The Perception of Benefit of Vocalization on Performance When Producing Maximum Effort

by

Kelly Morgan Davis

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Approved by

Mary J. Sandage, Chair, Ph.D., CCC-SLP, Assistant Professor of Speech-Language Pathology
Laura Plexico, Ph.D., CCC-SLP, Associate Professor of Speech-Language Pathology
David Pascoe, Ph.D., Distinguished Professor of Kinesiology

Abstract

Objectives/Hypothesis: The purpose of this study was to determine the presence of the belief that using voice during force production is beneficial to sport performance. This study was also used to determine if vocalization during effortful tasks was correlated to perception of voice impairment. The hypotheses were as follows: (A) there is a belief among athletes that voicing (using the voice) during high effort tasks improves performance and, (B) the use of the voice during high effort tasks is correlated with the perception of voice impairment.

Study Design: Information was gathered through an anonymous, on-line survey in which participants ages 19-70 answered questions regarding voicing and force production as well as the Voice Handicap Index-10 and a perceived phonatory effort measure.

Methods: The data obtained from the survey were evaluated using descriptive statistics and analyses of variance (ANOVA) to determine if there was a correlation between voice production and the perception of voice disorder.

Results: Three hundred and seventy eight participants' survey responses were used in the data analyses. The results of the on-line survey indicated that 49% of the participating athletes believed that the production of voice during maximum effort provided an advantage to performance. There was no correlation between individuals who used voice during force production and the perception of voice impairment. Therefore, the hypotheses were not met.

Conclusions: Findings indicated that while there was evidence of belief among athletes that producing voice during maximum effort improves performance, it was not a majority of the athletes queried. The evidence from this study did not support the belief that voice use during

high effort tasks is detrimental to voice function. Further research should be completed to objectively measure force production in both grunt and non-grunt trials concurrently with measures of vocal function.

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Table of Contents

Abstract……………………………………………………………………………………...ii

Acknowledgements…………………………………………………………………………iv

List of Tables ……………………………………………………………………...….vii

Chapter 1 Introduction ……………………………………………………………….. 1

Chapter 2 Review of Literature

Empirical evidence for use of voice for exertion…………………………………...…. 3

Belief systems supporting use of voice for sport performance…………………………... 5

Implications for vocal pathology……………………………………………………… 9

Sex differences…………………………………………………………………….. 13

Physiologic aspects of valsalva……………………………………………………… 15

Chapter 3 Justification…………………………………………………………………… 19

Chapter 4 Journal Manuscript…………………………………………………………… 21

Abstract………………………………………………………………………………… 21

Introduction…………………………………………………………………………….. 23

Methods/Procedures………………………………………………………………….... 27

Results……………………………………………………………………………...... 28

Discussion…………………………………………………………………………….. 33

References……………………………………………………………………………….. 38

Appendix A Recruitment Letter………..……………………………………………… 43

Appendix B Survey Questionnaire 44

List of Tables

Table 1. Participant Age, Sex, Ethnicity, and Geographical Region…………………………… 29

Table 2. Athlete Profiles………………………………………………………………………. 30

Table 3. Timing of Voice Production ………………………………………………………… 32

Table 4. Means and standard deviations for VHI-10 and PPE by group……………………… 32

Table 5. Pearson Correlation Coefficients, N=378 ……………………………………………. 33

I. Introduction

A little-studied aspect of vocal function is the use of voice during sport or endurance efforts. Many athletes believe that producing voice during maximum effort increases their performance. However, there is speculation that grunting during exertion can be damaging to an individual's vocal folds. There is also a belief by some who watch sports that the production of voice during a maximum effort can be distracting to others around the athlete. Subsequently, there has been a large push in some sports (i.e., tennis) to ban grunting while participating. Many professional athletes state that they will not be able to perform at the same level without producing voice. This study was conducted to help determine if there is a belief that grunting provides a performance advantage, and if voice production during sport is correlated with perception of voice impairment.

The vocal folds play a major role in lifting heavy objects by adducting tightly and keeping air inside of the lungs to provide a source of support (Stemple, Glaze & Klaben, 2000). This technique, known as "air trapping" or the Valsalva maneuver, is present when an individual is producing maximum effort, such as lifting a heavy object or pushing for maximum force. Air trapping is defined as "the trapping of exhaled air inside the thoracic cavity" (Naito & Niimi, 2000, p. 1147) and it is vital to accomplish many bodily functions such as defecation, labor, urination, coughing and vomiting (Niimi & Naito, 1993). In most individuals, the larynx is closed during maximum effort body movements, such as lifting weights and exerting maximum amounts of force (Naito & Niimi, 2000). The closure of the larynx is vital to the trapping of air in the thoracic cavity. However, there are questions regarding if the release of that air in the form of a grunt or vocalization while producing maximum force will increase power. A comprehensive review of the literature was conducted in order to gain insight on these inquiries.

II. Review of Literature

Empirical evidence for use of voice for physical exertion

It has been shown that when producing maximum effort, more power can be exerted during laryngeal closure resulting in improved strength of the upper limbs (Niimi & Naito, 1993). Conversely, reduced ability to produce power during lifting may occur when the ability to adduct the larynx is compromised. This occurs when individuals are unable to build up the intrathoracic pressure that is required for trunk stabilization. In a survey conducted on eighty-two surviving laryngectomees, individuals who had their larynx removed, it was determined that 57% of them experienced difficulties in lifting heavy objects post surgery (Jay, Ruddy & Cullen, 1991).

In a study conducted by Morales, Owen, and O’Connell (1999), it was determined that the use of grunting did not improve the dead lift force in athletes. The study included thirty-one male participants; 15 of which were college athletes, 16 who were not college athletes. These men ranged from 17 to 35 years of age. The participants were instructed to perform a total of six dead lift tasks. Three of the dead lift tasks involved the subjects grunting, while the other three of the dead lift tasks did not. While performing the dead lift tasks, adhesive EMG electrodes were applied to the participants’ biceps femoris and rectus femoris muscles to monitor muscle fatigue. Upon completion of the study, the researchers determined that there was no significant difference in performance between the “grunt” and “non-grunt” tasks (Morales, Owen & O’Connell, 1999). However, the experiment methods described lacked details that could have significantly impacted the results. The study description did not include the participant selection process. If the non-athlete participants did not regularly perform a dead-lift task, then it is probable that they did not have an established motor plan for their technique or a strong belief that vocalization would impact their dead-lift performance. The order in which the “grunt” and “non-grunt” trials occurred could have influenced the individuals’ performance. If the three “grunt” trials were conducted first, followed by the three “non-grunt” trials, the participants could have been fatigued and performed differently on the “non-grunt” trials. If the trials were alternated between “grunt” and “non-grunt” dead lifts, more reliable results may have been produced. The methods of the study failed to describe the order of which the trials were conducted. Due to the limitations identified in the study, it is difficult to conclude that grunting did not improve performance.

The effects of grunting on velocity and force production during tennis strokes was observed in a study in which thirty-two Division II and Division III collegiate tennis athletes participated as subjects. The participants had a mean age of 20.2 and there were 16 males and 16 females. These individuals completed 10-15 minute warm up of serves and ground strokes while grunting and not grunting. The participants performed randomized sets (3 with grunting and 3 without) of serves and forehand strokes both dynamically and isometrically. The velocities and isometric forces of the strokes were measured using a calibrated radar gun and calibrated dynamometer. Electromyography (EMG) data was obtained from the participants’ dominant pectoralis major and contralateral external oblique muscles. These measures were recorded and averaged for data analysis. A repeated measures multivariate analysis of variance (RM-MANOVA) compared dynamic stroke velocity, isometric muscle force, and peak EMG activity during each breathing condition at the 0.05 alpha levels. The findings indicated that dynamic velocity and isometric force of both serves and forehand strokes were significantly greater when the subjects grunted. Peak muscle activity in the external oblique and pectoralis major muscles was also greater when the individuals grunted during both types of strokes. It is also important to know that the participants' grunt history, gender, perceived advantages and disadvantages of grunting, years of experience, highest level of competition, as well as order of testing did not have significant impact on any of these results. The velocity, force, and peak muscle activity during both tennis serves and forehand strokes were significantly enhanced when athletes are allowed to grunt (O'Connell, Hinman, Hearne, Michael, & Nixon, 2014).

