ACOUSTIC VOICE QUALITY INDEX IN YOUNG PHONONORMALS USING SOVT- FRICATION EXERCISE: COMPARISON OF PRE-POST TRAINING

Ms. Sri Ranjani V

Register No: 19SLP029

A Dissertation Submitted in Part Fulfillment of Degree of Master of Science

(Speech-Language Pathology)

University of Mysore

Mysuru

ALL INDIA INSTITUTE OF SPEECH AND HEARING

MANASAGANGOTHRI, MYSURU-570 006

September 2021

CERTIFICATE

This is to certify that this dissertation entitled "**Acoustic Voice Quality Index in young phononormals using SOVT- Frication exercise: comparison of pre-post training**" is a bonafide work submitted in part fulfillment for degree of Master of Science (Speech-Language Pathology) of the student Registration number 19SLP029. This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other University for award of any other Diploma or Degree.

Mysuru

September, 2021

Dr. M. Pushpavathi

Director

All India Institute of Speech and Hearing

Manasagangothri,

Mysuru- 570006

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Mysuru

September, 2021

Guide

Dr. K. Yeshoda

Associate Professor in Speech Sciences

Department of Speech-Language Sciences

All India Institute of Speech and Hearing

Manasagangothri, Mysuru- 570006.

DECLARATION

This is to certify that this dissertation entitled **"Acoustic Voice Quality Index in young phononormals using SOVT- Frication exercise: comparison of pre-post training"** is the result of my own study under the guidance of Dr. K. Yeshoda, Associate Professor in Speech Sciences, Department of Speech-Language Sciences, All India Institute of Speech and Hearing, Mysuru, and has not been submitted earlier to any other University for award of any other Diploma or Degree.

Mysuru **Registration number: 19SLP029**

September, 2021

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ACKNOWLEDGEMENT

I am sincerely grateful to my guide Dr. K Yeshoda, who has always made sure to resonate her positive aura to people around her. Your persistent dedication, confidence and knowledge in the area of voice has always awe-struck me. The road of learning under your guidance was just as adventurous as it could be. Thank you so much ma’am for believing in me during the whole process.

I thank each and every participant in this study who have been very sincere and dedicated in doing the exercise during this long phase. I wouldn’t have pulled it off without your support.

I thank my mentors Dr. Pushpavathi ma’am, Dr. Goswami sir, Dr. Sridevi ma’am, Dr. Gopi Sankar sir, Dr. Jayashree ma’am, Dr. Hema ma’am, Dr. Sangeetha ma’am, Dr. Priya M B ma’am, Dr. Abhishek sir, Dr. Jayakumar sir, Dr. Rajasudhakar sir, Dr. Santosh sir, Dr. Anjana ma’am, Dr. Swapna ma’am, Dr. Yashomathi ma’am, Ms. Geetha M P ma’am, Ms. Prathima ma’am and Ms. Deepa ma’am for always inspiring me to be a better professional.

I am eternally thankful my mother, father and brother for being the pillar of support and guidance in all walks of my life. You have always been busy ensuring that I achieve all my dreams and made sure everything is possible. Words aren’t enough to describe how blessed I am to have you in my life.

My heartfelt thanks to my crazy bunch of amazing friends Vicky, Prachu and Tamil, who has never failed to provide me with all the emotional support and has always cheered me up beyond their reach each time during my journey in post-graduation. I really owe you guys a big time.

I thank my lucky charm, Ninja and Abu for taking it cool and in a ‘PATHUKALAM-PATHUKALAM’ mode, I thank Jeeva and VJ for being the best supporting system from the beginning and helping me cope with the new environment.

Zainab, a person who keeps showering her love, who keeps telling me to take one step at a time, who has shared my good and bad days. I cannot get over how thankful I am for the million times you have been there for me. Rushali, thank you for being my go to person even before my alarm rings till saying goodnight. I am so glad that I got to know you.

Last but not the least, My MAMMA LLAMAS, Zainab, Rushali, Yaazhini, Siddhi, Thiru and Aiza. I am happy to have you guys beyond melodies and words. Thank you for making my days in AIISH a very bright and colorful one. You all have been one of the reasons I smile every day.

DEDICATING THIS TO MY BUNDLE OF HAPPINESS AND MOTIVATION,

MY TWIN-ARAVIND

CHAPTER I

INTRODUCTION

Voice is an acoustic phenomenon that depends on the combined effort of the neurological system, the interdependent activity of various muscles, and the integrity of the laryngeal tissue. Interaction between the respiratory, phonatory and resonatory subsystem of speech leads to voice production, i.e. it is produced with the air passage from the lungs creating a subglottic air pressure below the level of vocal folds when they are in adducted position. Once the subglottic air pressure of the respiratory system overcomes the resistance offered by the adducted vocal folds, the compressed air is released, setting the vocal fold into vibration. Further, the air and the spectral energy pass through the vocal tract, wherein the movement and resonatory characteristics of the resonant cavities and vocal tract leads to the final vocal output.

