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Effects Of Simultaneous Exercise And Speech Tasks On The Perception Of

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EFFECTS OF SIMULATANEOUS EXERCISE AND SPEECH TASKS ON THE PERCEPTION OF EFFORT AND VOCAL MEASURES IN AEROBIC INSTRUCTORS

by

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ABSTRACT

The purpose of this study was to investigate the effects of voice production and perception of dyspnea in aerobic instructors during simultaneous tasks of exercise and speech production. The study aimed to document changes that occur during four conditions: 1) voice production without exercise and no use of amplification; 2) voice production without exercise and the use of amplification; 3) voice production during exercise without the use of amplification; 4) voice production during exercise with the use of amplification. Participants included ten aerobic instructors (two male and eight female). The dependent variables included vocal intensity, average fundamental frequency (F_0), noise-to-harmonic ratio (NHR), jitter percent (jitt %), shimmer percent (shim %), and participants' self-perception of dyspnea.

The results indicated that speech alone, whether it was with or without amplification, had no effect on the sensation of dyspnea. However, when combining speech with exercise, the speech task became increasingly difficult, even more so without the use of amplification. Exercise was observed to inhibit vocal loudness levels as vocal intensity measures were lowest in the conditions with exercise with the use of amplification. Increases in F_0 occurred in conditions involving exercise without the use of amplification. Moreover, four participants in various conditions exhibited frequencies that diverged from their gender's normal range. Participants' NHR increased during periods of exercise, however no participants were found to have NHR measures outside the normal range. Four participants were found to have moderate laryngeal pathology that was hemorrhagic in nature.

Findings suggest that traditional treatment protocols may need to be modified beyond hygienic approaches in order to address both the respiratory and laryngeal work-loads that are encountered in this population and others involving similar occupational tasks.

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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 1: INTRODUCTION

In many occupations, reliance of one's voice to perform a job adequately is crucial. Occupations such as singers, telemarketers, teachers, lawyers, ministers, sales personnel, and many others require the use of one's voice to adequately communicate with others in the work environment. In many cases, the demands placed on the voice production mechanism to deliver the message sufficiently can be vocally as well as physically challenging. Hoffman-Ruddy, Lehman, Crandell, Ingram, and Sapienza (2001) used the term "high-risk" to describe a group of vocal performers. Factors contributing to vocal difficulties included a less than optimum work environment such as physical interference with costumes, improper amplification, an outside stage environment with competing noise from crowds, and extreme amounts of performance demands. Unfortunately, when faced in conditions with high voice demand and environmental constraints, many individuals often engage in vocally abusive behaviors such as excessive screaming, loud talking, talking over environmental noise, inadequate breath support, increased pitch levels, excessive talking, dehydration, and musculoskeletal tension. These behaviors in turn can affect the larynx, resulting in a strained/strangled vocal quality, dysphonia, aphonia, and/or potentially lead to laryngeal pathologies. When speaking becomes too effortful, painful, or inadequate for one's occupational needs, livelihoods may be impacted, resulting in a loss of job or extended time off of regular work duties.

One occupation, which has not received considerable attention, is aerobic instructors. Aerobic instructors not only experience high levels of vocal demand and

compete against background noise, (i.e. music and noise created by aerobic participants), but are also required to produce a loud, high energy voice during increased levels of ventilatory activity required for the aerobic task. Like the theme park performers studied by Hoffman-Ruddy et al. (2001), aerobic instructors also face challenges with improper amplification, competition from environmental noise, and engage in excessive voice use at extreme loudness levels. Environmental challenges such as these can affect the laryngeal anatomy, potentially causing vocal abuse and laryngeal injury. Some of these conditions can include vocal fold edema, increased vascularity, vocal fold nodules, polyps, and/or polypoid changes (Sataloff, 1998; Heidel & Torgerson, 1993).

In the general body of literature, studies have historically focused on patterns of voice use, vocal abuse, intensity, and duration of voice production when observing changes to laryngeal structure or function. To date, there have been few studies that focus on describing the conditions or tasks that may influence voice production during exercise and speech. Since the occupational requirements of aerobic instructors require both speech and exercise to occur simultaneously, this seemed like an appropriate population to study. The intent of this descriptive study is to better understand the load of the respiratory and laryngeal systems during their simultaneous interaction in order to apply experimental protocols that may lead to more appropriate treatment paradigms to address both respiratory and laryngeal issues.

In a study comparing aerobic instructors and aerobic participants, Heidel & Torgerson (1993) concluded that aerobic instructors endure increased amounts of voice problems in comparison to aerobic participants. Of the aerobic instructors studied, 55%

experienced more hoarseness since beginning instructing, while only 4% of the aerobic participants felt more hoarseness since they began participating in aerobic activity. Overall, the instructors reported to experience more hoarseness, voice loss during and after aerobic instruction, and vocal nodules. Similarly, Long, Williford, Olson, and Wolfe (1998) presented self-reported voice problems in female aerobic instructors as well as the individuals teaching practices, illness, environment, and vocal hygiene practices. Results of the study indicated that 44% of the subjects reported experiencing voice loss, and 43% reported partial voice loss while instructing or immediately after instruction. Variables distinguishing the voice loss and no-voice loss groups were greater in teaching practices than other non-teaching variables, (i.e. illness and environment). The study also demonstrated that 88% of the instructors with self-reported voice problems indicated shouting as a way of cueing their instructional class. In addition, 67% of the instructors with voice problems did not use a microphone while instructing; although microphone usage and music volume were not statistically significant factors in differentiating the voice loss and no-voice loss groups. Overall, this study indicated that there was minimal knowledge among the instructors on vocal hygiene techniques.

Heidel & Torgerson (1993) demonstrated that despite the majority of the aerobic instructors being exposed at some point to methods of vocal hygiene, vocal problems still persisted. The authors suggested that intensifying vocal hygiene education and information might have a more positive effect. Several studies have shown that aerobic instructors experience similar voice demand during exercise as cheerleaders and also possess similar physical characteristics such as an athletic body type (Bravender, 1980),

and secondly, the subjects display an aggressive personality structure (Heidel & Torgerson, 1993), inferring that the hyperkinetic reaction of mucosa in the muscular body type is associated with aggressive hyperkinetic movements of phonation, resulting in a tendency to form vocal nodules (Bravender, 1980).

Similar to aerobic instructors and cheerleaders are drill sergeants. Drill sergeants vocal demand at work includes loud vocal use, with hard glottal attacks when commanding a large group of soldiers in an outside environment. Mann et al. (1999) aimed to document acoustic voice changes as a result of acute vocal abuse in this population over a 5 day vocally demanding training cycle. The training cycle included prolonged periods of shouting while instructing large groups of soldiers throughout the day. Acoustic analyses revealed positively skewed ratings during the latter half of training on perturbation measures of jitter and shimmer in 11 of the 26 subjects, suggesting that vocal abuse over extended periods of time can affect quality of voice. Analysis of the structural and functional changes observed on the vocal folds using laryngeal videostroboscopy proved to be a more sensitive tool for documenting the effects of vocal abuse, as significant increases in vocal fold edge irregularity, erythema, edema, mucosal wave, and amplitude of excursion were seen. The authors suggest that intersubject variability observed in acoustic and stroboscopic measures may have been due to differences in laryngeal anatomy, phonatory technique, and vocal hygiene practices, as well as the fact that the initial 42 participants seen revealed inadequate understanding of proper voice techniques.

Sapir, Atias, and Shahar (1990) compared symptoms of vocal attrition in women army instructors to their new recruits. These instructors had daily duties requiring many hours of voice use, under unfavorable conditions such as speaking against loud background noise and speaking in an open field to a large audience. Unlike the army instructors, the recruits' daily activities required no voice use, with the exception of repeating instructions in a loud voice or occasionally chanting while marching. It was found that the instructors had significantly more symptoms of vocal attrition than the recruits. Seventy percent of the instructors indicated that their symptoms had begun or increased in severity during their military service, versus only 11% of the recruits indicated their symptoms had begun or became more severe during service. However, nearly one quarter of the instructors were reportedly symptom free, suggesting that extensive vocal demands do not necessarily result in vocal problems (Sapir et al., 1990). Instead, efficient control of the vocal mechanism, awareness of hygienic vocal behaviors, biological resilience to trauma, personality, and/or belittling the significance of existing symptoms were other possible explanations (Bistrizki & Frank, 1981; Reich & McHenry, 1987; Keidar, Wetzel, & Cloninger, 1989).

In order to appropriately investigate how the demands of physical activity that are encountered with aerobic instruction affect laryngeal structure and function, an in-depth understanding of normal respiratory and laryngeal physiology must be understood and reviewed.

Normal Laryngeal Anatomy

The larynx is a musculo-cartilaginous structure located at the superior end of the trachea opposite approximately the fifth or sixth cervical vertebral body (Zemlin, 1988). The larynx is composed of three unpaired and three paired cartilages bound by ligaments and lined with mucus membranes (Zemlin, 1988). The unpaired cartilages include the thyroid cartilage, the cricoid cartilage, and the epiglottis. The paired cartilages include the arytenoids, corniculate cartilages, and the cuneiforms. The vocal folds lie within the laryngeal structure, which consists of three cavities. The first cavity is the supraglottic cavity, which is located between the vocal folds and the aryepiglottic folds. This cavity functions as a resonator of the sound produced by the vocal folds. The second cavity is the subglottal cavity, which is located between the vocal folds and the first tracheal ring. It is here that subglottal pressure increases until it is sufficient enough to begin vocal fold vibration. The third cavity consists of the ventricles, which are lateral spaces between the false and true vocal folds containing mucus glands imbedded within fatty tissue. The main function of the ventricles is to assist in resonance (Zemlin, 1988). The activity of both the intrinsic and the extrinsic laryngeal muscles is important to appreciate how the larynx responds to certain pathological conditions. In addition, the laryngeal muscles function must be understood in order to implement appropriate treatment for laryngeal problems.

The intrinsic laryngeal muscles have three origins and insertions within the laryngeal vestibule. The posterior cricoarytenoid is a significant muscle for breathing, functioning to abduct the vocal folds, and in turn, open the glottis. If this muscle is

bilaterally paralyzed, the vocal folds will remain closed, or in a state of partial adduction, thus obstructing normal breathing, which is a life threatening condition. The cricothyroid muscle decreases the distance between the thyroid and cricoid, which in turn increases the distance between the thyroid and arytenoids (i.e., increasing the length of the vocal folds, decreasing relative mass and increasing the tension). The result is an increase in fundamental frequency. The thyroarytenoid muscle is divided into two muscle groups: a) the thyrovocalis muscle group, and b) the thyromuscularis muscle. These muscles work to decrease the distance between the thyroid and arytenoids, and in turn decrease the length of the vocal folds by increasing relative mass and decreasing tension. As a result, fundamental frequency decreases. The lateral cricoarytenoid is located on the anterior surface of the muscular process of the arytenoids, its function being to adduct the vocal processes of the arytenoids, thus closing the vocal folds. The arytenoideus or interarytenoids are positioned between the two arytenoid cartilages. The effect of the interarytenoids are twofold: to adduct the arytenoids and close off the posterior glottis (Colton & Casper, 1996).

Extrinsic laryngeal muscles have one attachment in the laryngeal structure and a second attachment to structures outside the larynx, such as the mandible, the mastoid, styloid process, and sternum. Suprahyoid external laryngeal muscles (the digastric, the geniohyoid, the mylohyoid, and the stylohyoid) function mainly as laryngeal elevators while the infrahyoid external laryngeal muscles (the sternohyoid, sternothyroid and omohyoid) function as laryngeal depressors (Zemlin, 1988). Laryngeal tension resulting

from concomitant vocal behavior and compensatory straining of the larynx are often appreciated in the extra laryngeal musculature.

Dysphonia, in the absence of any identifiable structural disturbances to the larynx or neurological pathology, compromises a large percentage of the population seen in voice clinics (Schalen & Anderson, 1980). These dysphonias are often associated with abnormal muscle activation (Ludlow, 1990). This type of muscle activation in the larynx is characterized as an imbalance of individual movement of laryngeal muscles that are acted upon for voice production (Titze, 1994). Musculoskeletal tension is another term associated with abnormal type of muscular activation characterized as vocal hyperfunction (Aronson, 1990). An extreme example of this type of case is a conversion aphonia or dysphonia (Colton & Casper, 1996; Morrison, Rammage, 1994; Titze, 1994). Such a conversion reaction is characterized by a possible emotional, environmental, vocal demand or personality reaction (Aronson, 1990; Boone & McFarlane, 2000; Stemple, 2000) from stress and this may produce excessive muscle activation patterns that prevent the vocal folds from being set into vibration (Titze, 1994). Empirical studies have focused on reducing the excessive laryngeal height that occurs as an effect of musculoskeletal tension. Aronson (1990) infers that improvements in voice quality are proportional to a reduction in laryngeal musculoskeletal tension and lowering of the position of the larynx. Laryngeal muscle manipulation, often termed circumlaryngeal massage (Aronson, 1990; Roy, Bless, Heisey, & Ford, 1997; Roy & Leeper, 1993), is a technique that has been implemented in individuals with idiopathic dysphonia and has resulted in long-term improvement. This technique manually manipulates the over

activation of laryngeal muscles resulting in musculoskeletal tension and deviant voice quality symptoms. Boone & McFarlane, (1993) addressed the same issues with a behavioral technique involving a "yawn-sigh" approach. This approach focuses on changing jaw positioning to release tension while simultaneously manipulating exhalation. It has been successful in eliminating deviant voice quality changes. Given simultaneous voicing with exercise, many aerobic instructors find it quite difficult to maintain a relaxed laryngeal position in order to produce a voice that is of optimum quality. Because of the constant and consistent pressure needed for producing and maintaining frequency and intensity, the demands on the respiratory and laryngeal system can be considerably high. When the respiratory musculature fatigues, an increased sense of effort during loaded breathing may be experienced (Gandevia, Killian & Campbell, 1981; Supinski, Clary, Bark, & Kelsen, 1987). Kaufman & Blaylock (1998) reported that dysphonia in professional voice users can be directly linked to increased laryngeal muscle activation as a result of muscle fatigue in the respiratory musculature.

Respiratory Anatomy

The musculature for breathing can be subdivided into muscle groups responsible for inhalation and exhalation. Anatomically, they can be divided into muscles of the thorax and muscles of the abdomen (Zemlin, 1998). Unlike silent respiration where almost equal amounts of time are spent inhaling and exhaling, during speech about 90% of the time is spent on exhalation. Muscles of inhalation can be confined to the thorax, while muscles of exhalation can be confined primarily to the abdomen (Zemlin, 1998).

Muscular Forces of the Breathing Mechanism

Muscles that tend to raise the ribs are regarded primarily as inspiratory muscles, while those that lower the ribs are considered expiratory muscles. The diaphragm is a thin musculotendinous septem, which divides the thorax from the abdomen. The diaphragm is typically described as being dome-shaped, resembling an inverted bowl. Due to its anatomical continuity with structures of the thorax and abdomen, the diaphragm and its associated structures must always move in concert (Zemlin, 1998). The ribs are interconnected by intercostals muscles, which are further divided functionally into the external and internal intercostals muscles. In order for ventilation to take place, the principle that air flows from regions of higher pressure to regions of lower pressure applies. At resting expiratory level, the airways are open and the respiratory pump is in neutral position. Therefore, the pressure within the lungs (alveolar pressure) and outside the lungs (atmospheric pressure) are equal. For inspiration to occur, the alveolar pressure must be significantly decreased below atmospheric pressure so as a pressure gradient will occur, in favor of inward flow. It is these pressure differences that permit air to flow into and out of the lungs. Muscular forces in the respiratory apparatus create this gradient, increasing or decreasing the size of the thorax (Hixon, 1991).

Muscles of Inspiration

The diaphragm is regarded as the major inspiratory muscle. During contraction, the diaphragm is pulled downward and slightly forward, therefore increasing the size of

the thoracic cavity in a vertical direction. Due to its anatomical continuity with structures of the thorax, its contraction also increases the circumference of the thorax through elevation of the lower ribs (Hixon, 1991; Zemlin, 1998). Another set of inspiratory muscles is the external intercostals. These muscles are thin fibers arising from the lower margin of one rib and descend to insert on the upper margin of the next lower rib (Kent, 1997). Contraction of the external intercostals causes them to shorten, each elevating the rib below, therefore increasing the anteroposterior and transverse dimensions of the thorax. During quiet inspiration, the diaphragm and external intercostals muscles are most accountable for thoracic enlargement. Inspirations more vigorous in nature, as during increased cardiovascular activity, employ accessory muscles to aid in increasing thoracic volume. The muscle groups which can be involved are as follows: neck muscles (sternocleidomastoid, and scalenus), anterior thoracic muscles (pectoralis major, pectoralis minor, humerus, serratus anterior, and transverses thoracis), and posterior thoracic muscles (latissimus dorsimus, serratus posterior superior, serratus posterior inferior, sacrospinal muscles, costal elevators, and the quadratus lumborum) (Kent, 1997; Zemlin, 1998).

Muscles of Expiration

Quiet expiration is achieved mainly by recoil forces of the lungs and thorax, as well as the resistance to flow through the airways. These non-muscular forces return the lungs and thorax to their usual volumes at resting expiratory level. Although quiet expiration is typically described as a passive process, the inspiratory muscles do not

readily cease their activity the moment flow changes from inspiration to expiration. Instead, they continue their activity in the early phase of expiration, acting as a releasing brake against lung recoil forces (Hixon, 1991). The most important muscles for expiration are contained in the abdominal unit, consisting of the rectus abdominis, the transverses abdominis, the external oblique, and the internal oblique. Abdominal contraction draws the ribs downward, assisting in decreasing the size of the thoracic cavity. Mechanically, the oblique muscles are the most effective in depressing the ribs, while the transverses abdominis muscles are most effective in compressing abdominal contents (Zemlin, 1998). In addition, the internal intercostals muscles, arising from the lower margin of each rib and inserting on the upper margin of the next highest rib, are another major expiratory muscle (Kent, 1997). The interosseous portion of the internal intercostals can depress the ribs, aiding in exhalation.