Callison, Berg, and Slivka (2014) conducted a study to determine if grunting enhanced ball velocity in groundstrokes and if grunting increased the physiological cost of hitting. The participants for this study included 5 male and 5 female members of tennis teams at a Division I university who had just completed their indoor competitive season. The subjects participated in two hitting sessions where they repetitively hit forehand and backhand shots while either grunting or not grunting. The hitting sessions consisted of five 2-minute periods with a 1-minute break in between each period. A radar gun was used to measure ball velocity. While participating in each hitting session, the participants wore a portable metabolic measuring unit. The individuals' heart rate was monitored using a Polar monitor and their Rated Perceived Exercise (RPE) was assessed by using Borg's 6-20 scale. This study indicated that grunting increased ball velocity 3.8% as compared to the non-grunting trials. The physiological responses for the two hitting conditions were not significantly different for any variable. It was found that grunting increased ball velocity without increasing oxygen consumption or ventilation.

Belief systems supporting use of voice for sport performance

Aside from the empirical evidence that supports performance advantage when voice is used during exertion, a strongly held belief of its benefit may influence performance. There are many online forums for body builders and athletes that discuss the use of voice during maximum effort. Many athletes believe that they gain a performance advantage when they use their voice during force production. One sport in particular that is known for the use of voice when exerting force is women's tennis. Many elite women players produce a vocalization when hitting the ball, ranging from a low-pitched grunt to a higher-pitched shriek. There is a great amount of discussion regarding the use of voice during competitive elite women's tennis, with some opponents asserting that it is not vital to their athletic performance. In fact, it has been proposed that vocalizations in women's tennis be removed from the game of tennis altogether (Slothower, J. 2012). However, professional women's tennis players state that if vocalizations while playing were banned; they would not be able to perform at their usual level (Nagle, 2012). This supports the belief that vocalizing while performing has a considerable impact on an individual's performance. In an effort to rid sports of these vocalizations, it has been asserted that producing voice during maximum effort is damaging to the vocal folds. However, there is no empirical evidence to support this.

There is an assertion among the tennis world that professional tennis players may have an advantage by distracting their opponents when they grunt. The assertion is centered on the idea that it vital for the opponent to hear the ball strike the racket, and that the sound of a grunt can mask or distract the opponent's attention from this moment (Navratilova, 2009). In fact, there is scientific research indicating that when two visual objects collide, the sound of the collision is vital to the perception of one item bouncing off of another object (Sekuler, Sekuler, & Lau, 1997). Therefore, the grunting sound could potentially interfere with these beneficial effects by masking the sound of the racket hitting the ball. It should be taken into account that a grunting player may not share the opinion that their grunting could compromise their opponent's performance. In fact, the players who grunt could argue that their grunts may provide their opponent with a beneficial signal in regards to the force and the timing of the striking of the ball. Sinnet and Kingstone (2010) conducted a study to help determine the effects of grunting in tennis. For this study, the participants were provided with dynamic video clips of a professional tennis player striking a ball either forehand or backhand to either the left or right of a video camera. There were a total of four video clips for each shot type shown to the participants so that each clip was played with or without a grunt, and either ended at contact or 100 ms after contact. A standard auditory stimulus was used for this experiment, which was white noise (500 ms) that occurred during a tennis shot. Two loudspeakers were placed on both sides of the computer screen that played the sound at 60 decibels in order to ensure that the auditory and visual events originated from the same location. The participants were required to press the "M" on a keyboard with their right hand if they thought the shot was going to their right, and the "X" with their left hand if they thought the shot was going to their left. The results revealed that participants were slower to respond when a sound was present, as opposed to when a sound was not present. In fact, when an additional sound occurred at the same time as when the ball was hit, participants were significantly slower (ranging from 21-33 milliseconds) and made significantly more errors in decision (3-4%) in regards to the direction of the ball (Sinnett & Kingstone, 2010). There are aspects of this study that could impact the results that were found. The individuals that were selected for this study included thirty-three undergraduate students from the University of British Columbia who were participating in exchange for course credit. None of the participants had more than recreational tennis experience. As a result, these individuals most likely do not play at the same caliber as professional tennis players. Their errors in decision making may have be attributed to playing at a lower skill level than the individual in the video clips. These individuals may not be as accurate of a judge of when the ball strikes the racket and the direction in which it is traveling as someone who is a professional tennis player. Another factor of this study that should be taken into account is that the auditory stimulus that was provided along with the videos is not as loud as the grunts that are typically produced by professional tennis players. Half of the videos included an excessive noise while the other half did not.

An aspect of vocalization during exertion that may be related to performance outcome is the use of voice for mentally “psyching up” the athlete. This can either be accomplished just before the sport event or during the peak of exertion. A psyching-up technique used by martial artists is known as Ki or inner energy. Ki is energy that is believed to build up below the navel and is released by a sharp exhalation of air in the form of a yell known as a “kiap” (Tschampl, 2009). Martial artists place such importance on the use of voice in their physical exertions, that they named the voiced aspect of the technique. The kiap is used in a variety of sports where a burst of energy is necessary, such as power lifting, track and field, and martial arts. In a study using a handgrip exercise it was found that when using the kiap technique, individuals’ handgrip strength was increased by a mean of 8 percent when compared to the no kiap trials (Tschampl, 2009).

A confounding aspect of enhanced ballistic performance using voice is the commonly used practice of pre-performance preparation that may or may not include vocalization. Research has been conducted observing the effects of a technique known as “psyching-up” on performance. Gil, Iredale, and Tod (2003) define psyching-up as “self-directed cognitive strategies used immediately prior to or during skill execution that are designed to enhance physical performance” (p. 57). Many athletes use psyching-up techniques both in competitive and recreational physical activities believing that use of such techniques will improve their performance. In order to determine if psyching-up enhanced performance, Gil, Iredale, and Tod

(2003) conducted a review of the literature regarding this topic. They found that the most effective form of psyching-up was preparatory arousal. However, imagery, attentional focus, and self-efficacy were also empirically supported as being effective. Evidence suggested that any form of psyching-up positively influences strength and muscular endurance. The research that has been conducted has observed the influences of psyching up in specific situations, such as handgrip tasks and muscular endurance tasks. Further research needs to be conducted using different methods and participants in order to determine if the information gathered in previous studies is a valid indicator of the impact of psyching up on strength and muscular endurance.

There is little research that measured power in regards to psyching-up (Gil, Iredale & Tod, 2003). Parker, Sealey, & Swinbourne (2011) stated that an individual's level of arousal greatly impacts their sports performance. In explosive sports, such as weightlifting and boxing, a higher level of arousal is most advantageous for performance. A study was conducted on 12 swim athletes who participated in three 1-minute mental preparation strategies before performance. The group that participated in the preparatory arousal strategies showed a significant difference in performance during the handgrip trial and a 50-meter freestyle swim than those who did not (Parker, Sealey & Swinbourne, 2011).