According to the Source-Filter Theory (Fant, 1960), speech production occurs in two phases involving the generation of a sound source at the level of the vocal fold with its spectral shape, which is then filtered by the vocal tract's resonant characteristics, i.e. along the supraglottic area. The oral cavity and sometimes the nasal cavity of the vocal tract contributes significantly by taking part in the filter mechanism. At the level of the glottal source, voice is governed by the pitch and quality of voice. Further, the resonance characteristics of voice along with the voice quality changes, as the glottal sound passes through different configuration of the vocal tract. These interactions between the source and filter vary from one individual to another, leading to a distinctive and unique voice property.

Voice provides the identity to an individual, and its degree of importance depends on the users of the voice. A normal voice may be characterized by five aspects, each of which is almost related to its function. First, the voice must be loud enough with adequate power to be heard by the communication partner in various situations, such as a noisy environment and telephonic conversation, etc. Second, it must be produced in a hygienic and safe manner to not result in any forms of vocal trauma or lesions. Third, it should have a pleasant quality. Fourth, the normal voice should be flexible to express emotion and convey the speaker's respective indexical information (Boone et al., 2014). Thus, an individual's voice can be considered a “window into the soul” as it sometimes is difficult to mask the emotional state of mind in voice (Boone et al., 2014).

On observing the milestones of vocal function closely, infant vocalisation progresses to babbling. The prosodic features of the native language are absorbed to become words and phrases. As the social and emotional demand of a child's life expands, the vocal apparatus undergoes changes based on that individual's social class and geographical dialect. Later on, in adolescence and adulthood, the voice provides a coalescence of indexical information to the listener. Throughout these milestones, if there are incidents that impairs the physiological functioning of voice, then the communicator’s effectiveness to speak reduces. It is generally recognised that the voice provides a significant contribution to the intelligibility and perception of verbal communication. Generally, it is accepted that voices tend to be identified as belonging to particular individuals and can be recognised, like faces. Therefore, voice is considered an essential part of life as it fulfils several roles in the process of oral communication.

The voice of an individual might be influenced by various factors such as (i) hydration (Alves et al., 2019), (ii) hormonal influence (Pavela Banai, 2017), (iii) environmental condition, (iv) intake of drugs, alcohol and smoking, (v) vocal misuse or overload, (vi) structural abnormality, (vii) neurological influence, (viii) psychological influence etc. (Thomas et al., 2006 & Roy et al., 2005)

Across the researches, voice quality has usually been studied using various perceptual and objective measures. Perceptual measurement of the voice is a technique that utilizes the auditory perceptual processes, along with the incorporation of inputs from a rating system to make appropriate judgments on the typical nature and appropriateness of an individual's voice (Aronson & Bless, 2009). However, this auditory perceptual voice assessment is not considered as an objective measurement because it utilizes the perceiver's ears to interpret what they are hearing. Despite all the disadvantages, it is always considered the gold standard because it provides information readily to the examiner and is found to be economical in its usage (Oates, 2009). Some of the widely used perceptual evaluation assessment tools are Grade Roughness Breathiness Asthenic Strain (GRBAS) (Hirano, 1981), Consensus Auditory Perceptual Evaluation of Voice (CAPE-V) (Kempster et al., 2009), Buffalo Voice III Profile (Wilson, 1987), Vocal Profile Analysis Scheme (Laver et al., 1981), etc.

Hirano developed the GRBAS Scale in 1981. Individual parameters on the GRBAS scale describe phonatory quality characteristics: G (grade) indicates the overall severity of voice abnormality, R indicates roughness, B indicates breathiness, A represents aesthenic quality, and S indicates strain in voice. The tool also utilizes a four-point rating measure of 0 which is normal to 3 which is extreme in severity for all the above mentioned vocal characteristics.

The CAPE-V was developed by Kempster and colleagues in 2009 following the Consensus Conference on Auditory Perceptual Evaluation of Voice conducted at the University of Pittsburgh in June 2002. Clinicians use a tick mark on a visual analogue scale of 100 mm horizontal line to rate six features of voice, including Overall Severity, Roughness, Breathiness, Strain, Pitch, and Loudness. The instrument includes two unlabeled scales to comment on other significant features in voice such as tremor, diplophonia, pitch instability etc.

Despite the significance of the perceptual measures, objective evaluation plays a vital role in terms of its reliability, describing the parameters of voice more quantitatively and acting as a diagnostic indicator. Some of the objective measurements used towards assessing the voice parameters are acoustic measures, electroglottographic methods, aerodynamic measures, etc. However, there is an increase in evidence of using the acoustic parameters of voice assessment to evaluate the vocal functioning due to its non-invasive method of obtaining the data and as it focuses directly on the output characteristics.

