section.

Skeletal (Limb) Muscles

We have only just begun to explore and understand how laryngeal skeletal muscles produce fuel for muscle metabolism. Newer research suggests that vocal dose and metabolism of laryngeal muscle may differ depending on person and vocal task and should be considered as part of the picture when considering causes of vocal fatigue. More research is warranted in this area to help understand potential implications for how we view and manage vocal training, detraining, and fatigability in both habilitation and rehabilitation.

The human body contains about 400 skeletal muscles making up about 40% to 50% of human body weight (Powers & Howley, 2009; Suzuki et al., 2002). These muscles allow for movement, postural stability, and generation of heat. Skeletal muscle can be grouped by fiber type with two primary categories: type I slow twitch fibers and type II fast twitch fibers. Slow twitch fibers have certain characteristics that make them more resistant to fatigue compared with fast twitch fibers. Two reasons slow twitch fibers are fatigue resistant are: (1) they have a higher number of capillaries surrounding them compared with other fiber types, providing increased blood supply, and (2) they have numerous oxidative enzymes (which help slow down the way a muscle gets energy). Fast twitch fibers can further be subcategorized into type IIa and type IIx. Type IIx fibers are now thought to be the fastest but least efficient because the characteristics of this fiber type lead it to expend a significant amount of energy per unit of work (Powers & Howley, 2009). Type IIa fibers fall between type I and type IIx. IIa fibers have some degree of fatigue resistance, though they are not as fatigue resistant as type I fibers. Type IIa are adaptable with training and can further arm themselves against fatigue by increasing their oxidative capacity with training (Powers & Howley, 2009). It is interesting to note that muscle fibers can adapt to imitate other fiber types based on training and load (MacIntosh, Gardiner, & McComas, 2006; Powers & Howley, 2014).

Research on human laryngeal muscles and rat models indicates that human laryngeal skeletal muscles have similar characteristics to skeletal limb muscles with regard to fiber type, capillary density, and metabolic features (Hoh, 2005; Suzuki et al., 2002). The thyroarytenoid (TA) muscle contains only a few hundred muscle fibers compared with some of the larger limp muscles, which can contain hundreds of thousands of muscle fibers (MacIntosh et al., 2006). Cadaver studies on laryngeal muscles revealed similar numbers of muscle fibers across cadavers but variation in muscle fiber type both within and across cadavers (Rosenfield, Miller, Sessions, & Patten, 1982). This leads one to ponder whether or not these types of difference were a result of different vocal activity over a lifetime, or if different vocal activity was self-selected because of predisposed vocal presets based on individualized, genetically based muscle fiber typing. Studies on fiber typing have been conducted for the TA muscle, posterior cricoarytenoid muscle, and interarytenoid (IA) muscles (Tellis, 2004; Tellis, Rosen, Thekdi, & Sciote, 2004). The TA muscle and lateral cricoarytenoid muscle (LCA) are composed of about 80% type II fibers and 20% type I fibers. In contrast, the posterior cricoarytenoid muscle (PCA) is composed primarily of type I fibers (65%; Happak, Zrunek, Pechmann, & Streinzer, 1989; Tellis, 2004). Type I fibers also appear to be abundant in the cricothyroid muscle (CT) (Li, Lehar, Nakagawa, Hoh, & Flint, 2004). Interestingly, the metabolic characteristics of the IA muscle fibers make them susceptible to quick fatigue. Based on studies that have differentiated muscle fiber types for the laryngeal muscles, the fast twitch fiber density of the TA, IA, and LCA allow for rapid valving and closure for airway protection. In contrast, the slow twitch fibers that predominate in the PCA make the muscle very fatigue resistant, allowing for repetitive opening of the airway for respiration 24 hours per day. Most skeletal muscle is fairly evenly divided 50/50 between type I and type II muscle fibers, but muscle fiber types do not function in isolation and they can even combine toward a more hybrid muscle fiber type. Some elite athletes have larger distribution of one type over another, making them better sprinters versus distance runners or vice versa. Implication of this for vocal athletes warrants further consideration and investigation (Sandage & Smith, 2017).