Implications for vocal pathology

A comprehensive search of the literature did not yield evidence supporting a correlation between voice use during maximum exertion and voice disorders. However, knowledge of the manner in which voice is produced may provide insight on the effect that producing voice during a maximum effort can have on the laryngeal tissue and, ultimately, voice quality. Voice is produced through the vibration of the two vocal folds, which are located in the larynx. The vibration is initiated through the flow of air from the lungs and through the larynx. (Van den

Berg, 1958). It can be postulated that grunting while exerting maximum effort may damage the vocal folds due to higher proposed glottis closure forces. The muscles of the larynx adduct, or close, the larynx tightly while lifting heavy objects, due to thoracic fixation. When grunting, the vocal folds are closed together in a forceful manner, a behavior commonly referred to as phonotrauma (Branski, et al., 2006). Phonotraumatic vocalization during thoracic fixation may intensify the force with which the vocal folds close, creating a greater opportunity for damage to occur. Phonotraumatic vocal fold lesions may include hemorrhagic polyp nodules, cysts, fibrous masses, and reactive lesions (Behrman, Rutledge, Hembree, Sheridan, 2008).

Orlikoff (2008) conducted a study to research the physiologic changes in voice production associated with a weightlifting and support maneuver. Twenty healthy subjects, 10 men and 10 women, were selected to participate in the research. These individuals lifted hand-held weights and steadily supported them with outstretched arms as they either sustained comfortable phonation or repeated the syllable /pi/. Results showed that both male and female subjects showed an increase in the electroglottographic contact quotient, long-term fundamental frequency variability, and estimated laryngeal airway resistance attributable to an elevated driving pressure. There were also no significant changes in mean fundamental frequency, pitch perturbation quotient (jitter), or phonatory airflow between the pre-lift and lift portions of their voice production, regardless of the amount of weight supported. These results indicate that simultaneous phonation and weightlifting is associated with increased laryngeal airway resistance characterized by an elevation in driving pressure and medial compression of the vocal folds.

Little has been published regarding type of voice used, timing of voice relative to exertion effort, or duration of voicing during physical exertion. The type of voice used during maximum physical effort may also influence the probability of developing laryngeal pathology secondary to this behavior. Changing the pitch and intensity of one's voice requires modulation of vocal fold length and tension, as well as subglottal air pressure. The pitch of voice is the perceived attribute of the frequency, or rate, of vocal fold vibration. As an individual's fundamental frequency changes, the listener will perceive a change in pitch. The rate of the vocal fold vibration is determined by the (1) length of the vocal folds, (2) the tension of the vocal folds, and (3) the mass of the vocal folds per unit of length (Boone, McFarlance, Von Berg, & Zraick, 2010). Changes in subglottal pressure also occur as an individual changes frequency. As the vocal folds become longer, the tension increases and their mass per unit of length decrease. This results in fast vocal fold vibration and also a higher pitch. In order to change pitch, specific muscles must be involved. The primary intrinsic laryngeal muscles that play a role in the changing of pitch are the cricothyroid and thyroarytenoid muscles. Recent intramuscular EMG research has described nearly equal CT and TA muscle activity (Kochis-Jennings, Finnegan, Hoffman, Jaiswal, & Hull, 2014).When the cricothyroid muscle contracts, the distance between the anterior thyroid cartilage and the arytenoid cartilage increases, thus lengthening the vocal folds. When the vocal folds become shorter, less tense, and thicker, they vibrate at a slower rate, which is perceived by the listener as a lowering of pitch. The primary muscle responsible for producing a lower pitch is the thyromuscularis. Upon its contraction, the arytenoid cartilages move forward, which adducts and shortens the vocal folds.

When an individual reaches the upper end of their natural pitch range, the vocal folds' elasticity is increased. The increased elasticity results in increased glottal resistance, which requires increased subglottal air pressure in order to produce higher frequencies. Van den Berg (1958) stated that the average person must slightly increase subglottal air pressure in order to increase voice pitch; however, because increasing subglottal pressure has an abducting, or opening, effect on the vocal folds, the folds must continue to increase in tension (longitudinal tension) to maintain their closed position. While the main determinants of the frequency of voice are length, mass, and tension of the vocal folds, increases in frequency are typically characterized by the increase of subglottal pressures, increased medial compression of the vocal folds, and increased glottal airflow rates. Therefore, the pitch at which one uses their voice during maximal physical exertion may influence the degree of phonotraumatic behavior at the level of the larynx (Van den Berg, 1958).

The loudness of an individual's voice is the perceived attribute of the intensity of the sound wave that is generated during phonation. As the intensity changes, the listener perceives a change in the loudness of an individual's voice. The primary determinants of intensity are (1) subglottal pressure, (2) medial compression of the vocal folds, and (3) the duration, speed, and degree of vocal fold closure (Boone et al., 2010). Supraglottal adjustments, also referred to as vocal tract tuning, can also play a role in the production of vocal loudness. Hixon and Abbs (1980) described sound pressure level as being the primary factor contributing to the perception of the loudness of the voice, governed mainly by the pressure supplied to the larynx by the respiratory pump. As the supply of air in the lungs is increased, there is a greater buildup of subglottal air pressure when the vocal folds adduct, particularly the longer they remain adducted. As the intensity of voice increases, the vocal folds remain closed for longer periods of time throughout each cycle of vibration. When the vocal folds are eventually blown apart, they abduct, or move laterally, more widely than usual, which allows a greater amount of air to escape. This results in the production of air that is explosively turbulent and generates more acoustic power (Boone et al., 2010). This laryngeal behavior also promotes greater closure forces as a result of the increased air escape and more extensive lateral abduction of the vocal folds during voicing.

Knowledge of the role of the vocal folds and subglottal pressure in changing pitch and loudness provides insight for how these characteristics of voice could impact force production when exerting maximum effort. One could postulate that production of a lower pitch during maximum force production would be more likely to result in damage of the vocal folds because the amplitude of vocal fold excursion during voicing is greater than for higher frequencies. However, producing a lower pitch may be more effective because it is characterized by greater vocal fold closure along the vocal fold margins. Higher frequencies are produced with less lateral excursion of the membranous vocal fold, and therefore, may be less damaging to the vocal fold tissue during a power maneuver. It could be proposed that athletes also use higher intensities during their efforts. When athletes prepare to exert maximum force, they most likely build up a large amount of subglottal pressure, which would support use of louder voice use.

Sex differences

The frequencies and intensities used by men and women and subsequent vulnerability to vocal fold injury may differ due to physiological differences in vocal fold size and constituent make-up of the different vocal fold layers. The composition of the lamina propria in the vocal folds can affect an individual’s vocal performance. The contribution of the lamina propria can be explained by the cover-body theory of phonation. This theory states that vocal folds consist of three layers: the cover, which is comprised of the epithelium and the superficial layer of lamina propria; the intermediate layer, comprised of the intermediate and deep layers of lamina propria; and the body, comprised of the vocalis muscle (Hirano, 1974). The cover moves as a pliable unit relative to the deeper layers. This relationship is what allows the vocal folds to vibrate at such a consistent and controlled rate. Collagen plays a significant role in the mechanics of the lamina propria by providing tensile strength to the oscillating vocal fold. Hammond, Gray, and Butler (2000) conducted a study in which they observed the larynges in men and women, infant, adult, and geriatric age groups. By staining the vocal folds, the scientists were able to measure the distribution of collagen within the lamina propria. The results showed that there was an increase in the amount of collagen from infant to adult stages. Their research also demonstrated sex differences for the amount of collagen. Female vocal folds had about 59% of the collagen that was found in male vocal folds (Hammond, Gray & Butler, 2000). Knowing this information, it can be postulated that females may be more likely to develop a voice disorder than males due to fewer, shock-absorbing collagen fibers. However, it could be that the sex differences in laryngeal structure size, typical frequency range, and percent of collagen fibers results in a rather level playing field with regard to vocal fold injury. Females typically use a higher fundamental frequency than men, indicating that they may not experience the same degree of vocal fold closure forces that are observed at lower frequencies. It may be that men require additional collagen to offset the greater closure forces that can be proposed with lower frequency vocalizations.

