COMPARISON OF HABITUAL AND HIGH-PITCHED PHONATION TASKS BETWEEN TEACHERS WITH AND WITHOUT VOCAL FATIGUE

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CERTIFICATE

This is to certify that this dissertation entitled **"Comparison of habitual and high-pitched phonation tasks between teachers with and without vocal fatigue"** is a bonafide work submitted in part fulfillment for degree of Master of Science (Speech Language Pathology) of the student Registration Number: 17SLP037. This has been carried out under the guidance of the faculty of this institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree

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CERTIFICATE

This is to certify that this dissertation entitled **"Comparison of habitual and high-pitched phonation tasks between teachers with and without vocal fatigue"** has been prepared under my supervision and guidance. It is also being certified that this dissertation has not been submitted earlier to any other University for the award of any other Diploma or Degree

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Declaration

This is to certify that this dissertation entitled **"Comparison of habitual and high-pitched phonation tasks between teachers with and without vocal fatigue"** is the result of my own study under the guidance Dr. Santosh. M, Associate Professor, Department of Speech-Language Sciences, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier to any other University for the award of any other Diploma or Degree

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CHAPTER 1

INTRODUCTION

A human voice is produced mainly due to an aerodynamic phenomenon which results in the vibration of the vocal cords. These vocal cords carry a certain length, mass and tension differing in males, females, and children. Studies have reported fundamental frequency ie. the frequency with which the vocal folds vibrate in a second, of men and women to be 129 Hz and 238 Hz respectively (Rappaport, 1958). This difference between the genders can be attributed to the anatomical and physiological difference of the laryngeal system. However, if a discrepancy is seen in frequency or other acoustic parameters, it can indicate an underlying pathology, which can be implied to cause a voice disorder. These underlying pathologies can be evaluated based on subjective/perceptual and objective measurements. One of the most widely used and reliable objective measurement is the acoustic analysis. The main advantage of acoustic analysis is increased precision in diagnosing and hence providing appropriate intervention, better quantification of assessment, and treatment efficacy and aid in visual feedback (Nemr, et al., 2005).

Research studies show the prevalence of voice disorders to be higher in professional voice users when compared to non-professional voice users. Professional voice users are those individuals whose careers demand the use of voice extensively. Koufman and Blalock (1988) classified professional voice users at 4 levels: elite vocal performer (Level 1)- when a change or deviancy in voice will affect the professional careers of these individuals drastically (Examples: singers, actors, theatre artists etc); professional voice user (Level 2)- when a moderate variation in voice would bring about major breakdown in fulfillment of job demands (Examples: teachers, clergy, priests etc); non vocal professional (Level 3)- when a severe voice problem would

hamper the effectiveness with which the individual works in his employment setting (Examples: lawyers, physicians etc); non vocal non professional (Level 4)-those individuals for whom voice is not a fundamental aspect of their work setting (Examples: laborers, clerks etc).

Although elite vocal performers such as singers are trained on usage of vocally healthy behaviors, other professional voice users such as teachers, businessmen etc lack the basic awareness regarding vocal health and hygiene. This could be the fact due to which higher prevalence of voice problems is seen in these groups. In a study, results depicted 21.05% teachers had vocal nodule as a voice diagnosis and 25.79% teachers had laryngopharyngeal reflux (Aryal, Bhandary, Chhetri, Paudel, Tamrakar & Devkota, 2017)

It is very important to understand the risk factors that lead to develop such voice disorders, as it will help in prevention and early identification. A study done by Russell, Oates and Greenwood (1998) reported an increase in voice problems past the age of 50 years. This indicates age also can be considered as a risk factor. In another study, results reported risk of developing voice disorder for teachers with >20 years teaching experience to be 1.8 times more than those who had 0-10 years of teaching experience (Aryal, Bhandary, Chhetri, Paudel, Tamrakar & Devkota, 2017). This was also a supportive finding of Smith, Gray, Dove, Kirchner and Heras (1997), who reported voice disorders generally emerge after 10-20 years of work. Further the authors reasoned this finding to the prolonged use of maladaptive vocal behaviors, increased vocal load for a extended time over the years which could lead to a reduced mucosal wave of the vocal folds and presence of glottic chink (Sliwinska-Kowalska et al., 2006). Further Ohlsson, Andersson, Södersten, Simberg and Barregård (2012) reported a significant effect of gender and smoking on voice. Gender effect could have been present due to the variability seen in terms with impact of vocal loading on the laryngeal system in both these genders. However

voice problems in smokers can be attributed to the harmful effects of smoking on the system. Studies have also found evidences of certain phonotraumatic behaviors which can lead to voice disorders like loud shouting/screaming and extended use of high voice (Ramig & Verdolini, 1998).

Concurrently the main vocal symptoms reported in a study by teachers who are at risk to develop voice disorder is increase in vocal effort (81.5%), vocal fatigue at the end of a working day (60%) and hoarseness (55%) (Alvear, Barón & Martínez-Arquero, 2011). Furthermore sudden voice breaks, increased throat clearing, pain or feeling lump in the throat are some of the symptoms reported by Ohlsson, Andersson, Södersten, Simberg and Barregård (2012).