Voice Production

In order to produce voice, the vocal folds create the sound source. Through flow-induced osciculIations, where air pressure is created from the lung's recoil forces during expiration, a constant stream of air flows past the tissues of the vocal folds, creating the opening and closing maneuvers of the larynx to create "sound." Van den Berg's *aerodynamic-myoelastic theory* accounts for the aerodynamic and myoelastic properties taking place during passive convergent and divergent interactions of the vocal folds during phonation. At onset of phonation, subglottal pressure rises as expiratory forces are met with resistance from the adducted vocal folds. Once pressure rises to overcome

this resistance, usually between 4 and 6 cm H_2O for comfortable voicing, 8 to 10 cm H_2O for loud voicing, and greater than 30 cm H_2O for screaming, the vocal folds are blown apart, thus subglottal pressure diminishes. This creates a drop in pressure between the vocal folds, which in turn draws the vocal folds back in adducted position. In addition to the air pressure forces, the natural elastic tissue recoil of the vocal folds pulls them back toward midline, restarting the vibratory cycle. The understanding of the complexity of the vocal folds in regards to their detailed histologic tissue composition and vibratory mucosal waveforms has generated more complex theories about vocal fold vibration. Hirano's *body-cover theory* was the first to discern the function of the passive, non-muscular superficial layers accountable for the vibratory cycle. Recently, Titze (1994) has extended these theories, describing the vocal folds as a self-oscillating unit, maintained by the aerodynamic forces of pressure and flow. Stemple, Glaze and Klaben (2000) describe that pressure and flow are reciprocal: when flow is high, pressure is low, and the reverse. The driving force of respiration displaces the abducted vocal folds to osciculate, and the valving among the subglottal region, intraglottal space, and supraglottal region contributes to continual vocal fold vibration. In the subglottal region, the edges of the vocal folds are blown apart and set into motion by subglottal air pressure. Thereafter, the intraglottal pressure keeps the folds in continuous vibration, created by the alternating exchange of airflow and pressure. When the vocal folds are open, intraglottal pressure is positive, but this drops as the flow cuts off from the vocal folds closing. In addition, the supraglottal space aids in maintaining the vibratory cycle. Above the glottis, air molecules are compressed as a response to the alternating pressure and airflow cycle.

They are pushed down towards the glottis, then released in response to the sound energy given off from the vibrating vocal folds (Stemple et al. 2000).

The laryngeal system can affect vocal intensity by increasing the adductory behavior of the vocal folds, performed by the thyroarytenoid, cricothyroid, and lateral cricoarytenoid muscles (Hirano, 1987; Hirano, Ohala, & Vennard, 1969) as well as increasing the amplitude of vibration and laryngeal airway resistance. Simultaneously, the respiratory system can affect intensity by increasing respiratory drive, thereby increasing pressure within the lungs. Many studies have shown that tracheal pressure increases with intensity (Bouhuys, Proctor, & Mead, 1966; Higginas & Saxon, 1991; Holmberg, Hillman & Perkell, 1988). The contributions of laryngeal airway resistance and respiratory drive in determining tracheal pressure during intensity variation are poorly understood. Finnegan, Luschei, & Hoffman (2000) tested the hypothesis that the respiratory system plays the primary role in changes in tracheal pressure associated with alteration in overall intensity, and laryngeal adjustments are primarily responsible for transient changes in tracheal pressure related to emphasis. Respiratory drive, revealed by alveolar pressure, was found to be the primary mechanism in both transient and sustained tracheal pressure increases associated with increased intensity. Laryngeal activity was found to play a small role in modulation of tracheal pressure associated with vocal intensity. During modal phonation, changes in laryngeal airway resistance had little effect on tracheal pressure. Although, there was a tendency for laryngeal airway resistance to increase with intensity (Finnegan et al. 2000). Possible explanations for increased resistance could be that increased vocal fold stiffness is required in order to

maintain adduction during higher tracheal pressures, or increased laryngeal airway resistance does not result in increased adduction, but rather it is characteristic of increased tracheal pressure (Alipour, Scherer, & Finnegan , 1997).

Effects of Phonation on Ventilation

Although gas exchange is the primary physiological function of breathing, an important secondary function of breathing is to assist with the production of sounds (Cavagna & Margaria, 1968; Klatt, Stevens, & Mead, 1968; Otis and Clark, 1968.) During the production of speech, the larynx alters airflow from the lungs, and transforms the pressurized streams of air into a series of pulses over a wide range of fundamental frequencies (Cavagna & Margaria, 1968; Klatt et al. 1968). There is a minimal amount of expiratory airflow required to maintain vibration of the vocal folds, as well as an upper limit to the rate of airflow, which is dependent on the content, pitch, and intensity of the sound produced and expiratory airflow during speech. Bunn and Mead (1971) demonstrated that speech in resting subjects increased expiratory airflow, and ventilation increased by about 25%. These authors also indicated that by adding CO_2 to inspired air, resting ventilation was observed to double. Consequently, expiratory flows become too high for speech since ventilation is reduced during speech production, but not decreased to the level seen in the absence of CO_2. This infers an antagonistic relationship between gas-exchange and the phonatory functions of breathing, seen though restricted minute ventilations due to speech demands (Bunn & Mead, 1971; Doust & Patrick, 1981; Phillipson, McClean, Sullivan, & Zamel, 1978).

In a study by Otis and Clark (1968), resting ventilation was compared to ventilation during three types of reading material read aloud, each subsequently containing increased amounts of high volume consonants. The low-volume material, containing consonants requiring low-volume increments, showed no significant effect on total ventilation. The neutral material, containing an ordinary distribution of consonants, caused an increase in ventilation by roughly 10%, with alveolar ventilation increasing more, with frequency of breathing dropping from 19 to 14 breaths per minute. The high-volume material, containing consonants requiring large expiratory volume increments, produced the greatest ventilatory effect, revealing an increase of 30%. Therefore, these results inferred that airflow during breathing at rest is not optimal for speech, suggesting that speech involves a slight hyperventilatory response.

Ventilation and Exercise

Ventilation at rest and during exercise serves mainly to support gas exchange and oxygen delivery. Breathing and ventilation corresponds through regulatory centers and mechanisms, facilitating autonomic control and volitional breathing (Shea, 1996).

Exercise on its own is a complicated process, requiring many organ systems of the body to work in concert, regulating some physiological variable at or near a constant value, also known as *homeostasis*. An example of homeostasis is the lungs (pulmonary system) and heart (circulatory system) striving together to replenish oxygen and remove carbon dioxide from extracellular fluid. This occurs through an operation system called *negative feedback*, which is "negative" because the response of the control system is

opposite to the stimulus. This phenomenon can be seen during the respiratory system's regulatory activity of CO_2 concentration. An increase in extracellular CO_2 above normal levels stimulates a receptor, which is a component detecting change from homeostasis, and will in turn send that information to the respiratory control center to increase breathing. This increase in breathing reduces extracellular CO_2 concentrations back to a constant level (Powers & Howley, 2001). Breathing is controlled by two separate yet functionally related elements (Mitchel, & Berger, 1975; Plum, 1974): the metabolic respiratory control system and the behavioral control system. The metabolic system, located in the brainstem, receives afferent stimuli from the central and peripheral chemoreceptors and vagus nerves, primarily concerned with acid-base and oxygen homeostasis. On the other hand, the behavioral control system is involved in voluntary activities, such as phonation, which uses the ventilatory system for non-respiratory functions (Bunn, & Mead, 1971).

Not only do the pulmonary system and circulatory system interact, but so does the skeletal muscles. During exercise, skeletal muscles produce large amounts of lactic acid, causing increased amounts in intracellular and extracellular acidity. Moreover, large amounts in muscle O_2 and CO_2 are produced. Together, these changes call for the body to increase breathing and blood flow to increase O_2 delivery to the muscles and remove unwanted CO_2. Large amounts of heat are also produced, which must be removed to prevent heat exhaustion. With all of these changes in one's internal environment during exercise, many of the body's organ systems are constantly working to try and maintain a stable environment (Powers & Howley, 2001).

Effects of Exercise on Phonation

The laryngeal response to exercise is similar to that seen during voluntary hyperventilation (Bartlett, Knuth, & Knuth, 1981). In hyperpnoea caused by exercise, eucapneic hypoxia, and hypercapnia (England, Bartlett, & Knuth, 1982; England. & Bartlett, 1982), there is a slight increase in the widening of the glottis during inspiration. Under similar conditions, Bartlett (1979) and McCaffrey & Kern (1980) demonstrated in animal studies that there is slightly decreased inspiratory laryngeal resistance and increased posterior cricoarytenoid (PCA) activity as observed in human studies during increased chemical drive (Brancatisano, Dodd, & Engel, 1986). England & Bartlett (1982) reported the decrease in inspiratory laryngeal resistance to decrease the driving pressure required for elevated inspiratory flow rates. During expiration, the narrowing of the glottis is substantially decreased during hypercapnic and exercise hyperpnea. Doust and Patrick (1981) found speech during hard exercise to be louder with increased pitch, more tremulous, and with a "breathy" quality. Also, with heavier workloads, fewer words were spoken during each breath due to higher respiratory frequency and constant reading speed. The same results were also observed by Otis & Clark (1968). During increased ventilation periods, subjects were asked to perform a variety of speaking tasks, ranging from counting to reading a short passage. As the level of exercise became more difficult, the speaking tasks became more difficult, resulting in the subjects' showing difficulties in phrasing, running out of breath in the middle of a word, quick non-phonated expirations, and speech became louder and more tremulous at the highest rates

of ventilation. The increase in intensity was noted to be accompanied by increased subglottic pressure due to faster expiratory flow rates at higher ventilations. Subjectively, increases in pitch were observed, which is a typical correlate seen with increased subglottic pressure. In addition, during the hyperpnea of exercise, the number of letters or numbers spoken per breath decreased. These researchers also observed that despite increasing levels of exercise intensity, subjects appeared to adapt their rate of phonation, rather than being dependent on rate of airflow.

Ebbesen, Prkachin, Mills, and Green (1992) employed specific physical stressors during exercise to investigate the effects of acute exercise on cardiovascular reactivity to a variety of stress tests, one of them being public speaking. With the exception of exercise, public speaking is a similar speaking style to aerobic instructors since there is a need for accurate content and clarity. It has been observed that this speaking style elicits an increase in heart rate and systolic blood pressure, characteristic of increased stimulation of beta-adrenergic receptors (Weiss, Matthews, Detre & Graeff., 1984). Acute exercise reduced the response to stress, seen more apparently in diastolic blood pressure measures (Ebbesen et al., 1992). Although one and two hours of exercise were employed, one hour of exercise was sufficient to intercede with the ordinary arousal response to stressors (Ebbesen et al., 1992). Subjects' ratings of the three stress-tasks used were synchronous with their blood pressure behaviors. Unlike the blood pressure data, exercise did not affect the subjects' perceived stress ratings, implying that the physiologic and subjective results of exercise are not directly related. Unlike Roth's (1989) claim that acute exercise decreased the amount of feelings of anxiety in response

to cognitive stressors with no effect on ventilatory reactivity, Ebbesen et al. (1992) proclaims that collaboration with different tasks, as well as a multitude of intensities and durations of exercise, diminishes blood-pressure reactivity to stress.

The larynx has been observed to readily adapt to exercise, specifically strength-based exercise (Naito & Niimi, 2000). This is accomplished by increasing thoracic, abdominal, and subglottic pressure, which in turn helps a person perform their task more efficiently. This concept was observed by Naito & Niimi (2000). An endoscope capable of observing the larynx during various body movements was utilized, with a fiberscope fixed on the subjects helmet and a lightweight charged coupled device camera system. Activities such as pushing up against a horizontal bar, pull-ups, tennis, and Kendo (Japanese fencing) were performed. Results showed glottic closure during the beginning of maximum effort involving the upper limbs and varied glottic closure during constant power movements.

Effects of Phonation on Ventilation during Exercise

Few studies have examined the cardiovascular, physiological responses to speech production during exercise. Doust and Patrick (1981) measured baseline ventilation and ventilation during speech while running on a treadmill for seven minutes with five different workloads of 85, 95, 125, 150, and 160 beats per minute. All subjects were observed to have a reduction in ventilation during speech during every workload, with the mean value being 55% reduction when compared to the control ventilation. Speech caused a reduction in ventilation by reducing respiratory frequency while the tidal

volume remained about the same. This shows the body's ability to remain at the same physiological variable while adjusting the amount of gas exchange needed to fit that constant value. One of the most apparent changes in ventilation was extended expiration and reduced respiratory frequency. Without speech, ventilation increased during exercise through an increase in tidal volume and respiratory frequency. Therefore, speech imposes an additional a flow requirement, which attenuates the ventilatory response to the metabolic demands of increasing intensities of exercise (Doust & Patrick, 1981).

This finding was also observed by Phillipson et al. (1978) and Bunn and Mead (1978). In these studies, CO_2 was added to the inspired air in order to increase ventilatory requirements for their subjects completing an oral reading task. Ventilation decreased during speech but not to the level seen with the absence of CO_2. Phillipson et al. (1978) showed that the subjects, while speaking with the added stimulus of CO_2, decreased the ventilatory response to one- third of the control value in resting subjects. One possible reason for decreased ventilatory behavior is that due to the prolongation of expiration while speaking, the end-tidal alveolar Pco_2 rises, and then more slowly due to hypoventilation (Doust & Patrick, 1981). Doust and Patrick (1981) demonstrated that during a short period of speech in exercise, ventilation is reduced so as to meet the phonatory requirement for a low expiratory flow. It is recognized that within limits, the behavioral control system can override the metabolic system.

With phonation and exercise, the minute volume of ventilation increases, and the ventilatory response to hypercapnia is decreased (Bunn & Mead, 1971). Phillipson et al. (1978) studied the interaction between the metabolic and behavioral control systems, by

comparing the ventilatory response to hypercpania during quiet breathing and during speech. Ventilation was measured by means of a face mask, where participants re-breathed from a waterless spirometer filled with 4-5 liters of a gas mixture containing 7% CO_2 in O_2. This study demonstrated that during speech there was a disruption of the ventilatory response. Also, due to resultant ventilatory shortcomings, compensation was seen with rapid non-phonated expirations where phrasing permitted (Doust & Patrick, 1981; Otis & Clark; 1968). Additionally, even at the most intense exercise levels, total ventilation during speech was little more than half the control value. (Doust & Patrick, 1981).

Meckel, Rotstein, and Inbar (2002) studied the effects of speech production on physiological responses during sub maximal exercise (VO_2 max) of various intensities in male subjects. Baseline maximal aerobic power was first established during the first session in order to calibrate each person's work intensities corresponding to 65%, 75%, and 85% of their VO_2 max. While running on a treadmill performing each work intensity (with breaks in between), various respiratory measures were taken, and during the last session, the subjects performed the same protocol, but while simultaneously reading a passage aloud. The results of the study found a significant decrease in oxygen consumption (VO_2) during all three work intensities, as well as a significant drop in ventilation (VE). A significant increase in blood lactate was observed during speech production only during the lowest work intensity. Although this is contrary to what would be expected due to increased metabolic flux through the glycolytic pathway, this observation could be due to the limited number of participants. As mentioned by Doust

and Patrick (1981), reduced ventilation was observed. Although some of their reasoning behind this result was due to meeting the phonatory requirement for a low expiratory flow, Meckel et al. (2002) further explained that compensatory strategies persist to maintain VO_2 even during reduced ventilation/cardiac output, therefore these mechanisms may not contribute with the added component of speech production. Other changes noted in the ventilatory response were reductions in breathing frequency with no significant changes in tidal volume. Similar to Doust and Patrick (1981), this resulted in an increase in end tidal CO_2. During exercise alone, the mean ratio between expiratory time and total respiratory cycle time at the three work intensities were 0.52, 0.52, and 0.51, while adding speech the results increased to 0.64, 0.62, and 0.61. Therefore, a speech-dependent respiratory pattern is imposed on the body's ventilation system. In terms of expiratory airflow, a certain range must be held to sustain adequate vocal fold vibration for speech. During speech at rest, an increase of expiratory flow is needed when compared to expiratory air-flow rates during ventilation alone (Bunn & Mead, 1971; Phillipson et al., 1978). Meckel's et al. (2002) findings adhere to this pattern, and during speech, ventilation was lowered in comparison to silent exercise so to maintain appropriate airflow rates allowing the clarity of speech to be preserved. Interestingly, even though decreased VO_2 and VE measures were observed during speech and exercise, heart rate did not change due to the added component of speech when compared to exercise alone.

The general focus of the current study is to further investigate the effects that the respiratory system has on laryngeal function during simultaneous tasks of exercise and

speech in aerobic instructors. Specifically, this study seeks to understand the effects that exercise has on aerobic instructors perception of dyspnea during their occupational task of simultaneous speech with exercise and account for other environmental variables that may influence the physical and phonatory tasks.

CHAPTER 2: METHODS

Study Design

This study represents a within subject multiple baseline design. All subjects were measured under four conditions to describe how exercise and environmental noise may influence the voicing task. The independent variables for this study included exercise, speech during exercise, use of amplification, and environmental noise. The dependent variables included measures of vocal intensity, fundamental frequency and perturbation measures and participants' self-perception of dyspnea and effort during aerobic performance. Each measure had three trials per baseline, with the exception of dyspnea, with 1 trial per condition, per baseline. Baselines 1 and 2 were averaged.

Hypotheses

The general purpose of this study was to understand how changes in ventilation during exercise influence voice production in aerobic instructors. A secondary focus of this study was to describe the environmental noise influencing the voicing task for this population. The following research hypotheses will be addressed:

Hypothesis 1

Ha: With the use of amplification, vocal intensity will decrease;

Ho: The use of amplification does not change vocal intensity measures as compared to without amplification.

Hypothesis 2

Ha: During exercise alone, participants' self- perception of dyspnea will increase;

Ho: Exercise alone does not increase participants' self- perception of dyspnea.

Hypothesis 3

Ha: During simultaneous vocal and physical routines, participants' self- perception of dyspnea will increase;

Ho: Simultaneous vocal and physical routines do not change dyspnea ratings as compared to dyspnea ratings with physical demands alone.

Hypothesis 4

Ha: During simultaneous vocal and physical routines, with amplification participants' self- perception of dyspnea will decrease;

Ho: Simultaneous vocal and physical routines with amplification do not change dyspnea ratings as compared to dyspnea ratings with simultaneous vocal and physical routines without amplification.

Hypothesis 5

Ha: Vocal fold structure and function will be abnormal, showing signs of edema, increased vascularity, vocal pathology and/or compensatory behavior;

Ho: No signs of abnormal vocal fold structure or function will be seen.

Hypothesis 6

Ha: Participants will have abnormal measures according to their age and gender for measures of average fundamental frequency, jitter percent, shimmer percent, and noise to harmonic ratio during simultaneous vocal and physical routines.

Ho: Measures of average fundamental frequency, jitter percent, shimmer percent, and noise to harmonic ratio will be normal for participants' age and gender.

Subjects

In order to obtain a representative sample, gender ratios of 30 aerobic facilities in Orange and Seminole County in Florida were calculated. Overall, 80% were female and 20% were male. Therefore, ten aerobic instructors, two male and eight female, were included in this study. Participants were recruited from the Blanchard Park and Oviedo YMCA, Bally's Total Fitness, as well as the University of Central Florida Recreation and Wellness Center. Inclusionary criteria included experience teaching aerobic classes for a minimum of one year, teaching at least 2 one- hour classes per week, and between the ages of 18 and 45 years old. Exclusionary criteria included a history of chronic respiratory or neuromuscular disease, previous thoracic surgery or trauma, chest wall compliance limited by obesity, asthma, smoking, and heart problems.