Subglottal pressures will differ as well due to sex differences in respiratory capacity. Tidal volume (TV) is a term used to describe air volume that is moved during either the inspiratory or expiratory phase of each breathing cycle. When an individual is at rest, their TV ranges from 0.4 to 1.0 L of air per breath. When an individual takes a normal resting inhalation and then inspires as deeply as possible, the additional 2.5 to 3.5 L volume of air above the inspired tidal air represents the reserve ability for inhalation. This is known as the inspiratory reserve volume (IRV). When an individual produces a normal resting exhalation and then continues to force as much air as possible from the lungs, it is known as the expiratory reserve volume (ERV). The ERV ranges from 1.0 to 1.5 L in an average-sized man. When exercising, utilization of both the IRV and ERV produces a considerable increase in TV. The total volume of air that is voluntarily moved in one breath (from full inspiration to maximum expiration) represents the forced vital capacity (FVC). The FVC is composed of the TV, IRV, and ERV. The FVC varies with body size and composition and with body position during measurement. In healthy young men, FVC usually ranges between 4 and 5 L and between 3 and 4 L in young women. For tall individuals, values of 6 and 7 L are not uncommon. Unusually large FVC values have been reported for a professional football player at 7.6 L. An Olympic gold medalist in cross-country skiing was reported to have an FVC of 8.1 L. The large lung volumes in these athletes generally reflect genetic influences and body size characteristics. Exercise training does not substantially change static lung volumes (McArdle et al., 2001). This information would indicate that FVC volume could influence the degree of force production due to the fact that an athlete could trap a greater amount of air when using the Valsalva maneuver.

Physiologic aspects of Valsalva

The expiratory muscles play a role in pulmonary ventilation, ventilatory maneuvers of coughing and sneezing, and stabilization of the abdominal and chest cavities during heavy lifting. When an individual is quietly breathing, their intrapulmonic pressure decreases about 3 mm Hg during inhalation and raises a similar amount above atmospheric pressure in exhalation. However, if an individual closes the glottis (the most narrow part of the larynx through which air passes through the trachea) after a full inhalation while maximally activating the expiratory muscles, the intrathoracic pressure will increase more than 150 mm Hg above atmospheric pressure due to compressive forces. The pressures increase within the abdominal cavity during a maximum exhalation against a closed glottis. Forced exhalation against a closed glottis is known as the Valsalva maneuver (Findley, 2003). It occurs commonly in activities such as weight lifting and others that require a quick, maximum application of force of short duration. The Valsalva maneuver stabilizes the abdominal and thoracic cavities, which enhances the action of the chest muscles (McArdle, Katch, & Katch, 2001).

There are physiologic consequences that can occur as a result of utilizing the Valsalva maneuver. The primary hemodynamic consequence of a prolonged Valsalva maneuver is the result of an acute drop in blood pressure. The increased intrathoracic pressure during a Valsalva maneuver then becomes transmitted through the walls of the veins that pass through the thoracic region. Venous blood remains under low pressure, so whenever the thoracic pressure is transmitted through the thoracic region the thoracic veins collapse, reducing the blood flow to the heart. The reduction of venous return greatly reduces the heart's stroke volume, which triggers a significant fall in blood pressure below the resting level. When an individual performs a prolonged Valsalva maneuver during an exercise that involves straining, there is a dramatic reduction in venous return and arterial blood pressure. This diminishes blood supply to the brain, which may result in dizziness or fainting. Once the glottis reopens and the thoracic pressure returns to a normal state, the blood flow will reestablish by way of an "overshoot" in the blood pressure of the arteries (McArdle et al., 2001).

There are four phases of typical blood pressure response during the Valsalva maneuver in a healthy individual. In the first phase, the aortic pulse pressure has a small increase as the Valsalva maneuver begins. This most likely occurs as a result of the mechanical effect of the elevated intrathoracic pressure that ejects from the left ventricle into the aorta. Within six heartbeats of the beginning of the Valsalva, there is a biphasic response that consists of a considerable reduction in aortic pressure, which is followed by a small gradual rise and secondary decrease during the continued Valsalva strain. When the strain is released, and the Valsalva ends, the individual's blood pressure rises quickly and overshoots the resting value (McArdle et al., 2001).

There is a common misconception of the consequences of the Valsalva maneuver. There is a belief that the Valsalva maneuver causes the increases in blood pressure that occurs within heavy lifting. However, as stated in the previous paragraph, a prolonged Valsalva will dramatically reduce blood pressure. The confusion arises because a Valsalva maneuver that is not long enough to cause a prolonged lowering of blood pressure usually accompanies straining muscular efforts that are commonly seen in isometric and dynamic resistance exercise. These exercises, both with and without the Valsalva, will increase the resistance to blood flow in active muscle. Intramuscular fluid pressure increases in a linear manner with all levels of isometric force, from minimum to maximum. The increase of peripheral vascular resistance will significantly increase the arterial blood pressure also with the workload of the heart throughout exercise. These responses, not including the Valsalva because if it is prolonged it produces the opposite effect, can pose great danger to individuals who have cardiovascular disease. Due to this, most cardiac patients are advised to refrain from heavy resistance training. However, performing rhythmic muscular activity promotes a steady blood flow with a small increase in blood pressure and work of the heart. (McArdle et al., 2001).

Most trainers and therapists have advised against any breath holding during resistive exercise due to the fear of damaging the cardiovascular system. While it has been shown that the Valsalva maneuver results in a pronounced systolic blood pressure, there are reported performance benefits to a short breath-hold during resistive exercise. Published evidence has shown that the stress on the cerebral artery is decreased whenever resistance exercise is performed along with a Valsalva maneuver (Findley, 2003). The increase of the systolic blood pressure is cancelled out by the increase in intrathoracic pressure, intracranial pressure, and intra-abdominal pressure. The Valsalva maneuver may also benefit individuals from an orthopedic standpoint. When holding one's breath, an individual's intra-abdominal pressure increased. This can result in a healthy decompression during resistive exercises, which may help prevent lumbar injury (Findley 2003). The Valsalva maneuver may serve as a stabilizer and strengthener for the trunk musculature. Timing of the exhalation during resistive training is important. If an individual exhales too early, they may produce too much lumbar effort when lifting. Also, it is nearly impossible to avoid using the Valsalva maneuver in efforts that require 80% or more maximum ventilatory capacity.

The biological role of the larynx for thoracic fixation during production of a maximum effort is well understood. There is evidence that describes the importance of laryngeal closure for strength tasks; however, there is little published evidence to support or refute a performance advantage with use of voice during a maximum effort. Additionally, we lack an understanding of the extent to which athletes believe that vocalization is intrinsically beneficial for sport performance. Establishing athlete belief in sport performance benefits with voice use is an important aspect of understanding the larger issue of sport performance gains with vocalizations.

III. Justification

It is known that there is a build-up of pressure in the subglottal region when lifting heavy objects and this is accomplished by tightly closing the larynx and other supraglottic structures. Many athletes have a belief that allowing voice to be produced during this pressure build-up or release enhances their performance; however, there is insufficient evidence to support the use of vocalization for a performance advantage. There is speculation regarding laryngeal damage secondary to voicing during maximum effort. Despite the speculation, there has been little research conducted to support this hypothesis. Due to a belief by some athletes that vocalizing during maximum effort improves their performance and the potential for laryngeal tissue damage from that phonotraumatic behavior, there is a need for research in this area.