Acoustic characteristics give a vital profile of voice functioning while also ensuring consistency across clinicians. Some of the acoustic parameters predominantly used in the voice evaluation are fundamental frequency, noise to harmonic ratio, soft phonation index (SPI), short term perturbations of amplitude and frequency (shimmer and jitter), voice turbulence index (VTI), etc.

There is a surge in the trend of using a multivariate objective analysis of voice rather than unidimensional analysis. Some of the recently introduced multi-parametric acoustic measurement to identify the severity of dysphonia in voice are Dysphonia Severity Index (DSI) and Acoustic Voice Quality Index (AVQI).

The Dysphonia Severity Index (DSI), developed by Wuyts et al. (2000), is a tool that uses a prolonged phonation task to offer an objective and numerical measure to distinguish normal versus disordered voice changes. The highest frequency (F0-High in Hz), lowest intensity, maximum phonation time, and jitter in % are extracted to obtain DSI. For a perceptually normal voice, the DSI would be near +5 and for severely dysphonic voice, it would be -5. The worse the individual's vocal quality, the more negative would be the DSI.

AVQI uses a combination of vowel phonation and connected speech for analysis (Maryn, 2010). It is the first measure that has incorporated both vowel phonation and connected speech for the evaluation protocol. A stepwise multiple linear regression was incorporated on 13 acoustic measures such as on amplitude perturbation, fundamental frequency perturbation, spectral and cepstral analysis to construct a six-parameteric acoustic model for assessing overall voice quality

AVQI is derived using the six acoustic weighted combinations, time domain (i.e., shimmer local, shimmer local dB and harmonics-to-noise ratio), frequency domain (i.e., general slope of the spectrum and tilt of the regression line through the spectrum) and quefrency-domain (i.e. smoothed cepstral peak prominence).

Studies also focused on the ability of AVQI in order to speculate the amount of change in the severity of dysphonia after a treatment and its relationship with the perceptual evaluation of voice (G- in GRBAS). Wherein a group consisting of 22 females and 11 males were subjected to behavioural voice treatments. Results revealed that all the desirable attributes to be possessed by an objective parameter such as diagnostic precision, concurrent validity, concurrent cross-validity and responsiveness of AVQI to change were present in AVQI (Maryn et al., 2010).

Any minute changes in voice in terms of loudness, quality, or pitch might impact the individual's typical day-to-day functioning. Thus, it is essential for a speech language pathologist who treats patients with voice disorders to understand the range of the communicative functions of the voice to comprehend the effects of the vocal impairment on the individual. The role of a speech language pathologist is not only to diagnose and intervene but also to create awareness of the possible risk factors.

To preserve the overall functional system of voice, when voice is disordered, the therapeutic intervention focuses on providing the individuals with various evidence-based programs such as vocal hygiene program, vocal relaxation exercises such as Semi Occluded Vocal Tract Exercises (Titze, 2018), Resonant Voice therapy (Yui et al., 2017), Vocal Function Exercises (Stemple et al., 1994), counselling etc.

Out of the many evidence-based programs for voice rehabilitation, semi-occluded vocal tract exercises (SOVT) (Titze, 2006, 2018) are among the most utilized voice therapeutic tools in clinical voice disorders. Over the past two decades, SOVT exercises have been practiced as a tradition by singers and other professional voice users as vocal warm-ups. It involves creating a narrow vocal tract near the lips or tongue tip, and matching the impedance between the vocal folds and the supraglottic regions. SOVT exercises can be practiced with the use of materials (cup and straw) as well as includes tasks which can be performed without the use of materials (fricatives, trills, nasal consonants, vowels etc.). However, the target of all the exercises focuses on easing the phonatory function of the vocal folds. In a desirable voice training regime, a therapist could integrate the order of using the exercise from "greatest occlusive effect, higher resistance but more artificial" to "smallest occlusive effect, least resistance but closest to natural speech" i.e. in the following order of utilizing straw with smaller diameter, straw with larger diameter, voiced fricatives (bilabial or labiodental), lip or tongue trills, nasal consonant, vowel production to be most effective (Titze, 2006).

Reports revealed that both scales- GRBAS given by Hirano in 1981 and CAPE-V developed by Kempster and colleague in 2009 were more reliable and also mentioned its utilization in analyzing the quality of voice (Nemr et al., 2012). When these scales were implemented for analyzing the changes in voice pre- and post- SOVTE intervention in individuals with dysphonia, GRBAS scale showed a significant reduction in its overall severity (Kim et al., 2017), and CAPE-V showed significant improvement in the overall voice quality (Menezes et al., 2011).

Need for the Study

The current goal of using the SOVT exercises in the voice rehabilitation is that it promotes efficient and economic vocal output, thus directly reducing the risk of hyper functioning vocal folds (Croake et al., 2017). Studies have experimentally proved its scientific evidence towards its benefits in vocal functions (Andrade et al., 2014 & Titze, 2006). Various exercises such as usage of fricatives, nasal sounds, trills can be incorporated in the clinical setting without any usage of materials by the individual, but there is little information on all kinds of SOVT exercises and their impact as a long term therapeutic voice exercise. Evidences in the uses of these exercises can help in creating an effective voice strategy.