Procedures

Pulmonary Function Testing

Standard baseline pulmonary function testing (PFT) was performed with a minimum of three trials per subject to ensure the participant had normal lung function. Additionally, maximum expiratory pressure (MEP) and maximum inspiratory pressure (MIP) were obtained to gather information regarding the strength of the expiratory and inspiratory muscles. MEP and MIP were measured using a micro MPM digital pressure gauge. To obtain MEP measures, subjects were instructed to maximally inspire, place their lips around the mouthpiece, and then blow as hard as they could into the pressure-sensing device, while wearing nose clips. Three trials were averaged to obtain each subject's MEP measure per baseline. To obtain MIP measures, subjects were instructed to inhale as strongly as possible with their lips around the mouthpiece. Three trials were averaged to obtain each subject's MIP measure per baseline.

Laryngeal Examination

In order to assess the participants' vocal fold structure and function, standard procedures for oral rigid laryngostroboscopy were followed. Topical anesthesia (3 % Ponticaine) was employed in the examination of some of the participants' vocal structure to help prevent gagging. Vocal structure was assessed during quiet breathing. The Kay Elemetrics Laryngorhinostroboscopic system, Model RLS 9100 with a 70 degree Endo-

Stroboscope with Computer Integrated System Model 9195 was used to obtain the stroboscopic images during the sustained vowel /i/ produced at a comfortable effort level in order to evaluate laryngeal function. This procedure was performed within a participating medical facility with a board-certified otolaryngologist reviewing the procedure and diagnostic results.

Laryngostroboscopic measures were determined through evaluation results compiled from a speech language pathologist and otolaryngologist with a history of five years or greater experience in evaluating and treating voice disorders.

Acoustic Measures

Acoustic measures were obtained in a sound treated environment reflecting comfortable and high effort voice production. The signal was obtained with an Audiotechnica microphone model ATM 73A routed to a SONY TASCAM Digital Audio Tape Recorder and digitized directly to disk for analysis using the Kay Elemetrics Computerized Speech Lab (model 4300B) and Multidimensional Voice Profile (MDVP).

A digital sound level meter model 33-2055 was used to obtain vocal output levels in dB SPL for various voicing tasks during the aerobic instruction. Measures included average fundamental frequency (F_0), standard deviation of F_0 (SD F_0), jitter percent (jitt %), shimmer percent (shim %), noise-to-harmonic ratio (NHR) and vocal intensity.

Fundamental Frequency measures the number of cycles of vocal fold vibration/periodicity of an acoustic signal. Jitter and Shimmer reveal the source variability in the frequency and amplitude of the vocal fold vibration respectively. The

measurement of NHR compares the spectral energy (signal strength) with aperiodicity (energy of noise) existent in the voice signal. Vocal intensity measures reflect loudness levels in the vocal signal, measured in decibels (dB).

These measures were taken under the following conditions: Condition 1: Voice production without exercise and no use of amplification. Condition 2: Voice production without exercise with the use of amplification. Condition 3: Voice production during exercise and no use of amplification. Condition 4: Voice production during exercise with the use of amplification.

Intensity measures for sustained vowel “ah” and the standard functional phrase (Keep up the energy guys!) were measured in the aerobic class, with music and aerobic participation. In the lab environment, sustained vowel “ah” was obtained in order to measure vocal intensity, F_0, NHR, jitt %, and shim %, and the functional phrase was measured for intensity. Each measure had three trials per baseline. Baselines one and two were averaged.

Dyspnea Rating

Dyspnea ratings were collected from each subject after aerobic instruction in class and in the lab using a visual analog scale (VAS; see Appendix A). Subjects were asked to rate the amount of “breathlessness” or difficulty of perceived effort under 6 conditions: 1) voice production without exercise, 2) voice production without exercise and with the use of amplification, 3) during exercise alone, 4) voice production with exercise without the use of amplification, 5) voice production with exercise with the use of amplification,

and 6) no exercise, no voice production. Using a 100 mm line, subjects were asked to place an *X* on the line indicating their perceived level of effort. The 0 mm mark denoted no sensation of breathlessness and the 100 mm mark denoted a profound sensation of breathlessness. Each dyspnea measure had one trial per condition, per baseline. Baselines one and two were averaged. Additional written questions were asked, which included: 1) Do you experience greater sensations of breathlessness during specific situations more so than others? If so, please explain; 2) Please describe the amount of effort or how you physically feel during aerobic instruction that is only vocal compared to vocal plus simultaneous aerobic activity; 3) During high intensity voicing efforts, do you compensate to help you produce the voice and physical task? 4) If so, how do you compensate, what do you do? 5) Do you normally use amplification? If so, do you find it useful in decreasing the amount of physical effort? What parts of your task become easier?

Statistical treatment of Data

Descriptive statistics including mean, standard deviation, and percent differences were calculated from the database to describe acoustic measures, and dyspnea ratings. The design represents a within subject design with 6 factors (environmental noise, amplification, exercise, simultaneous voice use and exercise, vocal fold structure, vocal function) and seven response variables (dyspnea, average F_0, standard deviation of F_0, jitter percent, shimmer percent, noise to harmonic ratio, vocal output). Reliability of inter-measure reliability was subject to the Fisher LSD test. To account for differences

between conditions, the data was subjected to an Analysis of Variance (ANOVA). The Fisher LSD test was utilized to follow up statistically significant ANOVA's between the conditions. Significance was accepted at $p \leq .05$.

CHAPTER 3: RESULTS

Descriptive Statistics

This study represents a descriptive, multiple baseline design. Four conditions were studied with the following six dependent variables: intensity, average fundamental frequency, noise-to-harmonic ratio, jitter percent, shimmer percent, and dyspnea. Acoustic measures had three trials per baseline, per condition; dyspnea measures had one trial per baseline, per condition (conditions 3 and 4), and per environment (in the aerobic class and lab); intensity measures had three trials per baseline, per condition, and per environment (total of 80 trials per participant). Baselines 1 and 2 were averaged for each participant. Descriptive statistics included calculation of mean and standard deviation for the dependent variables. Participants A and F were males. The rest were females.

The four conditions observed in this study were as follows: Condition 1: voice production without exercise and no use of amplification. Condition 2: voice production without exercise with the use of amplification. Condition 3: voice production during exercise and no use of amplification. Condition 4: voice production during exercise with the use of amplification.

Descriptive Statistics for Vocal Intensity

Tables 3.1- 3.4 depict the group means and standard deviations for vocal intensity measures across the two environments and two vocal tasks. Participants were found to have the highest vocal intensity measures when they were not exercising and not using

amplification (condition 1). With the use of amplification, vocal intensity decreased. During exercise without amplification, vocal intensity measures increased in comparison to condition 2 (no exercise with amplification). However, in comparison to condition 1, (no exercise no amplification) intensity measures decreased. During exercise with amplification (condition 4), intensity measures were lower than measures during exercise without amplification and during condition 2, no exercise with amplification. All of the participants' individual measures can be found in Appendix B.

Table 3.1: Descriptive Statistics for Vocal Intensity in the aerobic classroom environment (unit of measure: decibels)

	Baseline 1		Baseline 2		Average	
Condition	Mean	SD	Mean	SD	Mean	SD
(1) No Exercise, No Amplification	106.8	6.1	110.0	5.2	108.4	5.3
(2) No Exercise, Amplification	99.2	6.4	99.8	7.6	99.5	6.9
(3) Exercise, No Amplification	101.4	4.1	104.9	4.2	103.1	4.1
(4) Exercise, Amplification	95.8	3.3	97.8	4.3	96.8	3.8

Table 3.2: Descriptive Statistics for Vocal Intensity in Lab (unit of measure: decibels)

	Baseline 1		Baseline 2		Average	
Condition	Mean	SD	Mean	SD	Mean	SD
(1) No Exercise, No Amplification	103.2	4.5	103.9	6.5	103.6	5.7
(2) No Exercise, Amplification	96.7	7.2	95.7	7.5	96.2	7.4
(3) Exercise, No Amplification	102.3	3.2	100.9	4.7	101.6	3.5
(4) Exercise, Amplification	96.2	6.6	97.2	7.9	96.7	7.5

Table 3.3: Descriptive Statistics for Vocal Intensity for Phrase Vocalization in Class (unit of measure: decibels)

	Baseline 1		Baseline 2		Average	
Condition	Mean	SD	Mean	SD	Mean	SD
(1) No Exercise, No Amplification	105.6	5.9	105.5	4.6	105.6	5.0
(2) No Exercise, Amplification	96.9	6.8	96.9	6.3	96.9	6.3
(3) Exercise, No Amplification	100.4	3.4	102.8	3.6	101.6	3.4
(4) Exercise, Amplification	95.7	2.5	96.7	4.7	96.2	3.4

Table 3.4: Descriptive Statistics for Vocal Intensity for Phrase Vocalization in Lab (unit of measure: decibels)

	Baseline 1		Baseline 2		Average	
Condition	Mean	SD	Mean	SD	Mean	SD
(1) No Exercise, No Amplification	94.1	3.7	94.8	3.8	94.4	3.8
(2) No Exercise, Amplification	90.6	2.5	89.7	5.3	90.2	3.9
(3) Exercise, No Amplification	95.3	3.9	92.7	3.2	94.0	2.9
(4) Exercise, Amplification	90.8	4.2	90.7	4.2	90.8	4.3

Descriptive Statistics for Laryngeal Function

Average fundamental frequency (F_0) was found to increase in conditions without amplification, regardless of exercise or not. In addition, F_0 was higher in condition 4, with exercise and amplification, versus condition 2, no exercise with amplification. A pattern for measures between condition 4 and condition 1 were not as apparent as the other conditions. F_0 and SD F_0 measures can be found in Tables 3.5 and 3.6. Participants B, D, and E for condition 1, E and H for condition 2, B, D, and E for condition 3, and B, E, and H for condition 4 showed abnormal measures of F_0, using normative ranges for females: 243.973 Hz ± 2 sd 27.457; males: 145.223 Hz ± 2 sd 23.406 (Baken & Orlikoff, 2000). Results shown in Table 3.7. Noise-to-harmonic ratio (NHR) was found to increase in conditions involving exercise. NHR measures can be found in Table 3.8. No

participants demonstrated abnormal NHR (abnormal: 0.19 and above; Baken & Orlikoff, 2000). Results shown in Table 3.9. In addition, jitter percent (jitt %) and shimmer percent (shim %) was also found to increase in conditions involving exercise. However, there was a stronger relationship between overall increases during exercise with jitt % versus shim %. Jitt % can be found in Table 3.10 and shim % can be found in Table 3.11. Participant G for condition 1, participants E and J for condition 2, participants C and G for condition 3, and participants B, C, F, and G for condition 4 demonstrated abnormal jitter values, which were considered abnormal at 1.04% and above (Baken & Orlikoff, 2000). Results shown in Table 3.12. Shimmer was considered outside of normal range at 3.81% and above (Baken & Orlikoff, 2000). Results shown in Table 3.13.

Table 3.5: Descriptive Statistics for Fundamental Frequency (unit of measure: Hertz)

	Baseline 1		Baseline 2		Average	
Condition	Mean	SD	Mean	SD	Mean	SD
(1) No Exercise, No Amplification	251.5	74.9	257.3	84.4	254.4	82.4
(2) No Exercise, Amplification	222.5	64.5	230.2	76.3	226.4	73.6
(3) Exercise, No Amplification	264.8	74.5	262.4	68.4	263.6	74.8
(4) Exercise, Amplification	239.9	62.5	248.4	74.0	244.1	71.5

Table 3.6: Descriptive Statistics for Standard Deviation of Fundamental Frequency

	Baseline 1		Baseline 2		Average	
Condition	Mean	SD	Mean	SD	Mean	SD
(1) No Exercise, No Amplification	3.2	1.5	3.1	1.7	3.1	1.5
(2) No Exercise, Amplification	2.9	1.3	3.1	1.7	2.9	1.4
(3) Exercise, No Amplification	6.7	2.8	5.6	1.6	6.2	2.1
(4) Exercise, Amplification	5.5	1.6	5.7	1.7	5.6	1.5

Table 3.7: Fundamental Frequency per Participant per Condition

	(1) No exercise, No Amplification			(2) No exercise with Amplification		
PARTIC	Baseline 1	Baseline 2	Mean	Baseline 1	Baseline 2	Mean
A	164.5	166.5	165.5	160.3	164.4	162.3
B	387.5	333.2	360.3	287.0	252.9	270.0
C	246.6	256.9	251.8	213.1	220.7	216.9
D	273.2	336.6	304.9	255.8	286.6	271.2
E	381.4	435.5	408.4	371.8	424.4	398.1
F	159.0	150.7	154.8	143.0	150.8	147.0
G	249.8	259.3	254.5	184.7	195.5	190.1
H	196.1	182.3	189.2	174.6	161.7	168.2
I	229.0	214.7	221.8	212.2	216.5	214.4
J	228.2	237.0	232.6	222.7	228.7	225.7
	(3) Exercise without amplification			(4) Exercise with amplification		
PARTIC	Baseline 1	Baseline 2	Mean	Baseline 1	Baseline 2	Mean
A	157.2	174.1	165.7	176.6	166.1	171.4
B	374.1	355.0	364.6	314.1	309.8	311.9
C	235.4	277.8	256.6	247.1	276.0	261.6
D	304.1	313.0	308.6	257.6	300.8	279.2
E	407.4	389.4	398.4	374.5	407.1	390.8
F	185.4	175.4	180.4	164.2	151.5	157.9
G	277.1	254.5	265.8	213.9	221.5	217.7
H	222.6	212.8	217.7	172.9	176.6	174.7
I	239.9	236.5	238.2	229.5	240.8	235.2
J	244.3	235.1	239.7	248.1	233.5	240.8

Table 3.8: Descriptive Statistics for Noise-to-Harmonic Ratio

	Baseline 1		Baseline 2		Average	
Condition	Mean	SD	Mean	SD	Mean	SD
(1) No Exercise, No Amplification	.12	.01	.12	.01	.12	.01
(2) No Exercise, Amplification	.11	.01	.12	.01	.11	.01
(3) Exercise, No Amplification	.13	.03	.13	.02	.13	.02
(4) Exercise, Amplification	.14	.03	.12	.01	.13	.02

Table 3.9: Noise-to-Harmonic Ratio Per Participant per Condition

	(1) No exercise, No Amplification			(2) No exercise with Amplification		
PARTIC	Baseline 1	Baseline 2	Mean	Baseline 1	Baseline 2	Mean
A	0.13	0.12	0.13	0.12	0.13	0.13
B	0.11	0.10	0.11	0.10	0.12	0.11
C	0.12	0.11	0.11	0.12	0.12	0.12
D	0.10	0.10	0.10	0.11	0.10	0.10
E	0.11	0.10	0.11	0.10	0.10	0.10
F	0.13	0.14	0.14	0.09	0.14	0.11
G	0.11	0.11	0.11	0.13	0.13	0.13
H	0.12	0.13	0.13	0.10	0.13	0.11
I	0.10	0.11	0.10	0.11	0.11	0.11
J	0.12	0.12	0.12	0.14	0.09	0.11

	(3) Exercise without amplification			(4) Exercise with amplification		
PARTIC	Baseline 1	Baseline 2	Mean	Baseline 1	Baseline 2	Mean
A	0.13	0.13	0.13	0.13	0.14	0.14
B	0.09	0.10	0.10	0.10	0.10	0.10
C	0.22	0.11	0.17	0.17	0.12	0.14
D	0.10	0.10	0.10	0.11	0.11	0.11
E	0.11	0.12	0.11	0.11	0.10	0.11
F	0.14	0.14	0.14	0.15	0.13	0.14
G	0.13	0.13	0.13	0.19	0.15	0.17
H	0.14	0.19	0.16	0.14	0.13	0.13
I	0.13	0.13	0.13	0.15	0.13	0.14
J	0.10	0.13	0.12	0.12	0.12	0.12

Table 3.10: Descriptive Statistics for Jitter Percentage

	Baseline 1		Baseline 2		Average	
Condition	Mean	SD	Mean	SD	Mean	SD
(1) No Exercise, No Amplification	.66	.26	.74	.36	.70	.26
(2) No Exercise, Amplification	.71	.26	.76	.49	.73	.32
(3) Exercise, No Amplification	.91	.44	.84	.22	.88	.19
(4) Exercise, Amplification	1.05	.41	.89	.20	.97	.28

Table 3.11: Descriptive Statistics for Shimmer Percentage

	Baseline 1		Baseline 2		Average	
Condition	Mean	SD	Mean	SD	Mean	SD
(1) No Exercise, No Amplification	.71	.47	.58	.46	.64	.46
(2) No Exercise, Amplification	1.14	.81	1.05	.75	1.10	.73
(3) Exercise, No Amplification	1.12	1.24	1.09	.76	1.10	.85
(4) Exercise, Amplification	1.96	1.64	1.50	.96	1.73	1.26

Table 3.12: Jitter Percentage Per Participant Per Condition

	(1) No exercise, No Amplification			(2) No exercise with Amplification		
PARTIC	Baseline 1	Baseline 2	Mean	Baseline 1	Baseline 2	Mean
A	0.59	0.30	0.44	0.31	0.67	0.49
B	1.07	0.70	0.89	1.08	0.98	1.03
C	0.42	0.74	0.58	0.81	0.60	0.71
D	0.54	1.43	0.98	0.57	0.41	0.49
E	0.73	1.09	0.91	0.65	1.98	1.32
F	0.90	0.51	0.70	0.84	0.36	0.60
G	0.94	1.16	1.05	0.68	1.02	0.85
H	0.28	0.32	0.30	0.35	0.36	0.35
I	0.32	0.46	0.39	0.64	0.24	0.44
J	0.86	0.70	0.78	1.14	0.93	1.04

	(3) Exercise without amplification			(4) Exercise with amplification		
PARTIC	Baseline 1	Baseline 2	Mean	Baseline 1	Baseline 2	Mean
A	0.54	1.20	0.87	0.69	0.88	0.78
B	0.82	0.64	0.73	1.97	0.92	1.44
C	1.54	0.81	1.17	1.47	1.04	1.26
D	0.68	0.71	0.70	0.47	0.59	0.53
E	0.97	0.86	0.91	0.92	1.07	0.99
F	0.63	1.09	0.86	1.30	1.02	1.16
G	1.89	0.61	1.25	1.10	1.05	1.08
H	0.61	0.90	0.76	0.87	0.67	0.77
I	0.95	0.52	0.73	0.86	0.56	0.71
J	0.49	1.11	0.80	0.86	1.12	0.91

Table 3.13: Shimmer Percentage Per Participant Per Condition

	(1) No exercise, No Amplification			(2) No exercise with Amplification		
PARTIC	Baseline 1	Baseline 2	Mean	Baseline 1	Baseline 2	Mean
A	0.46	0.36	0.41	0.16	0.34	0.25
B	0.79	1.10	0.94	0.26	0.19	0.23
C	0.89	0.94	0.92	1.21	1.28	1.25
D	1.63	0.58	1.11	0.62	1.81	1.22
E	1.41	1.59	1.50	1.16	1.72	1.44
F	0.12	0.12	0.12	1.41	0.48	0.95
G	0.76	0.50	0.63	2.87	1.37	2.12
H	0.28	0.13	0.21	0.95	0.70	0.83
I	0.29	0.30	0.30	0.58	0.15	0.36
J	0.43	0.20	0.31	2.22	2.47	2.34

	(3) Exercise without amplification			(4) Exercise with amplification		
PARTIC	Baseline 1	Baseline 2	Mean	Baseline 1	Baseline 2	Mean
A	0.18	0.81	0.50	0.28	0.63	0.46
B	2.63	0.68	1.66	0.39	0.30	0.34
C	4.17	1.48	2.83	4.42	1.70	3.06
D	0.26	0.82	0.54	0.76	1.90	1.33
E	1.45	2.71	2.08	1.57	1.78	1.67
F	0.49	0.19	0.34	0.41	0.73	0.57
G	0.71	2.17	1.44	4.08	3.52	3.80
H	0.61	0.66	0.63	4.57	1.90	3.23
I	0.42	0.34	0.38	1.39	0.31	0.85
J	0.23	1.06	0.65	1.76	2.19	1.98

Descriptive Statistics for Dyspnea

Dyspnea was found to be the highest during conditions involving exercise with speech. More specifically, exercising without the use of amplification was higher than exercising with the use of amplification. There was no reported sensation of dyspnea without exercise. Dyspnea results can be found in Table 3.14 and 3.15.