Vocalization during force production is considered essential for performance for some athletes, the degree of which is not currently known. Due to the speculation of vocalizing during maximum effort being damaging to the vocal folds or that vocalization may be used for psyching out the opponent, some professional sports are attempting to eliminate this action, perhaps to the detriment of athlete performance. The purpose of this study is to determine the presence of the belief that using voice during force production is beneficial to sport performance. This study will also be used to determine if vocalization during effortful tasks is correlated to perception of voice impairment.

Therefore, two specific questions will be addressed in this study:

(1) Is there belief among athletes and non-athletes that using the voice during high effort tasks improves ones performance?

(2) Is the use of voice during high effort tasks correlated with a perception of voice impairment?

Our hypotheses are as follows: (A) there is a belief among athletes that voicing (using the voice) during high effort tasks improves performance and, (B) the use of the voice during high effort tasks is correlated with the perception of voice impairment.

IV. Journal Manuscript

The Perception of Benefit of Vocalization on Performance When Producing Maximum Effort

ABSTRACT

Objectives/Hypothesis

The purpose of this study was to determine the presence of the belief that using voice during force production is beneficial to sport performance. This study was also used to determine if vocalization during effortful tasks was correlated to perception of voice impairment. The hypotheses were as follows: (A) there is a belief among athletes that voicing (using the voice) during high effort tasks improves performance and, (B) the use of the voice during high effort tasks is correlated with the perception of voice impairment.

Study Design

Information was gathered through an anonymous, on-line survey in which participants ages 19-70 answered questions regarding voicing and force production as well as the Voice Handicap Index-10 and a perceived phonatory effort measure.

Methods

The data obtained from the survey were evaluated using descriptive statistics and analyses of variance (ANOVA) to determine if there was a correlation between voice production and the perception of voice disorder.

Results

Three hundred and seventy eight participants' survey responses were used in the data analyses. The results of the on-line survey indicated that 49% of the participating athletes believed that the production of voice during maximum effort provided an advantage to performance. There was no correlation between individuals who used voice during force production and the perception of voice impairment. Therefore, the hypotheses were not met.

Conclusions

Findings indicated that while there was evidence of belief among athletes that producing voice during maximum effort improves performance, it was not a majority of the athletes queried. The evidence from this study did not support the belief that voice use during high effort tasks is detrimental to voice function. Further research should be completed to objectively measure force production in both grunt and non-grunt trials concurrently with measures of vocal function.

INTRODUCTION

A little-studied aspect of vocal function is the use of voice during sport or endurance efforts. Many athletes are observed to use vocalization during maximum effort as seen during powerful serves in professional women's tennis and when breaking boards in martial arts. There is speculation that grunting during exertion can be damaging to an individual's vocal folds. There is also a belief by some sports commentators that the production of voice during a maximum effort can be distracting to others around the athlete. Subsequently, there has been an effort in some sports (i.e., tennis) to ban vocalization in competition. The impact of vocalization during high intensity physical effort has not been investigated extensively. This study was conducted to help determine if there is support for the belief that grunting provides a performance advantage and if voice production during sport is correlated with perception of voice impairment.

The vocal folds play a primary role in lifting heavy objects by adducting tightly and keeping air inside of the lungs to provide a source of support (Stemple, Glaze & Klaben, 2000). This technique, known as "air trapping" or the Valsalva maneuver, is present when an individual is producing maximum effort, such as lifting a heavy object or pushing for maximum force. Air trapping is defined as "the trapping of exhaled air inside the thoracic cavity" (Naito & Niimi, 2000, p. 1147). In most individuals, the larynx is closed during maximum effort body movements, such as lifting weights and exerting maximum amounts of force (Naito & Niimi, 2000). Conversely, reduced ability to produce power during lifting may occur when the ability to adduct the larynx is compromised. This occurs when individuals are unable to build up the intrathoracic pressure that is required for trunk stabilization. In a survey conducted on eighty-two surviving laryngectomees, individuals who had their larynx removed, it was determined that 57%

of them experienced difficulties in lifting heavy objects post surgery (Jay, Ruddy & Cullen, 1991). The closure of the larynx is vital to the trapping of air in the thoracic cavity; however, there are questions regarding if the release of that air in the form of a grunt or vocalization while producing maximum force will increase power and subsequently improve performance.

In a study conducted by Morales, Owen, and O'Connell (1999), it was determined that the use of grunting did not improve the dead lift force in athletes. The effects of grunting on velocity and force production during tennis strokes was observed in a study in which thirty-two Division II and Division III collegiate tennis athletes participated (O'Connell, Hinman, Hearne, Michael, & Nixon, 2014). Electromyography (EMG) data was obtained from the participants' dominant pectoralis major and contralateral external oblique muscles. The findings indicated that dynamic velocity and isometric force of both serves and forehand strokes were significantly greater when the subjects grunted, despite prior athlete use of grunting or belief in importance of grunting. Peak muscle activity in the external oblique and pectoralis major muscles was also greater when the individuals grunted during both types of strokes. Callison, Berg, and Slivka (2014) conducted a study to determine if grunting enhanced ball velocity in groundstrokes and if grunting increased the physiological cost of hitting. It was found that grunting increased ball velocity without increasing oxygen consumption or ventilation.

Aside from the empirical evidence that supports performance advantage when voice is used during exertion, a strongly held belief of its benefit may influence performance. There are many online forums for body builders and athletes that discuss the use of voice during maximum effort. Some athletes believe that they gain a performance advantage when they use their voice during force production. There is a great amount of discussion regarding the use of voice during competitive elite women's tennis, with some opponents asserting that it is not vital to their athletic performance. In fact, it has been proposed that vocalizations in women's tennis be removed from the game of tennis altogether (Slothower, 2012). However, professional women's tennis players state that if vocalizations while playing were banned; they would not be able to perform at their usual level (Nagle, 2012). Even if there was a lack of empirical support for the benefit of vocalizing during power tasks, belief in the importance of vocalizing while performing may have a considerable impact on an individual's performance.

In an effort to rid sports of these vocalizations, it has been asserted that producing voice during maximum effort may be damaging to the vocal folds. To date, there is little empirical evidence to support this. A comprehensive search of the literature did not yield evidence supporting a correlation between voice use during maximum exertion and voice disorders. Knowledge of the manner in which voice is produced may provide insight on the effect that producing voice during a maximum effort can have on the laryngeal tissue and, ultimately, voice quality. Orlikoff (2008) investigated the physiologic changes in voice production associated with a weightlifting and support maneuver. The results of this study described greater EEG closed quotient indicating greater medial compression of the vocal folds when participants phonated while lifting a weight.

An aspect of vocalization that may be related to sport performance outcome is the use of voice for mentally "psyching up" the athlete. This can either be accomplished just before the sport event or during the peak of exertion. A psyching-up technique used by martial artists is known as Ki or inner energy. Ki is energy that is believed to build up below the navel and is released by a sharp exhalation of air in the form of a yell known as a "kiap" (Tschampl, 2009). Martial artists place such importance on the use of voice in their physical exertions, that they named the voiced aspect of the technique. The kiap is used in a variety of sports where a burst of energy is necessary, such as power lifting, track and field, and martial arts. In a study using a handgrip exercise it was found that when using the kiap technique, individuals' handgrip strength was increased by a mean of 8 percent when compared to the no kiap trials (Tschampl, 2009).

It is known that there is a build-up of pressure in the subglottal region when lifting heavy objects and this is accomplished by tightly closing the larynx and other supraglottic structures. There is a belief that allowing voice to be produced during this pressure build-up or release enhances sport performance; however, there is insufficient evidence to support the use of vocalization for a performance advantage. There is belief of potential laryngeal damage secondary to voicing during maximum effort that is not evidence supported. Due to a belief by some athletes that vocalizing during maximum effort improves their performance and the potential for laryngeal tissue damage from that phonotraumatic behavior, there is a need for research in this area.