Thus, the present study was planned to understand the use of SOVT fricative exercises and measure its effectiveness using a multivariate acoustic parameter (AVQI). The multivariate parameter of AVQI was selected for the reason that there are studies on the normative data of AVQI in Indian population (Vishali & Rajasudhakar, 2018). However, limited research is available that verify changes in the acoustic parameters using AVQI after a systematic voice therapeutic program. Scarce evidences are available that has evaluated the use of AVQI as a factor of prognostic indicator and its usage in a vocal hygiene program.

CHAPTER II

REVIEW OF LITERATURE

The distinctive nature of voice is exclusive to each individual and it is dependent to a greater extent on anatomical features, further maintained by the habitual voice settings of the vocal tract. Here, the voice setting is considered as the learned muscular adjustments of the vocal tract of an individual, can be influenced by the family, school, social, professional and occupational group (Ryan et al., 1982). The voice setting in an optimum condition facilitates better sustenance of artistic capability of vocal tract and communication both linguistically and emotionally. In the majority of speakers, there is no awareness of the voice setting as it is habitual. Thus, any adverse changes or inappropriate voice setting affects the timbre of the voice as well as the characteristic levels of volume and pitch.

In the current scenario, the prevalence of voice disorder in a general population is about 16.9%, wherein women and individuals greater than 65 years of age are more prone to voice problems (Lyberg-Åhlander et al., 2019). The prevalence occurs in the population who fall under the category of non-professional voice users (Menon et al, 2019) as well as professional voice users such as teachers (Sheyona & Devadas, 2020), singers (Pestana et al., 2017), Speech language pathologist (Dodderi et al., 2018) etc. These findings give an insight to increase the need of proactive awareness and voice therapy regimes.

Therefore, the focus of various voice therapeutic approaches such as implementing hygienic programs, symptomatic, psychogenic, physiologic and eclectic approaches intend on maintaining, facilitating or restoring the normal voice functioning so that the voice of an individual falls into the acceptable vocal profile. Semi occluded vocal tract exercises, is one of the physiological approaches which focuses on establishing efficient vocal tract functioning and is frequently recommended as a warm up routine for voice users.

Physiologically, the vocal cords change its shape during SOVT exercises, from a shape of convergence (at the level of the vocal processes, there is a tight adduction and a relaxed adduction beneath the vocal folds) to a glottal shape which is more rectangular (equal adduction from top to bottom), therefore, lowering the phonation threshold pressure (PTP) (Titze, 2018). Further, there is a contraction of the thyroarytenoid muscle during the SOVT exercise, which helps in the squaring up of the vocal cords. Therefore, hyper adduction at the level of the vocal processes is compensated for less (but more uniform) adductory force throughout the glottis. In terms of muscular activity, Titze (2006) reports that lateral cricoarytenoid activation is traded for slight activation of the thyroarytenoid muscle leading to an increase in the air pressures above and between the vocal cords, further maintaining the approximated vocal cords in a slightly separated position. It also allows an increase in inertance of the vocal tract, leading to "un-pressing" of the vocal cords.

Titze conducted a study in 2006 in order to evaluate the source and the filter interactions at the level of the vocal tract. The study utilized a self-oscillating vocal cord model and a 44-section vocal tract in the investigation, with computer simulation. The results showed that a semi-occlusion in front of the vocal tract (near the lips) increases the source–filter interaction by elevating the mean supraglottal and intraglottal pressures. The voice became more efficient and economical as a result of impedance matching of vocal cord adduction and epilarynx tube narrowing. To attain improved vocal efficiency, it was reasoned that therapeutic procedures should be intended to match the glottal impedance to the input impedance of the vocal tract. Thus a ‘‘greatest occlusive effect, higher resistance but most artificial’’ to ‘‘smallest occlusive effect, least resistance but closest to natural’’ is considered ideal and voice therapy approaches were framed in an order of smaller diameter stirring straw, larger diameter drinking straw, bilabial or labiodental voiced fricative, lip or tongue trill, nasal consonant, to vowel production of /u/ and /i/.

Andrade et al. (2014) opined that such adjustments also uncovers the fact that there is a fluctuation in the intraoral pressure due to the combined vibration at the vocal cords as well as the vibration of the vocal tract (distal end), thus creating a massage like effect on the musculatures.

A study conducted by Maxfield et al. (2015) studied the intra-oral pressure created by thirteen SOVTE gestures such as usage of large straw, small straw, straw in water, /v/, /m/, /n/, /u/, /z/, /3/,/b:/, tongue trill, lip trill and raspberry on ten male and ten female phononormal participants recorded via a thin, flexible- cannula pressure transducers. Results revealed that the intra-oral pressure of these SOVT gestures varied from 0.1-1.0 Kpa, wherein /v/ fricative usage approximately being 0.429 Kpa in males and 0.344Kpa in females (greater intra-oral pressure when compared to other labiodental or bilabial fricative but lesser than the straw phonation in water gesture). This finding draws us towards a concept that, even though these gestures of SOVTE are grouped together, they have a different effect on the vocal tract functioning.