Muscle Fuel

We will briefly describe how muscle tissue derives power in order to contract and relax. Bioenergetics refers to how energy stores are produced for muscular contraction (Sandage & Smith, 2017). There are three main avenues from which a muscle can derive fuel. Adenosine triphosphate serves as the primary power source needed for muscular contraction. This is available in small amounts for immediate consumption. This is the immediate energy system wherein there is a quick, powerful muscular response that lasts only a few seconds until it is depleted. After ATP is depleted, a supplemental fuel source (non-oxidative, glycolytic) is required to sustain activity. Finally, for longer contractions (2–3 minutes), oxidative energy sources become the primary fuel to sustain activity (Brooks, Fahey, & Baldwin, 2005; Sandage & Smith, 2017). These three pathways are not always used in isolation, rather they work together depending on the task. When training, these bioenergetic sources that support muscle metabolism are upregulated and adaptation. The result is better fatigue resistance for that particular muscle for that specific task. Once that activity ceases, however, those stores are downregulated, leading to a detraining effect. Smith and colleagues measured vocal dose of classroom music teachers. Intervals of the majority of voiced segments over a 7.5-hour teaching were around 3 seconds, supporting the hypothesis that vocal tasks associated with classroom music teaching rely on immediate bioenergetic muscle fuel sources. This type of research can better inform voice rehabilitation paradigms for this population (Smith, Sandage, Pascoe, Plexico, Lima, & Cao, 2017). The consideration of these phenomena for habilitative voice training requires further investigation (Sandage & Smith, 2017).

Basic Training Principles for Exercise Science

The analogy of the singer as an athlete is not a new one. In the sport fitness arena, we think of capabilities such as strength, flexibility, endurance, and recovery. These areas can be maximized with focused training. In the world of vocal athletes, these skills are also important, but measuring, reporting, and monitoring development of these skills becomes complex as there is much variation in how a singer produces sound and much of the "behind the scenes" actions are not visible, nor can they be easily differentiated. Further, there is great variability across singers as to how they perceive and describe their vocal output and we cannot be sure that reported symptoms correlate with anatomical changes in a predictable way. Additionally, research that has been done has been in a research setting and not real-life performance settings, which often require eight shows of high-level vocal performance per week. Still, as we continue to gain more knowledge on how exercise physiology principles apply to and translate to voice training, we will evolve our training paradigms to maximize and customize vocal training for optimal performance with lower risks of vocal injury (Phyland, 2017).

There is ample research on impact of exercise and strength training on general skeletal muscles, such as limb muscles; however, adequate research on impact of exercise on laryngeal muscles is inherently more challenging because of the locations and sizes of these muscles. The presence of vocal fold mucosa also differentiates the vocal folds, therefore findings from research done on general limb muscles cannot necessarily be transferred to laryngeal muscles. There is research to suggest that there are reasonable similarities between limb muscles and intrinsic laryngeal muscles (Hoh, 2005; Sciote, Morris, Horton, Brandon, & Rosen, 2002; Tellis et al., 2004). Specific similarities that have been described include muscle fiber type, metabolic attributes, changes in neuromuscular junction, and capillary density changes associated with aging (Kersing & Jennekins, 2001; McMullen & Andrade, 2006; Suzuki et al., 2002).

There are five primary principles described in exercise science literature to maximize strength, function, endurance, and longevity. The overriding tenet of these principles is that muscles, if trained in the appropriate manner, will undergo muscle fiber changes in addition to neural and metabolic changes, resulting in an adaptation to the new demand imposed upon them. This concept is referred to as Specific Adaptation to Imposed Demand (SAID). There is evidence in exercise physiology literature that if training is done with the following principles in mind, the above described physiologic changes will occur. The five principles of exercise training are: intensity, frequency, overload, specificity, and reversibility.

Intensity, frequency, and overload are best described inclusively. In order for the target muscle to undergo the desired physiologic adaptations, there must be adequate frequency, and an appropriate amount of intensity. These two factors will help ensure that the third principle (overload) is realized. Both frequency and intensity must surpass the target muscle's comfort zone; otherwise, the target muscle will persist in a state of homeostasis (maintenance) and adaptation will not occur. Demanding muscular exertion beyond its maintenance level will overload the muscle, leading to adaptation and change. A brief discussion of **vocal load** is appropriate here in order to differentiate it from the principle of overload. The concept of vocal load is discussed frequently in voice literature. Vocal load is typically used to describe vocal mileage with the specific parameters of duration, volume, and pitch in mind. A heavy or high load would involve above average activity in any or all of these parameters (Solomon, 2008; Titze, 1999). There is more discussion on impact of increased vocal load on vocal integrity in Chapter 7.