Vocalization during force production is considered essential for performance for some athletes, the degree of which is not currently known. Due to the speculation that vocalizing during maximum effort or for psyching up may be damaging to the vocal folds, some professional sports are attempting to eliminate this action, perhaps to the detriment of athlete performance. The purpose of this study was to determine if athletes believe that using voice during force production is beneficial to sport performance. This study was also designed to determine if report of vocalization during effortful tasks was correlated to perception of voice impairment. The hypotheses were as follows: (A) there is a belief among athletes that voicing (using the voice) during high effort tasks improves performance and, (B) the use of the voice during high effort tasks is correlated with the perception of voice impairment.

METHOD AND PROCEDURES

Participants

For this survey, males and females ages 19-65 were recruited to participate in an anonymous, on-line survey. Participants were recruited from sports teams and gyms throughout the United States. Flyers were posted and sent to coaches and trainers, as well as posted on on-line athlete forums requesting participants for the study. Participants included athletes and non-athletes. Competitive athlete was defined as follows: one who participates in competitive events, often times associated with a club or sports program (e.g. Collegiate Sports) and training is directed towards improvements in performance. Those who exercise may participate in competitions and their end goal may be related to health, fitness, weight loss, appearance, etc. but not specifically focused on performance. There were no exclusion criteria in this study.

Procedures

After receiving permission from Auburn University's Institutional Review Board, participants were recruited to participate in an on-line survey, generated by Qualtrics software, of the Qualtrics Research Suite (Copyright © 2015, Provo, UT). Participants who expressed interest in the study were directed to a website for the survey. The recruitment letter is in Appendix A. The anonymous survey consisted of demographic questions regarding the person's sex, age, and participants were asked to self-identify as either an athlete or non-athlete, with the definition for athlete as previously described provided within the survey. The participant determined if they believed that vocalizing during maximum effort (lifting weights, throwing, etc) increased their performance. The participant was also asked if they produced voice while participating in maximum force production activities or for psyching up. The participant was then directed to complete the Voice Handicap Index-10 (VHI-10; Rosen, Lee, Osborne, Zullo & Murry, 2004) to determine if there were any indications of perceived voice impairment. The detailed survey questions are provided in Appendix B.

Data Analysis

Descriptive statistics were used to describe the participant pool and address athlete belief that using voice during effort influences performance. Pearson correlation analysis was used in a 2 (athlete or non-athlete) by 2 (grunt or no grunt) by 2 (VHI and PPE) design to identify correlations between the groups. Significance was set at $\alpha<0.05$. No post hoc comparisons were performed. Normality assessments were made with visual inspection of QQ plots and histograms. All data met normality assumptions and no transformations of the raw data were required; therefore all of the data analyses reported in this investigation were based on the raw data. The correlation analysis for this paper were generated using SAS software, Version 9.3 of the SAS System for XP-Pro (*SAS Institute Inc., Cary, NC, USA).*

RESULTS

Participants

Four hundred and eighty seven participants were recruited for the study and 378 of the participants completed the entire survey. Those 378 completed surveys were used for data analyses. Approximately 68% of the participants were female, and 32% were male. While the majority of the participants were within the 19-29 year old range, ages 19-70+ were represented in the results. A large number of the participants who completed the survey considered themselves to be of the white/Caucasian race (91%). Individuals who considered himself or herself to be African American, Hispanic, Asian, or “other” (white American, Arabic, Indian, Mix-Caucasian/Pacific Islander, Black and White) were also represented. The majority of the participants lived within the South East region of the United States of America; however, most of the states within the US were represented. Six percent of the participants lived outside of the United States. Refer to Table 1 for a summary of participant demographics.

Table 1. Participant Age, Sex, Ethnicity, and Geographical Region

Demographics			
Age	**Male**	**Female**	**Total**
19-29	85	184	269
30-39	31	61	92
40-49	29	49	78
50-59	7	25	32
60-69	3	1	4
70+	1	3	4
Ethnicity			
White/Caucasian	136	303	439
African American	10	7	17
Hispanic	3	7	10
Asian	3	2	5
Native American	1	1	2
Pacific Islander	0	0	0
Other	3	5	8
Geographical Region			
Northeast	14	19	78
Southeast	90	254	344
Southwest	13	17	30
West	12	9	21
Midwest	10	13	23
Non-Continental U.S.	1	0	1
Not in U.S.	16	11	29

The participants of the survey were provided with a definition of a competitive athlete for the purposes of this study. Out of the group of 378 who finished the survey, 152 identified themselves as competitive athletes, 49% of males and 25% of females. The types of athletes that were represented in this study included: football, basketball, baseball, volleyball, tennis, weightlifter, soccer, mixed martial arts, running, Crossfit, tri-athlete, lacrosse, rugby, golf, and softball. Refer to Table 2 for a summary of athletes' profiles.

Table 2. Athlete Profiles

Gender	**Total**
Male	76
Female	82
Age Range	
19-29	96
30-39	37
40-49	18
50-59	7
60-69	1
70+	0
Race	
White/Caucasian	137
African American	8
Hispanic	4
Asian	3
Native American	2
Pacific Islander	0
Other	6
Geographical Region	
Northeast	15
Southeast	94
Southwest	11
West	17
Midwest	11
Non-Continental U.S.	0
Not in U.S.	11
White/Caucasian	
Type of Athlete	
Football	3
Basketball	1
Baseball	10
Volleyball	1
Tennis	6
Weightlifter	13
Soccer	5
Martial Arts/Mixed Martial Arts	4
Racquetball	0

Running	13
Crossfit	17
Triathlete	3
Other	20

Beliefs Regarding Use of Voice for Improved Performance

Of the 152 individuals who identified themselves as competitive athletes, 86 (56.6%) indicated that they *believed* that using their voice during a maximum effort provided a performance advantage. Of the 298 individuals who did not define themselves as competitive athletes, 134 (45%) responded that they *believed* that vocalizing during maximum force provided a performance advantage. One hundred and six participants (69%) who defined themselves as athletes indicated that they use their voice for force production, and 148 non-athletes (49%) state that they did as well. Out of the entire group of participants, both athletes and non-athletes, 100 male (22%) and 152 female (34%) participants responded that they produce voice with maximum effort. The results of the study also showed that grunting during force production is more common among the 19-29 age range (56%). Participants who were more likely to report that they used voice along with maximum effort were athletes such as bodybuilders and individuals who participate in Crossfit than other types of athletes such as football, baseball, basketball, volleyball, running and soccer. Of the individuals who stated that they use their voice with maximum effort, 11% reported that they use their voice in order to intimidate their opponent.

This study also evaluated the moment at which individuals produced voice during their effort; before, sometime during force production, or after. Fifty-six percent of the participants indicated that the most common timing for use of voice production is in the middle of maximum effort. For details regarding reports of voice timing during maximal effort, refer to Table 3.

Table 3. Timing of Voice Production

<table>
<tr><th colspan="3">Do you make noise with your voice when producing effort?</th></tr>
<tr><td rowspan="7">When do you use your voice for performance?</td><td></td><td>YES</td></tr>
<tr><td>Before the production of a maximum effort</td><td>9</td></tr>
<tr><td>At the beginning of a maximum effort</td><td>21</td></tr>
<tr><td>In the middle of the production of a maximum effort</td><td>115</td></tr>
<tr><td>At the end of a maximum effort</td><td>49</td></tr>
<tr><td>After the production of a maximum effort</td><td>10</td></tr>
<tr><td>TOTAL</td><td>204</td></tr>
</table>

Perception of Voice Impairment

Means and standard deviations for the Voice Handicap Index-10 (VHI-10) scores and perceived phonatory effort (PPE) are reported in Table 4. No significant differences were found between the groups when the full model was applied $F(3,256)=0.72$, $p=0.54$.. No post-hoc analysis was completed. The mean scores described for each group corresponded to a perception of mild voice impairment.