Need for the study:

Considering all these factors, hence prevention and early identification of voice disorders is a crucial aspect while taking professional voice users in general, and teachers to be more specific. For early identification, there is a need for sensitive and reliable tools or tasks to detect early signs of voice disorders. Recent research on professional voice users has showed promising results while considering vocal loading tasks as a predictor of fatigue and susceptibility to develop voice disorders. Several vocal loading tasks have been studied upon, although a recent study tried to determine if high pitched phonation can be used as a vocal loading task (Aithal, Bellur, John, Varghese & Guddattu, 2012). The study considered normal healthy individuals and compared acoustic parameters between normal phonation and high pitched phonation tasks. Results revealed a significant difference in these parameters for high pitched phonation task. This conclusion predicts the possible use of high pitched phonation as a vocal loading task. Since the authors considered vocally normal individuals and based on the future directions mentioned by them, it is only valid to determine the efficiency of high pitched phonation task in

professional voice users to predict the clinical application as a time efficient and reliable tool for detecting subtle changes in voice.

Aim of the study:

To compare habitual phonation (Hab P) and high-pitched phonation (HPP) tasks between teachers with and without vocal fatigue using acoustic measures.

CHAPTER 2

REVIEW OF LITERATURE

A voice disorder (VD) occurs when voice quality, pitch, and loudness differ or are inappropriate for an individual's age, gender, cultural background, or geographic location (Aronson & Bless, 2009). In professional voice users, these disorders can be attributed generally to the vocal loading tasks which result in phonotraumatic behaviors. Such phonotraumatic behaviors can be credited to the lack of awareness of vocal health issues. A study was done by Cielo, Ribeiro and Hoffmann (2015), where 47 subjects who were pursuing their high education geared towards a job that required the use of voice professionally were considered and a scale called Escala de Sintomas Vocais (Moreti, Zambon, Oliveira, & Behlau, 2014), which is a adaptation of the Voice Symptom Scale (Deary, Wilson, Carding, & Mackenzie, 2003) in Portuguese was used. The results of this study revealed, although the participants were studying to build a career in a profession with vocal demands, they had a high average vocal symptom, especially throat clearing, coughing, and problems in speaking in loud places. Hence, it is crucial to prepare professionals towards primary and vocal health care and to broaden their use of voice.

There are several studies that indicate a higher prevalence rate of voice disorders. For instance, Roy et al. (2004) reported a 58% career prevalence in teacher and 29% in the non-teacher group. Similarly, Ferriera, Latorre, Giannini, Ghiradi, Karmann and Silva et al., (2010) investigated 422 subjects that included elementary and secondary level teachers and found a prevalence of 60% for voice symptom. Charn and Mok (2011) reported a career prevalence rate of 32% for voice disorder in teachers. A National Survey done in 2015 to report the voice disorders in New Zealand Teachers found a prevalence of 33.2% of self-reported vocal problems

(Leão, Oates, Purdy, Scott & Morton2015).A prevalence rate of 17% was reported in primary school teachers in India (Devadas, Bellur, & Maruthy, 2017). Boominathan, Rajendran, Nagarajan, Seethapathy, & Gnanasekar (2008) reported 49% teachers had voice disorder. Among 448 primary and secondary school teachers, 9% of them reported to have voice problems, which was reflected using a self-reported questionnaire developed by Sebastien, Suresh, Simon and Ballraj(2012).

With a high prevalence rate of voice disorders in teachers, the general symptoms that they report are vocal effort, tiredness, neck and throat pain, laryngeal discomfort, reduced pitch range, voice loss, increase in symptoms across the speaking day and typically improvement of symptoms with rest (Verdolini, Rosen & Branski, 2006). These symptoms can be assessed using self-report questionnaires which help in detecting vocal loading.

Several research studies have been done as to check the prospects or conditions under which the possibility of developing a vocal pathology in the group of professional voice users is high. Behlau, Zambon, Guerieri, and Roy (2012) in their study recruited 3265 teachers and non teachers with a mean age of 40.1 years. Both the groups were categorized into 5 age groups (<29 years, 30-39 years, 40-49 years, 50-59 years and 60+years). The results revealed teachers of the age 30-39 years and above started showed increasing vocal disorders. The high prevalence rate in older age group of teachers were also inferred to the biological ageing like alteration of specific tissues of vocal folds, epithelial thickening, the breakdown of elastic fibers of the vocal ligaments which result in bowing, degeneration of mucous gland causing reduced lubrication of the vocal fold (Hirano, Kurita &Sakaguchi, 1989). In addition, changes may be seen in the biomechanical properties of the superficial epithelium and reduction in mobility of the thoracic cage which could affect the voice quality due to lack of breath support (Mathieson, 2001).

Sustained vocal phonotraumatic behaviors and other health problems can also be attributed to the increasing professional voice users developing voice disorders. Although years of teaching experience and age could be a co-dependent contributing factor as reported by Devadas, Bellur, and Maruthy (2017) in their study where they found a positive correlation between years of experience and reports of voice problems. Teachers who use voice for prolonged duration while teaching have a mounting effect on voice as reported by Roy et al., (2004). Moreover, long duration of loud speaking may increase glottal closure which impacts stress on the vocal folds, which could lead to vocal nodules or other functional voice problems.

Gender is another risk factor (Pizolato et al., 2013). It was reported that male teachers were less likely to have a variation in F0 of voice than female teachers. This could be directed to the distinct vocal apparatus that females have than males. Some authors used the vocal fatigue index to quantify vocal fatigue in both males and females and further reported an upraised level of self-reported vocal fatigue symptoms in females (Hunter & Banks, 2017). Further, Davis (2004) reported menopause causes the vocal fold tissue to dry out, which leads to throat clearing and hoarse quality of voice.