Table 3.14: Descriptive Statistics for Dyspnea in Class

	Baseline 1		Baseline 2		Average	
Condition	Mean	SD	Mean	SD	Mean	SD
(1) No Exercise, No Amplification	2.1	1.6	3.0	3.7	2.6	2.3
(2) No Exercise, Amplification	3.4	3.6	1.0	1.3	2.2	1.7
(3) Exercise, No Amplification	70.0	20.3	63.8	18.8	66.9	18.7
(4) Exercise, Amplification	40.9	22.5	38.8	24.5	39.9	22.2

Table 3.15: Descriptive Statistics for Dyspnea in Lab

	Baseline 1		Baseline 2		Average	
Condition	Mean	SD	Mean	SD	Mean	SD
(1) No Exercise, No Amplification	4.6	4.7	3.3	4.5	4.0	4.1
(2) No Exercise, Amplification	2.7	4.7	2.3	2.4	2.5	3.2
(3) Exercise, No Amplification	65.1	21.1	63.2	16.5	64.2	18.8
(4) Exercise, Amplification	51.6	20.4	46.7	13.7	49.2	16.7

Descriptive Statistics for Pulmonary Function

All participants were observed to have normal lung function. Participants' pulmonary function measures for Forced Vital Capacity (FVC), Maximum Expiratory Pressure (MEP), and Maximum Inspiratory Pressure (MIP) are presented in Tables 3.16, 3.17, and 3.18. These measures were used for screening purposes and were not subjected to inferential statistical analysis.

Table 3.16: Descriptive Statistics for Forced Vital Capacity (unit of measure: Liters)

	Baseline 1	Baseline 2	Average
Participants			
A	5.0	5.0	5.0
B	3.0	3.2	3.2
C	2.7	2.7	2.7
D	3.4	3.5	3.5
E	4.1	4.1	4.1
F	4.7	4.6	4.6
G	3.1	3.1	3.1
H	3.5	3.7	3.7
I	3.4	3.2	3.2
J	3.1	3.0	3.0

Table 3.17: Descriptive Statistics for Maximum Expiratory Pressure

	Baseline 1	Baseline 2	Average
Participants			
A	136.3	141.3	138.8
B	97.0	94.3	95.7
C	140.0	106.7	123.3
D	86.7	92.3	89.5
E	177.7	153.0	165.3
F	155.7	213.3	184.5
G	124.3	150.7	137.5
H	155.7	162.3	159.0
I	114.3	119.7	117.0
J	183.0	161.3	172.2

Table 3.18: Descriptive Statistics for Maximum Inspiratory Pressure

	Baseline 1	Baseline 2	Average
Participants			
A	86.7	86.3	86.5
B	77.0	77.3	77.2
C	101.3	103.3	102.3
D	59.7	67.3	63.5
E	90.0	97.7	93.8
F	109.3	121.3	115.3
G	94.0	91.3	92.7
H	73.7	86.3	80.0
I	63.0	70.7	66.8
J	108.3	130.0	119.2

Descriptive Statistics for Videolaryngostroboscopic Examination

Laryngostroboscopic results included evidence of moderate laryngeal pathology for four subjects. The type of pathology was hemorrhagic in nature, resulting in increased vascularity and generalized edema surrounding the middle two-thirds of the vibratory vocal folds. Participants exhibiting laryngeal pathology are shown in Table 3.19.

Table 3.19: Descriptive Statistics for Laryngeal Pathology

	No evidence of Pathology	Evidence of Pathology
PARTICIPANTS		
A		X
B	X	
C	X	
D	X	
E		X
F		X
G	X	
H	X	
I	X	
J		X

Inferential Statistics

Repeated measures analyses of variance (ANOVA) was the statistical test of choice. Reliability of inter-measure reliability was subject to the Fisher LSD test. Significant was accepted at $p \leq .05$.

Vocal Intensity

Vocal intensity measures reflect loudness levels in the vocal signal, measured in decibels (dB). The analysis of variance (ANOVA) conducted on vocal intensity in class (the actual aerobic class the instructors led) was designed to test differences between the conditions. The test of the sphericity assumption was not passed [Chi-Square (df 5) =11.356, $p = .046$]. Therefore, the Greenhouse-Geisser adjustment to the degrees of freedom was employed. The results from the ANOVA were statistically significant [F

(1.62, 14.54) = 25.082, $p < .0005$]. The Fisher LSD was utilized to follow up statistically significant ANOVA's between conditions. Vocal intensity in the aerobic classroom was significantly different then the other conditions. Follow-up tests indicated that scores in Condition 1 were significantly higher than scores from the other three conditions and that scores from Condition 3 were statistically higher than scores from Condition 4.

The next ANOVA was designed to test differences between conditions in terms of vocal intensity in the lab environment. The test of the sphericity assumption was passed [Chi-Square (df 5) = 3.315, $p = .655$]. Therefore, sphericity was assumed for the ANOVA. The results from the ANOVA were statistically significant [F (3, 24)= 13.190, $p < .0005$]. The Fisher LSD was utilized to follow up statistically significant ANOVA's between conditions. Vocal intensity in lab was statistically significant and indicated that each pair of conditions differed except that Condition 1 and Condition 3 (the two conditions without amplification) did not differ, and Condition 2 and Condition 4 (the two conditions with amplification) did not differ. Those conditions with amplification produced lower scores than those conditions without amplification.

The ANOVA conducted on vocal intensity in class with the standard functional phrase was designed to test differences between the conditions. The test of the sphericity assumption was not passed [Chi-Square (df 5) = 13.217, $p = .022$]. Therefore, the Greenhouse-Geisser adjustment to the degrees of freedom was employed. The results from the ANOVA were statistically significant [F (1.841, 16.571) = 17.261, $p < .0005$]. The Fisher LSD was utilized to follow up statistically significant ANOVA's between conditions. The ANOVA conducted on vocal intensity in class with the phrase

vocalization was statistically significant, and follow up tests indicated that each pair of conditions was statistically different with the exception of Conditions 2 and 4 (the two conditions involving amplification). Specifically, those conditions without amplification produced higher mean vocal intensity.

The ANOVA conducted on vocal intensity in the lab with the standard functional phrase was designed to test differences between the conditions. The test of the sphericity assumption was passed [Chi-Square (df 5) = 4.091, p = .540]. Therefore, sphericity was assumed for the ANOVA. The results from the ANOVA were statistically significant [F (3, 24)= 13.181, p < .0005]. The Fisher LSD was utilized to follow up statistically significant ANOVA's between conditions. The ANOVA conducted on vocal intensity in lab with the phrase vocalization was statistically significant, with follow up tests indicating that each pair of groups was statistically different except that Conditions 2 and 4 were not different and Conditions 1 and 3 were not different. Conditions 1 and 3 (the conditions without amplification) produced higher mean vocal intensity.

Fundamental Frequency

Fundamental Frequency (F_0) measures the number of cycles of vocal fold vibration/periodicity of an acoustic signal per second. The ANOVA was designed to test differences between conditions in terms of fundamental frequency. The test of the sphericity assumption was not passed [Chi-Square (df 5) = 11.539, p = .043]. Therefore, the Greenhouse-Geisser adjustment to the degrees of freedom was employed. The results from the ANOVA were statistically significant [F (1.540, 13.858)= 9.740, p< .004]. The

Fisher LSD was utilized to follow up statistically significant ANOVA's between conditions. Fundamental frequency was statistically significant and each pair of groups was statistically significant except that Condition 1 and Condition 4 did not differ. Exercise without amplification (i.e. Condition 3) produced the highest mean, while amplification without exercise (i.e. Condition 2) produced the lowest mean.

The next ANOVA was designed to test differences between conditions in terms of standard deviations of fundamental frequency (SD F_0). The test of the sphericity assumption was not passed [Chi-Square (df 5) = 15.506, p= .009]. Therefore, the Greenhouse-Geisser adjustment to the degrees of freedom was employed. The results from the ANOVA were statistically significant [F (1.381, 12.426)=23.284, p< .0005]. The Fisher LSD was utilized to follow up statistically significant ANOVA's between conditions. The ANOVA conducted on the SD F_0 was statistically significant and follow up tests indicated that each pair of groups differed except that Condition 1 and Condition 2 (the two conditions without exercise) did not differ, and Condition 3 and Condition 4 (the two conditions with exercise) did not differ. The conditions with exercise produced the highest means.

Noise-to-Harmonic Ratio

Noise-to-harmonic ratio (NHR) compares the spectral energy (signal strength) with aperiodicity (energy of noise) existent in the voice signal. The ANOVA was designed to test differences between conditions in terms of NHR. The test of the sphericity assumption was passed [Chi-Square (df 5) = 8.203, p = .148]. Therefore,

sphericity was assumed for the ANOVA. The results from the ANOVA were statistically significant [$F(3, 27) = 4.378$, $p < .012$]. The Fisher LSD was utilized to follow up statistically significant ANOVA's between conditions. The ANOVA conducted on NHR was statistically significant, and follow up tests indicated that only Conditions 2 (with a lower mean) and 4 (with a higher mean) were statistically different, indicating that whether or not exercise was included in the condition had an effect only where amplification was present.

Jitter Percent

Jitter reveals the source of variability in the frequency of vocal fold vibration. The ANOVA was designed to test differences between conditions in terms of jitter percent (jitt %). The test of the sphericity assumption was passed [Chi-Square (df 5) = 2.477, $p = .781$]. Therefore, sphericity was assumed for the ANOVA. The results from the ANOVA were statistically significant [$F(3, 27) = 3.819$, $p < .021$]. The Fisher LSD was utilized to follow up statistically significant ANOVA's between conditions. The ANOVA conducted on jitt % was statistically significant, with follow up tests indicating that Conditions 1 and 2 both differed from Condition 4. Condition 4 had the highest mean jitter percentage.

Shimmer Percent

Shimmer reveals the source of variability in the amplitude of vocal fold vibration. The ANOVA was designed to test differences between conditions in terms of shimmer percent (shim %). The test of the sphericity assumption was passed [Chi-Square (df 5)= 8.484, $p = .134$]. Therefore, sphericity was assumed for the ANOVA. The results from the ANOVA were statistically significant [$F (3, 27)= 3.810$, $p < .021$]. The Fisher LSD was utilized to follow up statistically significant ANOVA's between conditions. The ANOVA conducted on shim % was statistically significant, and follow up tests indicated that Condition 1 and Condition 4 were statistically different. Specifically, the condition involving exercise and amplification (Condition 4) had a higher mean shimmer percentage than the condition involving no exercise and no amplification (Condition 1).

Dyspnea

Dyspnea ratings measure the amount of "breathlessness" or difficulty of perceived effort. The ANOVA conducted on dyspnea in class was designed to test differences between the conditions. The test of the sphericity assumption was not passed [Chi-Square (df 5) = 30.455, $p = .0005$]. Therefore, the Greenhouse-Geisser adjustment to the degrees of freedom was employed. The results from the ANOVA were statistically significant [$F (1.424, 12.816) = 68.500$, $p < .0005$]. The Fisher LSD was utilized to follow up statistically significant ANOVA's between conditions. The ANOVA conducted on dyspnea in class was statistically significant, with follow up tests indicating that each pair of groups was statistically different except Conditions 1 and 2 (the two conditions

without exercise). Conditions 3 and 4 (the conditions involving exercise) had drastically higher means than Conditions 1 and 2 (the conditions not involving exercise).

The ANOVA conducted on dyspnea in lab was designed to test differences between the conditions. The test of the sphericity assumption was not passed [Chi-Square (df 5) = 24.297, $p = .0005$]. Therefore, the Greenhouse-Geisser adjustment to the degrees of freedom was employed. The results from the ANOVA were statistically significant [$F(1.328, 11.955) = 87.388$, $p < .0005$]. The Fisher LSD was utilized to follow up statistically significant ANOVA's between conditions. Similarly, the ANOVA conducted on dyspnea in lab was statistically significant, with follow up tests again indicating that each pair of conditions were different except for Conditions 1 and 2. Again, the conditions involving exercise (Conditions 3 and 4) had drastically higher means than the conditions without exercise (Conditions 1 and 2).

CHAPTER 4: DISCUSSION

The purpose of this study was to investigate the effects that the respiratory system has on voice production during simultaneous tasks of exercise and speech in aerobic instructors. This study aimed to document changes that occur during various conditions, accounting for speech, exercise, and environmental variables, including amplification and music.

The sound of a person's voice can be documented by numerous objective measures. The target measures in this study were fundamental frequency (F_0), jitter percent (jitt %), shimmer percent (shim %), noise-to-harmonic ratio (NHR), and vocal intensity. Participants' sensation of dyspnea was observed and was shown to vary depending upon the environmental conditions that were encountered.

Vocal Intensity

Vocal intensity measures while saying the standard functional phrase of "Keep up the energy guys," and sustained vowel "ah" during the class were found to be higher in condition 1 than for the other three conditions. Naturally, vocal intensity was higher in condition 1, in which there was no exercise and no amplification, as compared to condition 2, in which there was no exercise, but use of amplification. In addition, when comparing the two conditions involving exercise, vocal intensity was also significantly louder without the use of amplification. Therefore, as hypothesized, vocal intensity was significantly decreased with the use of amplification, thus rejecting the null hypothesis.

When comparing the two conditions where amplification was not utilized, there was a difference only on account of exercise. Exercise was found to inhibit vocal loudness. Exercise resulted in a significant decrease in vocal intensity but was offset by the use of amplification in conditions 2 and 4. Even though vocal loudness levels in condition 4 were lower than condition 2, they were not statistically significant. In contrast, Doust and Patrick (1981) and Otis and Clark (1968), found speech during exercise to be louder, although the exercise task was restricted to a treadmill without the added component of having to "teach" an aerobic routine. Unlike these previous studies, the environments that aerobic instructors are in consist of a battle between a rigorous choreographed aerobic routine and voicing to reach the perimeter of a room. One possible reason for the differences found is in having to perform aerobic activity involving full body movement, phonation is sacrificed secondary to the effects of inappropriate postures from the aerobic routine. In addition, these physical stressors endured during an aerobic routine create a challenge for individuals to produce voicing without laryngeal compensation. The compensation typically can be heard as vocal strain, but physically results in increased compression forces of the instrinsic laryngeal musculature and increased collision force of the vibrating vocal fold.

Posture involves maintaining balance while numerous forces act upon the body in varying directions. Our body as a whole, even at the laryngeal level, is a segmented structure held by articulated bones, skeletal muscles, and ligaments. Ideal postural alignment is maintained through base, pelvic, trunk, and neck support. Any disturbing force that causes one segment to change positions causes other segments to misalign in an

effort to compensate to maintain posture (Schneider, Dennehy, & Saxon, 1997). It has been documented that misaligned posture can result in excessive tension in muscle groups, joint strain, ligamentous instability, cartilage damage, mechanical stresses of the myofacial region, and can be a contributing factor to arthritic changes (Lehmkuhl & Smith, 1983). Therefore, the postural changes constantly endured during aerobic routines could affect vocal production. Good posture is necessary for any professional voice user. Frommhold and Hoppe (1966) demonstrated the importance of proper posture for vocal performance in singers. The investigators performed a series of experiments with the intent of observing laryngeal movements during singing. A summary of their findings underscores the need for a stabilized laryngeal position during singing:

> In an investigation of the problem of voice production in trained singers, the movements of the cervical vertebrae were studied by means of tomograms [an X-ray photograph in which a single plane is photographed with the outline of structures in other planes eliminated], as providing a fixed bony point of attachment for the extrinsic laryngeal musculature. Important postural differences were found dependent upon the level of training and ability of the singer. Outstanding international artists were conspicuous without exception for a constant posture over the entire vocal range, while students showed increasing tension resulting in kyphosis (changes in the angle of the axis between the vertebrae II and VI), isolated distortions and also gliding movements in individual segments.

In addition to the vocal demands encountered in singers and aerobic instructors, aerobic instructors also endure simultaneous physical exercise, in which posture is continuously changing due to choreographed routines. As a result of these constant postural alterations, differences in vocal measures were found with the aerobic instructors during periods of increased ventilation as compared to at rest.

Finnegan et al. (2000) found that alterations in respiratory drive was the primary mechanism responsible for transient and sustained tracheal pressure increases associated with vocal intensity. Tracheal pressure can be defined as alterations in laryngeal activity which only played a small role in the modulation of tracheal pressure associated with vocal intensity. Alipour, Scherer, & Finnegan (1997) also found that during higher vocal intensity tasks, when subglottic pressure increased, laryngeal airway resistance also increased without changes in vocal fold adduction. This finding suggests that laryngeal airway resistance may be altered in a passive and active manner. Therefore, the laryngeal tissue could offer higher airflow resistance as a result of increased stiffness of the vocal fold cover from increased vocal fold strain associated with greater tracheal pressure. This occurred without increases in laryngeal muscle activity. Since the respiratory system is the primary mechanism for increasing vocal intensity, it is no wonder that during conditions involving exercise, which are taxing on the respiratory system, vocal loudness was reduced. As a result of decreased respiratory drive, laryngeal compensation could have likely occurred, and the subjects' perception of dyspnea increased.

Unlike the condition of the aerobic classroom, the lab environment did not produce significant changes in intensity when comparing conditions 1 and 3 and 2 and 4.