There are shreds of evidence which supports that the SOVT exercises reduce muscular tension and improves overall voice quality (Sampaio et al., 2008). Based on electroglottographic and acoustic measures, a recent study of twenty-three healthy subjects carried out a series of SOVT (LaxVox, straw, lip-trill, tongue-trill, hand-over-mouth, humming, and tongue-trill combined with hand-over-mouth) exercises which demonstrated that the SOVT exercise has a massage like effect and provides a relaxed phonation in vocally healthy individuals (Andrade et al., 2014). Furthermore, it tends to increase vocal economy, in terms of expiratory lung pressure changes, acoustic measures (jitter and shimmer) for dysphonia individual who uses the types of SOVTEs such as Y-Buzz, Tongue trills, lip trills, tube in air, hand over mouth, tube in water, and consonant /m/ for a therapeutic period of 12 weeks (Kaneko et al., 2020).

A randomized placebo-controlled double-blind clinical trial was conducted in order to analyze the influence of SOVTE therapy associated with electromyographic feedback. Eleven women in the experimental group received vocal therapy with electromyographic biofeedback, while eleven women in the placebo group received vocal treatment with placebo electromyographic biofeedback and eight 30-minute session for twice a week. Two groups received semioccluded vocal tract exercises as part of their vocal treatment (trill, humming, and fricative). The results emphasized that frication exercise combined with other SOVT exercises such as trill, humming reduced the phonatory effort, increased the transglottic pressure, and modified the waveform of the mucosa, directly maintaining the balance in the functioning of the other intrinsic laryngeal musculature and increases the muscle endurance. However, the presence of biofeedback was more effective in terms of muscular electrical activity and had long effects than the traditional voice approaches (Ribeiro et al., 2019).

A study was conducted by Laukkanen et al. (1996) to experiment the laryngeal function and the vocal source changes during and after the exercise of voiced bilabial fricative /b:/ in 6 phononormals. The changes were measured using electroglottography, electromyography (non-invasive) and inverse filtering of an acoustic signal. The subjects were asked to perform the task in the following series: (i) 20 repeats of /a:p/ at habitual pitch and sound pressure levels, (ii) 20 repetitions of the utterance /b:p/ as a vocal exercise, (iii) series of 20 alternations between tasks (i) and (ii) and (iv) repetition of the task (i). Results revealed that the /a/ phonation after the frication exercise had mixed results on the vertical laryngeal elevation, the low activation of the laryngeal musculature in EGG, and steeper slope in the voice source spectrum. Thus, a decrease in the laryngeal muscles activation and better vocal economy seems to take place during the production of /b:/.

Laukkanen in 1992 conducted a study which implemented /b:/ fricative as a vocal training exercise on 3 trained female singers. Individuals were asked to phonate /i:/ three times for three seconds and were asked to produce the fricative /b:/ several times followed by the /i:/ phonation for three seconds. During the production of the fricative, two variants of the fricatives were reported; firm (with hard audible frication) and loose. The EGG analysis after the vocal exercise revealed that the firm production of /b:/ resulted in increased glottal activity, which occurred due to the inability to produce firm constriction at lip and loose at the level of vocal fold simultaneously. Further, reduced glottal activity was noticed after the loose /b:/ fricative, which was explained as the tendency of the muscles to activate in a synchronous manner of force.

The technique of sibilant fricative sound /z/ with 15 repetitions in two sets was used in a study on a young woman who had no vocal issues. Following training, there was a decrease in glottal noise, an improvement in the harmonic-noise ratio, a drop in the contact quotient between the vocal cords, an improvement in the quality of voice and resonance characteristics, and a decrease in the contact quotient between the vocal cords and subjective sense of a clearer voice were noticed. These changes, according to the authors, are due to greater vibrating frequency of the vocal fold mucous membranes, decreased glottal noise, and reduced midline contact of the vocal folds, resulting in reduced phonatory stress. (D’Avila et al., 2005; as cited in Cielo et al., 2013).

In summary, various researchers have tried experimenting with fricatives such as /z/, /v/, /b:/ as vocal exercises in phononormal individuals and reported to have found significant changes in the vocal effort, mobilization physiology and quality measures providing a few documents of evidence towards the use of fricatives as a vocal exercise. However, in the field of health care sciences, the evidence based practice is spreading in popularity due to its scientific underpinning and critical scientific methodology. According to American Speech and Hearing Association (2004), evidence based practice is an integration of evidence and clinical expertise. A speech language pathologist can provide high-quality programs that serve the interests, values, needs, and preferences of the person with communication difficulties if the two components of EBP are taken into consideration during treatment procedures. Hence, evidence based therapeutic protocols of SOVT exercises would play a significant role towards treating individuals with voice disorders.