Teachers who teach in high background noise also have been reported to have increasing voice problems since the need to raise loudness is necessary and hence vocal loading is more (Sodersten, Ternstrom, & Bohman, 2005; Vilkman, 2004). A study done by Devadas, Bellur, and Maruthy (2017) reflected the same by reporting a 4.4 times higher chance of teachers experiencing voice problem while teaching in high background noise. Health related issues like upper respiratory tract infections which include pharyngitis, sinusitis, laryngitis etc. are also have been found to be a sensitive trigger to evolve voice problems. Teachers who experience GERD have also been found to be at 4.8 times more prone to voice problems than those who do not

(Devadas, Bellur, & Maruthy, 2017). All these risk factors pose a greater effect on the quality of life of such a group of professional voice users due to their voice problems. Literature implied 38% of teachers report some kind of functional impairment for less than 7 days following voice problems and 27% account for leave taken for <7 days due to voice problems in their career span(Devadas, Bellur & Maruthy, 2017).

Literature suggested vocal fatigue is one of the main symptoms reported by professional voice users (Solomon, 2008). Vocal fatigue which is a multifactorial phenomenon of symptoms including increase in vocal effort, reduced pitch, decreased loudness, and reduced vocal quality with symptoms exacerbating as the day progresses preceding vocal rest (Solomon, 2008). Dhaeseleer, et al. (2016) conducted a pilot study on the factors affecting vocal fatigue by reviewing 1,150 patient files and found that 65% reported variables of vocal misuse & 57% reported stress. Furthermore besides vocal fatigue, 71% reported increased laryngeal tension and 74% had some form of vocal pathology. The study also highlighted lowered scores on Dysphonia Severity Index (DSI) for those patients who reported vocal fatigue.

With an overview of the prevalence rates, risk factors & symptoms, teachers can be given the 'at risk' status since they are vulnerable to laryngeal pathology. More so in developing countries like India where this study was based there is a lack of awareness about vocal hygiene, preventive care for voice, services available for assessment and management of voice disorders & follow ups. Hence this study dealt with taking a step forward in the prevention and early identification for this group of voice users, which is need of the hour. Although these steps can be effectively taken only with the help of sensitive tasks which can detect the subtle changes seen in voice of professional voice users following phonotraumatic behaviors.

Phonotraumatic behaviors which are preceded by long duration of speaking, loud phonation, using different F0 than when in normal conversation can cause vocal load and pose a risk factor to develop voice disorder (Buekers, 1998;Sodersten, Granqvist, Hammarberg & Szabo, 2002). Vocal loading was also seen to be more in females due to the hyperfunctional nature of voice and due to higher vibratory rates compared to men (Titze, Svec & Popolo, 2003). Vocal loading Tasks (VLT) have been used by many authors as stressors to the laryngeal system in detecting slight changes in voice. Authors described vocal loading tasks as those which undermine optimal laryngeal function. Vocal Loading tasks can be manipulated based on intensity, frequency and voice quality measures to give the desirable effect on the laryngeal mechanism. A study done by Boominathan, Rajendran, Mahalingam, and Gnanvel (2010) on 20 Indian adult males who were given a vocal loading task of reading a book at 75-80 dB SPL for an hour or until they reported fatigue revealed significantly lowered Maximum Phonation time in participants upto 6 seconds, significantly increased S/Z ratio and overall change in voice (Grade) using GRBAS based on perceptual evaluation. Acoustic Analysis was done using MDVP revealed increase in phonatory fundamental frequency range, short and long term frequency and amplitude measurements, noise and voice irregularity related measures after vocal loading and significant decrease in lowest fundamental frequency. Several authors have studied the outcome of vocal loading tasks using self-reported measures and aerodynamic measures. (Fujiki & Sivasankar, 2017)

A recent study revealed that high pitch phonation (HPP) as a vocal loading task is sensitive than normal phonation(NP) to identify vocal fatigue leading to a voice pathology (Aithal, Bellur, John, Varghese & Guddattu, 2012). They considered 48 normal healthy individuals and measured 8 acoustic parameters of voice to compare normal phonation (NP) and

high pitch phonation (HPP). The authors concluded to report a significance difference between the two tasks in terms of fundamental frequency (F0) and average fundamental frequency. It was also noted that there was a significance difference in the frequency range between 2 tasks which were attributed to the dynamics of the laryngeal system to control F0 in such vocal loading tasks. Significant differences were seen in Relative Jitter (Jitt), Relative Average perturbation (RAP), Pitch Perturbation Quotient in females. As the authors have suggested for future directions, research using similar vocal loading task to identify voice disorders in professional voice users who report vocal fatigue is warranted.

CHAPTER 3

METHOD

Participants

A total of 60 female teachers were included as participants in this study. These participants were in the age range of 25-45 years from 3 different English medium schools in Mysuru. Before they were recruited, they were asked to fill a self-reported questionnaire containing questions drawing information regarding vocal symptoms experienced by teachers, history of voice disorders or any consultation with ENT physicians or speech language pathologist for their voice pathologies, nature and demands of the job (hours of teaching in a day, duration of each class etc) and their knowledge about voice care (Devadas, Bellur & Maruthy, 2017). Any individual who had history of hearing loss, voice pathologies, upper respiratory tract infection, habit of smoking, alcohol intake, or tobacco consumption based on this self reported questionnaire were excluded from the study.