One possible reason for this could be that the aerobic routine was not as vigorous as it was in the actual aerobic classroom environment (even though participants target heart rate was monitored) therefore, differentiations based on exercise were not observed. Another plausible reason is the level of performance excitement that instructors had during the 'live' aerobic class, which was lacking in the lab environment. Although this is psychological in nature, increased levels of arousal have the potential to alter objective measures such as vocal intensity. Although the aerobic exercise level was not comparable, vocal intensity levels were distinguished among conditions with amplification having lower intensity levels as compared to conditions without amplification.

Vocal Function Measures

Fundamental frequency (F0) statistically differed among all conditions except for condition 1 and condition 4. Exercise without amplification produced the highest group mean, and no exercise without amplification (condition 1) produced the second highest group means. Interestingly, even though increases in vocal intensity were not found during exercise as previous studies had observed, increases in F_0 were observed in conditions involving exercise, more so in the most vocally challenging condition, condition 3, without amplification. Wolfe, Long, Youngblood, Williford, and Olson (2002), found increases in F_0 during periods of increased ventilation in aerobic instructors when compared to F_0 during conversational vocal tasks at rest. F_0 was lowest in the least physically and vocally challenging condition, condition 2, involving no exercise with the

use of amplification. This finding is likely due to an increase in frequency shifts as an attempt to compensate from the stressors of exercise, or from a more challenging vocal task (no amplification). One participant across all four conditions was found to have increased pitch levels beyond the norm for her gender. This participant in particular (participant E) spoke with a very loud voice and could be classified as the "screamer" of the group. As a result of these vocally abusive behaviors, vocal misuse occurred, such as laryngeal strain, resulting in abnormally high pitch levels. This participant also showed evidence of laryngeal pathology.

The standard deviation of fundamental frequency indicated that each condition differed except the two conditions without exercise and the two conditions with exercise. Meaning, all the other possible comparisons did differ—1 versus 3 and 4; 2 versus 3 and 4; 3 versus 1 and 2; and 4 versus 1 and 2. Conditions with exercise were found to have higher standard deviations than conditions without exercise, which can be attributed to participants having less control maintaining their pitch levels during periods of increased ventilation, which resulted in more variability in pitch.

Noise-to-harmonic ratio (NHR) differed among conditions 2 and 4, indicating that whether or not exercise was included in the condition, differences were apparent only when amplification was present. Condition 2 presented with the lowest NHR and condition 4 presented with the highest NHR. However, conditions involving exercise caused selected participants to have NHR values close to measures beyond the norm (abnormal: 0.19 and above, Baken & Orlikoff, 2000). No participants were found to have NHR values beyond the normative range, however, two participants were close in

condition 3 and one participant was close in condition 4 to exceeding normative ranges for NHR. It can be inferred, as exercise increased there was more physical and phonatory demands, which resulted in more aperiodic noise in the voice signal. As also found by Hoffman-Ruddy et al. (2001), singers classified as 'street performers,' who also like aerobic instructors performed high physical choreographed routines, were found to have an abnormally high amount of noise in the voice signal.

Both conditions without exercise differed in jitt % from condition 4, exercise with amplification. One possible reason for exercise with amplification having a higher jitt % than conditions without exercise, is that during exercise there is overall decreased control in the laryngeal area, subjectively heard by a more "tremulous" vocal sound. Therefore, the cycle-to-cycle variability in F0 is increased secondary to having to produce voice while under periods of increased ventilation. Although jitt % was also higher in condition 3 as compared to conditions 1 and 2, it was not significantly different. Normative range for jitt % is 1.04% and above (Kay Elemetrics Corporation Multi-Dimensional Voice Program, 1993; Baken & Orlikoff, 2000). In the present study, one participant (female) exceeded the normative values during condition 1, two participants (female) during condition 2, three participants (female) during condition 3, and four participants (one male, three females) during condition 4.

Shimmer percent was found to significantly differ between conditions 1 and 4. Although shim % was also higher in condition 3 as compared to condition 1, it was not significantly different. Similar to jitt% the effects of exercise caused a decrease in laryngeal control, which may have led to variations in vibratory amplitude.

Overall, during conditions with simultaneous vocal and physical routines, four participants were found to have F0 and jitt % values outside the normative range and no participants were found to have abnormal shim % or NHR values. Since only a minimal amount of participants were found to have vocal function measures outside the normative range during simultaneous vocal and physical routines, the null hypothesis is accepted.

Dyspnea

Dyspnea impacted all conditions except for differentiating between conditions without exercise. When not exercising, use of amplification while speaking did not affect participants perception of dyspnea, indicating that exercise was an important factor accounting for the sensation of breathlessness. Therefore, as hypothesized, exercise alone did increase participant perception of dyspnea, thus the null hypothesis was rejected. However, given aerobic activity, amplification was then a significant factor involved in the sensation of dyspnea, making further differentiating effects. It was demonstrated that dyspnea was significantly higher during exercise without the use of amplification compared to exercising with the use of amplification, therefore, the null hypothesis was rejected.

All ten participants reported to use amplification normally during instruction, in which nine out of the ten participants felt amplification helped decrease the amount of physical effort put forth. Interestingly, the participant who did not feel amplification assisted in decreasing dyspnea was the “screamer” of the group, participant E. In describing what part(s) of their task became easier when using amplification, seven of the

participants felt that both the respiratory and vocal task became easier, one felt the vocal task became easier, one felt the aerobic task became easier, and one felt it made no difference (see participants surveys in Appendix C).

Additional questions related to dyspnea presented in a questionnaire revealed that nine out of ten participants reported greater sensations of breathlessness during exercise without the use of amplification. More specifically, the type of exercise also affected this variable. Exercise involving simultaneous use of arms and legs, such as consecutive punching and kicking intervals, or plyometric sequences, such as jumping jack sequences, resulted in increased sensations of breathlessness. Step classes were also noted to be more aerobically challenging for instructors' due to the inability to stop aerobic participation since the class involves the constant need for a model of the aerobic routine. Kick-boxing, however, does not require constant instructor participation due to its more simplistic, repetitive nature of punching/kicking sequences in which aerobic-participant understanding can still be reached. Of the aerobic instructors/classes studied, five taught step classes, two taught kickboxing, and three taught a combination class. Participants also reported that reading The Rainbow Passage was the most challenging vocal task. As also found with Doust and Patrick (1981) and Otis and Clark (1968), fewer words were spoken during each breath due to higher respiratory frequency and attempts to maintain a constant reading speed. Reading, unlike natural, more conversational verbal/aerobic instruction, imposes less freedom for pausing and time to "catch one's breath." Therefore, it was not a surprise that reading was the most difficult of the vocal tasks.

In having to produce voice during exercise routines, regardless of amplification or not, 9 out of 10 instructors felt that in situations of high voicing efforts during exercise, compensatory strategies were necessary. Instructors reported the following strategies to try to make the task easier: "stopping verbal instructions, decreasing the aerobic intensity (also known as taking an *active rest*), using more gestures, and lowering the music." Instructors indicated that strategies to improve respiratory performance included: "pausing more between verbal instructions, taking deeper inhalations, and being aware of timing—vocal production with breathing or exhaling as I speak." Interestingly, the latter reason is how the body naturally responds to speech during high ventilatory tasks. Without speech, ventilation increases during exercise, seen by an increase in tidal volume and respiratory frequency. Doust and Patrick (1981), found that speech causes a reduction in ventilation by reducing respiratory frequency while the tidal volume remains the same. With speech, an added expiratory flow requirement is necessary, which attenuates the natural ventilatory response to the metabolic demands of increasing intensities of exercise, therefore the behavioral control system (speech) overrides the metabolic system. Russell and Stathopoulus (1988) found that when an individual speaks loudly, a deeper inhalation is initiated, with a greater degree of vocal fold adduction (Gauffin and Sundberg, 1989; Scherer, 1991), and larger articulatory excursions (Schulman, 1989) than for normal speech. Therefore, in having to produce voice in conditions of high ventilatory demand, compensatory strategies as well as the body's natural response to these conditions are necessary.

Endoscopic findings

Laryngostroboscopic results included evidence of moderate laryngeal pathology for four subjects. The type of pathology was hemorrhagic in nature, resulting in increased vascularity. Two of the four subjects showed evidence of a small mass on the true vocal folds. Coincidentally, at the time of the examination, these subjects indicated that they were not currently using amplification due to technical difficulties. Based on these findings, it can be postulated that use of amplification was effective in maintaining vocal health. Similar to findings of Hoffman-Ruddy et al. (2001), use of amplification was a significant factor in differentiating groups of singers' laryngostroboscopically. The group of singers most affected by laryngeal pathology was the "street theater group," which of all the groups studied, was most similar to aerobic instructors, even more so with the four instructors who were not using amplification at the time of the laryngeal examination. Environmental results indicated that the street theater performers wore heavy costumes in which excessive amounts of heat during their performance led to feelings of exhaustion and fatigue. In addition, the singers performed without amplification, and performed over elevated noise levels as the case of the four aerobic instructors who were found to have laryngeal pathology.

Summary

The occupational requirements of aerobic instructors demand both speech and exercise to occur simultaneously, making them a unique population to study. In an

attempt to understand the load the respiratory and laryngeal systems pose, significant correlations and levels of effect were established. During exercise alone, as expected, instructors faced increased amounts of dyspnea. However, combining speech with exercise further intensified the task. In order to differentiate between the two compounding variables, the effects of amplification and environmental variables were substantiated to further describe where the breakdown occurred, as measured through alterations in sensations of dyspnea and acoustic vocal measures.

Speech alone, whether it was with or without amplification, had no effect on the sensation of dyspnea. However, when combining speech with exercise, the task became increasingly difficult, but may not have been the direct result of increased ventilation from exercise alone. With the utilization of amplification during simultaneous speech and exercise tasks, dyspnea was significantly reduced as compared to conditions without amplification. The opinions obtained via questionnaire from the aerobic participants were that amplification assisted with both the respiratory and speech task or the respiratory/speech task alone. Therefore, despite various conceptions to what task became easier as a result of utilizing amplification, the overall and most important effect was decreasing the amount of effort put forth.

Overall, increases in F_0 were noted in conditions involving exercise and more challenging vocal tasks (not using amplification). However, the use of amplification during exercise lowered F_0, as compared to F_0 increasing during exercise without amplification, demonstrating the beneficial affects of amplification in decreasing vocal

effort levels. F_0 was lowest in the least physically and vocally challenging condition, which involved no exercise with the use of amplification.

Although differences were found in NHR between conditions involving amplification, with one condition involving exercise and the other not, none of the participants were found to have NHR measures outside the normal range. Six participants were found to have jitt % values outside the normal range. Exercise with amplification had significantly higher shim % than the condition involving no exercise and no amplification, however, no participants' shimmer values fell outside the normal range.

Limitations

This study would have benefited from a larger sample size. In addition, the level of aerobic effort produced in the lab environment condition may not have been as difficult as the exercise level reached in a live aerobic class. This was demonstrated by lower heart rates observed in the lab compared to the class. Having the instructors perform the same aerobic routine in the lab would have been more comparable to the 'live' class environment. Another limitation was that the loudness levels of music, aerobic room size, and number of aerobic participants taking the class may likely have an effect on vocal intensity. Future studies would benefit from using the same aerobic room and setting a standard loudness level for music with the same number of aerobic participants present.

Future Studies

Findings from the current study provide important information that may lead to more appropriate treatment protocols applied to address the respiratory and laryngeal demands encountered in this population and others. Future studies may include singers, athletes, cheerleaders, military personnel and populations with compromised respiratory function secondary to degenerative, neurological disease. Treatment protocols might involve strengthening the expiratory musculature as a means to eliminate compensatory laryngeal tension and strain. Treatment may also include training individuals to increase vocal loudness levels more appropriately through resonance training and vocal function exercises (Stemple, Lee, D'Amico, & Pickup, 1994). Training professional voice users to use amplification systems appropriately would also be of benefit, when used appropriately, amplification can assist in reducing vocal output in demanding conditions such as these.

APPENDIX A: VISUAL ANALOG SCALE

Visual Analog Scale

Place an X on the line indicating your perceived level of effort.

____

mild moderate severe

1. To what degree do you experience breathlessness during voice production when you're not exercising?

____

mild moderate severe

2. To what degree do you experience breathlessness during voice production without exercise and with the use of amplification?

____

mild moderate severe

3. To what degree do you experience breathlessness during exercise alone?

____

mild moderate severe

4. To what degree do you experience breathlessness during voice production with exercise without amplification?

____

mild moderate severe

5. To what degree do you experience breathlessness during voice production with exercise and use of amplification?

____

mild moderate severe

6. To what degree do you experience breathlessness without exercising and talking?

Please answer the following questions as thoroughly as you can

1. Do you experience greater sensations of breathlessness during specific situations more so than others? Please explain those situations.

2. Please describe the amount of effort or how you physically feel during aerobic instruction that is only vocal compared to vocal plus simultaneous aerobic activity?

3. During high intensity voicing efforts, do you compensate to help you produce the voice and physical task?

4. If so, how do you compensate, what do you do? (i.e. by stopping aerobic exercise, stopping verbal instructions, or any other way?)

5. Do you normally use amplification, if so, do you find it useful in decreasing the amount physical effort? What parts of your task become easier?

APPENDIX B: RAW DATA

Baseline 1 ***condition 1: No exercise, no amplification***

vocal task: sustained vowel "ah"

	vocal intensity during aerobic instruction				*vocal intensity during LAB*			
PARTIC.	**intens, # 1**	**intens, # 2**	**intens, # 3**	**intens, avg**	**intens, # 1**	**intens, # 2**	**intens, # 3**	**intens, avg**
A	116	115	112	114.33	109	107	108	108
B	110	115	114	113				
C	100	99	99	99.33	108	107	103	106
D	99	100	99	99.67	98	98	99	98.33
E	113	111	112	112	110	112	112	111.33
F	108	110	110	109.33	98	100	101	99.67
G	95	98	99	97.33	106	106	106	106
H	114	113	109	112	98	98	98	98
I	106	102	101	103	105	102	100	102.33
J	109	108	108	108.33	99	99	100	99.33

	noise to harmonic ratio				*jitter percent*			
PARTIC.	**NHR, # 1**	**NHR, # 2**	**NHR, # 3**	**NHR, avg**	**jitt, # 1**	**jitt, # 2**	**jitt, # 3**	**jitt, avg**
A	0.135	0.131	0.134	0.133333	0.364	0.994	0.411	0.589667
B	0.121	0.107	0.112	0.113333	0.803	1.428	0.987	1.072667
C	0.122	0.116	0.113	0.117	0.197	0.691	0.373	0.420333
D	0.086	0.106	0.102	0.098	0.344	0.516	0.746	0.535333
E	0.106	0.121	0.112	0.113	0.735	0.63	0.836	0.733667
F	0.181	0.1	0.116	0.132333	1.645	0.516	0.53	0.897
G	0.116	0.116	0.11	0.114	1.376	1.081	0.367	0.941333
H	0.12	0.122	0.124	0.122	0.31	0.28	0.236	0.275333
I	0.104	0.103	0.085	0.097333	0.371	0.246	0.339	0.318667
J	0.117	0.121	0.117	0.118333	0.647	0.706	1.213	0.855333

	average fundamental frequency				*standard deviation of fundamental freq.*			
PARTIC.	**fo, # 1**	**fo, # 2**	**fo, # 3**	**fo, avg**	**#1**	**#2**	**#3**	**avg**
A	163.195	165.279	165.036	164.5033	1.116	2.905	2.022	2.014333
B	389.542	388.056	384.994	387.5307	4.328	8.555	8.14	7.007667
C	249.844	252.906	236.932	246.5607	2.628	4.885	2.833	3.448667
D	271.539	274.7	273.309	273.1827	4.546	3.407	3.726	3.893
E	377.546	382.441	384.355	381.4473	3.838	2.82	3.536	3.398
F	158.429	159.037	159.538	159.0013	2.924	1.94	1.528	2.130667
G	250.735	250.433	248.103	249.757	5.447	2.981	2.909	3.779
H	197.268	196.452	194.587	196.1023	2.006	1.671	1.279	1.652
I	226.319	230.425	230.102	228.9487	1.35	1.154	1.918	1.474
J	227.378	228.476	228.673	228.1757	2.844	2.653	3.023	2.84

	shimmer percent			
PARTIC.	**shim, # 1**	**shim, # 2**	**shim, # 3**	**shim, avg**
A	0.403	0.334	0.633	0.456667
B	1.006	0.704	0.645	0.785
C	1.287	0.312	1.084	0.894333
D	1.47	1.755	1.679	1.634667
E	1.279	0.693	2.266	1.412667
F	0.138	0.108	0.102	0.116
G	0.506	0.758	1.016	0.76
H	0.216	0.327	0.3	0.281
I	0.212	0.378	0.27	0.286667
J	0.15	0.178	0.948	0.425333

Baseline 1 ***condition 1: No exercise, no amplification***

vocal task: saying the standard functional phrase

	vocal intensity during aerobic instruction				*vocal intensity during LAB*			
PARTIC.	**intens, # 1**	**intens, # 2**	**intens, # 3**	**intens, avg**	**intens, # 1**	**intens, # 2**	**intens, # 3**	**intens, avg**
A	108	110	105	107.67	94	97	95	95.33
B	113	113	114	113.33				
C	98	93	99	96.67	90	88	93	90.33
D	100	100	106	102	91	91	94	92
E	106	109	108	107.67	100	106	103	103
F	110	117	116	114.33	92	94	94	93.33
G	100	97	100	99	95	95	94	94.67
H	114	109	106	109.67	91	88	91	90
I	102	96	98	98.67	96	91	91	92.67
J	107	106	108	107	95	97	94	95.33

	mean fundamental frequency				*Standard Deviation of Fo*			
PARTIC.	**fo, # 1**	**fo, # 2**	**fo, # 3**	**fo, avg**	**# 1**	**# 2**	**# 3**	
A	194.46	219.21	223.2	212.29	18.03	21.5	18.58	19.37
B	265.13	268.55	285.66	273.1133	51.56	49.4	52.87	51.27667
C	236.15	241.22	233.92	237.0967	47.15	33.89	44.56	41.86667
D	230.89	227.47	207.01	221.79	74.67	75.04	73.2	74.30333
E	213.44	224.03	208.26	215.2433	38.16	20.76	54.03	37.65
F	157.43	160.32	163.78	160.51	23.32	26.85	29.43	26.53333
G	237.57	252.35	243.68	244.5333	50.27	49.59	51.91	50.59
H	219.92	214.11	211.09	215.04	22.91	24.84	28.69	25.48
I	251.2	272.41	271.42	265.01	48.32	28.79	28.4	35.17
J	264.75	256.16	253.31	258.0733	21.24	19.54	22.8	21.19333

