

THE RELATIONSHIP AMONG PERCEPTUAL AND OBJECTIVE REFLUX  
MEASURES IN SINGERS

by

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## **ABSTRACT**

Laryngopharyngeal reflux (LPR) is currently one of the most prevalent conditions associated with voice disorders being treated in voice care centers worldwide. Many singers experience voice related disturbances but are unaware that these disturbances may be the result of LPR. The purpose of this study was to quantify the perceptual symptoms and objective measures of LPR in a population of singers in order to understand the relationship between perceived symptoms, laryngeal findings, and evidence of acid exposure to the larynx. The Reflux Symptom Index (RSI), Reflux Finding Score (RFS), and the Dx-pH monitoring system were used to quantify participant symptoms, endoscopic findings, and pH levels in the oropharynx. The population included 12 semi-professional and professional singers. Significant correlations were found between the RFS, RSI and pH mild and moderate pH levels. This indicates that singers are sensitive to even small deviations of pH and this should be taken into consideration when evaluating a singers who have suspected LPR. Due to the variety of etiologies that can produce the symptoms and physical findings mentioned in this study, it is imperative that more objective data be obtained to confirm the presence of reflux in the oropharynx. As such, endoscopic findings and symptoms alone are not a good indication of reflux exposure and more objective data, like an oropharyngeal pH measurement system, should be implemented to quantify reflux in the oropharynx. The RSI and the RFS are valid tools for qualifying perceptions and physical findings however they are not without flaws.

This work is dedicated to all singers and the people who keep them healthy.

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## TABLE OF CONTENTS

LIST OF FIGURES .....	viii
LIST OF TABLES .....	ix
LIST OF ACRONYMS/ABBREVIATIONS.....	x
CHAPTER ONE: INTRODUCTION.....	1
Etiology of Reflux .....	3
Symptoms.....	7
Laryngeal Findings .....	10
Diagnosis.....	12
Treatment .....	14
Purpose of this Study.....	16
Hypotheses .....	18
CHAPTER TWO: METHODOLOGY .....	19
Study Design .....	19
Participants.....	19
Procedures.....	19
CHAPTER THREE: RESULTS.....	23
Descriptive Results .....	23
Upright: .....	23
Upright: Mild.....	23
Upright: Moderate.....	24
Upright: Severe.....	24
Supine:.....	24
Supine: Mild .....	24
Supine: Severe: .....	25
Refux Finding Score .....	31
Reflux Symptom Index .....	32
Inferential Statistics .....	32
CHAPTER FOUR: DISCUSSION.....	35

Study Limitations .....	45
Future Studies.....	46
Conclusions .....	47
APPENDIX A: IRB APPROVAL LETTER.....	48
APPENDIX B: REFLUX SYMPTOM INDEX (RSI).....	55
APPENDIX C: REFLUX FINDING SCORE (RFS) .....	57
APPENDIX D: CORRELATIONS BETWEEN ALL VARIABLES .....	59
LIST OF REFERENCES .....	64

## LIST OF FIGURES

Figure 1. Examples of endoscopic findings associated with LPR.....	11
Figure 2. The Dx-pH Measurement System.....	20
Figure 3. Number of upright reflux episodes below a pH of 6.5.....	25
Figure 4. Total time of upright reflux episodes below a pH of 6.5.....	25
Figure 5. Percentage of time of upright reflux episodes below a pH of 6.5.....	26
Figure 6. Number of upright mild, moderate, and severe reflux episodes.....	26
Figure 7. Total time of upright mild, moderate, and severe reflux episodes.....	27
Figure 8. Percentage of time for upright mild, moderate, and severe reflux episodes.....	27
Figure 9. Number of supine reflux episodes below a pH of 6.0.....	28
Figure 10. Total time of supine reflux episodes below a pH of 6.0.....	28
Figure 11. Percentage of time of supine reflux episodes below a pH of 6.0.....	29
Figure 12. Number of mild, moderate, severe supine reflux episodes.....	29
Figure 13. Total time of mild, moderate, and severe supine reflux episodes.....	30
Figure 14. Percentage of time of mild, moderate, and severe supine reflux episodes.....	30
Figure 15. Total Reflux Finding Score.....	31
Figure 16. Total Reflux Symptom Index.....	31



## LIST OF TABLES

Table 1. Significant correlations between variables .....	33
Table 2. Correlations between each item in the RFS and upright pH levels .....	60
Table 3. Correlations between each item in the RFS and supine pH levels .....	60
Table 4. Correlations between each item in the RSI and upright pH levels .....	61
Table 5. Correlations between each item in the RSI and supine pH levels .....	62
Table 6. Correlations between the RFS and the RSI .....	63

## **LIST OF ACRONYMS/ABBREVIATIONS**

LPR	Laryngopharyngeal Reflux
GERD	Gastroesophageal Reflux Disease
LES	Lower Esophageal Sphincter
NSAIDs	Nonsteroidal Anti-Inflammatory Drugs
VHI	Voice Handicap Index
W-BVAS	Well-Being in General Scale
UES	Upper Esophageal Sphincter
pH	Potential Hydrogen
OTC	Over the Counter
RSI	Reflux Symptom Index
RFS	Reflux Finding Score
LED	Light Emitting Diode
SPSS	Statistical Package of Social Sciences

## **CHAPTER ONE: INTRODUCTION**

Laryngopharyngeal reflux (LPR) is currently one of the most prevalent conditions associated with voice disorders being treated in voice care centers worldwide (Koufman, 1991). Often patients are empirically treated with antireflux medications with the rationale behind this treatment choice driven by patient symptoms and endoscopic findings. Although these are useful diagnostic tools, they are subjective and can be heavily influenced by artifacts in instrumentation, such as lighting or evaluator's experience. In order to ascertain if reflux is truly playing a primary role in a patient's voice difficulty and to fully understand the relationship between patient's symptoms and physical findings, more objective data is needed (Kelchner et al., 2007; Belafsky, Postma, & Koufman, 2001; Branski, Bhattacharyya, & Shapiro, 2002).

LPR has been described as the retrograde movement of gastric contents into the larynx, pharynx, and upper aerodigestive tract (Belafsky, Postma, & Koufman, 2001). It can occur in the absence of traditional esophageal symptoms and may go undetected, until more severe structural pathologies develop. Many singers experience voice-related disturbances but are unaware that these disturbances may be the result of LPR. As such, reflux has been implicated as an etiologic factor in the diagnosis of several structural pathologies such as nodules, generalized edema, and polyps, particularly in a population of professional singers (Spencer, 2006).

Reflux that affects the larynx might only cause subtle tissue changes (i.e. posterior interarytenoid edema and erythema and an excessive accumulation of mucous) yet, may result in noticeable changes in voice quality (i.e. hoarseness, loss of range, vocal fatigue). These subtle

changes can be especially problematic to singers because of the precision with which a singer utilizes the laryngeal musculature in order to coordinate a sung tone. For example, singers often sustain high frequencies where the vocal folds remain in an elongated and stretched position for extended periods of time. They maintain a high amount of subglottic air pressure in order to produce a loud sound, as well as produce sounds that are high and soft, requiring elongation of the vocal folds with less subglottic pressure (Hixon, T., 2006). These skills can often take years to cultivate. The demands singers place on their voices may render even slight alterations to the laryngeal tissue problematic, and could potentially impair performance (Sataloff, Castell, Katz, & Sataloff, 2006). The physical demand of training the respiratory and laryngeal musculature specifically for singing (i.e. the muscular coordination of the diaphragm, intercostal musculature, and abdominals) may place singers at an elevated risk for developing LPR due to the increase in the interabdominal pressure, making stress and dysfunction to the lower esophageal sphincter more likely (Pregun, et al., 2009; Cammarota, et al., 2007).

The lifestyle of the performer is certainly one typically prone to pressure and challenge. Singers can have anxiety and stress during auditions and performances. It is well known that psychological stress may result in hyperacidity and motility issues (Sataloff, Castell, Katz, & Sataloff, 2006). Since a singer's instrument is their body, the quality of their performance is largely dependent of the condition of their body (Selby, Gilbert, & Lerman, 2003). Singers also may not have ideal eating habits, due to late night rehearsals and performances and have an inconsistent sleep pattern. Therefore, singers will often be more affected by subtle tissue changes than the general population.

## Etiology of Reflux

The cause of reflux is a controversial topic and one that needs further investigation. Various causative factors might include: side effects of medications, irritation from foods, psychological stress, obesity, lifestyle, voice use, as well as other causes. These triggers can lead to dysfunction of different anatomic areas including: the upper and lower esophageal sphincters, the entire length of the esophagus, the larynx, the pharynx, oral cavity, trachea, and even the lungs. LPR is considered an aerodigestive disease because the dysfunction from lower esophageal structures can cause the back flow of gastric contents into the esophagus, larynx, pharynx, trachea, or lungs (Sataloff, Castell, Katz, & Sataloff, 2006; Sapienza & Ruddy, 2008). LPR and GERD (gastroesophageal reflux disease) can cause significant damage; and in some cases, can lead to more serious and life threatening complications, such as erosive esophagitis, Barrett's esophagus (a precancerous condition), laryngeal stenosis, and leukoplakia (Lenderking et al., 2003). While the severe complications associated with reflux can be life threatening, the subtle complications can be career altering or ruining, as in the case of a singer. A singer who constantly experiences hoarseness due to mucosal irritation caused by reflux may miss out on performances or audition opportunities that they might have been able to participate in, had it not been for the reflux irritation.

It is well known that the larynx is more susceptible to reflux injury than the esophagus, because the larynx lacks both extrinsic and the intrinsic epithelial defenses of the esophagus (Mesallam, Stemple, Sobeih, & Elluru, 2007). Therefore, the esophagus can tolerate greater acid exposure than the larynx and upper airway. The esophageal protective mechanisms include:

peristalsis (a symmetrical contraction of the esophageal muscles which creates a downward moving wave to help clear food and liquid), a mucosal structure that can better tolerate exposure to acid, and bicarbonate production, which helps prevent over acidity (Sataloff, Castell, Katz, & Sataloff, 2006). The presence of pepsin in the larynx may result in depletion of carbonic anhydrase isoenzyme III and squamous epithelial stress protein. These proteins provide protection to the tissue of the larynx and, when reduced, leave the laryngeal tissue more susceptible to injury (Johnston, et al., 2006; Johnston et al., 2004).

Certain foods can irritate the mucosal lining of the esophagus, as well as decrease lower esophageal sphincter (LES) pressure. This, in turn, leaves the esophagus and the larynx at risk of being exposed to gastric contents. Fatty foods, spicy foods, chocolate, caffeine, alcohol, citrus juices, tomato products, coffee, cola drinks, and tea have been found to be irritants and possibly contribute to GERD and LPR (Sapienza & Ruddy, 2008; Dent, Dodds, Friedman, et al., 1980).

Medications that can cause irritation might include: potassium chloride, iron sulfate, gelatin capsule antibiotics, nonsteroidal anti-inflammatory drugs (NSAIDs) and alendronate (de Groen et al., 1996). Medications known to decrease LES pressure include: progesterone, theophylline, anticholinergic agents, adrenergic agonists, adrenergic antagonists, diazepam, meperidine, nitrates, and calcium channel-blockers (de Groen et al., 1996; Sataloff, Castell, Katz, & Sataloff, 2006). Certain medications may have side effects that decrease esophageal pressures and promote reflux including: anticholinergics, sedatives, tranquilizers, tricyclic anti-depressants, theophylline, nitrates, and calcium channel-blocking agents (Sataloff, Castell, Katz, & Sataloff, 2006). It is important that physicians, clinicians, and patients understand this, so that medications can be altered, if possible, and diet modifications can be made.

When considering pressures exerted on the esophagus it is necessary to consider how breath coordination for singing functions and how it could play a role in reflux. The muscles of controlled exhalation raise the intra-abdominal pressure, forcing the diaphragm upward, thereby compressing air in the chest (Hixon, 2006; Spencer, 2006). Singers are especially prone to reflux because of the higher-than-normal abdominal pressures exerted during singing, which puts more pressure on the LES and can lead to dysfunction. Therefore, intra abdominal pressure created when producing breath coordination may increase the pressure against the stomach and intestines, increasing the likelihood of reflux. This can be thought of as similar to the pressure exerted on the LES after eating a big meal, the effects of pregnancy on a woman's body, the effects of obesity on the stomach and esophagus, as well as the effects of wearing tight-fitting clothing (Spencer, 2006). Gastric distension created when lifting heavy objects, during a bowel movement, creating breath support when singing, and after eating a big meal can stimulate the lower esophageal sphincter, causing it to relax. The latter of which is considered the most common cause of reflux episodes (Kikendall, Friedman, Oyewole, et al., 1983). Sataloff, and colleagues (2006) suggest that many singers do not eat before performing because a full stomach interferes with "breath support" and can induce reflux. Because of this, singers will often eat late at night, after a performance and go to bed shortly after, thereby increasing their chances of reflux events at night while sleeping (Sataloff, Castell, Katz, & Sataloff, 2006).

Other causative factors might include: emotional stress, smoking, and alcohol use. Smoking and alcohol use promote reflux by decreasing lower esophageal pressure, impairing esophageal motility and mucosal integrity, increasing gastric acid secretion, and delaying gastric emptying (Sataloff, Castell, Katz, & Sataloff, 2006). Stress is a well-known causative factor in

many illnesses and diseases. Increased life stressors or nervousness may overly activate the digestive system and precipitate reflux (Spencer, 2006). It is obvious then that stress affects the production of acid, as well as creates a vicious circle with pharyngeal stimulation relaxing the lower esophagus. Interestingly, stimulation to the pharynx, like when singing, can cause transient lower esophageal relaxation, which creates an open path for gastric acid to reflux into the esophagus and upper airway (Castell, 1999). Siupsinskiene and colleagues (2007) found that participants with LPR had a decline in quality of life scores and psychological disturbances based on the voice handicap index (VHI), hospital anxiety and depression scale, disability in social activities scale, and well-being in general scale (W-BVAS) than those found in the control group who were without LPR. The differences described in this study resolved after the participants began medical treatment for LPR. The authors concluded that psychological symptoms such as depression and anxiety might increase the perception of LPR symptoms in those without the disease. The authors also surmised that LPR itself might contribute to decreased psychosocial function and increased anxiety (Siupsinskiene, Adamonis, & Toohill, 2007).

Since LPR is considered an aerodigestive disease it is necessary to consider the upper and lower esophageal sphincters and their possible dysfunctions. The upper esophageal sphincter (UES) is open for only approximately 500 milliseconds during a swallow. The lower esophageal sphincter (LES) relaxes at the onset of a swallow and remains relaxed until the wave that propels a food bolus into the stomach has stopped. These sphincters must remain at a constant pressure when not swallowing to prevent the movement of air or food into the esophagus. When the



contraction of these sphincters relaxes, gastric content is free to reflux into the esophagus and the upper and lower airways.

Interestingly, it has been found that an abnormal pharyngeal pH environment can be caused by decreased salivary production, change in bacterial flora of the pharynx, and reflux of gastric juice into the pharynx (Korsten, Rosman, Fishbein, Shlein, Goldberg, & Biener, 1991; Sonnenberg, Steinkamp, Weise, Berges, Wienbeck, Rohner, & Peter, 1982). Only the latter is likely to be associated with LPR symptoms. Therefore, oropharyngeal pH measures in symptomatic patients need to be interpreted, keeping these other etiologies in mind.

### Symptoms

Voice and vocal quality are part of a person's identity and our judgments of others may be influenced by the quality of their voice. Thus, vocal problems can precipitate negative psychological, emotional, and social consequences for affected individuals (Lenderking et al, 2003). This can be especially true for a singer. When a person has intermittent abnormal sensations and perceived voice disturbances such as heartburn and hoarseness, it is perhaps noticed more than if someone has a consistent voice problem such as loss of vocal range. Symptom correlation in LPR patients may be more difficult, especially when symptoms are continuous and not intermittent (Sataloff, Castell, Katz, & Sataloff, 2006). For example, a patient that presents with vocal fatigue and explains that her voice has felt tired for a few months and is no longer able to sing softly may be unaware that the symptoms can be related to subtle tissue changes caused by reflux.