Further, Vocal Fatigue Index (Nanjundeswaran, Jacobson, Gartner-Schmidt, & Abbott, 2015) which is a self-reported questionnaire was filled by the teachers and used as a inclusionary criteria to classify the teachers as teachers with and without vocal fatigue. This questionnaire consists of 19 questions, marked on a 5-point Likert scale. As per norms(Nanjundeswaran, Jacobson, Gartner-Schmidt & Abbott, 2015), 30 teachers whose scores on factor 1 of the Vocal fatigue Index questionnaire were ≥24, or scores on factor 2 of the same questionnaire were ≥7 were grouped as teacher with voice fatigue. And 30 teachers whose scores of vocal fatigue were below the norms were grouped as teacher without vocal fatigue. Based on statistical analysis a significant ($p \leq 0.05$) increase was found in factor 1 [$t(58)=9.770$, $p<0.05$] and factor 2

[t(58)=14.733, p<0.05] in vocal fatigue group compared to without vocal fatigue. Hence the inclusionary criterion was met by the groups.

In the Vocal Fatigue (VF) group, majority of the participants reported a teaching experience of <5 years, except few who reported 5-10 years of teaching experience. On an average, number of classes taken per day by the participants was 5-10. The duration of each class was reported to be varying from 45 minutes to 1 hour. Other than few participants who reported the average student strength per class to be 50-70, most of them reported to have <50 students per class. The medium of instruction followed was English by most participants except few subject teachers like Kannada. Considering background noise, most participants reported constant noise from students at a medium level (50-90 dB).The vocal loudness reported by most participants was low and medium level except one who reported high level. Moreover most of them reported to have stress while teaching. Among the 30 participants, 4 of them were trained in singing for <5 years.

In the Without Vocal Fatigue (WVF) group, a teaching experience of <5 years was reported by most participants. No. of classes per day taken by most participants was <5 and duration of each class varied from 45 minutes and 1 hours. The average strength of students in class varied from <50 to 70 as reported. Most participants followed English as their medium of instruction except 2 participants who followed Kannada as a medium. Most participants reported constant background noise from students of medium to high level. Vocal loudness required while teaching was reported to be low by majority of the participants. Furthermore, most participants reported no stress while teaching. Among the participants, 5 participants were trained in singing for <5 years.

Table 1

VFI Scores of the participants in the VF & WVF group (VF-Vocal Fatigue, WVF-Without Vocal Fatigue)

VF group			**WVF group**		
Subject No.	**Factor 1**	**Factor 2**	**Subject No.**	**Factor 1**	**Factor 2**
1	18	8	1	10	4
2	15	9	2	13	3
3	23	8	3	12	5
4	19	9	4	11	6
5	24	10	5	13	2
6	21	8	6	12	3
7	29	9	7	8	4
8	18	9	8	10	2
9	18	8	9	10	5
10	17	7	10	8	2
11	19	10	11	10	4
12	23	12	12	15	4
13	26	10	13	14	2
14	26	9	14	16	5
15	19	8	15	12	4
16	20	8	16	17	2
17	23	7	17	16	3
18	27	9	18	19	5
19	19	7	19	11	2
20	18	7	20	10	3

21	18	7	21	14	4
22	18	9	22	16	3
23	21	10	23	14	4
24	24	13	24	13	4
25	24	10	25	17	6
26	21	8	26	14	2
27	20	7	27	17	4
28	19	8	28	12	2
29	18	8	29	12	4
30	18	9	30	10	1
	Mean=20.766	Mean=8.700		Mean=12.866	Mean=3.466
	SD=3.39	SD=1.441		SD=2.849	SD=1.306

Procedure

An informed consent was taken from all the teachers, briefing them about the nature and aim of the study. In this study, a sennheiser ME 66 shotgun directional microphone coupled with Olympus digital voice recorder WS-100 set at a sampling frequency of 44 KHz was used as transducers for sample recording and storage. The audio recordings were taken in a quiet empty classroom. The participants were asked to phonate /a/ thrice for 5-6 seconds at their habitual pitch and thrice at their comfortable yet high pitched voice as demonstrated by the experimenter. A change of atleast 25 Hz and above habitual phonation was considered as High Pitch Phonation (Aithal, Bellur, John, Varghese & Guddattu, 2012).

Acoustic Analysis

For analysis, a steady state portion of 3-4 seconds of each sample was taken for acoustic analysis. These samples were run on PRAAT & Multidimensional Voice Program (MDVP) software to obtain 10 acoustic parameters:

1. Mean Fundamental frequency (Hz),

2. Minimum F0 (Hz)

3. Maximum F0 (Hz)

4. Percent Jitter (Jitt)

5. Relative average perturbation (RAP),

6. Pitch perturbation quotient (PPQ),

7. Smoothened Pitch Perturbation Quotient (SPPQ),

8. Noise to Harmonic Ratio (NHR)

9. Cepstral Peak Prominence (CPP)

10. Smoothened Cepstral Peak Prominence (SCPP)

One of the key acoustic properties of sound is frequency. Considering the laryngeal system, the rate at which the vocal cords vibrate during a sustained phonation is called as fundamental frequency. The mean fundamental frequency (Mean F0) in females of age 21-50 years was found to be 222.68 Hz in study done by Ambreen, Bashir, Tarar, and Kausar (2019) using Multidimensional Voice Program (MDVP) software. Considering the vocal load that

professional voice users like teachers would have, it could be implied that the fundamental frequency measure of their voice could be affected. Hence, this parameter was considered for this study.