Baseline 1 ***condition 2: No exercise, yes amplification***

vocal task: sustained vowel "ah"

	vocal intensity during aerobic instruction				*vocal intensity during LAB*			
PARTIC.	**intens, # 1**	**intens, # 2**	**intens, # 3**	**intens, avg**	**intens, # 1**	**intens, # 2**	**intens, # 3**	**intens, avg**
A	107	110	110	109	106	105	105	105.33
B	100	104	106	103.33				
C	98	98	98	98	96	99	101	98.67
D	86	88	84	86	97	96	94	95.67
E	104	105	100	103	112	111	112	111.67
F	107	108	105	106.67	90	93	93	92
G	97	98	91	95.33	91	89	91	90.33
H	98	93	93	94.67	90	87	86	87.67
I	95	98	94	95.67	97	95	97	96.33
J	100	100	102	100.67	95	92	92	93

	noise to harmonic ratio				*jitter percent*			
PARTIC.	**NHR, # 1**	**NHR, # 2**	**NHR, # 3**	**NHR, avg**	**jitt, # 1**	**jitt, # 2**	**jitt, # 3**	**jitt, avg**
A	0.119	0.12	0.119	0.119333	0.271	0.236	0.424	0.310333
B	0.099	0.113	0.099	0.103667	0.852	0.674	1.718	1.081333
C	0.115	0.118	0.12	0.117667	0.633	0.494	1.312	0.813
D	0.1	0.112	0.109	0.107	0.303	0.331	1.081	0.571667
E	0.104	0.102	0.099	0.101667	0.657	0.628	0.678	0.654333
F	0.097	0.083	0.088	0.089333	0.853	0.892	0.773	0.839333
G	0.132	0.14	0.121	0.131	0.645	0.716	0.69	0.683667
H	0.064	0.148	0.088	0.1	0.333	0.315	0.407	0.351667
I	0.118	0.11	0.108	0.112	0.446	0.428	1.044	0.639333
J	0.126	0.137	0.149	0.137333	0.986	1.139	1.308	1.144333

	mean fundamental frequency				*standard deviation of fundamental freq.*			
PARTIC.	**fo, # 1**	**fo, # 2**	**fo, # 3**	**fo, avg**	**#1**	**#2**	**#3**	**avg**
A	159.885	160.886	160.218	160.3297	1.288	1.332	1.051	1.223667
B	289.764	285.752	285.39	286.9687	5.491	3.984	8.341	5.938667
C	215.703	210.889	212.617	213.0697	3.638	2.487	4.386	3.503667
D	258.333	254.082	254.988	255.801	2.154	2.038	3.771	2.654333
E	367.918	372.498	374.893	371.7697	4.146	3.497	3.565	3.736
F	141.781	143.142	144.157	143.0267	2.396	2.145	2.064	2.201667
G	184.887	184.555	184.579	184.6737	3.26	3.619	2.365	3.081333
H	172.98	177.129	173.737	174.6153	1.342	1.499	1.267	1.369333
I	210.159	212.157	214.315	212.2103	3.116	1.346	2.806	2.422667
J	224.843	221.22	222.05	222.7043	2.477	2.46	2.732	2.556333

	shimmer percent			
PARTIC.	**shim, # 1**	**shim, # 2**	**shim, # 3**	**shim, avg**
A	0.147	0.171	0.166	0.161333
B	0.304	0.287	0.201	0.264
C	1.493	1.531	0.618	1.214
D	0.187	0.751	0.913	0.617
E	1.342	1.105	1.02	1.155667
F	1.462	1.325	1.453	1.413333
G	3.057	4.132	1.421	2.87
H	1.119	0.676	1.068	0.954333
I	0.551	0.543	0.647	0.580333
J	2.859	1.536	2.26	2.218333

Baseline 1 ***condition 2: No exercise, yes amplification***

vocal task: standard functional phrase

	vocal intensity during aerobic instruction				*vocal intensity during LAB*			
PARTIC.	**intens, # 1**	**intens, # 2**	**intens, # 3**	**intens, avg**	**intens, # 1**	**intens, # 2**	**intens, # 3**	**intens, avg**
A	107	104	102	104.33	88	90	96	91.33
B	103	105	106	104.67				
C	95	93	96	94.67	95	93	91	93
D	82	87	78	82.33	92	91	91	91.33
E	98	94	99	97	98	95	87	93.33
F	104	103	102	103	92	92	93	92.33
G	98	92	87	92.33	88	83	90	87
H	94	96	94	94.67	87	83	87	85.67
I	94	90	94	92.67	88	91	93	90.67
J	105	104	102	103.67	90	92	90	90.67

	mean fundamental frequency				*Standard Deviation of Fo*			
PARTIC.	**fo, # 1**	**fo, # 2**	**fo, # 3**	**fo, avg**	**# 1**	**# 2**	**# 3**	**avg**
A	176.54	208.35	213.66	199.5167	13.94	20.89	16.84	17.22333
B	261.88	258.95	258.43	259.7533	29.78	34.02	31	31.6
C	242.03	244.76	231.83	239.54	43.43	51.54	46.48	47.15
D	260.86	265.15	259.97	261.9933	39.11	40.17	40.68	39.98667
E	204.9	223.23	221.79	216.64	27.27	42.4	25.38	31.68333
F	148.67	149.05	149.28	149	20.63	28.94	26.36	25.31
G	215.74	211.37	199.83	208.98	48.79	37.19	48.2	44.72667
H	181.55	184.29	184.76	183.5333	25.87	15.5	20.64	20.67
I	270.47	254.63	256.53	260.5433	18.1	42.11	27.81	29.34
J	237.14	241.38	246.51	241.6767	37.54	23.97	21.01	27.50667

Baseline 1 ***condition 3: Exercise, yes amplification***

vocal task: sustained vowel "ah"

	vocal intensity during aerobic instruction				*vocal intensity during LAB*			
PARTIC.	**intens, # 1**	**intens, # 2**	**intens, # 3**	**intens, avg**	**intens, # 1**	**intens, # 2**	**intens, # 3**	**intens, avg**
A	104	108	107	106.33	108	107	109	108
B	98	98	100	98.67				
C	99	100	100	99.67	100	95	94	96.33
D	100	100	99	99.67	104	103	100	102.33
E	105	104	102	103.67	104	104	106	104.67
F	107	105	110	107.33	99	103	104	102
G	95	94	96	95	103	103	107	104.33
H	103	108	110	107	97	100	102	99.67
I	99	99	99	99	103	102	105	103.33
J	97	100	96	97.67	99	100	101	100

	noise to harmonic ratio				*jitter percent*			
PARTIC.	**NHR, # 1**	**NHR, # 2**	**NHR, # 3**	**NHR, avg**	**jitt, # 1**	**jitt, # 2**	**jitt, # 3**	**jitt, avg**
A	0.141	0.125	0.119	0.128333	0.642	0.436	0.548	0.542
B	0.104	0.079	0.098	0.093667	0.987	0.486	0.984	0.819
C	0.216	0.268	0.179	0.221	1.408	1.791	1.414	1.537667
D	0.105	0.105	0.102	0.104	0.677	0.401	0.971	0.683
E	0.108	0.11	0.115	0.111	0.87	1.148	0.884	0.967333
F	0.129	0.147	0.134	0.136667	0.532	0.844	0.503	0.626333
G	0.134	0.133	0.132	0.133	1.986	1.912	1.775	1.891
H	0.136	0.15	0.136	0.140667	0.402	0.958	0.468	0.609333
I	0.146	0.129	0.125	0.133333	0.694	1.469	0.685	0.949333
J	0.108	0.098	0.106	0.104	0.481	0.499	0.481	0.487

	average fundamental frequency				*standard deviation of fundamental freq.*			
PARTIC.	**fo, # 1**	**fo, # 2**	**fo, # 3**	**fo, avg**	**#1**	**#2**	**#3**	**avg**
A	156.719	156.377	158.572	157.2227	3.671	3.632	2.583	3.295333
B	369.517	377.805	375.102	374.1413	7.557	7.842	10.375	8.591333
C	232.449	235.282	238.378	235.3697	7.61	8.647	7.014	7.757
D	299.316	305.466	307.608	304.13	10.252	6.131	5.368	7.250333
E	401.091	409.651	411.514	407.4187	5.327	7.642	6.907	6.625333
F	188.473	181.435	186.149	185.3523	4.466	3.203	3.74	3.803
G	280.122	276.873	274.182	277.059	14.544	12.102	12.757	13.13433
H	223.051	224.525	220.349	222.6417	4.985	8.637	6.037	6.553
I	239.582	238.824	241.28	239.8953	6.378	7.279	5.182	6.279667
J	242.568	243.679	246.533	244.26	3.345	3.125	3.517	3.329

	shimmer percent			
PARTIC.	**shim, # 1**	**shim, # 2**	**shim, # 3**	**shim, avg**
A	0.213	0.16	0.181	0.184667
B	2.758	2.864	2.281	2.634333
C	2.304	6.027	4.188	4.173
D	0.357	0.208	0.205	0.256667
E	1.51	1.283	1.562	1.451667
F	0.364	0.526	0.59	0.493333
G	0.303	0.375	1.445	0.707667
H	0.391	1.078	0.353	0.607333
I	0.4	0.461	0.388	0.416333
J	0.213	0.172	0.298	0.227667

Baseline 1 ***condition 3: Exercise, no amplification***

vocal task: standard functional phrase

	vocal intensity during aerobic instruction				*vocal intensity during LAB*			
PARTIC.	**intens, # 1**	**intens, # 2**	**intens, # 3**	**intens, avg**	**intens, # 1**	**intens, # 2**	**intens, # 3**	**intens, avg**
A	93	105	104	100.67	96	92	96	94.67
B	97	97	98	97.33				
C	100	100	93	97.67	91	88	94	91
D	98	100	98	98.67	94	97	100	102.33
E	102	100	102	101.33	99	101	103	101
F	106	106	106	106	97	96	94	95.67
G	95	97	100	97.33	92	91	93	92
H	105	105	109	106.33	93	88	91	90.67
I	97	98	95	96.67	101	96	92	96.33
J	99	100	107	102	94	97	92	94.33

	mean fundamental frequency				*Standard Deviation of Fo*			
PARTIC.	**fo, # 1**	**fo, # 2**	**fo, # 3**	**fo, avg**	**# 1**	**# 2**	**# 3**	**avg**
A	204.77	214.47	211.15	210.13	14.61	17.92	20.2	17.57667
B	218.94	215.24	236.85	223.6767	72.35	65.25	69.01	68.87
C	233.83	257.8	254.37	248.6667	49.74	48.53	44.79	47.68667
D	234.14	247.1	271.71	250.9833	65.75	66.93	49.88	60.85333
E	219.29	216.25	231.83	222.4567	28.84	45.07	19.38	31.09667
F	195.9	196.13	189.45	193.8267	22.19	27.19	27.34	25.57333
G	206.17	213.7	233.43	217.7667	79.83	67.31	61.91	69.68333
H	245.37	246.87	241.91	244.7167	30.76	34.17	36.86	33.93
I	269.51	288.67	275.94	278.04	52.05	23.18	33.26	36.16333
J	289.12	276.04	282.47	282.5433	21.25	27.65	24.72	24.54

Baseline 1 ***condition 4: Exercise, yes amplification***

vocal task: sustained vowel "ah"

	vocal intensity during aerobic instruction				*vocal intensity during LAB*			
PARTIC.	**intens, # 1**	**intens, # 2**	**intens, # 3**	**intens, avg**	**intens, # 1**	**intens, # 2**	**intens, # 3**	**intens, avg**
A	100	98	99	99	105	107	110	107
B	90	90	95	91.67				
C	97	100	92	96.33	96	93	92	93.67
D	88	95	96	93	86	94	95	91.67
E	100	102	100	100.67	103	105	104	104
F	100	102	99	100.33	98	98	99	98.33
G	90	92	91	91	88	91	93	90.67
H	95	95	96	95.33	84	86	83	84.33
I	90	92	100	94	101	99	97	99
J	94	95	100	96.33	96	97	97	96.67

	noise to harmonic ratio				*jitter percent*			
PARTIC.	**NHR, # 1**	**NHR, # 2**	**NHR, # 3**	**NHR, avg**	**jitt, # 1**	**jitt, # 2**	**jitt, # 3**	**jitt, avg**
A	0.127	0.125	0.132	0.128	0.861	0.693	0.504	0.686
B	0.108	0.097	0.1	0.101667	2.504	1.165	2.232	1.967
C	0.216	0.131	0.16	0.169	1.769	1.364	1.28	1.471
D	0.106	0.112	0.108	0.108667	0.339	0.536	0.536	0.470333
E	0.118	0.1	0.113	0.110333	0.866	0.926	0.96	0.917333
F	0.151	0.147	0.154	0.150667	1.629	0.976	1.307	1.304
G	0.177	0.222	0.16	0.186333	1.396	0.895	1.02	1.103667
H	0.129	0.15	0.129	0.136	0.644	0.86	1.1	0.868
I	0.114	0.21	0.129	0.151	1.272	0.841	0.466	0.859667
J	0.111	0.12	0.117	0.116	0.828	0.876	0.872	0.858667

	average fundamental frequency				*standard deviation of fundamental freq.*			
PARTIC.	**fo, # 1**	**fo, # 2**	**fo, # 3**	**fo, avg**	**#1**	**#2**	**#3**	**avg**
A	177.346	176.635	175.883	176.6213	2.95	2.872	2.119	2.647
B	316.322	312.202	313.751	314.0917	7.222	7.284	6.882	7.129333
C	254.085	247.957	239.256	247.0993	8.936	6.398	6.172	7.168667
D	258.042	253.526	261.111	257.5597	3.997	4.528	3.902	4.142333
E	369.946	375.855	377.784	374.5283	6.99	4.806	7.023	6.273
F	163.451	165.738	163.533	164.2407	4.499	3.739	4.025	4.087667
G	212.854	210.208	218.647	213.903	6.135	10.689	7.658	8.160667
H	172.794	173.258	172.505	172.8523	4.188	5.166	7.209	5.521
I	229.177	233.282	226.178	229.5457	5.667	6.759	4.49	5.638667
J	248.745	247.943	247.499	248.0623	4.238	4.598	4.656	4.497333

	shimmer percent			
PARTIC.	**shim, # 1**	**shim, # 2**	**shim, # 3**	**shim, avg**
A	0.31	0.308	0.231	0.283
B	0.439	0.308	0.412	0.386333
C	3.918	2.541	6.81	4.423
D	0.293	0.371	1.61	0.758
E	0.765	1.9	2.03	1.565
F	0.852	0.145	0.229	0.408667
G	4.066	4.901	3.278	4.081667
H	4.442	3.927	5.332	4.567
I	0.32	3.614	0.227	1.387
J	1.881	1.688	1.703	1.757333

Baseline 1 ***condition 4: Exercise, yes amplification***

Vocal task: standard functional phrase

PARTIC.	*vocal intensity during aerobic instruction* intens, # 1	intens, # 2	intens, # 3	intens, avg	*vocal intensity during LAB* intens, # 1	intens, # 2	intens, # 3	intens, avg
A	91	96	96	94.33	93	95	94	94
B	89	93	90	90.67				
C	98	95	98	97	90	88	88	88.67
D	91	94	95	93.33	87	89	87	87.67
E	97	95	100	97.33	100	97	97	98
F	95	103	102	100	93	90	95	92.67
G	95	96	91	94	87	82	85	84.67
H	97	98	99	98	85	87	84	85.33
I	95	98	96	96.33	93	95	92	93.33
J	97	97	95	96.33	95	93	90	92.67

PARTIC.	*average fundamental frequency* fo, # 1	fo, # 2	fo, # 3	fo, avg	*Standard Deviation of Fo* # 1	# 2	# 3	avg
A	187.12	199.05	207.13	197.7667	17.2	20.09	27.26	21.51667
B	287.41	294.57	273.13	285.0367	36.43	33.09	42.75	37.42333
C	225.8	248.58	252	242.1267	48.47	47.43	47.17	47.69
D	265.46	283.97	289.39	279.6067	42.29	24.42	22.42	29.71
E	246.59	226.02	192.34	221.65	72.68	59.89	18.1	50.22333
F	164.17	166.81	161.85	164.2767	26.86	28.79	29.51	28.38667
G	264.66	249.92	263.7	259.4267	31.73	41.42	39.91	37.68667
H	202.87	208.87	187.75	199.83	26.67	20.55	23.65	23.62333
I	278.17	267.62	254.96	266.9167	22.81	27.31	43.2	31.10667
J	282.02	245.35	269.75	265.7067	19.3	50.3	23.19	30.93

Baseline 2 ***condition 1: No exercise, no amplification***

vocal task: sustained vowel "ah"

PARTIC.	*vocal intensity during aerobic instruction*				*vocal intensity during LAB*			
	intens, # 1	intens, # 2	intens, # 3	intens, avg	intens, # 1	intens, # 2	intens, # 3	intens, avg
A	110	119	114	114.33	110	113	112	111.67
B	110	110	113	111				
C	116	113	114	114.33	105	103	104	104
D	100	105	105	103.33	102	97	95	98
E	113	116	119	116	115	119	119	117.67
F	117	114	120	117	100	101	101	100.67
G	99	107	105	103.67	103	103	102	102.67
H	110	108	111	109.67	95	93	96	94.67
I	103	103	102	102.67	101	103	104	102.67
J	107	108	109	108	100	107	104	103.67

PARTIC.	*noise to harmonic ratio*				*jitter percent*			
	NHR, # 1	NHR, # 2	NHR, # 3	NHR, avg	jitt, # 1	jitt, # 2	jitt, # 3	jitt, avg
A	0.125	0.115	0.13	0.123333	0.329	0.333	0.238	0.3
B	0.095	0.106	0.1	0.100333	0.915	0.529	0.667	0.703667
C	0.115	0.116	0.103	0.111333	1.013	0.52	0.676	0.736333
D	0.109	0.103	0.098	0.103333	0.897	2.536	0.855	1.429333
E	0.108	0.103	0.093	0.101333	0.994	1.018	1.244	1.085333
F	0.151	0.13	0.135	0.138667	0.659	0.378	0.487	0.508
G	0.116	0.115	0.098	0.109667	1.117	1.807	0.545	1.156333
H	0.126	0.137	0.141	0.134667	0.352	0.326	0.271	0.316333
I	0.126	0.091	0.099	0.105333	0.704	0.361	0.303	0.456
J	0.124	0.125	0.121	0.123333	0.583	0.735	0.767	0.695