Table 4. Means and standard deviations for VHI-10 and PPE by group

Athlete	Voice	VHI-10 (mean; SD)	PPE (mean; SD)
No	No	4.06 (5.10)	16.79 (22.03)
No	Yes	3.04 (3.56)	16.96 (23.12)
Yes	No	3.64 (5.13)	15.24 (24.38)
Yes	Yes	3.36 (4.83)	18.18 (23.27)

VHI-10 score range = 0-30; PPE score range = 0-100 mm

Correlation of Voice Use with Perceived Voice Effort

Statistical analyses indicated a moderate correlation (0.38, $p<.0001$) between PPE and VHI-10 scores. No significant correlation between use of voice with effort and VHI-10 (-0.08, p=0.13) or use of voice with effort and PPE (0.04, p=0.46) was identified. Refer to Table 5 for details of the correlation analyses.

Table 5. Pearson Correlation Coefficients, N=378

	Grunt	**VHI-10**	**PPE**
Grunt	1.000	-0.077 *p*=0.134	0.038 *p*=0.456
VHI-10		1.000	0.377 *p*<.0001*
PPE			1.000

VHI-10=Voice Handicap Index-10; PPE=perceived phonatory effort; * indicates significant

Discussion

The purpose of this study was to determine if there was a belief among athletes that producing voice during maximum effort provided a performance advantage and if those who do use voice report a greater perception of voice impairment than those individuals who do not use voice. It was hypothesized that there is a belief among athletes that the use of voice improves performance and that those athletes who produce voice were more likely to have a perception of voice impairment. The results of the on-line survey showed that about half of the participating athletes believed that the production of voice during maximum effort provided an advantage to performance. Therefore, the hypothesis that athletes believe that vocalization improves performance was met. There was no correlation between individuals who use voice during force production and the perception of voice impairment.

There is a belief among athletes that producing voice during maximum effort provides a performance advantage (Nagle, 2012) and the results obtained from this survey supported this assertion. While early literature stated that there is no performance advantage from using voice (Morales, Owen & O'Connell, 1999), more recent literature supports the hypothesis of an increase in force production when using voice (Callison, Berg, & Slivka, 2014; O'Connell, Hinman, Hearne, Michael, & Nixon, 2014). The survey results indicated, however, that the number of participants who reported a belief in the benefit of voice use for performance gains (69%) was lower than the number of participants reporting that they actually use voice during force production (56.6%). Even if some athletes do not believe that voicing during force production is helpful, many report using their voice when producing a maximum effort.

It has been speculated that individuals who use voice during sport performance are more likely to damage their vocal folds than those who do not. The results of this survey showed no correlation between individuals who use voice during maximum effort and perception of voice disorder. While use of the VHI-10 does not provide direct evidence of vocal fold damage or voice disorder, it is considered to be a valid measure of perceived vocal impairment for evidence-based practice (Rosen, Lee, Osborne, Zullo, & Murry, 2004). It could be hypothesized that degree of voice impairment may depend on exactly how the voice is used for specific sports. While the number of respondents to this survey provided adequate responses for the hypotheses proposed in this study, additional work to study specific types of athletes, endurance versus power, and specific voice use patterns would refine our understanding of perceived vocal impairment associated with physical effort.

It has also been speculated in previous literature (Sinnett & Kingstone, 2010; Sekuler, Sekuler, & Lau, 1997; Navratilova, 2009) that individuals who produce voice during effort are trying to intimidate their opponents. A recent study provided evidence to dispute this assertion by concluding that rather than intimidating opponents, voicing in tennis may cue the opponent as to where the ball will go (Sinnett & Kingstone, 2010). Perhaps the vocalizations do less to intimidate the opponent and more to provide information of performance. While the survey results do not support opponent intimidation as a conscious reason to use voice during force production, it may be that some athletes use voice unconsciously to intimidate their opponents despite indicating voice use for power production and psyching up.

An interesting finding of this study was the moderate correlation determined between the VHI-10 scores and perceived phonatory effort (PPE) rating reported. The visual analog scale method for determining PPE is commonly used in clinical and research efforts; however, this scale has not been standardized or validated to date. This evidence provides some support for use of the PPE visual analog scale in future investigations that include PPE as a measure.

The findings from this survey could be useful for athletes, coaches, speech language pathologists and otolaryngologists. Athletes in competitive sports could use the evidence gathered from this study to consider if grunting during maximum effort can provide a performance advantage. Self-reflection on how vocalization is used in sport can help an athlete maximize use of grunting with the kinetic chain of movement required to produce the most power output. Coaches of competitive sports could advise their athletes to experiment with the use of voice when producing maximum effort to determine if it assists their performance. Coaches could also consider when use of vocalization is most beneficial for the athletes, e.g., more toward the end of competition when fatigue is setting in. Speech language pathologists (SLPs) and otolaryngologists who treat athletes with voice disorders should keep in mind the importance of voicing during effort tasks for competitive athletes. Rather than recommending that athletes completely stop voicing during effort, the cost-benefit ratio for competitive performance should be considered in the context of the presenting voice disorder. SLPs could assist athletes in altering the way that they produce voice. Changing the pitch or intensity with which athletes produce voice with effort could potentially provide a less harmful way to harness the benefits of vocalization with less vocal fold tissue damage.

Strengths of this study included development of a survey that was easy to access and complete, therefore a large number of responders were obtained. Due to the accessibility of the study, a wide age span was represented in the results and individuals from all over the United States of America were able to participate in the survey. There was also almost equal representation from both men and women athletes. Use of a well-validated measure of perceived vocal impairment (VHI-10) was an additional strength of the study. A validated measure elicits information that is considered to actually evaluate what it claims to assess. By providing participants with a well-validated measure, the study was able to obtain information that is valid and reliable. The data acquired through the VHI-10 provides a score that reliably identifies perception of voice disorder. This was an improved method from merely asking the participants to self-report if they had a voice disorder.

Limitations of this study included the possibility that the survey questions were misinterpreted by participants and may not have been a true representation of what the participants believed or experienced. The portion of the study that evaluated the timing of voicing with effort could have provided more in depth questions in order to gain more insight as to the exact nature of voice use. The option was not presented to the participants to select if they produced voice throughout the entire force production. It may be that producing voice for the entire duration of force production could make an individual more susceptible to a voice disorder. More opportunity should have been provided so participants could expand on their voice use experiences in their own words. Gaining individual's insight could have provided a more in depth understanding of the belief of performance advantage with voice production. For example, athletes may have a bias regarding type of voice used, e.g., short grunt versus a higher-pitched yell. Exact nature of type of voice used during exertion could offer additional direction for understanding if particular voice use patterns are more likely to correlate with perception of voice disorder.

Additional questions regarding state of health in general would have been beneficial as many factors may influence perception of vocal impairment. If individuals were taking medications that had a drying effect on the vocal folds (i.e., decongestants, anti-depressants), this may have made voicing more effortful with a subsequent change to both the VHI-10 and PPE scores. Other health conditions can contribute to voice impairment such as presence of reflux, allergies, or asthma.

While representation from various parts of the United States of America was seen, the study lacked balanced representation from all parts of the US. This initial survey allowed athletes and non-athletes to participate in the study; however, a survey targeting only athletes may yield results that would have allowed comparisons between different athlete types. The evaluation of different athlete types would provide insight on which type of athletes were more likely to produce voice during maximum effort. If a specific group of athletes had a higher prevalence of voice disorders, then that could affect the way that those athletes should be trained. A more in depth examination of specific types of athletes, their use of grunting during force production, and the prevalence of voice disorder would be useful information in the treatment and prevention in future athletes.