Another acoustic parameter that can be measured by the MDVP software is the minimum F0 (Min F0) and maximum F0 (Max F0) which indirectly reflects the range of F0. In a study done to compare acoustical parameters in teachers before and after vocal loading task of teaching on a working day, the authors reported Min F0 to be 124.40 Hz and Max F0 to be 270.75 using PRAAT software (Alexander, Shetty, & Mathew, 2017). Although there was decrease in the values of Min F0 suggesting a decrease in range of F0, it was not statistically significant.

Percent Jitter (Jitt) is the "the average absolute difference between consecutive periods, divided by average period, expressed as a percentage" (Teixeira, Oliveira & Lopes, 2013). A result suggesting increase in jitter after a vocal loading task in singers and non singers has been reported by Gelfer, Andrews, and Schmidt (1991). Since teachers are subjected to vocal loading during their working hours, it is crucial to measure this acoustic parameter.

Relative Average Perturbation (RAP) is "the average absolute difference between a period and the average of it and its two neighbors, divided by the average period. It is expressed as a percentage" (Teixeira, Oliveira, & Lopes, 2013). Aithal, Bellur, John, Varghese, and Guddattu (2012) reported to find significant increase in RAP values in females when compared between normal phonation and high pitched phonation i.e. 0.38 during normal phonation and 0.57 during high pitched phonation. The authors implied this increase to the evidence of aperiodicity of vocal cords during high pitched phonations task.

Pitch Perturbation Quotient (PPQ) is a relative assessment of period to period variability of the pitch within the analyzed voice sample with a smoothening factor of 5. A study done to

measure acoustic parameters in healthy normal men and women of the age range of 31-40 years reported PPQ values to be 0.24% in women (Ambreen, Bashir, Tarar, & Kausar, 2019). Furthermore PPQ values were reported to be increased from 0.37 to 0.55 when taken in comparison between normal phonation and high pitched phonation in females (Aithal, Bellur, John, Varghese, & Guddattu, 2012). Smoothened Pitch Perturbation Quotient (SPPQ) is a relative evaluation of the short- or long-term variability of the pitch period within the analyzed voice sample at a user-defined smoothening factor of 55 periods. Similarly to PPQ, an increase in SPPQ values ie. 0.48 and 0.60 for normal phonation and high pitched phonation respectively were reported in females. Although it was not statistically significant. (Aithal, Bellur, John, Varghese, & Guddattu, 2012)

Noise Harmonic Ratio (NHR) is the average ratio of the inharmonic spectral energy to the harmonic spectral energy in the frequency range 70-4200 Hz. Studies have shown NHR to be a good predictor of presence of breathiness or hoarseness in voice or in other words it can reflect the severity of dysphonia in the voice (Childers & Lee, 1991). In a normative study, NHR has been reported to be 0.007 in younger females (18-28 years) and 0.012 in older females (63-86 years) (Goy, Fernandes, Pichora-Fuller, & Lieshout, 2013).

Cepstral Peak Prominence (CPP) is a "measure of the relative amplitude of the cepstral peak prominence in relation to the expected amplitude as derived via linear regression. This measure reflects the degree of regularity or periodicity in the voice signal. Higher values reflect greater periodicity" (Watts & Awan, 2011). Smoothened Cepstral Peak Prominence (SCPP) is an adaptation from CPP where the cepstra obtained is smoothened across time and quefrency domains. This alternative measure was derived to provide a better predictive value for speech signals. Several studies have reported CPP measures to be a good predictor of overall

voice quality (Heman-Ackah, Michael & Goding, 2002), (Ferrer, De Bodt, Maryn et al., 2007) (Maryn & Weenink, 2015). Although normative data for the same seems to be varying across studies using different acoustic analysis program software. One of the study that aimed at looking into the cepstral measures in teachers with mean age 42.6 years having healthy voice reported 23.6 and 13.6 for CPP and SCPP parameters respectively (Phadke, Laukkanen, Ilomäki, Kankare, Geneid, & Švec, 2018).

A reliability analysis: Intrajudge i.e. the author would again analyze 10% (n=12) of the overall total sample (n=120) for all the parameter considered in this study; Interjudge i.e. the author would ask a speech language pathologist to analyze 10% (n=12) of the overall total sample (n=120) for all the parameters in this study. Hence, *Cronbach 's alpha* for Mean F0, Min F0, Max F0, RAP, PPQ, SPPQ, NHR, Jitt, CPP and SCPP was found to be ≥0.97 for intrajudge reliability and ≥0.96 for interjudge reliability.

Statistical Analysis

Repeated Measures Analysis of Variance (RANOVA) was done to compare phonation type (Hab P and HPP) as within subject factor and group as between subject factor (VF and WVF). Further, Post hoc analysis was done using *Paired t-test* and *Independent t-test*.