PARTIC.	*mean fundamental frequency*				*standard deviation of fundamental freq.*			
	fo, # 1	fo, # 2	fo, # 3	fo, avg	#1	#2	#3	avg
A	166.633	165.965	166.955	166.5177	1.423	1.202	1.313	1.312667
B	337.469	331.244	330.938	333.217	4.626	2.296	2.754	3.225333
C	267.08	254.172	249.578	256.9433	3.437	3.966	3.788	3.730333
D	331.973	338.849	339.072	336.6313	6.786	7.387	5.42	6.531
E	434.669	435.316	436.368	435.451	4.084	4.293	7.136	5.171
F	150.474	150.742	150.757	150.6577	2.137	1.611	1.597	1.781667
G	260.544	257.438	259.942	259.308	3.404	4.796	2.44	3.546667
H	184.19	181.684	180.914	182.2627	1.698	1.537	1.127	1.454
I	209.695	215.775	218.619	214.6963	1.839	1.628	0.842	1.436333
J	237.995	237.02	236.089	237.0347	1.926	2.431	2.539	2.298667

PARTIC.	*shimmer percent*			
	shim, # 1	shim, # 2	shim, # 3	shim, avg
A	0.433	0.32	0.322	0.358333
B	1.089	0.769	1.45	1.102667
C	0.826	1.2	0.806	0.944
D	0.698	0.538	0.494	0.576667
E	1.879	2.067	0.824	1.59
F	0.111	0.149	0.106	0.122
G	1.114	0.171	0.211	0.498667
H	0.121	0.135	0.147	0.134333
I	0.204	0.357	0.352	0.304333
J	0.141	0.177	0.286	0.201333

Baseline 2 ***condition 1: No exercise, no amplification***

vocal task: standard functional phrase

	vocal intensity during aerobic instruction				*vocal intensity during LAB*			
PARTIC.	**intens, # 1**	**intens, # 2**	**intens, # 3**	**intens, avg**	**intens, # 1**	**intens, # 2**	**intens, # 3**	**intens, avg**
A	107	105	107	106.33	95	98	97	96.67
B	107	108	107	107.33				
C	107	109	107	107.67	95	96	96	95.67
D	101	99	95	98.33	96	92	92	93.3
E	108	107	108	107.67	100	106	106	104
F	117	115	114	115.33	94	94	90	92.67
G	105	103	100	102.67	93	91	91	91.67
H	109	106	105	106.67	92	90	90	90.67
I	99	101	98	99.33	92	95	91	92.67
J	106	101	105	104	95	96	96	95.67
	mean fundamental frequency				*Standard Deviation of Fo*			
PARTIC.	**fo, # 1**	**fo, # 2**	**fo, # 3**	**fo, avg**	**# 1**	**# 2**	**# 3**	**avg**
A	198.06	221.34	208.13	209.1767	22.43	25.49	49.29	32.40333
B	240.29	281.16	281.45	267.6333	67.82	43.54	52.61	54.65667
C	282.29	259.54	278.56	273.4633	40.81	50.77	43.61	45.06333
D	276.49	295.73	315.56	295.9267	68.68	49.71	9.82	42.73667
E	216.62	225.6	246.55	229.59	19.07	18.25	25.36	20.89333
F	162.68	159.21	153.53	158.4733	25.68	29.4	35.1	30.06
G	248.37	258.2	224.07	243.5467	46.74	38.73	62.6	49.35667
H	193.4	212.44	210.75	205.53	32.13	16.67	18.26	22.35333
I	251.76	270.07	256.34	259.39	46.46	28.22	23.23	32.63667
J	268.9	261.05	248.42	259.4567	17.33	26.09	37.21	26.87667

Baseline 2 ***condition 2: No exercise, yes amplification***

vocal task: sustained vowel "ah"

	vocal intensity during aerobic instruction				*vocal intensity during LAB*			
PARTIC.	**intens, # 1**	**intens, # 2**	**intens, # 3**	**intens, avg**	**intens, # 1**	**intens, # 2**	**intens, # 3**	**intens, avg**
A	120	114	111	115	94	93	94	93.67
B	100	105	102	102.33				
C	104	102	102	102.67	100	101	100	100.33
D	96	94	91	93.67	94	91	94	93
E	102	105	106	104.33	110	113	115	112.67
F	108	105	101	104.67	97	97	98	97.33
G	92	100	95	95.67	93	92	96	93.67
H	87	85	84	85.33	84	81	83	82.67
I	100	98	96	98	97	94	96	95.67
J	97	96	95	96	90	94	93	92.33

	noise to harmonic ratio				*jitter percent*			
PARTIC.	**NHR, # 1**	**NHR, # 2**	**NHR, # 3**	**NHR, avg**	**jitt, # 1**	**jitt, # 2**	**jitt, # 3**	**jitt, avg**
A	0.139	0.127	0.128	0.131333	0.863	1.279	0.668	0.668
B	0.11	0.12	0.118	0.116	1.954	1.37	0.979	0.979
C	0.115	0.117	0.115	0.115667	2.015	0.576	0.598	0.598
D	0.104	0.101	0.098	0.101	0.269	0.323	0.414	0.414
E	0.108	0.097	0.087	0.097333	0.543	0.958	1.978	1.978
F	0.139	0.137	0.133	0.136333	0.586	0.477	0.362	0.362
G	0.126	0.131	0.122	0.126333	0.547	1.237	1.024	1.024
H	0.086	0.141	0.151	0.126	0.313	0.328	0.355	0.355
I	0.099	0.106	0.129	0.111333	0.657	0.659	0.244	0.244
J	0.096	0.094	0.08	0.09	0.908	1.205	0.932	0.932

	mean fundamental frequency				*standard deviation of fundamental freq.*			
PARTIC.	**fo, # 1**	**fo, # 2**	**fo, # 3**	**fo, avg**	**#1**	**#2**	**#3**	**avg**
A	162.782	164.545	165.749	164.3587	2.168	2.236	2.096	2.166667
B	254.841	252.286	251.767	252.9647	4.606	3.977	3.255	3.946
C	223.89	219.48	218.585	220.6517	4.212	3.797	4.15	4.053
D	286.612	286.501	286.605	286.5727	6.753	2.874	2.452	4.026333
E	411.791	431.16	430.159	424.37	3.399	7.288	11.099	7.262
F	152.038	150.085	150.213	150.7787	1.353	2.223	1.235	1.603667
G	193.429	194.693	198.477	195.533	2.688	3.141	2.73	2.853
H	159.853	162.366	162.974	161.731	1.291	1.118	0.913	1.107333
I	214.372	214.531	220.626	216.5097	1.66	1.686	0.982	1.442667
J	228.053	228.61	229.51	228.7243	2.465	2.755	2.356	2.525333

	shimmer percent			
PARTIC.	**shim, # 1**	**shim, # 2**	**shim, # 3**	**shim, avg**
A	0.188	0.254	0.581	0.341
B	0.197	0.133	0.233	0.187667
C	0.915	1.383	1.548	1.282
D	1.397	1.883	2.159	1.813
E	0.575	2.92	1.653	1.716
F	0.279	0.719	0.456	0.484667
G	1.254	1.369	1.496	1.373
H	0.619	0.672	0.813	0.701333
I	0.109	0.198	0.14	0.149
J	2.665	2.463	2.279	2.469

Baseline 2 ***condition 2: No exercise, yes amplification***

vocal task: standard functional phrase

	vocal intensity during aerobic instruction				*vocal intensity during LAB*			
PARTIC.	**intens, # 1**	**intens, # 2**	**intens, # 3**	**intens, avg**	**intens, # 1**	**intens, # 2**	**intens, # 3**	**intens, avg**
A	108	107	107	107.33	94	97	97	96
B	99	103	100	100.67				
C	101	98	95	98	95	92	91	92.67
D	88	89	89	88.67	83	81	85	83
E	97	100	101	99.33	98	98	98	98
F	102	107	102	103.67	88	91	92	90.33
G	95	97	97	96.33	84	88	85	85.67
H	86	84	85	85	83	80	81	81.33
I	96	96	93	95	91	91	91	91
J	98	95	92	95	89	89	91	89.67

	mean fundamental frequency				*Standard Deviation of Fo*			
PARTIC.	**fo, # 1**	**fo, # 2**	**fo, # 3**	**fo, avg**	**# 1**	**# 2**	**# 3**	**avg**
A	203.73	224.51	185.11	204.45	27.81	28.36	43.98	33.38333
B	234.09	255.17	253.19	247.4833	41.86	39.57	33.93	38.45333
C	246.99	244.13	223.95	238.3567	34.35	44.95	42.42	40.57333
D	209.88	273.73	267.78	250.4633	78.63	35.55	41.87	52.01667
E	212.82	231.96	229.21	224.6633	21.77	19.3	16.69	19.25333
F	155.93	157.19	156.73	156.6167	22.92	21.7	25.06	23.22667
G	221.29	207.06	218.05	215.4667	41.84	39.08	35.35	38.75667
H	181.77	151.59	170.25	167.87	19.84	27.36	16.17	21.12333
I	242.91	241.19	243.52	242.54	35.64	32.57	24.05	30.75333
J	257.21	249.67	244.57	250.4833	21.9	21.08	18.59	20.52333

Baseline 2 ***condition 3: Exercise, no amplification***

vocal task: sustained vowel "ah"

	vocal intensity during aerobic instruction				*vocal intensity during LAB*			
PARTIC.	**intens, # 1**	**intens, # 2**	**intens, # 3**	**intens, avg**	**intens, # 1**	**intens, # 2**	**intens, # 3**	**intens, avg**
A	105	103	108	105.33	107	106	105	106
B	99	110	109	106				
C	108	101	101	103.33	103	103	103	103
D	104	96	96	98.67	97	99	98	98
E	105	106	108	106.33	107	110	109	108.67
F	110	114	112	112	98	98	96	97.33
G	98	100	93	97	96	98	95	96.33
H	108	110	108	108.67	97	95	94	95.33
I	107	99	110	105.33	104	106	107	105.67
J	109	104	104	105.67	97	98	98	97.67

	noise to harmonic ratio				*jitter percent*			
PARTIC.	**NHR, # 1**	**NHR, # 2**	**NHR, # 3**	**NHR, avg**	**jitt, # 1**	**jitt, # 2**	**jitt, # 3**	**jitt, avg**
A	0.124	0.115	0.136	0.125	1.676	0.926	0.996	1.199333
B	0.093	0.106	0.107	0.102	0.635	0.6	0.677	0.637333
C	0.118	0.109	0.114	0.113667	0.641	0.742	1.043	0.808667
D	0.092	0.099	0.097	0.096	0.249	1.219	0.66	0.709333
E	0.105	0.118	0.125	0.116	0.812	0.862	0.906	0.86
F	0.12	0.15	0.149	0.139667	1.129	1.123	1.023	1.091667
G	0.132	0.129	0.131	0.130667	0.879	0.525	0.421	0.608333
H	0.172	0.202	0.19	0.188	0.542	1.046	1.117	0.901667
I	0.122	0.132	0.141	0.131667	0.366	0.583	0.599	0.516
J	0.122	0.134	0.124	0.126667	0.814	1.03	1.486	1.11

	average fundamental frequency				*standard deviation of fundamental freq.*			
PARTIC.	**fo, # 1**	**fo, # 2**	**fo, # 3**	**fo, avg**	**#1**	**#2**	**#3**	**avg**
A	175.137	173.59	173.63	174.119	3.643	2.861	3.627	3.377
B	359.061	352.808	353.258	355.0423	5.305	5.909	5.305	5.506333
C	282.29	264.699	286.395	277.7947	5.933	6.156	7.501	6.53
D	310.461	314.556	314.08	313.0323	5.39	5.186	5.434	5.336667
E	387.232	387.803	393.255	389.43	5.014	6.092	6.514	5.873333
F	173.322	177.739	175.145	175.402	3.349	4.836	4.422	4.202333
G	257.904	249.9	255.632	254.4787	7.31	7.073	7.243	7.208667
H	213.276	214.551	210.498	212.775	6.978	10.515	9.388	8.960333
I	234.442	237.399	237.642	236.4943	4.264	6.018	5.618	5.3
J	234.874	236.27	234.26	235.1347	3.203	4.324	4.874	4.133667

	shimmer percent			
PARTIC.	**shim, # 1**	**shim, # 2**	**shim, # 3**	**shim, avg**
A	0.936	0.839	0.646	0.807
B	0.666	0.683	0.683	0.677333
C	1.844	1.372	1.216	1.477333
D	1.02	0.619	0.811	0.816667
E	2.46	2.849	2.821	2.71
F	0.182	0.229	0.164	0.191667
G	1.119	2.933	2.471	2.174333
H	0.522	0.867	0.59	0.659667
I	0.309	0.359	0.338	0.335333
J	1.322	0.772	1.095	1.063

Baseline 2 ***condition 3: Exercise, no amplification***

vocal task: sustained vowel "ah"

	vocal intensity during aerobic instruction				*vocal intensity during LAB*			
PARTIC.	**intens, # 1**	**intens, # 2**	**intens, # 3**	**intens, avg**	**intens, # 1**	**intens, # 2**	**intens, # 3**	**intens, avg**
A	104	99	101	101.33	94	92	95	93.67
B	105	105	104	104.67				
C	106	98	106	103.33	97	100	96	97.67
D	99	98	93	96.67	91	92	89	90.67
E	104	105	101	103.33	96	98	97	97
F	105	108	114	109	92	92	94	92.67
G	99	100	99	99.33	90	93	89	90.67
H	107	104	106	105.67	88	86	87	87
I	98	97	101	98.67	95	94	93	94
J	108	103	106	105.67	94	89	89	90.67

	mean fundamental frequency				*Standard Deviation of Fo*			
PARTIC.	**fo, # 1**	**fo, # 2**	**fo, # 3**	**fo, avg**	**# 1**	**# 2**	**# 3**	**avg**
A	211.42	222.86	225.51	219.93	14.74	18.21	17	16.65
B	279.81	278.41	249.66	269.2933	49.36	60.77	64.73	58.28667
C	239.07	232.65	233.57	235.0967	58.69	54.63	56.87	56.73
D	265.93	299.32	305.34	290.1967	59.96	20.8	27.14	35.96667
E	250.85	224.09	230.29	235.0767	51.2	41.15	22.58	38.31
F	186.12	200.57	198.21	194.9667	31.94	29.57	28.97	30.16
G	240.46	240.58	244.7	241.9133	55.66	47.53	50.76	51.31667
H	221.54	219.65	211.5	217.5633	29.27	26.13	24.67	26.69
I	283.75	274.79	272.45	276.9967	24.67	23.05	21.17	22.96333
J	277.18	262.66	262.4	267.4133	26.43	18.55	23.79	22.92333

Baseline 2 ***condition 4: Exercise, yes amplification***

vocal task: sustained vowel "ah"

	vocal intensity during aerobic instruction				*vocal intensity during LAB*			
PARTIC.	**intens, # 1**	**intens, # 2**	**intens, # 3**	**intens, avg**	**intens, # 1**	**intens, # 2**	**intens, # 3**	**intens, avg**
A	100	99	95	98	110	106	106	107.33
B	99	100	95	98				
C	100	101	102	101	99	103	103	101.67
D	90	87	96	91	90	95	93	92.67
E	100	104	102	102	107	108	107	107.33
F	105	103	108	105.33	91	91	94	92
G	91	90	93	91.33	89	91	93	91
H	98	98	96	97.33	83	81	85	83
I	95	97	93	95	106	103	105	104.67
J	94	96	106	98.67	94	96	94	94.67

	noise to harmonic ratio				*jitter percent*			
PARTIC.	**NHR, # 1**	**NHR, # 2**	**NHR, # 3**	**NHR, avg**	**jitt, # 1**	**jitt, # 2**	**jitt, # 3**	**jitt, avg**
A	0.138	0.149	0.139	0.142	0.651	1.332	0.658	0.880333
B	0.095	0.115	0.101	0.103667	0.932	0.943	0.873	0.916
C	0.118	0.113	0.127	0.119333	1.025	0.544	1.559	1.042667
D	0.129	0.097	0.111	0.112333	0.499	0.814	0.458	0.590333
E	0.099	0.107	0.105	0.103667	0.887	1.053	1.276	1.072
F	0.131	0.139	0.128	0.132667	0.939	0.914	1.21	1.021
G	0.158	0.145	0.136	0.146333	1.136	0.934	1.09	1.053333
H	0.154	0.115	0.113	0.127333	0.631	0.715	0.655	0.667
I	0.134	0.125	0.132	0.130333	0.469	0.589	0.623	0.560333
J	0.115	0.117	0.125	0.119	1.209	1.265	0.898	1.124

	mean fundamental frequency				*standard deviation of fundamental freq.*			
PARTIC.	**fo, # 1**	**fo, # 2**	**fo, # 3**	**fo, avg**	**#1**	**#2**	**#3**	**avg**
A	164.693	166.97	166.624	166.0957	2.279	4.064	2.841	3.061333
B	311.207	309.06	308.998	309.755	5.035	7.607	4.99	5.877333
C	277.388	276.849	273.789	276.0087	6.115	6.572	9.901	7.529333
D	292.225	305.468	304.613	300.7687	14.741	6.685	4.43	8.618667
E	407.501	407.292	406.525	407.106	3.733	6.779	8.211	6.241
F	148.218	151.778	154.44	151.4787	3.884	4.193	3.306	3.794333
G	223.965	217.264	223.382	221.537	5.887	7.008	7.029	6.641333
H	178.211	176.691	174.837	176.5797	5.041	4.601	5.015	4.885667
I	241.588	238.89	241.975	240.8177	6.207	5.088	6.531	5.942
J	232.649	232.935	235.014	233.5327	3.518	4.559	3.723	3.933333

	shimmer percent			
PARTIC.	**shim, # 1**	**shim, # 2**	**shim, # 3**	**shim, avg**
A	0.496	0.823	0.568	0.629
B	0.243	0.269	0.385	0.299
C	1.654	2.909	0.53	1.697667
D	2.297	1.533	1.862	1.897333
E	1.652	2.149	1.546	1.782333
F	1.256	0.803	0.144	0.734333
G	3.158	4.299	3.097	3.518
H	0.801	1.818	3.08	1.899667
I	0.392	0.251	0.284	0.309
J	2.361	2.231	1.991	2.194333

Baseline 2 ***condition 4: Exercise, yes amplification***

vocal task: standard functional phrase

	vocal intensity during aerobic instruction				*vocal intensity during LAB*			
PARTIC.	**intens, # 1**	**intens, # 2**	**intens, # 3**	**intens, avg**	**intens, # 1**	**intens, # 2**	**intens, # 3**	**intens, avg**
A	95	87	95	92.33	91	92	94	92.33
B	97	95	98	96.67				
C	103	105	103	103.67	94	96	93	94.33
D	87	91	90	89.33	86	88	90	88
E	96	103	99	99.33	99	97	96	97.33
F	104	104	104	104	91	90	90	90.33
G	96	93	93	94	86	84	88	86
H	94	92	95	93.67	84	83	82	83
I	93	96	91	93.33	91	94	97	94
J	99	100	102	100.33	90	93	91	91.33

	mean fundamental frequency				*Standard Deviation of Fo*			
PARTIC.	**fo, # 1**	**fo, # 2**	**fo, # 3**	**fo, avg**	**# 1**	**# 2**	**# 3**	**avg**
A	210.27	207.37	230.48	216.04	12.79	13.34	41.15	22.42667
B	278.95	268.02	277.66	274.8767	50.34	53.27	51.36	51.65667
C	245.15	244.11	248.48	245.9133	51.11	50.54	50.08	50.57667
D	237.38	268.75	253.74	253.29	67.98	45.41	71.06	61.48333
E	217.72	238.08	219.51	225.1033	34.95	41.85	22.07	32.95667
F	179.11	175.91	178.21	177.7433	23.33	28.7	27.89	26.64
G	253.63	257.93	243	251.52	40.24	51.62	48.78	46.88
H	187.52	189.54	189.62	188.8933	13.12	13.31	11.21	12.54667
I	285.5	286.36	278.61	283.49	34.4	26.72	45.83	35.65
J	250.9	262.23	258.41	257.18	38.73	21.11	16.65	25.49667

	Baseline 1: Dyspnea				**Baseline 2: Dyspnea**			
	exercise, N amp		*exercise, Y amp*		*exercise, N amp*		*exercise, Y amp*	
	class	*LAB*	*class*	*LAB*	*class*	*LAB*	*class*	*LAB*
PARTIC.	**dyspnea**	**dyspnea**	**dyspnea**	**dyspnea**	**dyspnea**	**dyspnea**	**dyspnea**	**dyspnea**
A	51	39	14	18	32	36	18	27
B	98	98	83	64	98	100	71	71
C	49	68	26	48	78	61	66	39
D	98	65	56	55	77	62	67	51
E	75	72	59	76	70	66	65	58
F	67	24	11	20	70	49	13	40
G	75	52	51	53	67	69	28	56
H	74	66	47	35	58	49	36	25
I	82	77	48	77	50	64	5	44
J	31	90	14	70	38	76	19	56

APPENDIX C: DYSPNEA QUESTIONNAIRES

PARTICIPANT A: aerobic class

Please answer the following questions as thoroughly as you can

1. Do you experience greater sensations of breathlessness during specific situations more so than others? Please explain those situations.