Likewise, measuring treatment outcome is also a part of evidence based practice. Enormous assessment procedures and parameters are used to measure the acoustic correlates of disordered and phononormal voice. There is no single parameter that could summarize or be foolproof to describe the characteristic or severity of voice disorder. However, there is a current escalation in the use of multiparametric acoustic voice evaluation, which has led to the usage of a linear regression model of voice parametric tool named Acoustic Voice Quality Index (AVQI). AVQI is a multivariate 6 factor analysis model obtained from an initial set of 13 acoustic variables developed by Maryn et al. (2010), which provides a severity index for concatenated sample of sustained vowel and phonation task in range of 0-10.

Across the timeline, AVQI has got its revised version to maximize its feasibility and to reduce the processing steps (Maryn & Weenink, 2015). AVQI version alpha initially was calculated using the computerized program called Speech Tool (James Hillenbrand, Western Michigan University, Kalamazoo, MI, USA, 2011) to derive the CPPS parameter and Praat software (Boersma & Weenink, version 4.6.15, https://www.praat.org/) to derive the acoustic measurements such as HNR, Shimer local, Shimmer dB, slop and tilt (Maryn et al., 2010). Further, the AVQI beta version (second version) was developed in such a way that the complete derivation of values including CPPS can be obtained in Praat software alone. And the results of both the original version and second version yielded highly acceptable approximation. (Maryn et al., 2015)

In the recent years, AVQI version 3 was developed with a notion to establish an equal proportion of sustained speech sample and continuous speech sample to reach increased ecological validity. As the length of speech sample was much smaller for the analysis after the separation of the voice and voiceless segments, the length of continuous speech was increased from 17 to 22 syllables to roughly 34 syllables (Barsties & Maryn, 2015).

As AVQI has its linguistic component analysis, a study was conducted (Maryn et al., 2014) wherein the investigation of the AVQI's performance in four language (English, Dutch, German, and French) was assessed. Fifty phononormal participants recorded reading tasks in the four languages and produced a sustained vowel. Results revealed there were no statistical differences observed between languages.

Despite its usage of linguistic sample for analysis, the AVQI was identified to be stable across different languages such as South Indian Languages (Malayalam, Kannada & Tamil), Dutch, German, Korean, Finnish, Lithuanian and Japanese etc. (Jayakumar et al., 2020 & Maryn et al., 2014)

Table 1

AVQI normative values across languages

S.no	Authors & year	Language	AVQI score
1	Latoszek, Ulozaitė-Stanienė, Maryn, Petrauskas, &Uloza (2019)	Lithuanian	2.32 (SD ± 0.79)
2	Maryn, Corthals, Van Cauwenberge, et al. (2010)	Dutch	2.95 higher cut off score
3	Jayakumar, Benoy, &Yasin (2020)	Kannada, Tamil, Malayalam	Adult:3.03±0.32 Pediatric: 4.02± 0.75 Older adult: 3.89±0.52
4	Vishali & Rajasudhakar (2019)	Tamil	2.76±0.76
5	Reynolds, Buckland, Bailey, et al. (2012)	English (Australian)	3.46
6	Shabnam & Pushpavathi (2021)	Kannada	Adult Male: 1.79± 0.70 Adult Female: 1.87± 0.59

Based on a normative study conducted in the Indian population (Jayakumar et al., 2020), wherein 200 participants from the pediatric to geriatric population were taken up to measure the AVQI value. The AVQI values obtained for the Indian population were slightly higher than those previously reported for European and East Asian populations in the literature. In comparison to adults, the AVQI achieved by pediatric and older adult groups was significantly greater. However, gender effects were not significantly different on AVQI in Indian scenario.

Studies also reported good to moderate correlation of AVQI with GRBAS perceptual rating scale with good inter-judge and intra-judge reliability (Benoy & Jayakumar, 2017). Further, research conducted on dysphonic and normophonic children (Reynolds et al., 2012) revealed that AVQI was found to have diagnostic accuracy and specificity in the population of children with and with- out dysphonia. Moreover, AVQI had moderate correlation with ratings of severity on the GRBAS. Thus, revealing that AVQI is a potential tool to aid for the diagnosis of pediatric voice disorders.

Further, multi-dimensional voice assessment, i.e. Dysphonia Severity Index (DSI) and AVQI changes were measured in order to evaluate change in AVQI on a 35 young adults with dysphonia (mean age of 21 years). The impact of SOVT exercise such as lip trill, a water resistant therapy (WRT), a straw phonation group were measured in pre- and post- conditions through a blinded study. The lip trill, WRT and straw phonation were given to three separate groups who practiced their SOVT exercise for three weeks, whereas the control group received a sham treatment for those three weeks. Results revealed no significant difference in AVQI in the treatment outcomes, which was explained based on the assumption that it might be because of the reduced number of participants and short duration of treatment period (Meerschman et al., 2019).