CHAPTER 4

RESULTS

Based on the descriptive statistics of the current study, when compared between groups (Vocal fatigue and Without vocal fatigue) results reveal a increase in values in without vocal fatigue group for Mean F0, Max F0, CPP and SCPP measures in habitual phonation and high-pitched phonation. However in the same group there was a decrease in the values for Min F0, RAP, SPPQ and Jitt in habitual and high pitched phonation. The same trend was seen in PPQ values but only in habitual phonation, in high pitched phonation there was a increase in PPQ values in the without vocal fatigue group. Although when compared between the phonation types (Habitual phonation and high-pitched phonation), results reveal increase in high-pitched phonation values in both the groups (Vocal fatigue and without vocal fatigue) for Mean F0, Min F0, Max F0, CPP and SCPP measures. Nonetheless there was a decrease in high pitched phonation values for RAP, SPPQ and Jitt in both the groups. On the other hand, PPQ measure showed an increasing trend in values for high-pitched phonation task in vocal fatigue group and decreasing trend in values for high pitched phonation task in the without vocal fatigue group (Table 2).

For the further statistical analysis, *RANOVA* was done with phonation type (Hab P and HPP) as within subject factor and group (VF and WVF) as the between subject factor. The significance level, $\alpha=0.05$ was considered in this study. Results of *ANOVA* suggested significant ($p<0.05$) main effect for phonation type z (Hab P and HPP) for 4 acoustic parameters ie. Mean F0, Min F0, Max F0 and Jitt (Table 3). Further, the results suggested significant ($p<0.05$) main effect for groups (VF and WVF) in Mean F0, Min F0, Max F0, SPPQ, Jitt and CPP parameters.

However significant ($p<0.05$) interaction between phonation type (Hab P and HPP) versus group (VF and WVF) was found only for Mean F0 and Max F0. As there was a significant ($p < 0.05$) interaction effect, a post hoc analysis using *paired t-test* was done to compare type of phonation (Hab P and HPP) within each group (VF and WVF) for Mean F0 and Max F0. The results revealed statistical significance ($p<0.05$) difference between two types of phonation for both the parameters (Table 4).

Similarly, an *independent t-test* was done to compare two groups (VF and WVF) within each type of phonation (Hab P and HPP) for Mean F0 and Max F0 parameters. The results revealed statistical significance for Max F0 in Hab P when compared between two groups (VF and WVF). Statistical significance was also found for Mean F0 and Max F0 in HPP when compared between two groups (VF and WVF) (Table 5).

Table 2

Mean and standard deviation values between phonation type (Hab P and HPP) in the groups (VF and WVF) across acoustic parameters (Hab P-Habitual Phonation, HPP-High Pitched Phonation, Min F0-Minimum Fo, Max F0-Maximum F0, RAP-Relative Average Perturbation, PPQ-Pitch Perturbation Quotient, SPPQ-Smoothened Pitch Perturbation Quotient, NHR-Noise to Harmonic Ratio, Jitt- Percent Jitter, CPP-Cepstral Peak Prominence, SCPP-Smoothened Cepstral Peak Prominence)

Parameters		Vocal Fatigue (VF)		Without Vocal Fatigue (WVF)	
		Mean	SD	Mean	SD
Mean F0	Hab P	206.83	24.47	212.12	26.24
	HPP	284.07	44.38	312.99	41.08

Min F0	Hab P	226.08	31.48	191.353	33.47
	HPP	305.17	52.07	286.05	42.57
Max F0	Hab P	187.71	29.18	234.37	35.48
	HPP	253.54	52.04	338.39	62.64
RAP	Hab P	0.81	0.44	0.77	0.46
	HPP	0.79	0.72	0.57	0.37
PPQ	Hab P	0.95	0.51	1.33	2.59
	HPP	1.59	4.64	0.63	0.43
SPPQ	Hab P	1.39	0.82	0.98	0.56
	HPP	1.25	1.04	0.90	0.85
NHR	Hab P	0.13	0.12	0.18	0.29
	HPP	0.15	0.23	0.21	0.39
Jitt	Hab P	1.18	0.78	0.92	0.69
	HPP	0.85	0.57	0.60	0.33
CPP	Hab P	23.24	3.37	24.31	2.57
	HPP	23.25	2.51	24.51	2.13
SCPP	Hab P	13.19	2.68	13.74	1.80
	HPP	13.35	2.40	13.76	1.61

Based on the post hoc *paired t-test* analysis and Table 2, it can be noted in group (VF and WVF) when compared within each phonation type (Hab p and HPP), Mean F0 and Max F0 was lower in Hab p and higher in HPP. This suggests that the desired effect intended for the experimental manipulation of increased F0 for HPP task was produced successfully by both the group (VF and WVF). Furthermore, based on the post hoc *independent t-test* analysis and Table 2, it can be noted when compared between group (VF and WVF) in Hab P type, Max F0 was decreased in VF group in comparison with WVF group. Whereas while considering HPP type, Mean F0 and Max F0 was significantly reduced in VF group when compared to WVF group.