Common symptoms in the general population associated with LPR include: morning hoarseness, sensation of a lump in the throat, throat tickle, sore throat, a sensation of fullness in the throat, night time cough, regurgitation, swallowing difficulty, globus sensation, throat clearing, and excessive mucous (Belafsky, Postma, & Koufman, 2001). Some of the less common laryngeal and pharyngeal symptoms include: worsening asthma, wheezing, shortness of breath, dental hypersensitivity, laryngospasm, nausea, otalgia, muscle spasms, bronchospasm from aspiration, and halitosis. It should also be discussed that GERD could cause indirect irritation to the larynx due to esophageal irritation caused by a vagal reflex. This reflex can trigger a cough or throat clear, which in turn can cause mechanical trauma on the vocal folds resulting in mucosal irritation (Sataloff, Castell, Katz, & Sataloff, 2006).

Reflux has been known to cause breathing problems or exacerbate respiratory disease. Harding, Guzzo, and Richter (1997) found that 70-80% of asthmatics also had a history of GERD. The pathologic linkage of the digestive and respiratory systems has been heavily studied. Results yield solid evidence of a relationship between reflux and asthma through “silent” microaspiration and connecting vagal innervations of the esophagus and bronchi (Spencer, 2006). It was suggested by O’Connor, Singer, and Richter (1999) that empiric treatment with reflux suppressive medications, followed by pH testing, to be the most cost-effective way of determining whether GERD plays a role in a patient’s asthma. It is well known that some of the most common symptoms of asthma are wheezing and shortness of breath. It seems valid then to assume that these symptoms would have negative effects on a person’s ability to speak or sing. The ability to sustain long phrases could be reduced, the overall comfort for producing voice might be reduced, the ability to take a deep breath could be reduced, and

these respiratory problems, in turn, could cause a person to become hyperfunctional in their voice production. When this occurs, patients might subconsciously strain to compensate with the muscles of the throat and neck (Spiegel, Sataloff, Cohn, Hawkshaw, & Epstein, 1988).

In order to sing well, one must have exquisite control and coordination of the respiratory, phonatory, and articulatory systems. Any imbalance to these systems and voice production can be negatively affected (breathiness, hoarseness, loss of range, discomfort, etc.). Subtle changes in the ability to balance these systems may cause a singer to compensate and create tension, leading to further vocal difficulties and problems (Lundy, Casiano, Sullivan, Roy, Xue, & Evans, 1999).

When working with singers who have voice problems, it is obvious that singers experience specific symptoms and are affected by microscopic changes, which the general population may not experience or readily recognize. Furthermore, Lloyd, Lehman, Spector, McCrea, Carson, & Ruddy (2009) found that the items on the RSI might not be sensitive enough to capture the subtle symptoms that singers may perceive when experiencing LPR. Therefore, additional questions were developed and studied by Lloyd, Lehman, Spector, Meemon, Lewis, & Ruddy (2010). They were found to be more sensitive in capturing the effects of LPR in this population. The questions included, related to the perception of increased effort when singing, loss of vocal range, difficulty with producing soft sounds, vocal fatigue, a change in vocal quality, and hard tonal onset.

Cammarota et al., (2007) and Pregon et al., (2009) investigated the prevalence of GERD symptoms in a large population of professional opera choristers and found that opera choristers had a statistically significant higher prevalence of reflux related symptoms than the general

population. The most common symptoms included: heartburn, regurgitation, cough, and hoarseness. In these two studies, the authors surmised that singers are often predisposed to reflux because singing requires extreme changes of subglottal pressure and intra-abdominal pressure, placing resistance and strain on the diaphragm, causing reflux. The diaphragm consists of striated muscle fibers, which fatigue quickly when being contracted for long periods of time. Shafik, Shafik, El-Sibai, & Mostafa (2004) found that the crural electromyographic activity disappeared after a period of being strained, and thus lacked response after having been strained for that period. It seems logical that the intra-abdominal pressure employed in singing could cause the same to occur and thus induce reflux. This suggests that intra-abdominal pressure could indeed play a causative role in reflux.

### Laryngeal Findings

Irritation from LPR has the potential to cause structural changes to the larynx including: edema, polypoid degeneration, Reinke's edema, erythema, contact ulcers, laryngeal granuloma, interarytenoid pachydermia, supraglottic and subglottic stenosis, partial or obliteration of the laryngeal ventricle, pseudosulcus, delayed wound healing; and, in severe cases, laryngeal cancer (Sataloff, Castell, Katz, & Sataloff, 2006; Rothstein, 1998; Belafsky, Postma, & Koufman, 2001; Lenderking, Hillson, Crawley, Moore, Berzon, & Pashos, 2003). Erythema and edema of the mucosa on top of the arytenoid cartilages are reported to be some of the most prevalent laryngeal findings with LPR (Sataloff, Castell, Katz, & Sataloff, 2006). Specific vocal fold findings which are listed on the RFS (Belafsky, Postma, & Koufman, 2001) include: pseudosulcus (infraglottic edema), ventricular obliteration, erythema/hyperemia, vocal fold edema, diffuse laryngeal

edema, posterior commissure hypertrophy, granuloma/granulation, and thick endolaryngeal mucus. A study by Chung, et al., (2009) employed 24-hour ambulatory double pH monitoring, the RSI, and the RFS and found that edema is one of the most prevalent finding in the larynx related to LPR. Examples of these endoscopic findings are depicted in Figure 1.

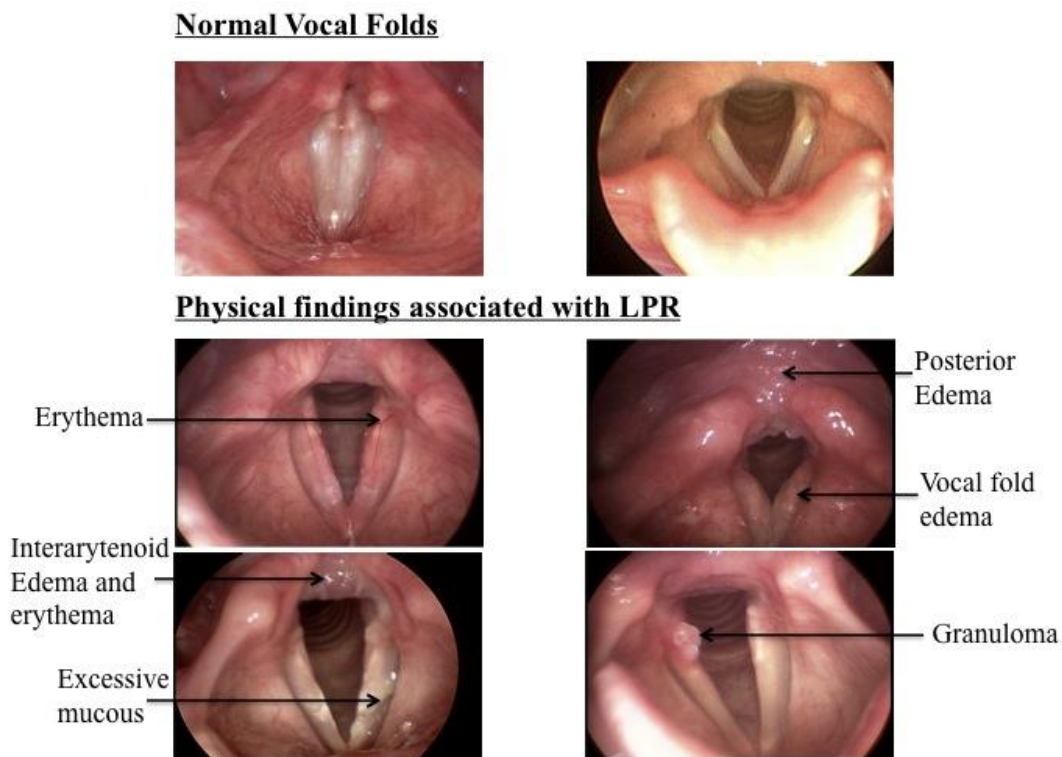


Figure 1. Examples of endoscopic findings associated with LPR

Lundy, Casiano, Sullivan, Roy, Xue, & Evans (1999) found that 73% asymptomatic singing students had posterior erythema, which is suggestive of reflux irritation. This finding suggests that singers may be seemingly asymptomatic to reflux irritation yet perhaps if they did not have the posterior erythema, their vocal production might improve even more.

## Diagnosis

Diagnosis of GERD or LPR is based on patient's history and symptoms, diagnostic tests, and relief of symptoms. Typical diagnostic tests related to GERD and LPR include: barium radiographic study, esophagoscopy, laryngoscopy, esophageal motility testing, and pH monitoring. Physicians may also evaluate the upper esophageal sphincter pressure, lower esophageal sphincter pressure, as well as esophageal clearance. Endoscopy is used to document visual mucosal changes and disease. According to Sataloff and colleagues (2006), prolonged pH monitoring is the most important study to quantify reflux and to determine whether patient's symptoms are related to GERD or LPR. 24-hour pH impedance studies with symptom indices have proven invaluable and offer advantages over empirical management alone (Sataloff, Castell, Katz, & Sataloff, 2006). Yet, with all of those tests, it has been stated that the gold standard for reflux diagnosis is an empiric trial with antireflux medications (Vaezi, 2008).

Research has demonstrated that symptoms and mucosal changes associated with LPR are found in the general population and that some degree of symptoms and findings are normal (Hicks, Ours, Abelson, Vaezi, & Richter, 2002; Reulbach, Belafsky, Blalock, Koufman, & Postma, 2001). These studies reinforce the notion that, although reflux may play a role in a voice problem, there could be other etiologic factors that need to be taken into consideration.

Studies have been undertaken to test the reliability in rating endoscopic findings. The reliability of endoscopic findings is a topic of controversy. It has been found that inter-rater reliability for rating endoscopic findings was poor and there was extreme variability for various physical findings and concluded that accurate clinical assessment of laryngeal physical findings is not reliable from clinician to clinician (Kelcher et al., 2007; Branksi, Bhattacharyya, &

Shapiro, 2002). This reinforces the idea that more objective data is needed in the diagnostic process and, although endoscopic findings can be valid and helpful, they should not be the only diagnostic tool used.

When examining the literature on the normal physiologic limit of reflux in the larynx and pharynx, several studies have found that limit is not well defined. Two events per day of LPR with a pH below 4 have been found in healthy controls without LPR disease (Merati, Lim, Ulualp, & Toohill, 2005; Vincent, Garrett, Radionoff, Reussner, & Stasney, 2000; Ylitalo, Lindestad, & Ramel, 2001; Ylitalo & Ramel, 2002). Moreover, Koufman (1991) undertook a study on animals which suggested that as few as 3 pharyngeal reflux events per week are sufficient to produce laryngeal damage, especially with pre-existing mucosal injury.

Kawamura, Aslam, Rittmann, Hofmann, & Shaker (2004) reported that liquid and mixed forms of reflux were not significantly found in the pharynx for LPR participants yet aerosolized reflux was found to be significant. This finding suggests that use of a device that specifically measures gaseous or aerosolized reflux is an invaluable tool to use in the diagnostic process. Harrell, et al. (2005) found that adding the hypopharyngeal sensor increases the detection of gastric content that might reach the pharynx and larynx. Similarly, Katz (1990) studied ambulatory esophageal and hypopharyngeal pH monitoring and found that 70% of the participants had hypopharyngeal reflux findings, yet only 30% had esophageal reflux. These studies demonstrated the importance of using a hypopharyngeal sensor when performing ambulatory pH monitoring. Specifically the use of a device that can detect aerosolized reflux, in order to accurately diagnosis possible reflux related voice problems.

Several studies have been completed to establish abnormal pH thresholds for pharynx and larynx. Ayazi, et al. (2009) found that the pattern of pharyngeal pH environment was significantly different in the upright and supine positions and therefore required different thresholds. For this group of normal participants the discriminatory pH thresholds were found to be between 6.5 and 6.0 for mild upright reflux exposure, between 6.0 and 5.5 for moderate upright reflux exposure, and below 5.5 for severe upright reflux exposure. Likewise, the discriminatory pH thresholds were found to be between 6.0 and 5.5 for mild supine reflux exposure, between 5.5 and 5.0 for moderate reflux exposure, and below 5.0 for severe reflux exposure.

Additionally, it has been found that both the oropharyngeal probe and the standard dual channel pH probe reliably documented LPR events, yet the oral pharyngeal probe was better tolerated by participants (Golub, Johns, Lim, DelGaudio, & Klein 2009; Wiener, et al., 2009).

### Treatment

Reflux is a chronic and relapsing condition. Treatment focuses on elimination of symptoms, healing of mucosal injury, management of complications, and maintenance of symptomatic remission. Treatment often focuses on lifestyle modifications, pharmacologic therapy, and antireflux surgery. There is also much controversy about how to treat reflux from both a medical and behavioral standpoint. Once diagnosed with LPR, the singer is often placed on prolonged or lifetime doses of antireflux medication (Sataloff, Castell, Katz, & Sataloff, 2006). The gastric content that is refluxed is mostly hydrochloric acid and the enzyme pepsin (Spencer, 2006). Typical antireflux medications include: over the counter (OTC) antacids, OTC



and prescription strength H<sub>2</sub>-receptor antagonists, prokinetic agents, and OTC and prescription strength proton pump inhibitors.

GERD and LPR tend to recur quickly once therapy is stopped or medication dosage is decreased (Sataloff, Castell, Katz, & Sataloff, 2006). Kamel, Hanon, and Kahrilas (1994) found that hoarseness reoccurred after 6 months after being off treatment. Most patients, especially those with extraesophageal disease, like the symptoms associated with LPR, require long-term medical treatment or surgery to achieve adequate healing and relief of symptoms. Although these medications have proven to be safe, long-term side effects are unknown. To take these medications over several years or a lifetime, can be quite costly. Furthermore, these medications do not totally eliminate or cure reflux; they merely neutralize the acid that has been refluxed. Patients can continue to be irritated from pH-neutral fluid, bile salts, and other substances that can be irritating to the upper airway (Sataloff, Castell, Katz, & Sataloff, 2006). Therefore, when medications and lifestyle changes fail to stop or reduce the reflux irritation, surgical treatment may be an option. Of course, surgery has its advantages and disadvantages, especially for the singer. Currently, a typical surgical procedure that is performed for GERD is Nissen's fundoplication. In this procedure the upper part of the stomach is wrapped around the lower part of the esophagus, which creates a tighter sphincter to improve control of the reflux of gastric content (Gaegea, 1991).

Many singers are prescribed proton pump inhibitors or H<sub>2</sub>-receptor inhibitors because they present with visual signs on endoscopic examination and have perceived symptoms associated with LPR. Some individuals might have complete acid control but continue to have persistent symptoms not related to reflux. Considering this, it is necessary to investigate other

causes of the symptoms that patients might experience. These causes might include hyperfunction or poor vocal hygiene. Although many studies have been conducted exploring visual signs, pH levels, and patients symptoms of reflux, (Branski, Bhattacharyya, Shapiro, 2002; Noordzij, Khidr, Desper, et al., 2002; Marambaia, Andrade, Varela, et al., 2002; Maronian, Haggitt, Oelschlager, et al., 2003; Hill, Simpson, Velazquez, & Larson, 2004) evidence confirming the diagnostic significance of signs and symptoms is contradictory. As such, more research is needed with larger populations and more precise measurements.

The population of the singers was selected for this study because of the known relationship between life style, occupational demand, voice use, and factors related to LPR. Moreover, performers may behaviorally exacerbate their problems by eating large meals late in the evening after performances, using their respiratory system for singing in a way that might provoke reflux, as well as being subjected to stress, etc. All of which have the potential to result in hyperacidity and motility issues.

#### Purpose of this Study

The purpose of this study is to quantify the perceptual symptoms and objective measures of LPR in a population of singers in order to understand the relationship between perceived symptoms, laryngeal findings and evidence of acid exposure to the larynx. The specific aims of this study include:

Aim 1: To determine if a relationship exists between endoscopic findings and oropharyngeal pH levels in singers.

Aim 2: To determine if a relationship exists between perception of symptoms and oropharyngeal pH levels in singers.

Aim 3: To determine if a relationship exists between perception of symptoms and endoscopic findings of reflux in singers.