In summary, AVQI remains considerably stable across languages including Indian and other foreign languages. It remains stable even in considering gender variations. However, AVQI values change across the age range with pediatric and older adults having a greater value than adults. It has a good potential in differentiating normal voice versus pathological voice. However, the role of AVQI on post behavioral voice treatments, especially using SOVT exercises is less researched. This necessitated the need to document the outcome of SOVT exercises training protocol in phononormals using AVQI.

Aim

The current study aimed to investigate the effects of SOVT frication exercise /v/ on voice using AVQI measurement.

Objectives

a) To find out the long term effect of SOVT frication exercise /v/ in young phononormals using Acoustic Voice Quality Index (AVQI).
b) To compare the AVQI pre- and post- frication exercise training.
c) To check for gender differences, if any, and document the same.

CHAPTER III

METHOD

Participants

A total of 24 healthy phononormals in the age range 20-30 years with equal numbers of female and male participants took part in the study. The participants fulfilling the inclusion and exclusion criteria were enrolled in the study.

Inclusion Criteria

1. Age range: 20 to 30 years
2. Healthy normal individuals with no histories of allergies or infections of speech subsystems.
3. Participants with normal speech, language and hearing, communication and cognitive skills.
4. Speakers with English as second language who were proficient in comprehending, reading and speaking English fluently.

All the participants were screened perceptually using GRBAS scale (Hirano, 1981) by the experimenter as a selection protocol. Only those participants with an overall score of "0" in the GRBAS scale were selected for participation. They were clearly explained regarding the aim, objectives and approximate number of days required for completion of the training and their written consent was obtained (Appendix A).

Exclusion Criteria

1. Participants with any history of voice complaints

2. Participants with any history of alcohol consumption, smoking, respiratory tract illness, neurological impairment and communication disorders
3. Participants with any history of head and neck surgery
4. Professional voice users (actors, singers, teachers)
5. Females with any issues in the menstrual cycle

Tasks

A continuous phonation sample of vowel /a/ for a minimum of 5 seconds and a continuous reading sample (The Rainbow passage, Fairbanks, 1960) was recorded. These tasks were recorded twice for all participants, baseline (pre-training, prior to the beginning of the training protocol) and Post-training (after the completion of the training).

Instruments

Computerised Speech Lab (CSL) 4500 model (KAY PENTAX, New Jersey, USA) was used for audio recording of the stimuli for all the participants. PRAAT (version 6.1.16) software (Boersma & Weenink, 2019) for analysis of the audio recorded data.

Procedure

The complete data collection was conducted in two phases.

Phase I: (Baseline)

The following procedure was conducted for all the participants as a baseline protocol. The recording session was conducted in an acoustically treated room with low ambient noise. The participants were asked to sit comfortably on a chair, and a distance of 10 cm from lips to the microphone was maintained.

First, the participants were asked to phonate a sustained vowel /a/ for a minimum of 5 seconds, followed by reading the rainbow passage. Both the samples were recorded at the participants' comfortable pitch and loudness level. For the purpose of analysis, the recorded samples were saved in .wav file format.

The Praat software (version 6.1.16) was used to analyze the samples of each individual. AVQI (v02.02) was measured using the algorithm (Maryn & Weenink, 2015) and AVQI formula as follows:

AVQI=9.072 - 0.245 X CPPSPraat - 0.161 X HNR - 0.470 X SL + 6.158 X SLdB - 0.071 X Slope - 0.170 X Tilt.

AVQI Script given by Maryn & Weenink (2015) was copied into a text file and saved. Then, the saved .wav files was opened in the Praat software. Wherein each sustained vowel phonation sample was renamed as 'sv' and middle portion of the continuous speech sample of standardized passage was cropped and renamed as 'cs' in the object window of Praat software.

Along with these files, the script file was opened by choosing the Praat option→open Praat script → select the text. Script and the AVQI values and its constituent parameters were extracted after running the algorithm in the Praat software.

The measures documented were:

1. Acoustic Voice Quality Index (AVQI)
2. Smoothened Cepstral Peak Prominence (CPPs)
3. Harmonic to Noise Ratio (HNR)
4. Shimmer local (SL)
5. Shimmer dB (shdB)

6. Slope of Long term average spectrum (LTAS)

7. The tilt of the regression line through the Long-term average spectrum (Tilt)

After the baseline, the participants began the SOVT exercises- labiodental fricative task /v/ for a period of '21' days and practiced '2' times a day. The participants were monitored for regular practice (every day for 21 days) through regular checks using phone-calls/ WhatsApp along with a daily log form (Appendix B). The participants were counselled regarding the voice hygiene program.

The following activities were carried as part of the SOVT exercises.

Exercise 1:

The participants were asked to sustain the fricative /v/ for four trials of 10 seconds duration and a break in between each trial for 5 seconds duration.