Table 3

*F values, p values, and partial eta-squared effect size (η_p^2) for all inferential statistical analysis for all acoustic parameters, Phonation Type (Hab P and HPP), Group (VF and WVF), Phonation type*Group. *p≤ 0.05(Hab P-Habitual Phonation, HPP-High Pitched Phonation)*

Parameter	Condition	Inferential results
Mean F0	Phonation Type	F(1,58)=304.43,P=0.00, (η_p^2) =0.84 p=1.00
	Group	F(1,58)=5.187,P=0.026,(η_p^2) =0.08 p=0.610
	Phonation Type*Group	F(1,58)=5.360,P=0.024,(η_p^2)=0.085 p=0.625
Minimum F0	Phonation Type	F(1,58)=261.57,P=0.00,(η_p^2)=0.819 p=1.00
	Group	F(1,58)=8.873,P=0.004,(η_p^2)=0.133 p=0.834
	Phonation Type*Group	F(1,58)=2.108,P=0.152,(η_p^2)=0.035 p=0.298
Maximum F0	Phonation Type	F(1,58)=131.051,P=0.00,(η_p^2)=0.693 p=1.00
	Group	F(1,58)=47.661,P=0.00,(η_p^2)=0.451 p=1.00
	Phonation Type*Group	F(1,58)=6.627,P=0.013,(η_p^2)=0.103 p=0.716
Relative Average Perturbation	Phonation Type	F(1,58)=1.367,P=0.247,(η_p^2)=0.023 p=0.210
	Group	F(1,58)=1.715,P=0.195,(η_p^2)=0.029 p=0.251
	Phonation Type*Group	F(1,58)=0.969,P=0.329,(η_p^2)=0.016 p=0.162
Pitch Perturbation Quotient	Phonation Type	F(1,58)=0.004,P=0.949,(η_p^2)=0.00 p=0.050
	Group	F(1,58)=0.353,P=0.555,(η_p^2)=0.006 p=0.090
	Phonation Type*Group	F(1,58)=1.899,P=0.174,(η_p^2)=0.032 p=0.273
Smoothened Pitch Perturbation Quotient	Phonation Type	F(1,58)=0.569,P=0.454,(η_p^2)=0.010 p=0.115
	Group	F(1,58)=5.672,P=0.021,(η_p^2)=0.089 p=0.649
	Phonation Type*Group	F(1,58)=0.045,P=0.833,(η_p^2)=0.001 p=0.055
Noise to Harmonic Ratio	Phonation Type	F(1,58)=0.230,P=0.633,(η_p^2)=0.004 p=0.076
	Group	F(1,58)=1.198,P=0.278,(η_p^2)=0.020 p=0.190
	Phonation Type*Group	F(1,58)=0.044,P=0.835,(η_p^2)=0.001 p=0.055
Percent Jitter	Phonation Type	F(1,58)=8.727,P=0.005,(η_p^2)=0.131 p=0.828
	Group	F(1,58)=4.670,P=0.035,(η_p^2)=0.075 p=0.566
	Phonation Type*Group	F(1,58)=0.001,P=0.971,(η_p^2)=0.00 p=0.050
Cepstral Peak Prominence	Phonation Type	F(1,58)=0.090,P=0.766,(η_p^2)=0.002 p=0.060
	Group	F(1,58)=3.842,P=0.055,(η_p^2)=0.062 p=0.487
	Phonation Type*Group	F(1,58)=0.073,P=0.788,(η_p^2)=0.001 p=0.058
Smoothened Cepstral Peak Prominence	Phonation Type	F(1,58)=0.103,P=0.749,(η_p^2)=0.002 p=0.062
	Group	F(1,58)=1.013,P=0.318,(η_p^2)=0.017 p=0.168
	Phonation Type*Group	F(1,58)=0.054,P=0.817,(η_p^2)=0.001 p=0.056

Table 4

Paired T-Test (Post Hoc Analysis I) comparison of phonation type (Hab P and HPP) within each group (VF and WVF) for Mean F0 and Max F0 values.

POST HOC ANALYSIS I		
		Habitual Phonation Vs High Pitched Phonation
Vocal Fatigue (VF)	Mean	$t(29)=-10.487, p<0.05$
	Max F0	$t(29)=-6.378, p<0.05$
Without Vocal Fatigue (WVF)	Mean	$t(29)=-14.272, p<0.05$
	Max F0	$t(29)=-9.759, p<0.05$

Table 5

Independent Sample T-Test (Post Hoc Analysis II) comparison of groups (VF and WVF) within each type of phonation (Hab P and HPP) for Mean F0 and Max F0

POST HOC ANALYSIS II		
		Vocal Fatigue (VF) Vs Without Vocal Fatigue (WVF)
Habitual Phonation	Mean	$t(58)=0.807, p>0.05$
	Max F0	$t(58)=5.561, p<0.05$
High Pitched Phonation	Mean	$t(58)=2.619, p<0.05$
	Max F0	$t(58)=5.706, p<0.05$

CHAPTER-5

DISCUSSION

The present study aimed at determining if high pitched phonation can be used as a novel vocal loading task considering professional voice users such as teachers. In the Literature, many vocal loading tasks have been researched like reading loudly (65-75dB) (Remacle, Finck, Roche & Morsomme, 2012), reading with increased ambient noise (60-70dB) (Whitling, Rydell & Åhlander, 2015), singing above 80dB (Yiu et al., 2013) etc following which a significant difference in acoustic parameters were found.

While considering clinical application of such tasks, the few limitations are time consumption; some tasks such as singing cannot be performed by individuals who are not trained for it; poor predictor for susceptibility to voice problem. In order to overcome these, it is important to have a task effective enough to induce vocal loading, provide reliable acoustic data and be time efficient. According to studies, it has been established females have higher fundamental frequency and hence high vocal vibratory rate in comparison to men. Physiologically pitch increases when the cricothyroid and throarytenoid muscle in counter action tense the vocal folds resulting in an increase in their length and stiffness but decrease in their mass (Hollien, 1962). Therefore following a vocal loading task, females show increased effect of vocal loading (Titze, 2003).