## Hypotheses

1.) Ho: Singer's perceptions of reflux symptoms will not correlate with pH levels below 6.5 when upright and below 6.0 when supine.

Ha: Singer's perceptions of reflux symptoms will correlate with pH levels below 6.5 when upright and below 6.0 when supine.

2.) Ho: Singer's endoscopic findings will not correlate with pH levels below 6.5 when upright and below 6.0 when supine.

Ha: Singer's endoscopic findings will correlate with pH levels below 6.5 when upright and below 6.0 when supine.

3.) Ho: Singer's mild, moderate, and severe pH levels when in the upright or supine positions will not correlate with perceptions of reflux.

Ha: Singer's mild, moderate, and severe pH levels when in the upright or supine positions will correlate with perceptions of reflux.

4.) Ho: Singer's mild, moderate, and severe pH levels when in the upright and supine positions will not correlate with endoscopic findings.

Ha: Singer's mild, moderate, and severe pH levels when in the upright and supine positions will correlate with endoscopic findings.

5.) Ho: Singer's perceptions of reflux will not correlate with endoscopic findings.

Ha: Singer's perceptions of reflux will correlate with endoscopic findings.

## CHAPTER TWO: METHODOLOGY

### Study Design

This study represents a prospective descriptive study with a population of singers (semi-professional and professional). The dependant variables include patient symptoms, endoscopic findings, and pH levels. The independent variable is the group of singers.

### Participants

Participants for this study included 12 (5 male and 7 female) professional and semi-professional singers from the greater Orlando area. Participants were recruited from The Ear Nose and Throat Surgical Associates Voice Care Center or The University of Central Florida Voice Care Center associated with the Department of Communication Sciences and Disorders. The medical history for each participant was reviewed and included in the results and discussion when relevant. Participants were included in this study if they are a professional/semiprofessional singer, including college music students. Participants were excluded from this study if under the age of 18 or over the age of 65. Informed consent from the University of Central Florida Review Board was obtained for each participant (See Appendix A).

### Procedures

pH measurement: Once the RSI and RFS was completed, a pH monitoring study was performed. The Dx-pH Measurement System™ from Respiratory Technology Corporation (*Restech*) was employed to determine pH levels in the pharynx, larynx and oral cavity. The sensor detects aerosolized and liquid acid and changes voltage potential relative to the pH of the

environment it is exposed to (Ayazi, et. al., 2009). The Restech pH monitoring system collects data outside of the esophagus therefore the pH measurement has the potential to provide a more objective measurement directly related to LPR.

The Dx-pH sensor is 1.5 mm in diameter. Prior to insertion, the sensor was calibrated in solutions of pH 7 and 4. This sensor was inserted into the nose and placed in the oropharynx behind the uvula. A lubricating gel was used to insert it into the nose for participant comfort. A light emitting diode (LED) flashed for the first several hours, which aided in the insertion and correct placement of the sensor. The sensor's catheter was secured to the participant's face using Tegaderm tape, passed over the ear and then taped again to the neck. A transmitter was clipped to the participants clothing and the data recorder was clipped to the participant's waistline. The transmitter was wirelessly attached to the patient's clothing and allowed for good range of motion. The sensor was connected to a small microcomputer that was clipped to the waist, so that the participant could be monitored as they moved around in daily life. Fitting the pH probe took approximately 5 minutes and was then left in position for 18-24 hours. The participant presented to the clinical setting after 18-24 hours and the probe was removed.



Figure 2. The Dx-pH Measurement System

Data was collected by the sensor twice every second and was digitized by the Dx-Transmitter

and then sent to the *Restech* recorder. It was then stored in a non-volatile memory data card. Due to pH not remaining steady or reliable during meal times, the participant recorded in a diary when they ate, as well as indicated eating times on the device worn on the waist. These times were then be excluded when analyzing the data. The participant indicated when they laid down in a supine position, as the normative data for normal and abnormal pH is different in the upright and supine positions. A study of asymptomatic participants analyzed pH at 0.5 intervals between 4 and 6.5 and found ranges for mild, moderate, and severe reflux in both upright and supine (Ayazi et al., 2009). Those thresholds and severity levels were used when reporting this data and in the correlation in the current study.

**Patient Perception:** The reflux symptom index (RSI), a psychometrically tested 9-item questionnaire used to quantify patient's perceptions of reflex symptoms in the larynx and pharynx (Belafsky, Postma, & Koufman, 2002). Each item was scored on a 5-point scale (See Appendix B for the RSI scale).

**Laryngeal findings:** The reflux finding score (RFS), a visual perceptual instrument, used to document physical finding of LPR from the videolaryngostroboscopic examination (Belafsky, Postma, & Koufman, 2001). The RFS consists of 8 categories of varying scores. For example, a score of 0, 2, or 4 is assigned to the presence of erythema, depending of the severity of the finding. The categories on the reflux finding score include: pseudosulcus (infraglottic edema), ventricular obliteration, erythema/hyperemia, vocal fold edema, diffuse laryngeal edema, posterior commissure hypertrophy, granuloma/granulation, and thick endolaryngeal mucus. (See appendix C for the RFS scale). According to Belafsky, Postma, & Koufman (2001), a score of 7 or above suggests abnormal findings and could indicate the presence of reflux irritation.

Analysis of the laryngeal examination obtained from the Kaypentax digital videolaryngostroboscopy system, model 9295, was completed by an independent otolaryngologist with the RFS. The rater had a history of more than 20 years evaluating and treating voice, upper airway and aerodigestive disorders in a clinical setting. The evaluator was blinded to the participant's history and symptoms when rating the videolaryngostroboscopic examination with the RFS instrument. Scoring for each item varied depending on the severity of the finding and the rater's subjective interpretation.



## CHAPTER THREE: RESULTS

### Descriptive Results

This design represents a prospective descriptive with three factors: the reflux system index (9 response variables), the reflux finding score (8 response variables), and pH monitoring (8 variables), a total of 25 response variables. Data analysis included scoring the RSI, RFS and pH monitoring for each participant followed by calculation of mean and standard deviation. The number of reflux episodes in the upright and supine positions, the total time in minutes of reflux episodes during upright and supine positions, and the percentage of time of reflux episodes during upright and supine positions are depicted in figures 3 through 14. The total RSI score and the total RFS for each participant are in Figures 15 and 16.

#### Upright:

During the upright condition, figure 3 shows a range of reflux episodes from 0 to 344. In particular, it should be noted that participant 4 had 1 upright reflux episode below a pH level of 6.5, however, Figure 4 shows that this single episode lasted 732.6 minutes, which reflects 99.2% of time in figure 5. In another example, it can be seen that participant 6 had 344 upright reflux episodes below 6.5, however, these episodes lasted 266.6 minutes representing 30% of time in the upright position. Lastly, figure 3 shows that participant 11 had 157 upright reflux episodes below a pH level of 6.5 and, these episodes lasted 759.4 minutes, representing 86.4% of time.

#### Upright: Mild

In figure 6 it can be seen that participant 6 had 221 mild upright reflux episodes between a pH of 6.5 and 6.0, however, figure 7 shows that these episodes lasted 198 minutes, which reflects 22.9% of time in figure 8.

#### Upright: Moderate

In figure 6 it can be seen that participant 11 had 1 moderate upright reflux episode between a pH of 6.0 and 5.5 however, figure 7 shows that this episode lasted 333.6 minutes, which reflects 37.8% of time in figure 8.

#### Upright: Severe

In figure 6 it can be seen that participant 4 had 15 severe upright reflux episodes below a pH of 5.5, however, figure 7 shows that these episodes lasted 681 minutes, which reflects 92.3% of time in figure 8.

#### Supine:

The range of mild reflux episodes can be seen in figure 9, which spans from 0 to 87. In particular, it should be noted that participant 4 had 1 supine reflux episode below a pH level of 6.0, however, Figure 10 shows that this single episode lasted 574.1 minutes, which reflects 100% of time in figure 11. Participant 8 had 29 supine reflux episodes below a pH level of 6.0, however, these episodes lasted 63.9 minutes, which reflects 12.2% of time. Participant 9 had 87 supine reflux episodes below a pH level of 6.0, however, these episodes lasted 38.9 minutes, which reflects 7.2% of time. Participant 11 had 23 supine reflux episodes below a pH level of 6.0, however, these episodes lasted 480.9 minutes, which reflects 99.7% of time.

#### Supine: Mild

In figure 12 it can be seen that participant 9 had 87 mild supine reflux episodes between a pH of 6.0 and 5.5, however, figure 13 shows that these episode lasted 38.9 minutes, which reflects 100% of time in figure 14.

Supine: Severe:

In figure 12 it can be seen that participant 4 had 1 severe supine reflux episode below a pH of 5.0, however, figure 13 shows that this episode lasted 574.15 minutes, which reflects 100% of time in Figure 14. Similarly, participant 11 had 14 severe supine reflux episodes below a pH of 5.0, however, these episode lasted 314.1 minutes, which reflects 62.5% of time.

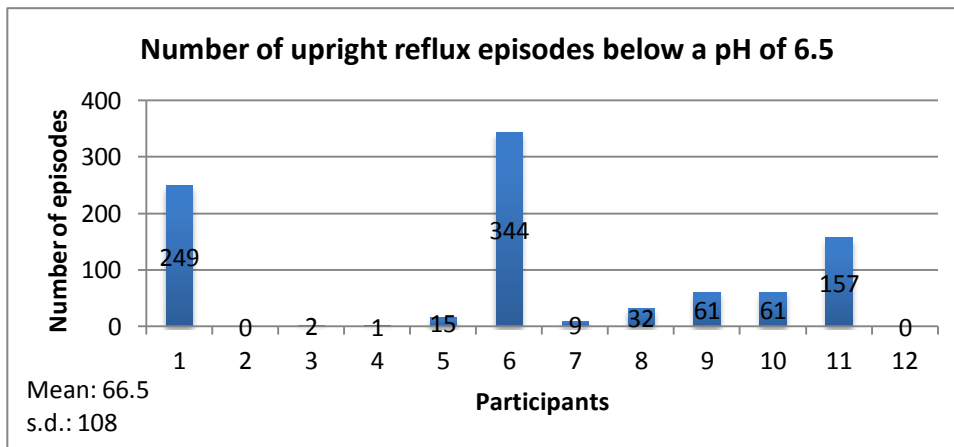


Figure 3. Number of upright reflux episodes below a pH of 6.5

Figure 3 represents the number of reflux episodes for each participant below the baseline pH of 6.5 when in the upright position. The x axis represents all of the participants and the y axis represent the number of reflux episodes for each participant.

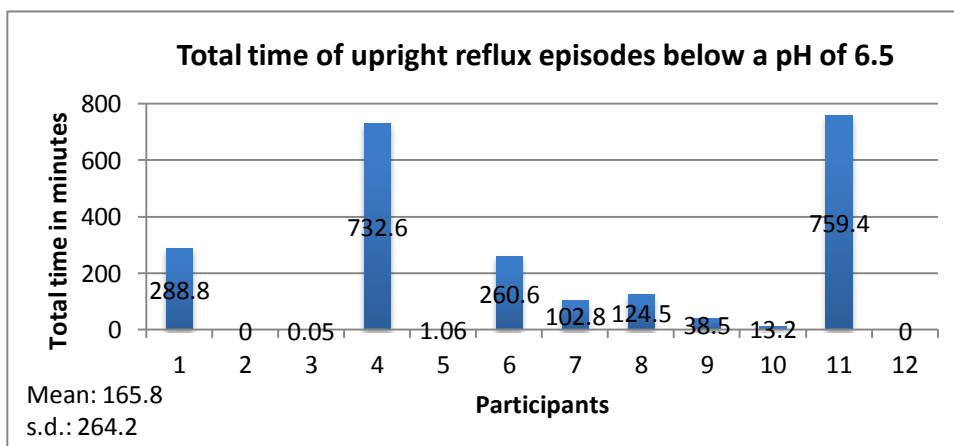


Figure 4. Total time of upright reflux episodes below a pH of 6.5

Figure 4 represents the total time each participant experienced reflux below the pH baseline pH of 6.5 when in the upright position. The x axis represents all of the participants and the y axis represent the total time each participant experienced reflux episodes in the upright position.

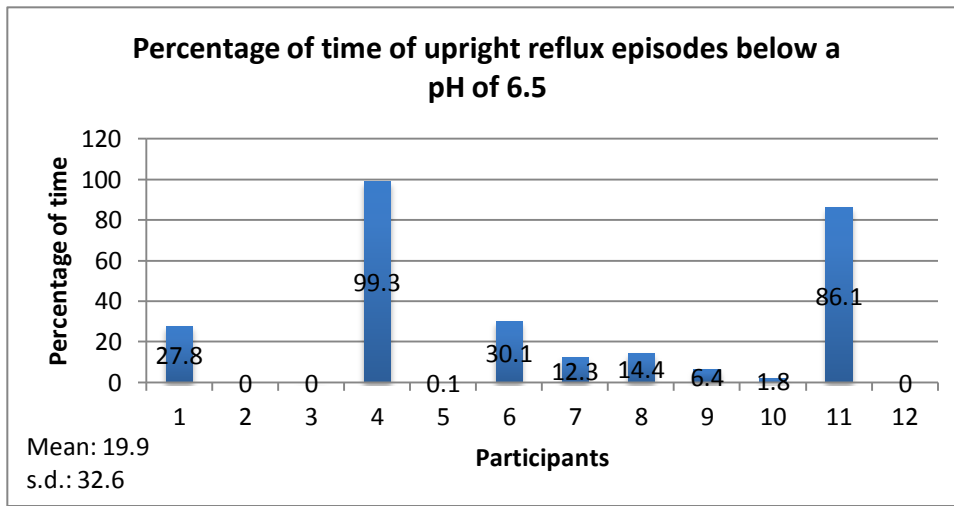


Figure 5. Percentage of time of upright reflux episodes below a pH of 6.5

Figure 5 represents the percentage of time each participant refluxed below the pH level of 6.5 when in the upright position. The x axis represents all of the participants and the y axis represent the percentage of time that each participant experienced reflux episodes in the upright position.

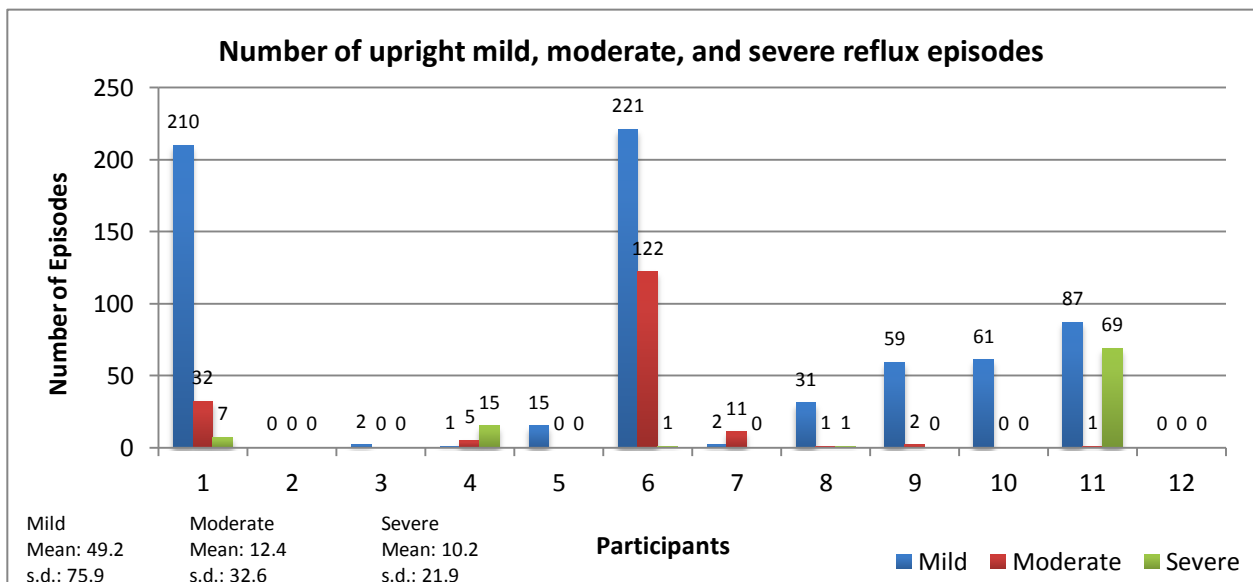


Figure 6. Number of upright mild, moderate, and severe reflux episodes

Figure 6 represents the number of reflux episodes for mild (between a pH baseline of 6.5 and 6.0, depicted in blue), moderate (between a pH baseline of 6.0 and 5.5, depicted in red), and severe (below a pH baseline of 5.5, depicted in green) reflux that each participant experienced when in the upright position. The x axis represents all of the participants and the y axis represents the number of reflux episodes for each participant within the pH three severity groups in the upright position.