> The concept of neural adaptation as part of athletic training and in particular vocal training should not be underappreciated. When training the voice, we must not only consider the biomechanical strengthening and coordination but also the neuromuscular efficiencies that are also being strengthened. With this in mind, a teacher must be monitoring if the student is in a "learning state" with a receptive nervous system to receive new neurologic input in order to maximize learning and successful duplication. More on this is discussed in the motor learning chapter.

There are a number of adaptive changes that occur during this training process. Of particular interest are the changes in the muscle fibers, neural adaptations, and metabolism. These changes are not in tandem, however. In fact, the neural and metabolic adaptations typically precede the muscle fiber hypertrophy (Lieber, 2010; Sale, 1988). Initial gains in strength are due to the neural adaptations, which occur over a period of 4 to 5 weeks. These changes can be seen after about 2 weeks of training before any measurable increase in actual muscle bulk (Lieber, 2010).

Metabolic changes are also an important contributor to improved muscular strength. When the appropriate frequency and intensity levels are implemented for the target muscle, there is increased efficiency in the delivery of adenosine triphosphate (ATP), which provides energy to the muscle for contraction. In turn, muscle fatigue is reduced. Over time an increase in capillary density around the muscle occurs.

This ensures that there is better oxygen transmission from the blood to the target muscle (MacIntosh, Gardiner, & McComas, 2006). This is an important benefit because capillary density has been shown to decrease with age (Russell, Nagai, & Connor, 2008).

Specificity refers to the concept that strength training must be designed to appropriately target the specific muscle or

> The neuromuscular junction is the place where the nerve meets the muscle.

> Real-life physical example of intensity, frequency, overload, specificity, and reversibility principles: If you wanted to improve leg muscle strength by using squats (specificity), the frequency (how many times you perform the exercise), the intensity (how challenging you make the squat influenced by how low you go or by adding weight), and overload (challenging the muscle via heavier weight and/or lower bend beyond its maintenance level to the point of muscle failure) will over time result in progressive muscle change. If you stop doing squats, the muscle fibers will revert (reversibility) back to their pre-exercise state.

muscle group with the intended skill or task. Research in exercise science suggests that while some generalization exists across muscles, there is not full carryover to the muscles if the training task differs from the demanded task. As an example, consider the two activities of running and cycling. Both tasks require the use of the majority of the muscles in the leg, but training specifically for one task (running) does not automatically make one skilled in the other (cycling). This concept likely has implications regarding different styles of singing, especially when employing different registers or vocal genres.

The final exercise principle is reversibility or detraining. Put very simply, if you stop going to the gym, you lose previously attained gains in strength and endurance. Recall that the muscle adapts to increased demands. Therefore, if the demand decreases or stops, there will be a detraining effect, and the muscle will return to its pre-training level of function, as all of the physiologic gains will have reversed. Detraining happens very quickly. Further, the longer the hiatus from training, the longer it will take to regain the strength. For example, if you stop strength training for 2 weeks, exercise science research suggests that it could take up to 4 weeks to reacquire post-training gains (Sandage & Pascoe, 2010). If this applies to voice training, there are implications to consider regarding complete vocal rest.

Research on Exercise Science for Voice

Historically, there is an association between exercise physiology and kinesiology with physical fitness, athletics, and physical therapy. Speech pathologists have also applied these principles to voice therapy and rehabilitation (Patel, Bless, & Thibeault, 2010; Sandage & Pascoe, 2010; Saxon & Schneider, 1995; Stathopoulos & Duncan, 2006; Stemple, Lee, D'Amico, & Pickup, 1994; Thibeault, Zelazny, & Cohen, 2009). Vocal pedagogy has also moved toward a physiologic and functional approach to voice training. One study looked at the impact of overload principle on voice training. The experimental group that had target overload tasks in the form of lip trills at a certain intensity for a period of time over six sessions demonstrated improved vocal quality, stability, intensity, and acoustic measures compared with the traditional voice training group, and these gains were maintained over a 30-day period, suggesting that adaptations had occurred (DaSilva, Riberio, Siqueira, Moreira, Brasolotto, & Silverio, 2017).

Physiologic studies regarding specifically exercise physiology principles and voice provide the basis for consideration of