Based on this knowledge it can be attributed that any task which includes the use of higher vibratory rates, which could be due to increased loudness or pitch can result in vocal loading. A study done to compare between normal phonation and high pitched phonation in normal individuals reported a significant difference in acoustic parameters between the two

tasks. The authors accounted the change in the acoustic values to the vocal loading caused due to the high pitched phonation task (Aithal, Bellur, John, Varghese, & Guddattu, 2012).

Most of the studies in the literature report results in coherence to healthy voice individuals who are not professional voice users (Fujiki & Sivasankar, 2017). Hence the present study considered teachers who are professional voice users and aimed to examine the efficiency of high pitched phonation task when compared to habitual phonation. Vocal Fatigue Index (Nanjundeswaran, Jacobson, Gartner-Schmidt, & Abbott, 2015) was used as inclusionary criteria to group the participants into vocal fatigue (VF) and without vocal fatigue (WVF) group. The WVF group functioned as the control group and the participants who reported vocal fatigue were grouped considering their susceptibility to voice disorder.

The *independent t-test* was done to compare factor1 and factor 2 of the Vocal Fatigue Index (Nanjundeswaran, Jacobson, Gartner-Schmidt, & Abbott, 2015). The results revealed statistically significant increase for factor 1 and factor 2 in vocal fatigue (VF) group when compared to without vocal fatigue (WVF) group.

The results of this study based on *post hoc independent t-test* analysis shows decreased Max F0 in vocal fatigue (VF) when compared to without vocal fatigue (WVF) group during habitual phonation (Hab P), and more importantly there was a decrease of Mean F0 and Max F0 values in VF group during high pitched phonation (HPP) task. These results can imply participants who reported vocal fatigue had poor or decreased vocal fold vibratory rates when compared to those who don't report of any vocal fatigue. Although 10 acoustic parameters based on previous research studies were considered for this study, only 2 parameters were statistically significant. This could be because these parameters are not sensitive enough to detect the subtle

voice changes in professional voice users with vocal fatigue or it could be speculated since high-pitched phonation is a short duration task, acoustic parameters are not able to detect the changes.

The significant difference in the acoustic parameters seen in vocal fatigue (VF) group in comparison with without vocal fatigue (WVF) group during high pitched phonation is indicative that high pitched phonation as a vocal loading task in teachers is a good predictor of individuals who are vulnerable to develop voice disorders. Although this study is one of the first few to research on high pitched phonation (HPP) as a vocal loading task, the limitations of this study could be consideration of only female participants, choosing acoustic parameters which are more sensitive to vocal loading. The future research considering high pitched phonation (HPP) task in males and females with and without vocal fatigue with or without underlying laryngeal pathology is warranted.

CHAPTER 6

SUMMARY AND CONCLUSION

Voice assessment and diagnosis is the key foundation of treating persons with voice disorders. Without decisive and sensitive tools, it would be challenging to make an accurate diagnosis and plan intervention programs.

Since the advancement of technology, objective measures have taken the lead in clinical practice. However research indicates, for a better critical evaluation it is mandate to correlate objective with subjective measures. Based on literature, it is inferential that professional voice users are the most susceptible group to acquire voice problems. Therefore, the need for evaluating the efficiency of existing vocal assessment tools in these groups and developing dependable and precise tools in necessary

Literature reports vocal loading task as a good predictor of emerging voice problems. The present study aimed at determining the potency of high-pitched phonation (HPP) as a vocal loading task in professional voice users such as teachers with and without vocal fatigue. The study considered 60 participants, who were grouped based on Vocal Fatigue Index (VFI) and also a self reported questionnaire consisting of demographic details, history of voice problems, awareness of vocal hygiene etc was given. A voice sample of habitual phonation (Hab P) and high-pitched phonation (HPP) was recorded and analyzed for deriving 10 acoustic parameters. Statistical analysis was done and the results revealed significant difference for Mean F0 and Maximum F0 values in high-pitched phonation (HPP) task in the vocal fatigue (VF) group in comparison to without vocal fatigue (WVF) group. This indicates a positive outcome in considering high-pitched phonation (HPP) as a vocal loading task.

Implications of the study:

1) High-pitched phonation task can be used as a time efficient tool to assess subtle voice changes in teachers.
2) The decrease in frequency measures like Mean F0 and Maximum F0 is suggestive of presence of vocal fatigue.

Limitations of the study

1) Only female participants were considered.
2) No grouping of teachers in terms of age, teaching experience or education level of teaching was done.

Future Directions

1) Efficiency of high-pitched phonation as a vocal loading task in males and other professional voice users such as singers can be conducted.
2) This study considered Vocal Fatigue Index (VFI) which is a self reported questionnaire as inclusionary criteria for the groups instead voice disorder population in comparison to normal individuals can be done.
3) This study considered only 30 participants in each group; instead a larger sample size can be taken up for a reliability study.
4) This study considered 10 acoustic parameters, out of which only 2 parameters showed significant difference for high-pitched phonation task instead more sensitive acoustic parameters can be chosen to explore.

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