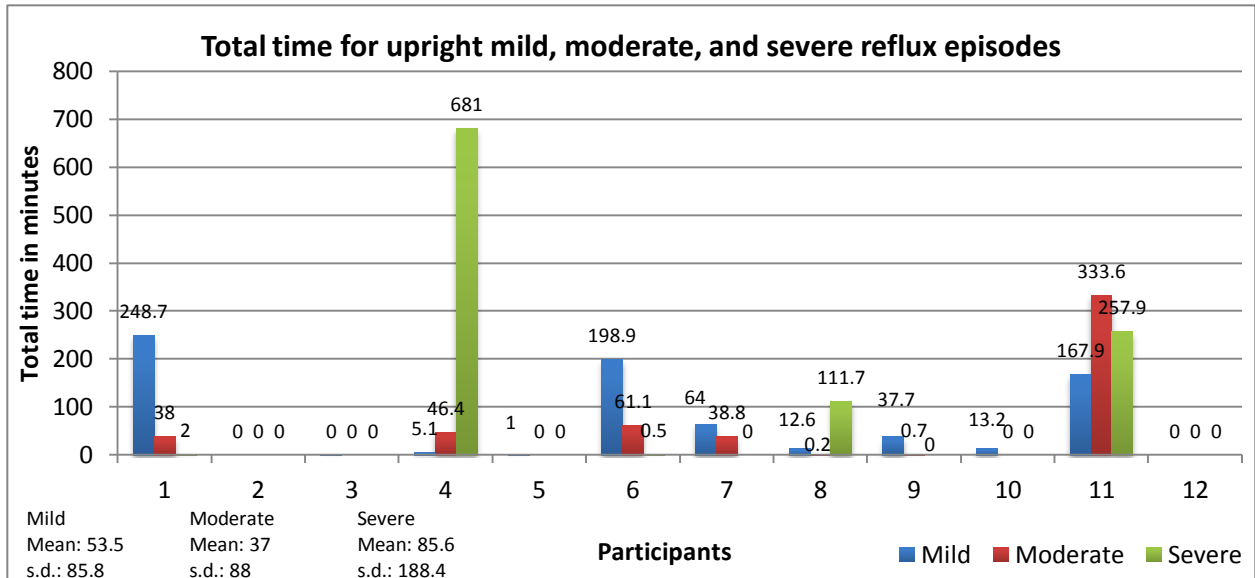


Figure 7. Total time of upright mild, moderate, and severe reflux episodes

Figure 7 represents the total time of reflux episodes for mild (between a pH baseline of 6.5 and 6.0, depicted in blue), moderate (between a pH baseline of 6.0 and 5.5, depicted in red), and severe (below a pH baseline of 5.5, depicted in green) reflux that each participant experienced when in the upright position. The x axis represents all of the participants and the y axis represent the total time each participant experienced reflux episodes within the three severity groups in the upright position.

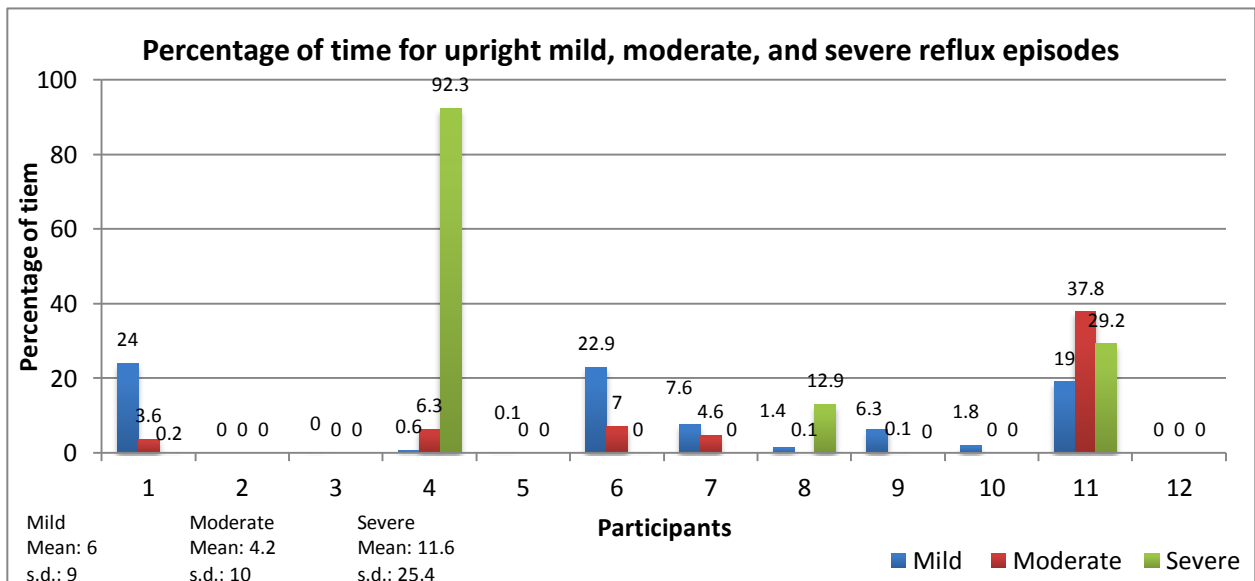


Figure 8. Percentage of time for upright mild, moderate, and severe reflux episodes

Figure 8 represents the percentage of time for mild (between a pH baseline of 6.5 and 6.0, depicted in blue), moderate (between a pH baseline of 6.0 and 5.5, depicted in red), and severe (below a pH baseline of 5.5, depicted in green) reflux that each participant experienced when in the upright position. The x axis

represents all of the participants and the y axis represent the percentage of time that each participant experienced reflux episodes within the three severity groups in the upright position.

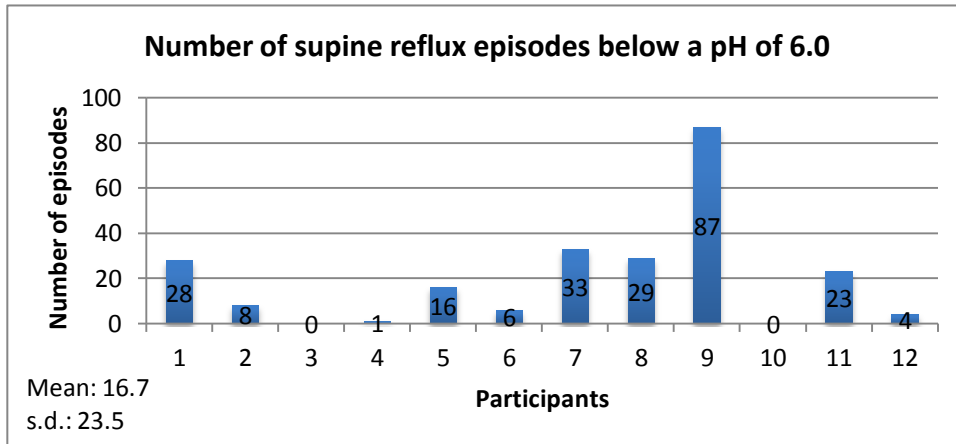


Figure 9. Number of supine reflux episodes below a pH of 6.0

Figure 9 represents the number of reflux episodes for each participant below the baseline pH of 6.0 when in the supine position. The x axis represents all of the participants and the y axis represents the number of reflux episodes for each participant in the supine position.

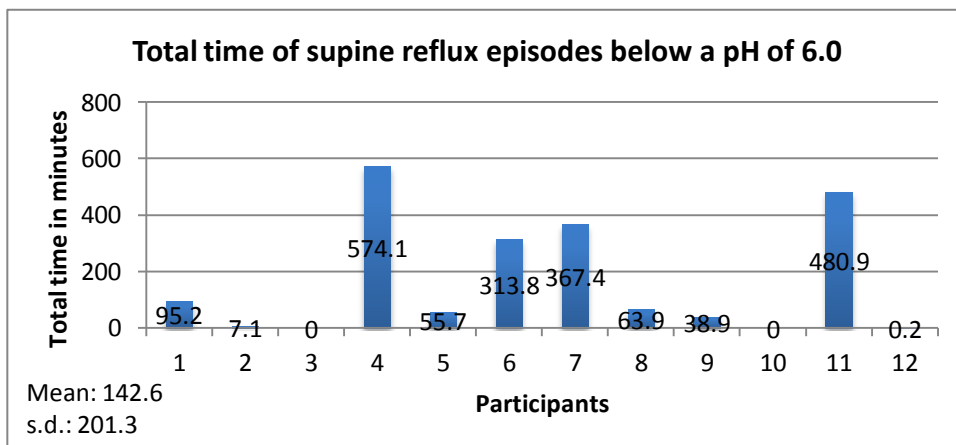


Figure 10. Total time of supine reflux episodes below a pH of 6.0

Figure 10 represents the total time each participant experienced reflux below the pH baseline pH of 6.0 when in the supine position. The x axis represents all of the participants and the y axis represent the total time each participant experienced reflux episodes in the supine position.

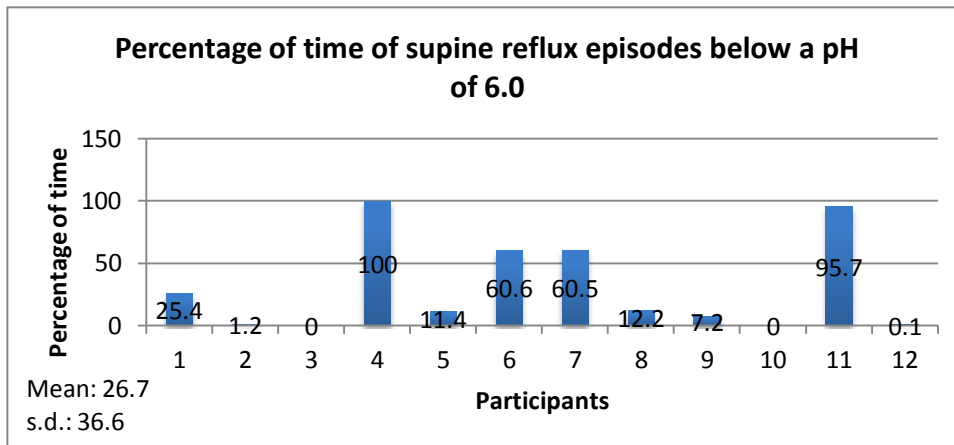


Figure 11. Percentage of time of supine reflux episodes below a pH of 6.0

Figure 11 represents the percentage of time each participant refluxed below the pH level of 6.0 when in the supine position. The x axis represents all of the participants and the y axis represent the percentage of time that each participant experienced reflux episodes in the supine position.

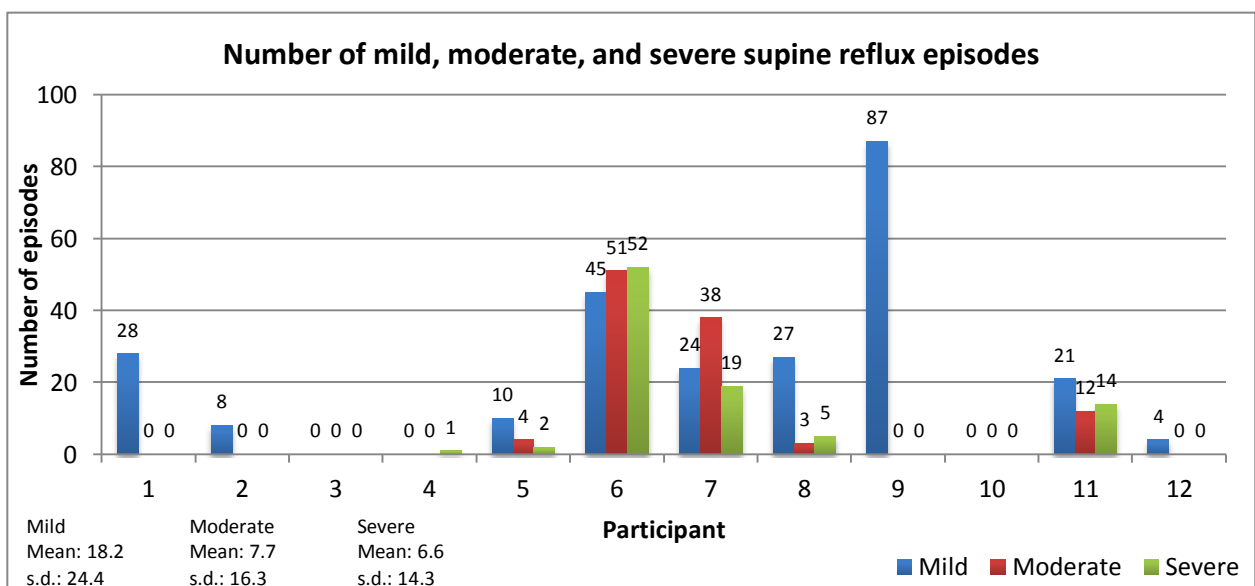


Figure 12. Number of mild, moderate, severe supine reflux episodes

Figure 12 represents the number of reflux episodes for mild (between a pH baseline of 6.0 and 5.5, depicted in blue), moderate (between a pH baseline of 5.5 and 5.0, depicted in red), and severe (below a pH baseline of 5.0, depicted in green) reflux that each participant experienced when in the supine position. The x axis represents all of the participants and the y axis represents the number of reflux episodes for each participant within the three severity groups in the supine position.

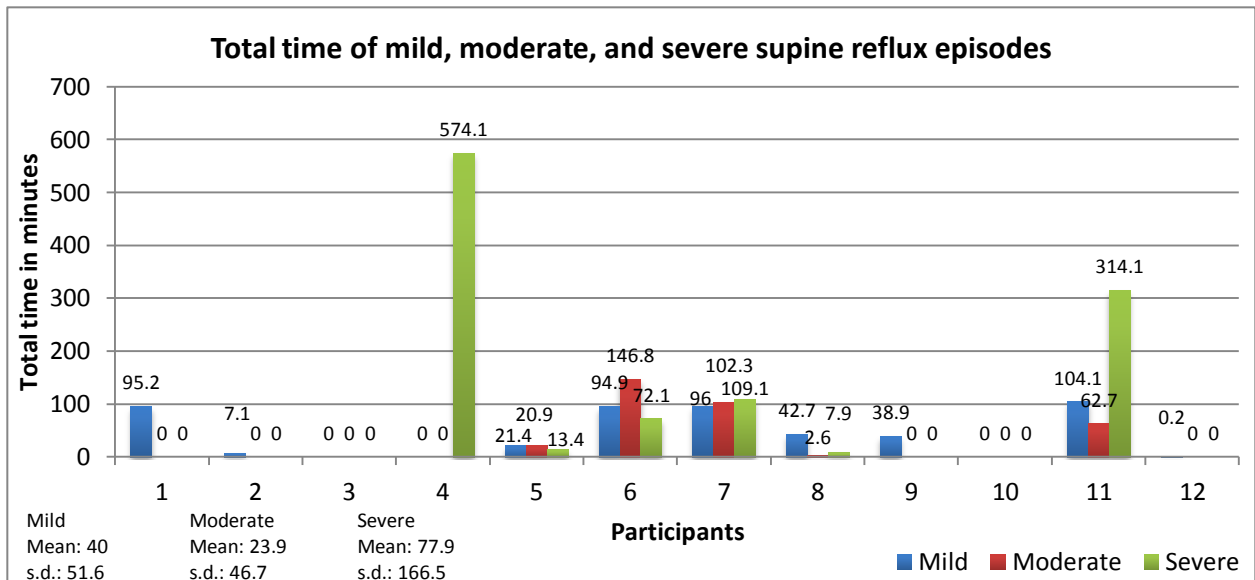


Figure 13. Total time of mild, moderate, and severe supine reflux episodes

Figure 13 represents the total time of reflux episodes for mild (between a pH baseline of 6.0 and 5.5, depicted in blue), moderate (between a pH baseline of 5.5 and 5.0, depicted in red), and severe (below a pH baseline of 5.0, depicted in green) reflux that each participant experienced when in the supine position. The x axis represents all of the participants and the y axis represent the total time each participant experienced reflux episodes within the three severity groups in the supine position.