   Yes, more energy required, i.e. I get tired faster. Higher voice level without microphone.

2. Please describe the amount of effort or how you physically feel during aerobic instruction that is only vocal compared to vocal plus simultaneous aerobic activity?

   Get more tired with cardio

3. During high intensity voicing efforts, do you compensate to help you produce the voice and physical task?

   Yes

4. If so, how do you compensate, what do you do? (i.e. by stopping aerobic exercise, stopping verbal instructions, or any other way?)

   Walking around room checking everybody is doing ok while performing a combination

5. Do you normally use amplification, if so, do you find it useful in decreasing the amount physical effort? What parts of your task become easier?

   Voice level gets lower, thus conserving more energy. Aerobic task becomes easier doing tasks.

PARTICIPANT A: lab environment

<u>Please answer the following questions as thoroughly as you can</u>

1. Do you experience greater sensations of breathlessness during specific situations more so than others? Please explain those situations.

   Reading a paragraph was more tiring than saying other things

2. Please describe the amount of effort or how you physically feel during aerobic instruction that is only vocal compared to vocal plus simultaneous aerobic activity?

   You get tired faster when you are talking while exercising.

3. During high intensity voicing efforts, do you compensate to help you produce the voice and physical task?

   Yes

4. If so, how do you compensate, what do you do? (i.e. by stopping aerobic exercise, stopping verbal instructions, or any other way?)

   Deep breath in beginning, little breaths between sentences.

5. Do you normally use amplification, if so, do you find it useful in decreasing the amount physical effort? What parts of your task become easier?

   Yes, it takes more energy raising the voice without a mike than speaking normally with a mike.

PARTICIPANT B: aerobic class

Please answer the following questions as thoroughly as you can

1. Do you experience greater sensations of breathlessness during specific situations more so than others? Please explain those situations.

   Yes. Certain classes cause greater breathlessness then others. For example, step vs kickboxing. Step is harder because you are constantly doing the moves physically, where as in kickboxing you can stop and walk around the class. Also, when the class is at its peak intensity, I become more breathless.

2. Please describe the amount of effort or how you physically feel during aerobic instruction that is only vocal compared to vocal plus simultaneous aerobic activity?

   Aerobic instruction that is only vocal is much easier because you do not run out of breath. I tend to scream louder in these types of classes because I have more energy.

3. During high intensity voicing efforts, do you compensate to help you produce the voice and physical task?

   Yes

4. If so, how do you compensate, what do you do? (i.e. by stopping aerobic exercise, stopping verbal instructions, or any other way?)

   I will sometimes walk around the class (if possible) or if teaching step I will not do the arms or not do the step to the full potential I would if I was not using my voice as much.

5. Do you normally use amplification, if so, do you find it useful in decreasing the amount physical effort? What parts of your task become easier?

   Yes, I always use amplification. It definitely decreases the physical effort. I do not have to yell as loud so I can concentrate on the people in the class more as well as my own form. Everything in a sense becomes easier.

PARTICIPANT B: lab environment

<u>Please answer the following questions as thoroughly as you can</u>

1. Do you experience greater sensations of breathlessness during specific situations more so than others? Please explain those situations.

   Reading the passage was the hardest because it was long and hard to read while exercising.

2. Please describe the amount of effort or how you physically feel during aerobic instruction that is only vocal compared to vocal plus simultaneous aerobic activity?

   Only vocal was easy and I did not use any effort but with aerobic activity my effort increased. Using the microphone helped decrease my effort.

3. During high intensity voicing efforts, do you compensate to help you produce the voice and physical task?

   Yes

4. If so, how do you compensate, what do you do? (i.e. by stopping aerobic exercise, stopping verbal instructions, or any other way?)

   By taking deeper breaths and by not exercising as intensely.

5. Do you normally use amplification, if so, do you find it useful in decreasing the amount physical effort? What parts of your task become easier?

   Yes, it helped with the vocal task.

PARTICIPANT C: aerobic class

Please answer the following questions as thoroughly as you can

1. Do you experience greater sensations of breathlessness during specific situations more so than others? Please explain those situations.

   Jumping Jack sequence; when explaining a new technique (especially if class looks confused), i.e. more anxiety more fatigue; punching and kicking bag (anything with hand and leg movement).

2. Please describe the amount of effort or how you physically feel during aerobic instruction that is only vocal compared to vocal plus simultaneous aerobic activity?

   Normal up to a point where voice projection becomes more demanding, i.e. a larger class or larger aerobic room.

3. During high intensity voicing efforts, do you compensate to help you produce the voice and physical task?

   Yes occasionally

4. If so, how do you compensate, what do you do? (i.e. by stopping aerobic exercise, stopping verbal instructions, or any other way?)

   I move around the room or I stop the verbal instruction.

5. Do you normally use amplification, if so, do you find it useful in decreasing the amount physical effort? What parts of your task become easier?

   Yes, I use it. It's helpful in loudness and clarity (pitch). Laying down and speaking (abs) are easier.

PARTICIPANT C: lab environment

<u>Please answer the following questions as thoroughly as you can</u>

1. Do you experience greater sensations of breathlessness during specific situations more so than others? Please explain those situations.

   With exercise, without amplification during the reading.

2. Please describe the amount of effort or how you physically feel during aerobic instruction that is only vocal compared to vocal plus simultaneous aerobic activity?

   Little during vocal projection with aerobic yet when exercising and using voice inflection it becomes much more effortful.

3. During high intensity voicing efforts, do you compensate to help you produce the voice and physical task?

   Yes

4. If so, how do you compensate, what do you do? (i.e. by stopping aerobic exercise, stopping verbal instructions, or any other way?)

   I exhale as I speak. Take a deep breath in before speaking helped a lot.

5. Do you normally use amplification, if so, do you find it useful in decreasing the amount physical effort? What parts of your task become easier?

   Yes exercise becomes easier with amplification. More so, amplification helped to maintain a more natural breathing pattern.

PARTICIPANT D: aerobic class

Please answer the following questions as thoroughly as you can

1. Do you experience greater sensations of breathlessness during specific situations more so than others? Please explain those situations.

   More breathless without a microphone.

2. Please describe the amount of effort or how you physically feel during aerobic instruction that is only vocal compared to vocal plus simultaneous aerobic activity?

   I put forth more effort while I'm exercising.

3. During high intensity voicing efforts, do you compensate to help you produce the voice and physical task?

   Yes sometimes.

4. If so, how do you compensate, what do you do? (i.e. by stopping aerobic exercise, stopping verbal instructions, or any other way?)

   By stopping verbal instruction.

5. Do you normally use amplification, if so, do you find it useful in decreasing the amount physical effort? What parts of your task become easier?

   Yes. Vocabulary and breathing.

PARTICIPANT D: lab environment

<u>Please answer the following questions as thoroughly as you can</u>

1. Do you experience greater sensations of breathlessness during specific situations more so than others? Please explain those situations.

   Reading paragraph effected by breathlessness during talking and exercising. A little easier with microphone.

2. Please describe the amount of effort or how you physically feel during aerobic instruction that is only vocal compared to vocal plus simultaneous aerobic activity?

   Its harder to talk while exercising versus just standing still.

3. During high intensity voicing efforts, do you compensate to help you produce the voice and physical task?

   Yes

4. If so, how do you compensate, what do you do? (i.e. by stopping aerobic exercise, stopping verbal instructions, or any other way?)

   Pause longer between talking.

5. Do you normally use amplification, if so, do you find it useful in decreasing the amount physical effort? What parts of your task become easier?

   Yes.

PARTICIPANT E: lab environment

Please answer the following questions as thoroughly as you can

1. Do you experience greater sensations of breathlessness during specific situations more so than others? Please explain those situations.

   While reading and exercising.

2. Please describe the amount of effort or how you physically feel during aerobic instruction that is only vocal compared to vocal plus simultaneous aerobic activity?

   Great when not exercising—easy.

3. During high intensity voicing efforts, do you compensate to help you produce the voice and physical task?

   Yes

4. If so, how do you compensate, what do you do? (i.e. by stopping aerobic exercise, stopping verbal instructions, or any other way?)

   Take breaths more frequently, slow down my exercise pace.

5. Do you normally use amplification, if so, do you find it useful in decreasing the amount physical effort? What parts of your task become easier?

   Doesn't make much difference.

PARTICIPANT F: aerobic class

Please answer the following questions as thoroughly as you can

1. Do you experience greater sensations of breathlessness during specific situations more so than others? Please explain those situations.

   Leaving the floor while teaching; Jumping; intense exercise without microphone.

2. Please describe the amount of effort or how you physically feel during aerobic instruction that is only vocal compared to vocal plus simultaneous aerobic activity?

   No difference up to moderately high intensity exercise. Difference—must be aware of timing (vocal production with breathing)

3. During high intensity voicing efforts, do you compensate to help you produce the voice and physical task?

   Yes

4. If so, how do you compensate, what do you do? (i.e. by stopping aerobic exercise, stopping verbal instructions, or any other way?)

   See "timing" above. Maybe fewer instructions (with mic). Definitely fewer instructions without microphone.

5. Do you normally use amplification, if so, do you find it useful in decreasing the amount physical effort? What parts of your task become easier?

   Yes. For intense exercise. Talking is easier. Maybe exercise.

PARTICIPANT F: lab environment

Please answer the following questions as thoroughly as you can

1. Do you experience greater sensations of breathlessness during specific situations more so than others? Please explain those situations.

   Though relatively mild, the breathlessness during continuous reading while exercising was greatest. Use of amplification had little effect—it appeared to be more related to the required timing for continuous reading.

2. Please describe the amount of effort or how you physically feel during aerobic instruction that is only vocal compared to vocal plus simultaneous aerobic activity?

   Instruction only is not much effort unless the competing background noise is high.

3. During high intensity voicing efforts, do you compensate to help you produce the voice and physical task?

   Yes

4. If so, how do you compensate, what do you do? (i.e. by stopping aerobic exercise, stopping verbal instructions, or any other way?)

   Time voicing to exhale.

5. Do you normally use amplification, if so, do you find it useful in decreasing the amount physical effort? What parts of your task become easier?

   Not really. There was no competing background sound.

PARTICIPANT G: aerobic class

<u>Please answer the following questions as thoroughly as you can</u>

1. Do you experience greater sensations of breathlessness during specific situations more so than others? Please explain those situations.

   Greater sensations of breathlessness when talking and exercising at the same time. Also when combining lower and upper body or doing explosive/plyometric moves.

2. Please describe the amount of effort or how you physically feel during aerobic instruction that is only vocal compared to vocal plus simultaneous aerobic activity?

   Less effort when just vocal.

3. During high intensity voicing efforts, do you compensate to help you produce the voice and physical task?

   Sometimes, if needed.

4. If so, how do you compensate, what do you do? (i.e. by stopping aerobic exercise, stopping verbal instructions, or any other way?)

   Stop verbal instructions or bring aerobic exercise intensity down. This is called an active rest.

5. Do you normally use amplification, if so, do you find it useful in decreasing the amount physical effort? What parts of your task become easier?

   Yes. Not so hard on the throat, feel like I have more authority. Less effort physically with amplification. More saliva produced without amplification. Without amplification, I feel I need to face the exercisers.

PARTICIPANT G: lab environment

Please answer the following questions as thoroughly as you can

1. Do you experience greater sensations of breathlessness during specific situations more so than others? Please explain those situations.

   Yes, more during the reading session. A little less with amplification.

2. Please describe the amount of effort or how you physically feel during aerobic instruction that is only vocal compared to vocal plus simultaneous aerobic activity?

   A lot less effort when just vocal.

3. During high intensity voicing efforts, do you compensate to help you produce the voice and physical task?

   Yes

4. If so, how do you compensate, what do you do? (i.e. by stopping aerobic exercise, stopping verbal instructions, or any other way?)

   Took large inhalations in between reading tasks.

5. Do you normally use amplification, if so, do you find it useful in decreasing the amount physical effort? What parts of your task become easier?

   Yes. Both exercise and talking is easier.

PARTICIPANT H: lab environment

Please answer the following questions as thoroughly as you can

1. Do you experience greater sensations of breathlessness during specific situations more so than others? Please explain those situations.

   Reading was harder and more strenuous without amplification. Still experienced some breathlessness with microphone when reading a passage.

2. Please describe the amount of effort or how you physically feel during aerobic instruction that is only vocal compared to vocal plus simultaneous aerobic activity?

   Slight increase in heart rate and exerted energy.

3. During high intensity voicing efforts, do you compensate to help you produce the voice and physical task?

   Yes

4. If so, how do you compensate, what do you do? (i.e. by stopping aerobic exercise, stopping verbal instructions, or any other way?)

   While reading inhaled deeper.

5. Do you normally use amplification, if so, do you find it useful in decreasing the amount physical effort? What parts of your task become easier?

   Without microphone always exerts more energy. Your output becomes easier with microphone.

PARTICIPANT I: aerobic class

Please answer the following questions as thoroughly as you can

1. Do you experience greater sensations of breathlessness during specific situations more so than others? Please explain those situations.

   Any situation when teaching without a microphone and more so advanced combos without a microphone.

2. Please describe the amount of effort or how you physically feel during aerobic instruction that is only vocal compared to vocal plus simultaneous aerobic activity?

   I always feel like I'm shouting whether I have the mic or not.

3. During high intensity voicing efforts, do you compensate to help you produce the voice and physical task?

   Sometimes.

4. If so, how do you compensate, what do you do? (i.e. by stopping aerobic exercise, stopping verbal instructions, or any other way?)

   I'll modify if I don't have use of a microphone. I'll change an advanced combo to an intermediate combo or an intermediate to a beginner if I don't have the microphone. If I do have a microphone, I never modify the combo or the amount of voicing.

5. Do you normally use amplification, if so, do you find it useful in decreasing the amount physical effort? What parts of your task become easier?

   Yes. It is easier to call the combo and keep everyone together because they can hear me clearer through the microphone.

PARTICIPANT I: lab environment

Please answer the following questions as thoroughly as you can

1. Do you experience greater sensations of breathlessness during specific situations more so than others? Please explain those situations.

   The reading during exercise with and without amplification was more tiring.

2. Please describe the amount of effort or how you physically feel during aerobic instruction that is only vocal compared to vocal plus simultaneous aerobic activity?

   Just talking is much easier. Talking and running is much harder for me than talking while teaching step.

3. During high intensity voicing efforts, do you compensate to help you produce the voice and physical task?

   No

4. If so, how do you compensate, what do you do? (i.e. by stopping aerobic exercise, stopping verbal instructions, or any other way?)

5. Do you normally use amplification, if so, do you find it useful in decreasing the amount physical effort? What parts of your task become easier?

   Yes. Both became easier because I could spend more energy on physical task and less on vocal task.

PARTICIPANT J: aerobic class

Please answer the following questions as thoroughly as you can

1. Do you experience greater sensations of breathlessness during specific situations more so than others? Please explain those situations.

   During high intensity—such as plyometrics and deep lunges. No microphone and teaching, I get breathless and a little dizzy for 1-3 seconds. I feel okay with microphone (feels hard).

2. Please describe the amount of effort or how you physically feel during aerobic instruction that is only vocal compared to vocal plus simultaneous aerobic activity?

   Have to push voice to project (heavy pushing) without microphone that makes me slightly dizzy.

3. During high intensity voicing efforts, do you compensate to help you produce the voice and physical task?

   Yes.

4. If so, how do you compensate, what do you do? (i.e. by stopping aerobic exercise, stopping verbal instructions, or any other way?)

   Without microphone—I use hand signals and sign language, lower music, keep moves very basic so cues are less frequent.

5. Do you normally use amplification, if so, do you find it useful in decreasing the amount physical effort? What parts of your task become easier?

   Yes. Doing the exercising I have to push voice-push body—feels more taxing without microphone.

APPENDIX D: IRB APPROVAL

University of Central Florida

Office of Research

May 30, 2004

Heather Koblick
3363 Mission Lake Dr. Apt. 384
Orlando, FL 32817

Dear Ms. Koblick:

With reference to your protocol entitled, "Effects of Simultaneous Exercise and Speech Tasks on the Perception of Effort and Vocal Measures in Aerobic Instructors," I am enclosing for your records the approved, executed document of the UCFIRB Form you had submitted to our office.

Please be advised that this approval is given for one year. Should there be any addendums or administrative changes to the already approved protocol, they must also be submitted to the Board. Changes should not be initiated until written IRB approval is received. Adverse events should be reported to the IRB as they occur. Further, should there be a need to extend this protocol, a renewal form must be submitted for approval at least one month prior to the anniversary date of the most recent approval and is the responsibility of the investigator (UCF).

Should you have any questions, please do not hesitate to call me at 823-2901.

Please accept our best wishes for the success of your endeavors.

Cordially,

Chris Grayson
Institutional Review Board (IRB)

Copies: Dr. Bari Ruddy
IRB File

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