Conclusion

This study supported the hypothesis that there is a belief among athletes that producing voice with maximum effort provides a performance advantage. There was no correlation between the use of use of voice with effort and the perception of voice impairment. The moderate correlation between the VHI-10 and the PPE measurement provides support for future use of the visual analog scale for PPE rating. Based on these findings, future directions for research could include objective measurement of force production concurrent with vocal function measures in both grunt and non-grunt trials. Athletes who participate in this study should include those who typically grunt when producing effort as well as those who do not typically use voice with force production. The intensity and pitch of voice that is produced during maximum effort should also be monitored. The vocal folds of both grunting and non-grunting athletes should be evaluated through the use of video stroboscopy in order to determine if there are indicators of phonotrauma. Insight on the effects that voicing during maximum effort has on performance may help athletes and coaches better understand the role that vocalization plays physiologically. Additional insight may also help health care providers refine treatment pathways for athletes with voice disorders.

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Appendix A

Information Letter
For a Research Study Entitled

You are invited to participate in a research study to evaluate the perception of the impact of vocalization during maximum force production. This study is being conducted by researchers in the Department of Communication Disorders at Auburn University: Mary Sandage, Ph.D.,CCC-SLP, Assistant Professor; Laura Plexico, Ph.D., CCC-SLP, Associate Professor; and Kelly Davis, a master's student in Speech-Language Pathology at Auburn University. You are invited to be a participant if you are age 19 years of older, and are a competitive athlete.

If you decide to participate in this research study you will be asked to complete an online survey form. Your total time commitment will be approximately 5 to 20 minutes.

There is always a risk of break of confidentiality with surveys; however, all responses will be completely anonymous with no identifying information whatsoever being collected. All reasonable and customary security measures will be taken. The data will be sorted behind a secure firewall and all security updates are applied in a timely fashion.

Any data obtained in connection with this study will remain anonymous. Information collected through your participation may be published in a professional journal, and/or presented at a professional meeting.

If you wish to withdraw after you start the survey, simply close your browser without submitting the data. Once you have submitted anonymous data, it cannot be withdrawn due to it being unidentifiable.

I hope that you will consider completing the survey. If you have any additional questions or concerns, please feel free to contact me.

HAVING READ THE INFORMATION ABOVE, PLEASE DECIDE IF YOU WANT TO PARTICIPATE IN THIS RESEARCH PROJECT. IF YOU DECIDE TO PARTICIPATE, INDICATE THAT YOU AGREE TO DO SO BY CLICKING ON THE FOLLOWING LINK TO ACCESS THE SURVEY.

I AGREE TO PARTICIPATE:

YOU MAY PRINT A COPY OF THIS LETTER TO KEEP.

If you have any questions, please contact:

Mary Sandage, Ph.D., CCC-SLP
sandamj@auburn.edu

Kelly Davis
kmd0008@auburn.edu

Auburn University IRB
(334) 844-4784

Appendix B

Vocalization and Sport Performance Questionnaire

Q1 Gender

- Male
- Female

Q3 Age Range

- 19-29
- 30-39
- 40-49
- 50-59
- 60-69
- 70+

Q4 In what state do you currently reside?

- Alabama
- Arizona
- Arkansas
- California
- Colorado
- Connecticut
- Delaware
- District of Columbia
- Florida
- Georgia
- Idaho
- Illinois
- Indiana
- Iowa
- Kansas
- Kentucky
- Louisiana
- Maine

- Maryland
- Massachusetts
- Michigan
- Minnesota
- Mississippi
- Missouri
- Montana
- Nebraska
- Nevada
- New Hampshire
- New Jersey
- New Mexico
- New York
- North Carolina
- North Dakota
- Ohio
- Oklahoma
- Oregon
- Pennsylvania
- Rhode Island
- South Carolina
- South Dakota
- Tennessee
- Texas
- Utah
- Vermont
- Virginia
- Washington
- West Virginia
- Wisconsin
- Wyoming
- Puerto Rico
- Alaska
- Hawaii
- I do not reside in the United States

Q7 What is your race?

- ❍ White/Caucasian
- ❍ African American
- ❍ Hispanic
- ❍ Asian
- ❍ Native American
- ❍ Pacific Islander
- ❍ Other ____________________

Q8 Are you a competitive athlete? We have defined a competitive athlete as one who participates in competitive events, often times associated with a club or sports program (e.g. Collegiate Sports). Their training is directed towards improvements in performance. Those who exercise may participate in competitions and their end goal may be related to health, fitness, weight loss, appearance, etc. but not specifically focused on performance.

- ❍ Yes
- ❍ No

Q9 What type of athlete are you?

- ❍ Football
- ❍ Basketball
- ❍ Baseball
- ❍ Volleyball
- ❍ Tennis
- ❍ Weightlifter
- ❍ Soccer
- ❍ Martial Arts/Mixed Martial Arts
- ❍ Racquetball
- ❍ Running
- ❍ Crossfit
- ❍ Triathlete
- ❍ Other ____________________

Q15 How many times each week do you exercise?

- ❍ Not at all
- ❍ 1-2 times per week
- ❍ 3-4 times per week
- ❍ 5 or more times per week

Q15 What is the approximate duration of your exercise sessions?

- ❍ 15-30 minutes
- ❍ 30 minutes to 1 hour
- ❍ 1-2 hours
- ❍ 2 or more hours

Q16 At what intensity do you perform during exercise?

- ❍ Light intensity
- ❍ Medium intensity
- ❍ High intensity

Q10 Do you use your voice by yelling, singing, or grunting before a maximum effort to psych yourself up prior to a performance?

- ❍ Yes
- ❍ No

Q17 Which of the following do you use to before a maximum effort to psych yourself up prior to a performance?

- ❍ Yelling
- ❍ Singing
- ❍ Grunting

Q11 Do you believe that using your voice, such as grunting or yelling, during maximum effort provides an advantage to performance?

- ❍ Yes
- ❍ No

Q12 Do you make noise with your voice during your maximum effort?

- Yes
- No

Q18 When do you use your voice for performance?

- Before the production of a maximum effort
- At the beginning of a maximum effort
- In the middle of the production of a maximum effort
- At the end of a maximum effort
- After the production of a maximum effort

Q13 Do you use your voice to intimidate your opponent?

- Yes
- No

Q16 The Voice Handicap Index-10 (Laryngoscope, 114:1549-1556, 2004).Instructions: These are statements that many people have used to describe their voices and effects of their voices on their lives. Circle the response that indicates how frequently you have the same experience.

	0= never	1=almost never	2= sometimes	3=almost always	4=always
My voice makes it difficult for people to hear me.	❍	❍	❍	❍	❍
People have difficulty understanding me in a noisy room.	❍	❍	❍	❍	❍
My voice difficulties restrict personal and social life.	❍	❍	❍	❍	❍
I feel left out of conversation because of my voice.	❍	❍	❍	❍	❍
My voice problem causes me to lose income.	❍	❍	❍	❍	❍
I feel as though I have to strain to produce voice.	❍	❍	❍	❍	❍
The clarity of my voice is unpredictable.	❍	❍	❍	❍	❍
My voice problem upsets me.	❍	❍	❍	❍	❍
My voice	❍	❍	❍	❍	❍

makes me feel handicapped.					
People ask, "What's wrong with your voice?"	❍	❍	❍	❍	❍

Q17 Please use the line below to indicate how effortful voicing is for you. Move the slider to the point of the line that matches how much effort you use for your voice. A mark on the left end would indicate little or no effort. A mark on the right end would indicate a lot of effort.

No effort Maximum Effort