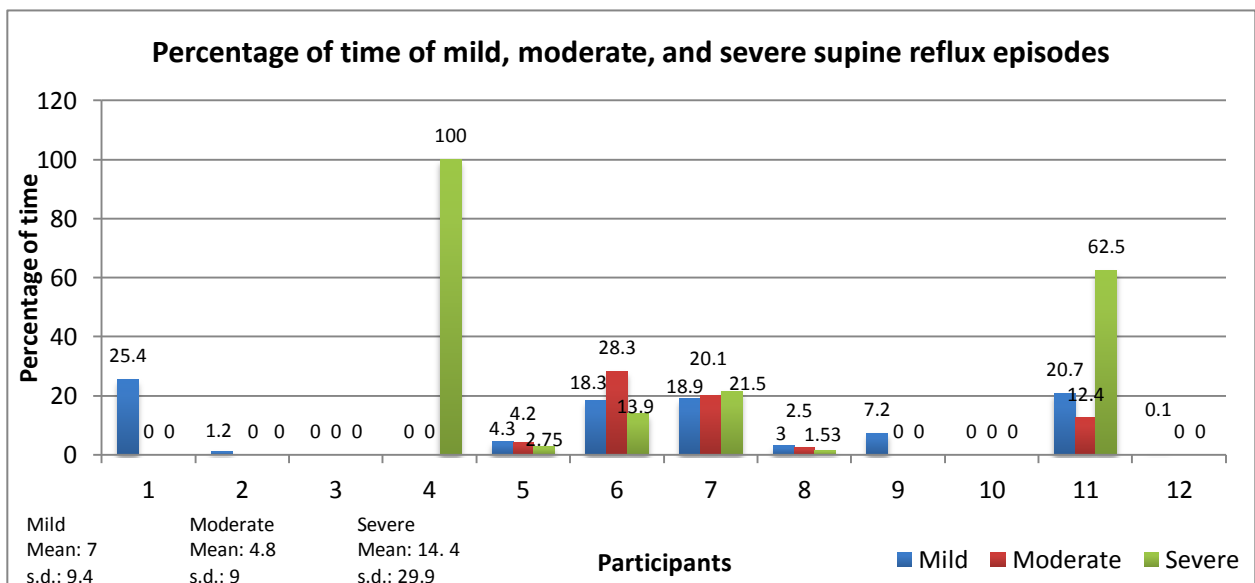


Figure 14. Percentage of time of mild, moderate, and severe supine reflux episodes

Figure 14 represents the percentage of time for mild (between a pH baseline of 6.0 and 5.5, depicted in blue), moderate (between a pH baseline of 5.5 and 5.0, depicted in red), and severe (below a pH baseline of 5.0, depicted in green) reflux that each participant experienced when in the supine position. The x axis



represents all of the participants and the y axis represent the percentage of time that each participant experienced reflux episodes within the three severity groups in the supine position.

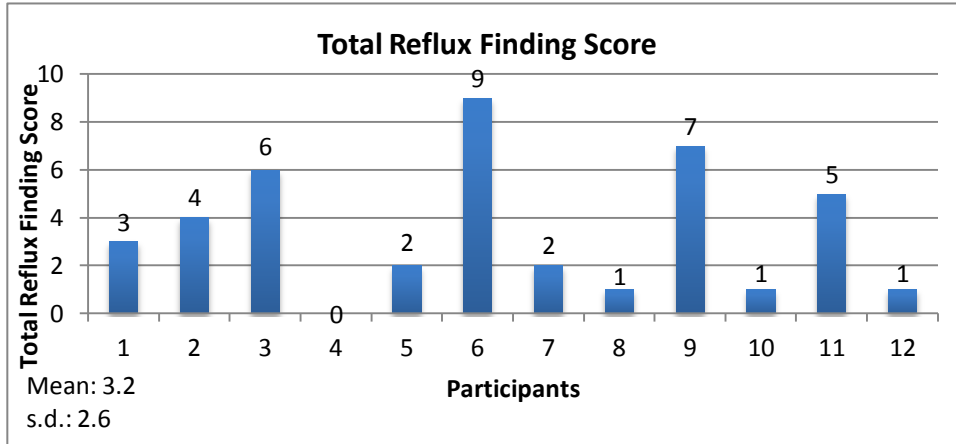


Figure 15. Total Reflux Finding Score

Figure 15 represents the total RFS for each participant. The highest possible score is 26. The x axis represents all the participants and the y axis represents the reflux finding score for each participant. An abnormal score is considered to be 7 or above.

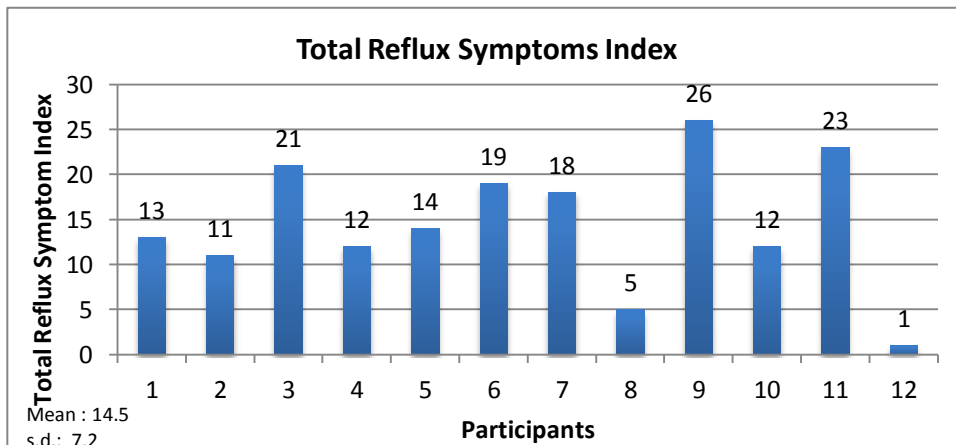


Figure 16. Total Reflux Symptom Index

Figure 16 represents the total RSI score for each participant. The highest possible score is 45. The x axis represents all of the participants and the y axis represents the reflux symptom index score for each participant. An abnormal score is considered to be 13 or above.

### Reflux Finding Score

It can be seen in figure 15 that only 2 of the 12 participant had a significant score on RFS as set forth by Belasky and colleagues (2001). On the other hand, it can also be seen that all

participants, except participant 4, had some endoscopic findings as rated by an otolaryngologist, even if only given the score of one.

### Reflux Symptom Index

It can be seen in figure 16 that 7 out of 12 had a score on the RSI that is considered to be abnormal as set forth by Belasky and colleagues (2002). Additionally, 3 other participants had scores that were close to abnormal.

### Inferential Statistics

Spearman correlation coefficient was subjected to the data set to test if correlations existed between the pH score, RFS, RSI (Table 1 for significant correlations; see the appendix D for all correlation data). Spearman's correlation was used because the continuous variables in the pH data are not normally distributed, RSI are ordinal variables, and RFS variables, which were converted into a binary variable, can be used with a non-parametric analysis such as Spearman Rank Correlation Coefficient (Sprent & Smeeton, 2001). These tests were completed using the statistical analysis software SPSS version 19.

Posterior commissure hypertrophy was correlated ( $p < 0.05$ ) with total time that each participant had a pH level that was below 6.0 when in the supine position. This is also a combination of mild, moderate and severe total times. Sensation of something sticking in the throat or a lump in the throat was correlated ( $p < 0.05$ ) with total time that each participant had a pH between 6.0 and 5.5 when in the supine position. Clearing your throat was correlated ( $p < 0.05$ ) with total time that each participant had a pH between 6.5 and 6.0 when in the upright position. Coughing after eating or after lying down was correlated ( $p < 0.05$ ) with the total time that each participant had a pH between 6.5 and 6.0 when in the upright position. Excess throat

mucous was correlated ( $p < 0.05$ ) with the total time that each participant had a pH between 6.0 and 5.5 when in the upright position. Hoarseness or a problem with the voice was correlated ( $p < 0.05$ ) with the total time that each participant had a pH between 5.5 and 5.0 when in the supine position. Erythema/hyperemia was correlated ( $p < 0.05$ ) with clearing the throat. Thick endolaryngeal mucus was correlated ( $p < 0.05$ ) with clearing the throat. Thick endolaryngeal mucus was correlated ( $p < 0.05$ ) with excess throat mucous. Erythema/hyperemia was correlated ( $p < 0.05$ ) with difficulty swallowing food, liquids or pills. Erythema/hyperemia was correlated ( $p < 0.05$ ) with coughing after eating or after lying down. Erythema/hyperemia was correlated ( $p < 0.05$ ) with breathing difficulties or choking episodes. Pseudosulcus (infraglottic edema) was correlated ( $p < 0.05$ ) with troublesome or annoying cough. Pseudosulcus (infraglottic edema) was correlated ( $p < 0.05$ ) with sensation of something sticking in the throat or a lump in the throat.

Table 1. Significant correlations between variables

Correlated variables	Correlation coefficient	Significance level
RFS 6 x pH below 6.0 in supine	$r = -0.584$	$p = 0.046$
RFS 8 x mild pH in supine	$r = 0.590$	$p = 0.044$
RSI 2 x mild pH in upright	$r = 0.715$	$p = 0.009$
RSI 5 x mild pH in upright	$r = 0.617$	$p = 0.033$
RSI 3 x moderate pH in upright	$r = 0.617$	$p = 0.033$
RSI 1 x moderate pH in supine	$r = 0.611$	$p = 0.035$
RFS 3 x RSI 2	$r = 0.626$	$p = 0.029$
RFS 8 x RSI 2	$r = 0.770$	$p = 0.003$
RFS 8 x RSI 3	$r = 0.619$	$p = 0.032$
RFS 3 x RSI 4	$r = 0.958$	$p = 0.000$
RFS 3 x RSI 5	$r = 0.642$	$p = 0.024$
RFS 3 x RSI 6	$r = 0.713$	$p = 0.009$
RFS 1 x RSI 7	$r = 0.577$	$p = 0.050$
RFS 1 x RSI 8	$r = 0.590$	$p = 0.043$

Table 1 represents the significant correlations between the total time of upright pH episodes (Below 6.5, mild, moderate, and severe) and total time of supine pH episodes (Below 6.0, mild, moderate, and severe)

and all the variables on the reflux symptom index reflux and finding score (see appendices B and C for a listing of all the variables).

## CHAPTER FOUR: DISCUSSION

This study set out to quantify the perceptual symptoms and objective measures of LPR in a population of singers in order to understand the relationship between perceived symptoms, laryngeal findings, and evidence of acid exposure to the larynx. The population of singers is an important one to study because of their increased voice demands, as compared with other occupational voice users, their performance and daily living habits, and the demands placed on the respiratory system in order to sustain a sung tone. Also of importance are anecdotal reports from treatment seeking patients related to idiopathic voice disturbances which included intermittent hoarseness, increased effort when singing, loss of vocal range, difficulty with producing soft sounds, vocal fatigue, a change in vocal quality, and hard tonal onset (Lloyd, Lehman, Spector, Meemon, Lewis, & Ruddy, 2010). As can be seen throughout the literature (Lundy, Casiano, Sullivan, Roy, Xue, & Evans, 1999; Casiano, Zaveri, & Lundy, 1992; Branski, Bhattacharyya, & Shapiro, 2002; Kelchner, et al., 2005), symptoms and endoscopic findings alone do not always provide an accurate diagnosis for reflux as a causative factor in voice disturbances.

This is particularly a challenge when the reflux symptoms are mild, due to the lack of objective tools available that are sensitive enough to capture mild events. Therefore, the primary focus in this study was to quantify the degree of singer's sensitivity to alterations experienced in voice quality with the number and duration of reflux events due to the increasing numbers of treatment seeking singers seen as a national trend (Koufman, 1991; Koufman, Amin, & Panetti, 2000; Zerbib & Stoll, 2009; Sataloff, Castell, Katz, & Sataloff, 2005; Khan, Hashmi,

Elahi, Tariq, & Ingrams, 2006) necessitating voice evaluation and empirical medical and behavioral treatment.

In this study it was shown that reflux affecting the larynx might only cause subtle tissue changes, yet resulted in statistically significant perceptual symptoms. For instance, participant 1 had a score of 13 on the reflux symptom index, with the highest rated symptom being difficulty swallowing food, liquids, or pills. This particular symptom is typically indicative of a substantial disturbance in symptoms (Belafsky, Postma, & Koufman, 2002). Yet, this participant received a score of 3 on the reflux finding score, which is not considered abnormal (Belafsky, Postma, & Koufman, 2001). When looking at pH levels, it can be seen in figures 6-8 and 12-14 that this participant was predominately experiencing mild reflux in the upright and supine positions. Because their RSI score was considered abnormal, their RFS was within normal limits, and their pH levels were in the mild range it is uncertain whether or not this participant would actually receive medical or behavioral management for reflux in a clinical setting. More likely, this participant would be diagnosed with vocal hyperfunction and prescribed a vocal hygiene program only (Sapienza & Ruddy, 2008; Timmermans, Vanderwegen, & De Bodt, 2005).

Similarly, participant 6 has comparable pH findings with mild reflux being the most significant in the upright position, yet a relatively even amount of mild, moderate, and severe reflux in the supine position. This participant had a score of 19 on the reflux symptom index and a score of 9 on the reflux finding score. This symptom profile indicates that this person experienced mostly mild reflux in the upright position, yet experienced mild, moderate, and severe reflux in the supine position. Furthermore, both the RSI and the RFS scores were found

to be substantial with the highest rated variables being hoarseness or a problem and erythema/hyperemia for the physical findings.

When considering the data for participant 4 it is obvious that this participant had severe reflux events in both upright and supine positions (see figures 6-8 and 12-14). Interestingly this participant had a score of 0 on the RFS, which indicates that there were no abnormal physical findings on laryngeal examination, yet scored a 12 on the RSI, which is just below the level that is considered abnormal reflux symptoms (Belafsky, Postma, & Koufman, 2002). It should also be noted that this participant is an educated and a well-trained vocal performance professor who reportedly takes good care of their body and larynx. It is also important to note that this participant was on Aciphex, 20mg b.i.d. (a proton pump inhibitor medication taken twice daily) during the testing. This profile shows that symptoms and endoscopic findings alone do not always give good representation of acid exposure to the larynx. If, in fact, only symptoms and endoscopic findings were taken into consideration, this participant, with notable severe reflux, might have been misdiagnosed.

Similarly, it can be seen that participant 7 had more exposure to reflux throughout the three severity groups in the supine position. The RSI score was 18 (abnormal score), with the highest rated variables including hoarseness and throat clearing (Belafsky, Postma, & Koufman, 2002). Yet this participant was only assigned a score of 2 for the RFS. Again, this suggests that perhaps physical findings alone are not always the best indicator of reflux related exposure or symptoms.

This study also revealed that evaluating reflux episodes alone may not be the best indicator of reflux severity. From a clinical perspective, this is a critical factor to consider, as a more accurate analysis of acid exposure to the oropharynx might be found in the total time (or percentage of time) of acid exposure to the upper airway. For example, participant 8 and participant 11 presented with interesting findings. Both participants had a small number of severe reflux episodes yet those episodes lasted longer than most participants in this study. As a corollary to this, participant 9 had a large number of reflux episodes, yet those episodes occurred for a shorter period of time. The number of episodes, the total time of reflux episodes, and percentage of time of reflux episodes were all listed for each participant because each measure adds a piece to the diagnostic puzzle. For example, participant 4 only had one upright reflux episode that fell below a pH of 6.5. Yet that episode lasted 732.6 minutes, this was 99.32 percentage of the time that this participant was in the upright position. Considering this, total time in minutes was selected for correlation analysis because it provides the most accurate data in reference to the amount of acid exposure. This is especially true when considering the implications of mild, moderate, and severe pH levels. Future studies need to include this in the research design to ascertain the most accurate interpretation of data in order to confirm or rule out a diagnosis of LPR.

The data of participant 9 is also of interest. They presented with mild reflux events in both upright and supine. Their RFS was assigned a 7, with the highest scored variables being pseudosulcus (infraglottic edema), erythema/hyperemia, and thick endolaryngeal mucus. Their reflux symptom index score was a 26, the highest of all the participants, with the highest rated variables being hoarseness or a problem with your voice, clearing your throat, and troublesome



or annoying cough. This profile of findings and symptoms could indicate another etiology as the source of vocal problems, such as allergies or phonotrauma (Behlau, Oliveira, & Pontes, 2009; Roth, & Ferguson, 2010). As such, it should be noted that these symptoms and physical findings could have a different etiology other than reflux. As can be seen from the data in this study, a high RSI score does not always relate to physical findings or substantial pH levels. (Figures 6 – 8, 12 – 14, 15 and 16). Therefore, other etiologies such as allergies, vocal over use, misuse, organic disease, etc, could be the cause of the voice disturbance and tissue change (Sapienza & Ruddy, 2008; Behlau, Oliveira, & Pontes, 2009; Roth, & Ferguson, 2010). Such results highlight the need for more objective data for the diagnosis and treatment of reflux.

It is interesting when comparing the RSI and RFS data. It can be seen in figure 15 and 16 that participants 1, 3, 5, 6, 7, 9, and 11 had a score that is considered abnormal on the RSI and yet only participants 6 and 9 had a score that was considered abnormal on the RFS. Due to singer's sensitivity to even slight alternations in tissue change, an endoscopic exam of the larynx may not capture the microscopic changes that a singer perceives. This assumption can be further confirmed by considering the pH levels for these participants. We see in figures 6 – 8 and 12 – 14 that participants 1, 3, 5, 6, 7, 9, and 11 all had upright reflux and all, but participant 3, had supine reflux. Such results demonstrate that although endoscopic findings did not indicate reflux, the pH levels do. With that said, another study by this author (Lloyd, Lehman, Spector, McCrea, Carson, & Ruddy, 2009) found abnormal scores on the RFS that did not coincide with scores on the RSI. This suggests that the variables presented on the RSI may also not be sensitive enough to the singer and who might experience more singing related voice disturbances, such as increased effort when singing, loss of vocal range, difficulty with

producing soft sounds, vocal fatigue, a change in vocal quality, and hard tonal onset. These variables are not currently included in the RSI however these particular indices are being subjected to a test of sensitivity and specificity by the current author.

Whether or not reflux is the etiology behind voice disturbances of the singers in this study, voice problems can precipitate negative psychological, emotional, and social consequences for affected individuals. This is especially true to the singer and can be seen in the high rated symptom index. Substantial scores on the RSI, were observed in 7 out of the 12 participants, if persistent long enough, might be a factor in reduced quality of life and an increase in stress and anxiety. Cheung, et al. (2009) found that LPR participants had taken sick leave, reported an adverse impact on their social life, worse scores on the VHI, worse social functioning, pain, as well as higher depression scores. Singer's quality of life would likely be greatly reduced, considering the preciseness with which they use voice and how small changes in the tissue and create adverse reactions and changes to the production of sound.

Oyer, Anderson, & Halum (2009) found that the mean RSI score of participants with a psychiatric disorder was higher than those without a psychiatric disorder. Yet, the participants with psychiatric disorders had a less reported abnormal pH probe studies. The authors concluded that anxiety and depression impairs the predictive value of the RSI for LPR. Considering a population of singers, performance anxiety and nervousness might affect the results of the RSI. The results of this study are similar to the findings of Wright and colleagues (2005) where they found that participants with GERD who also experienced psychosocial stressors had increased perceptions of reflux symptoms like heartburn yet did not have measurable increases in the amount of esophageal reflux.

It can be seen from the current study that 5 out of the 12 participants indicated that they had symptom related to breathing difficulties or choking episodes. Reflux has been known to cause breathing problems or exacerbate respiratory disease. As was found by Harding, Guzzo, and Richter (1997) 70-80% of asthmatics also had GERD. Spencer (2006), suggests pathologic linkage of the digestive and respiratory systems has yielded solid evidence of relationships between reflux and asthma through “silent” microaspiration and connecting vagal innervations of the esophagus and bronchi. Considering this, it is easy to see how these microaspirations could cause irritation and could lead to throat clearing, coughing, and other breathing related vocal fold behaviors.

Erythema and edema of the mucosa on top of the arytenoid cartilage are reported to be some of the most prevalent laryngeal findings with LPR (Chung, et al., 2009; Sataloff, Castell, Katz, & Sataloff, 2006). The structural changes found in the current study included pseudosulcus (infraglottic edema) erythema/hyperemia, vocal fold edema, diffuse laryngeal edema, posterior commissure hypertrophy, and thick endolaryngeal mucus. The current study found similar findings to Chung and colleagues (2009) and Sataloff and colleagues (2005) where Erythema/hyperemia and posterior commissure hypertrophy were reported substantially. With that said, Lundy and colleagues (1999), reported that 70% of asymptomatic singers had posterior erythema. This can explain that although acid exposure can change the appearance of the tissue it does not always cause symptoms, or at least not the symptoms that are included on the RSI. Therefore, an area for future study should test singer specific variables to include: increased effort when singing, loss of vocal range, difficulty with producing soft sounds, vocal fatigue, a

change in vocal quality, and hard tonal onset (Lloyd, Lehman, Spector, Meemon, Lewis, & Ruddy, 2010).

The amount of acceptable acid exposure or the acceptable amount of time for pH to be below certain thresholds is unknown and more future research needs to be designed in order to determine how much acid exposure is normal and how much is abnormal. Two events per day of reflux below a pH of 4 were reported in healthy controls (Merati, Lim, Ulualp, & Toohill, 2005; Vincent, Garrett, Radionoff, Reussner, & Stasney, 2000; Ylitalo, Lindestad, & Ramel, 2001; Ylitalo & Ramel, 2002), yet the total time of this exposure is unknown. What is also unknown is if those participants were professional voice users or singers. In this study participants with an oropharyngeal pH that was below the pH level of 4 also had significant symptoms and endoscopic findings. Therefore, that measure of severity may not be appropriate for this population. On the other hand, 3 pharyngeal reflux events per week have been found to produce laryngeal damage, especially if a pre-existing mucosal injury exists (Koufman, 1991). Although many singers have good and precise vocal technique, singers also tend to overuse their voice or have poor speaking voice habits. This can cause irritation to the vocal folds and that coupled with mild exposure of reflux could be detrimental to a singer.

When looking at the significant correlations between the pH levels physical findings, and perceptions, it is interesting that only mild and moderate pH was found to correlate with symptoms and findings. In this population of singers, who seem to be significantly affected by mild and moderate pH levels, it is vitally important that these pH levels be considered when interpreting the results of study and comparing them to physical findings and perceived

symptoms. One explanation for this finding may be that singers rarely wait until symptoms become severe, as subtle voice changes can have a severe impact on vocal quality, vocal performance, and in particular, a singers livelihood.

When considering the correlations within the RSI and RFS dataset it is interesting that erythema/hyperemia was correlated with throat clearing, thick endolaryngeal mucus was correlated with throat clearing, and thick endolaryngeal mucus was correlated with excess throat mucous. The forceful contact of throat clearing can produce a sheering force on the vocal folds resulting in irritation in the form of erythema and whether or not mucous or the sensation of something stuck in the throat is caused by reflux, it is important to consider reflux as a possible etiology behind these problems (Noordzij, et al., 2002).

Due to the larynx being more sensitive to damage than the esophagus (Mesallam, Stemple, Sobeih, & Elluru, 2007), it is not surprising that there were no significant correlations between the typical esophageal symptoms of heartburn, chest pain, indigestion, or stomach acid coming up, physical findings, and pH levels. When considering the current population, which only presented with significant correlations between mild and moderate reflux, it is understandable that it would take a lower pH level to cause symptoms in the esophagus. Likewise, a milder pH might still cause symptoms in the larynx due to its sensitivity and less protective tissue as compared to the esophagus.

The standard abnormal pH for the esophagus is  $\text{pH} < 4$  (Wiener, Tsukashima, Kelly et al., 2009). The abnormal pH that affects the oropharynx increases due to the gradient of increasing pH from the lower esophagus to the oropharynx. This brings up an important discussion point. When using the Dx-pH measurement system (Restech, San Diego, California) to evaluate

oropharyngeal pH, many studies have indicated the discriminatory pH thresholds are 5.5 for upright and 5.0 for supine (Tan, Raeburn, & Emmanuel, 2011; Sun, et al., 2009; Ayazi et al., 2009; Chheda, Seybt, Schade, & Postma, 2009; Wiener et al., 2009).

When considering the normal range of pH, Ayazi and colleagues (2009) analyzed pH at 0.5 intervals between 4 and 6.5 and found ranges for mild, moderate, and severe reflux in both upright and supine. As can be seen in the present study, those thresholds and severity levels were used when reporting this data and in the correlation analysis. The discriminatory thresholds of 5.5 for upright and 5.0 for supine according to the Ayazi and colleagues are found to be the thresholds for severe reflux in the oropharynx. Considering that the participants of the current study were all singers, it was of interest to see the effects of mild and moderate reflux on their symptoms and physical findings.

The Dx-pH measurement system software automatically has a set pH threshold of 5.5. The investigator had to manually reset the pH threshold and analyze the data for all severity groups. A popular calculation done using the percentage of time of pharyngeal acid exposure below 5.5 in upright and 5.0 in supine, as well as the number of episodes and the duration of the longest episode below these thresholds is called the RYAN score. It yields a standardized value and then compares that to the participant's calculated value. This analysis was not used in the present study due to the calculation only considering thresholds below the severe range. This is an important aspect to consider when using the Dx-pH measurement system software, as mild and moderate pH levels are not taken into consideration with this analysis. Unfortunately, many medical practices, including the one associated with this study, defer to the manufacturer's thresholds (RYAN score) as a means by which a diagnosis is reached. As the current study

suggests, there is clinical value in considering mild and moderate pH levels, especially with singers who present symptomatically to less severe pH levels.

### Study Limitations

The small sample size presents a substantial limitation for the current study, however, the data shows trends in quantifying reflux and will be considered in future study design. Furthermore, the 24 hour pH monitoring has some disadvantages. A 24 hour test is merely a small glimpse into the life of one being tested. As stated earlier, very small amounts of refluxed content can cause trauma and damage to the sensitive tissue of the larynx and pharynx (Koufman, 1991). It is certainly possible that one or two reflux episodes per week could cause a singer's voice to malfunction. Considering this, longer testing may be necessary to accurately diagnose and treat this disorder. In this study, those participants who had normal pH levels but reported significant symptoms or had significant physical findings could simply not have had a reflux event during the 24 hours when the pH test was done. Therefore, it's possible that more comprehensive testing would be of benefit. It should be pointed out that normal results on a pH study do not indicate the absence of reflux. This simply indicates that, at the time of the study there were no incidences of reflux. Also, it could also be possible that the symptoms and physical findings are a result of other etiologies such as hyperfunction, allergies, or non-acidic reflux. This suggests that reflux of pH-neutral liquid may still be present and may produce symptoms, especially for the professional voice user. This type of reflux will register as normal on a typical 24-hour pH study. Furthermore, this type of testing is not routinely done in clinical practice due to the invasiveness, expense, and long duration of data collection. However, it should be taken

into consideration when diagnosing and treating voice disorders associated with patient symptoms and visual findings associated with reflux (Sataloff, Castell, Katz, & Sataloff, 2006).

Another limitation is that not all of the pH exams were the same length of time. Exams were between 18 and 24 hours therefore the number of reflux symptoms, total time of episodes, and percentage of time could be skewed as a result of somewhat uneven length between each participant. Future studies may control for this. Furthermore, the directions on the RSI tool state, “Within the last MONTH, how did the following problems affect you?” Therefore, the participant’s perceptions for reflux may not always coincide with the physician rated endoscopic findings as rated on the RFS. Perhaps more significant correlations would be found if participants answered the questions on the RSI according to their current perceptions on the day of their endoscopic exam.

### Future Studies

Future studies should include a larger sample size of singers and designed to collect from a wider age span, different genres of vocal performance, and extent of vocal training. Furthermore, future studies should attempt to better understand motility issues (abdominal distension, coordination and muscle group patterns implemented in the teaching of singing) and a possible relationship that exists between breath coordination, GERD, and LPR. It would also be valuable to have the singers actually perform or practice singing while doing the evaluation, to exam if pH changes occur while singing. This could be done by having the singer wear the pH monitoring device during a voice lesson, voice therapy session, or during a rehearsal. It would be interesting to see if there were changes in pH levels with changes in subglottal pressure for



loud, soft, high and low pitches. The mild, moderate and severe levels of severity presented in this study need to be further evaluated in a population of singers that have been diagnosed with reflux. Due to singers sensitivity to irritation in the larynx, it would be valuable to study individuals with abnormal pharyngeal pH before and after treatment to see if pH levels and perpetual symptoms improve.

### Conclusions

Many singers experience voice related disturbances and the results of the current study reveal that indeed reflux that reaches the oropharynx may be playing a role in these disturbances. This study further strengthens the notion that endoscopic findings alone are not a good indication of reflux exposure and more objective data, like an oropharyngeal pH measurement system should be implemented to quantify reflux in the oropharynx. It is also evident that the subtle tissue changes that occur in the larynx may result in noticeable changes in voice quality to the singer but not to the general population of occupational voice users. RSI and the RFS are valid tools for qualifying perceptions and physical findings but they are not without flaws. One conclusion from the current study is that perhaps the variables presented on the RSI are not sensitive enough for the subtle changes in vocal abilities of a singer and a new scale with additional questions should be created to better serve this population. Although significant correlations were found between the RFS, RSI and pH levels, only mild and moderate pH levels were found to correlate with symptoms and findings. This indicates that singers are sensitive to even small deviations for pH and this should be taken into consideration when evaluating a singer who has suspected LPR.

## **APPENDIX A: IRB APPROVAL LETTER**



**Symptoms, visual findings, and pH results of Laryngopharyngeal Reflux (LPR): Is it truly reflux or are we dealing with another cause?**

**Informed Consent**

Principal Investigator(s): Adam Lloyd, M.M.

Sub-Investigator(s): Jeffrey Lehman, M.D.  
Jeffrey Fichera P.A.-C

Faculty Supervisor: Bari Hoffman Ruddy, Ph.D

Investigational Site(s): The Ear, Nose, and Throat Surgical Associates Voice Care Center

**Introduction:** Researchers at the University of Central Florida (UCF) study many topics. To do this we need the help of people who agree to take part in a research study. You are being invited to take part in a research study, which will include about 30 people in the Orlando area. You have been asked to take part in this research study because you are a collegiate level singer or a treatment seeking patient at the Ear, Nose, and Throat Surgical Associates. You must be 18 years of age or older to be included in the research study.

The person doing this research is Adam Lloyd of the Department of Communication Sciences and Disorders at the University of Central Florida. Because the researcher is a graduate student he is being guided by Bari Hoffman Ruddy, a UCF faculty supervisor in the Department of Communication Sciences and Disorders.

**What you should know about a research study:**

- Someone will explain this research study to you.
- A research study is something you volunteer for.
- Whether or not you take part is up to you.
- You should take part in this study only because you want to.
- You can choose not to take part in the research study.
- You can agree to take part now and later change your mind.

- Whatever you decide it will not be held against you.
- Feel free to ask all the questions you want before you decide.

**Purpose of the research study:** The **purpose** of this study is to quantify the perceptual and objective symptoms, as well as pH results of LPR in collegiate level vocalists and treatment seeking patients and to understand the relationship between physical/structural laryngeal findings, perceived symptoms, and the amount of acid exposure to the larynx. We seek to answer the question: Are endoscopic findings in the larynx and patient symptoms consistent with positive pH findings in collegiate level vocalists and treatment seeking patients? The results of this study could be helpful when deciding a treatment path for patients presenting with these symptom profiles.

**What you will be asked to do in the study:**

- Participants will be asked to consent to having the researches review their medical results that are part of their standard care (a reflux symptom questionnaire and videolaryngostroboscopy exam only).
- Participants will also be fitted with a minimally invasive catheter, which will be inserted into the nose and placed at back of the throat behind uvula, away from the participant's discomfort level. This will be used to detect any liquid and gaseous reflux events. This catheter will be left in position for 18 to 24 hours and will be held in place by surgical tape to the nose and ear.
- In order to participate in the study participants will need to visit the The Ear, Nose, and Throat Surgical Associates two times, for insertion and removal of the catheter.
- The participant will only interact with the staff listed above.

**Location:**

The Ear, Nose, Throat & Plastic Surgery Associates  
44 W. Michigan St.  
Orlando, FL 32806  
407-422-4921

or

The Ear, Nose, Throat & Plastic Surgery Associates  
201 N. Lakemont Avenue, Suite 100  
Winter Park, Florida 32792  
407-644-4883

**Time required:** We expect that you will be in this research study for one week. The data collection will require two five-minute sessions. (One for insertion and one for removal of the catheter) Each session will take place Monday-Friday during the hours of 8am-5pm.

**Risks:**

There are no foreseeable risks for participating in this study. The catheter is non to minimally invasive. Participants might feel slight pressure in the nose during insertion of the catheter and might sense a foreign object in the back of the throat when swallowing. This should be brief, yet could last as long as the catheter is in the nose (18-24 hours).

**Benefits:**

We cannot promise any benefits to you or others from your taking part in this research. However, possible benefits include receiving a free oral, pharyngeal, and laryngeal pH study. Participants will have the opportunity to learn more about how to prevent acid reflux from a behavioral and lifestyle perspective. This knowledge could have life long benefits.

**Compensation or payment:**

There is no compensation or other payment to you for taking part in this study.

**Confidentiality:** Your identity will be kept confidential. The researcher will make every effort to prevent anyone who is not on the research team from knowing that you gave us information, or what that information is. Your information will be combined with information from other people who took part in this study. When the researcher writes about this study to share what was learned with other researchers, he will write about this combined information. Your name will not be used in any report, so people will not know how you answered or what you did. There are times when the researcher may have to show your information to other people. The researcher may have to show your identity to people who check to be sure the research was done right. These may be people from the University of Central Florida or state, federal or local agencies or others who pay to have the research done.

**Study contact for questions about the study or to report a problem:** If you have questions, concerns, or complaints, or think the research has hurt you, talk to Adam Lloyd, Graduate Student, Communication Sciences and Disorders Program, College of Health and Public Affairs, (407) 823-4798 or Dr. Bari Hoffman Ruddy, Faculty Supervisor, Department of Communication Sciences and Disorders at (407) 823-4804 or by email at bhruddy@mail.ucf.edu.

**IRB contact about your rights in the study or to report a complaint:** Research at the University of Central Florida involving human participants is carried out under the oversight of the Institutional Review Board (UCF IRB). This research has been reviewed and approved by the IRB. For information about the rights of people who take part in research, please contact: Institutional Review Board, University of Central Florida, Office of Research & Commercialization, 12201 Research Parkway, Suite 501, Orlando, FL 32826-3246 or by telephone at (407) 823-2901. You may also talk to them for any of the following:

- Your questions, concerns, or complaints are not being answered by the research team.
- You cannot reach the research team.
- You want to talk to someone besides the research team.
- You want to get information or provide input about this research.

**Withdrawing from the study:**

If you decide to leave the study, contact the investigator so that the investigator can collect the pH catheter if you decide to be removed from this study while data collection is taking place

**HIPAA Authorization Form**

**Project Title:** Symptoms, visual findings, and pH results of Laryngopharyngeal Reflux (LPR): Is it truly reflux or are we dealing with another cause?

**Principal Investigator:** Adam Lloyd  
**Co-Investigator:** Bari Hoffman Ruddy

**Name of Research Subject/Participant:**  
**Date of Birth:**  
**Street Address:**  
**City, State & Zip Code:**

**Authorization to Use and Disclose Protected Health Information**

Under federal law, people who conduct research studies under certain circumstances, using information about the health of their research participants are required, except in specific circumstances, to get written permission to use their participants' health information for the research study. Because you have agreed to participate in a research study, your written permission is needed to use your health information. This Authorization asks your permission to allow certain people and/or groups to use and/or disclose your health information for the research study in which you have agreed to participate. In order to take part in the research study, you must sign this Authorization.

**A. What is the Purpose of this Authorization?**

The purpose of this Authorization is to allow the people and/or groups listed below to use and/or disclose certain information about your health for the research study titled: Symptoms, visual findings, and pH results of Laryngopharyngeal Reflux (LPR): Is it truly reflux or are we dealing with another cause?

**B. What Information Will Be Used and/or Disclosed For the Research Study?**

The following information about your health ("Protected Health Information") will be used and/or disclosed for the Research Study:

- *Name*
- *City / Place of residence*



- *Date directly related to an individual, including birth date, admission date, discharge date, date of death: and all ages over 89*
- *Medical records*

**C. Who Will Use and/or Disclose My Protected Health Information?**

1. **Custodians.** The following people and/or groups who hold your medical records ("Custodians") are permitted to disclose your Protected Health Information for the Research Study to the Designated Users listed in Section C.2:
  - Adam Lloyd, M.M.
  - Jeffrey Lehman, M.D.
  - Jeffrey Fichera P.A.-C
  - Bari Hoffman Ruddy, Ph.D
  
2. **Designated Users.** The following people and/or groups are permitted to use your Protected Health Information for the Research Study ("Designated Users"):
  - Adam Lloyd, M.M.
  - Jeffrey Lehman, M.D.
  - Jeffrey Fichera P.A.-C
  - Bari Hoffman Ruddy, Ph.D
  
3. **Designated Recipients.** The Designated Users are permitted to disclose your Protected Health Information to the following people and/or groups who are involved in or connected to the Research Study ("Designated Recipients"):
  - *The University of Central Florida Institutional Review Board (UCF IRB) and The Office of Human Research Protections in the U. S. Department of Health and Human Services*

**D. Authorization Expiration Date/Event?**

End of research study.

**How Long Will My Permission Last?** This Authorization does not have an automatic end date, unless such date is indicated above. Usually, the authorization expiration date will be the end of the research study. However, you have the right to end this Authorization by withdrawing it, in writing, at any time. Please note that your written withdrawal will not be effective to the extent that the Custodians or Designated Users have already acted in reliance on this Authorization. This means that, in certain circumstances, a researcher may be allowed to continue using your Protected Health Information for research that is already in progress even after you have withdrawn your Authorization. If you withdraw this Authorization, you can no longer actively participate in the Research Study. Your withdrawal must be made in writing and addressed to:

Bari Hoffman Ruddy  
*Department of Communication Sciences & Disorders*  
*University of Central Florida*  
*P.O. Box 162215*  
*Orlando, FL 32816-2215*

**E. Is My Permission Voluntary?**

You are not required to sign this form, and you may refuse to do so. The health care providers listed herein (or other health care providers) may not refuse to provide you treatment or other health care services if you refuse to sign this form. However, if you refuse to sign this form, you cannot participate in the Research Study, because the researchers will not be able to access and utilize the information they need to conduct their research.

**F. Could My Protected Health Information Be Disclosed Outside the Research Study?**

There are no recipients of your Protected Health Information for this study.

**G. Will I Be Allowed to See My Research Records?**

During the course of the Research Study, you will have the right to inspect or copy your Protected Health Information obtained or created by the Designated Users for use in the Research Study.

**H. Certification and Signatures**

You should take as much time as you need to decide whether you wish to permit the use and disclosure of your Protected Health Information for the Research Study. Please feel free to ask questions about any aspects of this Authorization that are unclear to you.

**Subject Certification: I have read this Authorization, which describes how my Protected Health Information will be used and/or disclosed for the Research Study. I have had the opportunity to ask, and I have received answers to, any questions I had regarding the use and disclosure of my Protected Health Information for the Research Study. I agree to the use and/or disclosure of my Protected Health Information, as described above, for the Research Study.**

Your signature below indicates your permission to take part in this research and to the use and disclosure of your protected health information.

**DO NOT SIGN THIS FORM AFTER THE IRB EXPIRATION DATE BELOW**

\_\_\_\_\_  
Name of participant

\_\_\_\_\_  
Signature of participant

\_\_\_\_\_  
Date

\_\_\_\_\_  
Signature of person obtaining consent

\_\_\_\_\_  
Date

\_\_\_\_\_  
Printed name of person obtaining consent





## **APPENDIX B: REFLUX SYMPTOM INDEX (RSI)**

Reflux Symptom Index (RSI).

<b>Instructions:</b> These are statements that many people have used to describe their voices and the effects of their voices on their lives. Please circle the response that indicates how frequently you have the same experience.						
Within the last MONTH, how did the following problems affect you?						
0 = No problem						
5 = Severe problem						
1	Hoarseness in your voice	1	2	3	4	5
2	Clearing your throat often	1	2	3	4	5
3	Bad taste in the mouth	1	2	3	4	5
4	Excess throat mucous	1	2	3	4	5
5	Difficulty swallowing food, liquids or pills	1	2	3	4	5
6	Coughing after eating or after lying down or constant cough	1	2	3	4	5
7	Breathing difficulties or choking episodes	1	2	3	4	5
8	Sensations of something sticking in your throat	1	2	3	4	5
9	Heartburn, chest pain, indigestion, or stomach acid coming up	1	2	3	4	5

## **APPENDIX C: REFLUX FINDING SCORE (RFS)**

Reflux Finding Score (RFS).

The maximum score is 26, but an RFS of more than 5 is considered abnormal		
Laryngeal Finding	Scale	Score
1. Pseudosulcus (infraglottic edema)	0 = Absent 2 = Present	
2. Ventricular obliteration	0 = Absent 2 = Present 4 = Complete	
3. Erythema/hyperemia	0 = None 2 = Arytenoids only 4 = Diffuse	
4. Vocal fold edema	0 = None 1 = Mild 2 = Moderate 3 = Severe 4 = Polypoid	
5. Diffuse laryngeal edema	0 = None 1 = Mild 2 = Moderate 3 = Severe 4 = Obstructing	
6. Posterior commissure hypertrophy	0 = None 1 = Mild 2 = Moderate 3 = Severe 4 = Obstructing	
7. Granuloma/granulation	0 = Absent 2 = Present	
8. Thick endolaryngeal mucus	0 = Absent 2 = Present	
	<b>Total:</b>	

Additional Comment:

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## **APPENDIX D: CORRELATIONS BETWEEN ALL VARIABLES**

Table 2. Correlations between each item in the RFS and upright pH levels

		Up_below 6.5	Up_mild	Up_moderate	Up_severe
RFS1	Correlation Coefficient	-0.357	-0.227	-0.201	-0.361
	Sig. (2-tailed)	0.255	0.478	0.530	0.249
RFS2	Correlation Coefficient	.	.	.	.
	Sig. (2-tailed)	.	.	.	.
RFS3	Correlation Coefficient	0.368	0.564	0.432	0.191
	Sig. (2-tailed)	0.239	0.056	0.161	0.552
RFS4	Correlation Coefficient	-0.335	-0.223	-0.145	-0.218
	Sig. (2-tailed)	0.287	0.485	0.654	0.497
RFS5	Correlation Coefficient	0.219	0.394	0.408	0.146
	Sig. (2-tailed)	0.495	0.205	0.188	0.651
RFS6	Correlation Coefficient	-0.324	-0.065	-0.403	-0.217
	Sig. (2-tailed)	0.304	0.841	0.194	0.499
RFS7	Correlation Coefficient	.	.	.	.
	Sig. (2-tailed)	.	.	.	.
RFS8	Correlation Coefficient	0.307	0.419	0.491	-0.031
	Sig. (2-tailed)	0.331	0.175	0.105	0.924
<b>Interpretation:</b> There is no significant correlations between each item in RFS and their PH levels.					

Table 3. Correlations between each item in the RFS and supine pH levels

		Sup_below 6.5	Sup_mild	Sup_moderate	Sup_severe
RFS1	Correlation Coefficient	-0.260	-0.065	-0.361	-0.415
	Sig. (2-tailed)	0.415	0.840	0.249	0.180
RFS2	Correlation Coefficient	.	.	.	.
	Sig. (2-tailed)	.	.	.	.
RFS3	Correlation Coefficient	0.098	0.370	0.082	-0.105

	Sig. (2-tailed)	0.762	0.237	0.800	0.746
RFS4	Correlation Coefficient	-0.279	-0.197	0.031	-0.208
	Sig. (2-tailed)	0.379	0.540	0.924	0.516
RFS5	Correlation Coefficient	0.219	0.220	0.536	0.233
	Sig. (2-tailed)	0.495	0.492	0.073	0.466
RFS6	Correlation Coefficient	-0.584	0.000	-0.144	-0.622
	Sig. (2-tailed)	0.046	1.000	0.654	0.031
RFS7	Correlation Coefficient	.	.	.	.
	Sig. (2-tailed)	.	.	.	.
RFS8	Correlation Coefficient	0.363	0.590	0.342	0.298
	Sig. (2-tailed)	0.246	0.044	0.277	0.348

Table 4. Correlations between each item in the RSI and upright pH levels

		Up_below	Up_mild	Up_moderate	Up_severe
RSI1	Correlation Coefficient	0.088	0.176	0.227	-0.065
	Sig. (2-tailed)	0.786	0.585	0.477	0.841
RSI2	Correlation Coefficient	0.493	0.715	0.568	0.06
	Sig. (2-tailed)	0.103	0.009	0.054	0.853
RSI3	Correlation Coefficient	0.496	0.489	0.617	0.169
	Sig. (2-tailed)	0.101	0.107	0.033	0.6
RSI4	Correlation Coefficient	0.309	0.521	0.308	0.139
	Sig. (2-tailed)	0.328	0.083	0.33	0.666
RSI5	Correlation Coefficient	0.242	0.617	0.399	-0.135
	Sig. (2-tailed)	0.448	0.033	0.199	0.676
RSI6	Correlation Coefficient	0.035	0.106	0.126	-0.1
	Sig. (2-tailed)	0.913	0.743	0.697	0.756

RSI7	Correlation Coefficient	-0.033	0.014	0.19	-0.208
	Sig. (2-tailed)	0.919	0.966	0.555	0.516
RSI8	Correlation Coefficient	-0.235	-0.197	-0.082	-0.313
	Sig. (2-tailed)	0.463	0.539	0.801	0.321
RSI9	Correlation Coefficient	0.241	0.27	0.211	0.04
	Sig. (2-tailed)	0.45	0.397	0.511	0.902

Table 5. Correlations between each item in the RSI and supine pH levels

		Sup_below 6.0	Sup_mild	Sup_moderate	Sup_severe
RSI1	Correlation Coefficient	0.183	0.235	0.611	0.331
	Sig. (2-tailed)	0.569	0.461	0.035	0.293
RSI2	Correlation Coefficient	0.315	0.512	0.343	0.25
	Sig. (2-tailed)	0.318	0.089	0.275	0.433
RSI3	Correlation Coefficient	0.468	0.249	0.379	0.56
	Sig. (2-tailed)	0.125	0.434	0.224	0.058
RSI4	Correlation Coefficient	0.018	0.311	-0.113	-0.254
	Sig. (2-tailed)	0.957	0.325	0.726	0.425
RSI5	Correlation Coefficient	0.248	0.547	0.458	0.102
	Sig. (2-tailed)	0.437	0.066	0.134	0.753
RSI6	Correlation Coefficient	-0.09	0.095	0.197	0.031
	Sig. (2-tailed)	0.78	0.77	0.54	0.923
RSI7	Correlation Coefficient	0.265	0.055	0.174	0.245
	Sig. (2-tailed)	0.405	0.866	0.59	0.443
RSI8	Correlation Coefficient	-0.041	0.215	0.109	0.01
	Sig. (2-tailed)	0.899	0.502	0.737	0.975
RSI9	Correlation	0.036	-0.219	-0.099	0.118



	Coefficient				
	Sig. (2-tailed)	0.912	0.494	0.759	0.715

Table 6. Correlations between the RFS and the RSI

		RSI1	RSI2	RSI3	RSI4	RSI5	RSI6	RSI7	RSI8	RSI9
RFS1	Correlation Coefficient	0.068	0	-0.034	0.109	0.102	0.109	0.577	0.590	-0.264
	Sig. (2-tailed)	0.834	1	0.916	0.737	0.753	0.736	0.05	0.043	0.407
RFS2	Correlation Coefficient	.	.	.	.	.	.	.	.	.
	Sig. (2-tailed)	.	.	.	.	.	.	.	.	.
RFS3	Correlation Coefficient	0.23	0.626	0.233	0.958	0.642	0.713	-0.054	0.131	0.225
	Sig. (2-tailed)	0.472	0.029	0.466	0.000	0.024	0.009	0.866	0.684	0.483
RFS4	Correlation Coefficient	0.379	-0.114	-0.206	0.187	0.088	0.312	0.124	0.209	0.199
	Sig. (2-tailed)	0.225	0.724	0.52	0.561	0.786	0.323	0.701	0.514	0.535
RFS5	Correlation Coefficient	0.502	0.089	0.231	0.146	0.458	0.196	0.243	-0.281	0.045
	Sig. (2-tailed)	0.096	0.782	0.47	0.65	0.134	0.542	0.447	0.377	0.891
RFS6	Correlation Coefficient	-0.068	-0.133	-0.342	0.362	0.068	0.363	-0.36	0.139	-0.396
	Sig. (2-tailed)	0.834	0.681	0.276	0.248	0.834	0.247	0.25	0.667	0.202
RFS7	Correlation Coefficient	.	.	.	.	.	.	.	.	.
	Sig. (2-tailed)	.	.	.	.	.	.	.	.	.
RFS8	Correlation Coefficient	0.204	0.770	0.619	0.249	0.439	0.343	0.31	0.508	0.085
	Sig. (2-tailed)	0.525	0.003	0.032	0.435	0.154	0.274	0.327	0.092	0.792

## LIST OF REFERENCES

- Ayazi, S., Lipham, J. C., Hagen, J. A., Tang, A. L., Zehetner, J., Leers, J. M., Oezcelik, A., Abate, E., Banki, F., DeMeester, S. R., & DeMeester, T. R. (2009). A new technique for measurement of pharyngeal pH: Normal values and discriminating pH threshold. *Journal of Gastrointestinal Surgery*, *13*, 1422–1429
- Behlau, M., Oliveira, G., & Pontes, P. (2009). Vocal fold self-disruption after phonotrauma on a lead actor: a case presentation. *Journal Of Voice: Official Journal Of The Voice Foundation*, *23*(6), 726-732.
- Belafsky, P. C., Postma, G. N., & Koufman, J. A. (2001). The validity and reliability of the reflux finding score (RFS). *The Laryngoscope*, *111*(8), 1313-1317.
- Belafsky, P. C., Postma, G. N., & Koufman, J. A. (2002). Validity and Reliability of the reflux symptom index (RSI). *Journal of Voice*, *16*(2), 274-277.
- Belafsky, P. C., Postma, G. N., & Koufman, J. A. (2001). Laryngopharyngeal reflux symptoms improve before changes in physical findings. *Laryngoscope*, *111*, 979-981.
- Branski, R. C., Bhattacharyya, N., Shapiro, J. (2002). The reliability of the assessment of endoscopic laryngeal findings associated with laryngopharyngeal reflux disease. *Laryngoscope*, *112*(6), 1019-1024.
- Cammarota, G., Masala, G., Cianci, R., Palli, D., Capaccio, P., Schindler, A., Cuoco, L., Galli, J., Ierardi, E., Cannizzaro, O., Caselli, M., Dore, M., Bendinelli, B., & Gasbarrini, G. (2007). Reflux symptoms in professional opera choristers. *Gastroenterology*, *132*(3), 890.
- Casiano, R. R., Zaveri, V., & Lundy, D. S. (1992). Efficacy of videostroboscopy in the diagnosis of voice disorders. *Otolaryngology, Head, and Neck Surgery*, *107*, 95-100.
- Castell, D. O. (1999). *The Esophagus*. (3<sup>rd</sup> ed.). Philadelphia, PA: Lippincott.
- Chheda, N. N., Seybt, M. W., Schade, R. R., & Postma, G. N. (2009). Normal values for pharyngeal pH monitoring. *Annals of Otolaryngology, Rhinology, and Laryngology*, *118*(3), 166-171.
- Chung, J. H., Tae, K., Lee, Y. S., Jeong, J. H., Cho, S. H., Kim, K. R., Park, C. W., & Han, D. S. (2009). The significance of laryngopharyngeal reflux in benign vocal mucosal lesions. *Otolaryngology, Head, and Neck Surgery*, *141*, 369-373.

- de Groen, P. C., Lubbe, D. E. Hirsch, L. J., et al. (1996). Esophagitis associated with the use of alendronate. *N Engl J Med*, 335(14), 1016-1021.
- Dent, J., Dodds, W. J., Friedman, R. H., et al. (1980). Mechanism of gastroesophageal reflux in recumbent asymptomatic human subjects. *The Journal of Clinical Investigation*, 65, 256-267.
- Gaegea, T. (1991). Laproscopic Nissen's fundoplication preliminary report on ten cases. *Surgical Endoscopy*, 5(4), 170-173.
- Golub, J. S., Johns, M. M., Lim, J. H., DelGaudio, J. M. & Klein, A. M. (2009). Comparison of an oropharyngeal pH probe and a standard dual pH probe for diagnosis of laryngopharyngeal reflux. *Annals of Otolaryngology, Rhinology, & Laryngology*, 118(1), 1-5.
- Harding, S. M., Guzzo, M. R., & Richter, J. E. (1997). Prevalence of GERD in asthmatics without reflux symptoms. *Gastroenterology*, 4, A141.
- Harrell, S., Evans, B., Goudy, S., et al. (2005). Design and implementation of an ambulatory pH monitoring protocol in patients with suspected laryngopharyngeal reflux. *Laryngoscope*, 115(11), 89-92.
- Hicks, D. M., Ours, T. M., Abelson, T. I., Vaezi, M. F., & Richter, J. E. (2002). The prevalence of hypopharynx findings associated with gastroesophageal reflux in normal volunteers. *Journal of Voice*, 16, 564-579.
- Hill, R. K., Simpson, C. B., Velazquez, R., Larson, N. (2004). Pachydermia is not diagnostic of active laryngopharyngeal reflux disease. *Laryngoscope*, 114(9), 1557-1561.
- Hixon, T. J. (2006). *Respiratory function in singing: A primer for singers and singing teachers*. Tucson, AZ, Redington Brown.
- Johnston, N., Dettmar, P.W., Lively, M. O., et al. (2006). Effect of pepsin on laryngeal stress protein (Sep70, Sep53, and Hsp70) response: Role in laryngopharyngeal reflux disease. *Annals of Otolaryngology, Rhinology, and Laryngology*, 115, 47-58.
- Johnston, N., Knight, J. Dettmar, P. W., et al. (2004). Pepsin and carbonic anhydrase isoenzyme II as diagnostic markers for laryngopharyngeal reflux disease. *Laryngoscope*, 114, 2129-2134.
- Kamel, P. L. Hanon, D., & Kahrilas, P. J. (1994). Omeprazole for the treatment of posterior laryngitis. *American Journal of Medicine*, 96, 321-326.
- Katz, P. O. (1990). Ambulatory esophageal and hypolaryngeal pH monitoring in patients with hoarseness. *American Journal of Gastroenterology*, 85, 38-40.

- Kawamura, O., Aslam, M., Rittmann, T., Hofmann, C., & Shaker, R. (2004). Physical and pH properties of gastroesophagopharyngeal refluxate: A 24 hour simultaneous ambulatory impedance and pH monitoring study. *American Journal of Gastroenterology*, 99, 1000-1010.
- Kelchner, L.N, Horne, J., Lee, L., Klaben, B., Stemple, J.C., Adam, S., Kereiakas, T., Levin, L. (2007). Reliability of speech-language pathologist and otolaryngologist rating of laryngeal signs of reflux in an asymptomatic population using the reflux finding score. *Journal of Voice*, 21(1), 92-100.
- Kikendall, J. W., Friedman, A. C., Oyewole, M. A., et al. (1983). Pill-induced esophageal injury: Case reports and review of the medical literature. *Dig Dis Sci*, 28, 174-182.
- Korsten, M.A., Rosman, A.S., Fishbein, S., Shlein, R.D., Goldberg, H.E., & Biener, A. (1991). Chronic xerostomia increases esophageal acid exposure and is associated with esophageal injury. *American Journal of Medicine*, 90, 701-706.
- Koufman, J. A. (1991). The otolaryngologic manifestations of gastroesophageal reflux disease (GERD): A clinical investigation of 225 patients using ambulatory 24-hour pH monitoring and an experimental investigation of the role of acid and pepsin in the development of laryngeal injury. *The Laryngoscope*, 101(4), 1-78.
- Lenderking, W.R., Hillson, E., Crawley, J.A., Moore, D., Berzon, R., Pashos, C.L. (2003). The clinical characteristics and impact of laryngopharyngeal reflux disease on health-related quality of life. *Value in Health*, 6(5), 560-565.
- Lloyd, A.T., Lehman, J., Spector, B., McCrea, C., Carson, C., & Ruddy, B.H. (2009, November). *Description of Laryngopharyngeal Reflux (LPR): Symptoms and Endoscopic Findings in College Level Vocalists*. Poster session presented at the annual conference of the American Speech-Language and Hearing Association, New Orleans, LA.
- Lloyd, A.T., Lehman, J., Spector, B, Meemon, N., Lewis, V., & Ruddy, B. H. (2010, November). *Quantifying Singer's Perceptions of Reflux Symptoms*. Poster session presented at the annual conference of the American Speech-Language and Hearing Association, Philadelphia, PA.
- Lundy, D. S., Casiano, R. R., Sullivan, P. A., Roy, S., Xue, J. W. & Evans, J. (1999). Incidence of abnormal laryngeal findings in asymptomatic singing students. *Otolaryngology – Head and Neck Surgery*, 121(1), 69-77.
- Marambaia, O., Andrade, N. A., Varela, D. G., et al. (2002). Laryngopharyngeal reflux: Prospective study that compares early laryngoscopic findings and 2-channel 24-hour pH monitoring. *Revista Brasileira de Otorrinolaringologia*, 68(4), 527-531.

- Maronian, N., Haggitt, R., Oelschlager, B. K., et al. (2003). Histologic features of reflux-attributed laryngeal lesions. *American Journal of Medicine*, 115(supplement 3A), 105S-108S.
- Merati, A., Lim, H., Ulualp, S., & Toohill, R. (2005). Meta-analysis of upper probe measurements in normal subjects and patients with laryngopharyngeal reflux. *Annals of Otolaryngology, Rhinology, and Laryngology*, 114, 177-182.
- Mesallam, T. A., Stemple, J.C., Sobeih, T.M., Elluru, R.G. (2007). Reflux symptom index versus reflux finding score. *Annals of Otolaryngology, Rhinology, & Laryngology*, 116(6), 436-440.
- Noordzij, J. P., Khidr, A., Desper, E. et al. (2002). Correlation of pH probe measured laryngopharyngeal reflux with symptoms and signs of reflux laryngitis. *Laryngoscope*, 112(12), 2192-2195.
- O'Connor, J. F. B., Singer, M. E., & Richter, J. E. (1999). The cost-effectiveness of strategies to assess gastroesophageal reflux as an exacerbating factor in asthma. *American Journal of Gastroenterology*, 94(6), 1472-1480.
- Pregun, I., Bakucz, T., Banai, J., Molnár, L., Pavlik, G., Altorjay, I., Orosz, P., Csernay, L., Tulassay, Z., & Herszényi, L. (2009). Gastroesophageal reflux disease: Work-related disease? *Digestive Diseases*, 27(1), 38-44.
- Roth, D., & Ferguson, B. (2010). Vocal allergy: recent advances in understanding the role of allergy in dysphonia. *Current Opinion In Otolaryngology & Head And Neck Surgery*, 18(3), 176-181.
- Rothstein, S. G. (1998). Reflux and vocal disorder in singers with bulimia. *Journal of Voice*, 12(1), 89-90.
- Sataloff, R. T., Castell, D. O., Katz, P. O., & Sataloff, D. M. (2006). *Reflux laryngitis and related disorders* (3<sup>rd</sup> ed.). San Diego, CA: Plural Publishing.
- Sapienza, C. M., Ruddy, B. H. (2008). *Voice Disorders*. Grand Rapids: Plural, Incorporated.
- Shafik, A., Shafik, A. A., El-Sibai, O., & Mostafa, R. M. (2004). Effect of straining on diaphragmatic crura with identification of the straining-crural reflex. The reflex theory in gastroesophageal competence. *BMC Gastroenterology*, 4, 24.
- Selby, J.C., Gilbert, H.R., Lerman, J.W. (2003) Perceptual and acoustic evaluation of individuals with laryngopharyngeal reflux pre- and post- treatment. *Journal of Voice*, 17(4), 557-570.
- Sapienza, C. M., Ruddy, B. H. (2008). *Voice Disorders*. Grand Rapids: Plural, Incorporated.

- Spiegel, J. R., Sataloff, R. T., Cohn, J. R., Hawkshaw, M., & Epstein, J. (1988). Respiratory function in singers: Medical assessment, diagnoses, and treatments. *Journal of Voice*, 2(1), 40-50.
- Siupsinskiene, N., Adamonis, K., & Toohill, R. J. (2007). Quality of life in laryngopharyngeal reflux patients. *Laryngoscope*, 117, 480-484.
- Sonnenberg, A., Steinkamp, U., Weise, A., Berges, W., Wienbeck, M., Rohner, H. G., & Peter, P. (1982). Salivary secretion in reflux esophagitis. *Gastroenterology*, 83, 889–895.
- Spencer, M. L. (2006). Laryngopharyngeal reflux and singers: Diabolus in gula? *Journal of Singing*, 63(2), 177-184.
- Sprenst, P. & Smeeton, N. C. (2001). *Applied nonparametric statistical methods* (3<sup>rd</sup> ed.). Boca Raton, FL: Chapman & Hall.
- Sun, G., Muddana, S., Slaughter, J., Casey, S., Hill, E., Farrokhi, F., Garrett, G., & Vaezi, M. F. (2009). A new pH catheter for laryngopharyngeal reflux: Normal values. *The Laryngoscope*, 119, 1639-1643.
- Tan, K., Raeburn, A., & Emmanuel, A. (2011). The role of poor oesophageal clearance in patients with suspected laryngopharyngeal reflux. *Gut Journal*, 60, A187.
- Timmermans, B., Vanderwegen, J., & De Bodt, M. (2005). Outcome of vocal hygiene in singers. *Current Opinion In Otolaryngology & Head And Neck Surgery*, 13(3), 138-142.
- Wiener, G. J., Tsukashima, R., Kelly, C., Wolf, E., Schmeltzer, M., Bankert, C., Fisk, L., & Vaezi, M. (2009). Oropharyngeal pH monitoring for the detection of liquid and aerosolized supraesophageal gastric reflux. *Journal of Voice*, 23(4), 498-504.
- Vaezi, M.F. (2008) Laryngeal manifestations of gastroesophageal reflux disease. *Current Gastroenterology Reports*, 10(3), 271-277.
- Vincent, D., Jr., Garrett, J., Radionoff, S., Reussner, L., & Stasney, C. (2000). The proximal probe in esophageal pH monitoring: Development of a normative database. *Journal of Voice*, 14, 247-254.
- Ylitalo, R. & Ramel, S. (2002). Gastroesophagopharyngeal reflux in patients with contact granuloma: A prospective controlled study. *Annals of Otolaryngology, Rhinology, & Laryngology*, 111, 441-446.

Ylitalo, R., Lindestad, P., & Ramel, S. (2001). Symptoms, laryngeal findings, and 24-hour pH monitoring in patients with suspected gastroesophago-pharyngeal reflux. *Laryngoscope*, *111*, 1735-1741.

Zerbib, F. & Stoll, D. (2009). Management of laryngopharyngeal reflux: An unmet medical need. *Neurogastroenterology*, *22*, 109-112.