Exercise 2:

After the completion of the sustained fricative task, the participants were instructed to do a series of vocal pitch glide from low to high and then from high to low in one breath covering a wide range of pitch. The participants were asked to carry out the same for ten trials with a break of 5 seconds in between each trial.

Exercise 3:

The final task involved tuning the melodic pattern of the song 'Happy Birthday' using the SOVTE frication for four consecutive trials with a break of 30 seconds duration in between.

Table 2

Summary of SOVT frication exercise training protocol

Exercise	Steps	Trials and Breaks	Duration
1	Sustain the fricative /v/ for 10 seconds	4 trials with 5 seconds break in between	1 minute
2	vocal pitch glide of fricative /v/ in one breath from • low to high **to** • high to low	10 trials with 5 seconds break in between	10 minutes and 50 seconds
3	Melodic pattern of the song ’happy birthday’ using the fricative /v/	4 trials with 30 seconds break in between	4 minutes and 40 seconds

Phase II: (Post training)

The tasks recorded for baseline training as mentioned in Phase I were re-recorded after completion of the 21 days of the training protocol. The AVQI parameters were extracted as mentioned in Phase I and noted as post training measures.

Statistical analysis

The Statistical Package for Social Studies (SPSS) software version 20.0 was used to carry the statistical analysis of the extracted AVQI measures for pre and post training samples.

CHAPTER IV

RESULTS

Shapiro Wilk's test of normality was carried out on the data. When the test of normality was carried out on the 22 subjects, the results revealed that the data followed a normal distribution ($p>0.05$).

Table 3 lists the descriptive statistics i.e. mean and standard deviation values of AVQI and its individual parameters gender wise for pre- and post- training phases.

Table 3

Mean and Standard Deviation for male and female participants across pre- and post-training phases

Parameters	Male		Female	
	Pre training M(SD)	**Post training M(SD)**	**Pre training M(SD)**	**Post training M(SD)**
AVQI	3.62(0.71)	4.25(0.55)	3.26(0.46)	3.78(0.46)
CPPs	13.43(1.33)	13.35(1.50)	13.17(0.62)	12.71(0.62)
HNR	14.73(1.44)	14.30(1.65)	18.88(1.28)	18.30(1.14)
SHIMMER LOCAL	7.63(1.23)	6.53(1.50)	5.60(0.73)	5.12(1.13)
SHIMMER dB	0.75(0.08)	0.72(0.08)	0.58(0.05)	0.58(0.05)
SLOPE LTAS	-16.55(1.86)	-16.80(2.86)	-19.61(2.82)	-18.58(3.60)
TILT LTAS	-11.80(1.22)	-10.96(0.42)	-11.08(0.53)	-10.31(0.57)

Note. M- Mean, SD- Standard Deviation

Mixed ANOVA i.e. repeated measures ANOVA was done for the comparison between pre- and post- training with gender as a between-group factor i.e. to check the within-subject group effect, between-subject group effect and interaction between them.

Further, table 4 shows the F value and p value for pre- and post- training phases for all the participants.

Table 4

F value, significance across Pre- and Post-training phases for all the participants

Parameters	**F value**	**Significance Level (p)**
AVQI	37.62	0.00*
CPPs	5.87	0.02*
HNR	4.82	0.03*
SHIMMER LOCAL	13.22	0.00*
SHIMMER dB	0.52	0.47
SLOPE LTAS	0.59	0.44
TILT LTAS	19.05	0.00*

Note. *p value<0.05

From the values mentioned in the table 4, the parameters, AVQI, CPPs, HNR, Shimmer local and tilt LTAS were statistically significant ($p<0.05$), thus, showing a within subject group differences across pre- and post- vocal training phases.

Further, the F-value, significance level of between-subject variables i.e. comparison between the male and the female participants is given in table 5.

Table 5

F value and p value between male and female participants

Parameters	**F value**	**Significance level (p)**
AVQI	3.92	0.06
CPPs	1.08	0.31
HNR	61.07	0.00*
SHIMMER LOCAL	15.84	0.00*
SHIMMER dB	35.25	0.00*
SLOPE LTAS	5.29	0.03*
TILT LTAS	7.75	0.01*

Note. *p value <0.05

Based on the values listed in table 5, the parameters, HNR, Shimmer local, Shimmer dB, slope LTAS, tilt LTAS were significant statistically ($p<0.05$) between the male and the female participants.

Further, the interaction effects between gender and pre and post training phases was carried out and the results are shown in Table 6.

Table 6

F value and p value of the interaction between gender, pre- and post- training phases

Parameters	**F value**	**Significance level (p)**
AVQI	0.34	0.56
CPPs	2.82	0.10
HNR	0.11	0.73
SHIMMER LOCAL	2.03	0.16
SHIMMER dB	1.34	0.25
SLOPE LTAS	1.59	0.21
TILT LTAS	0.03	0.86

There was no significant difference ($p>0.05$) in the interaction of the gender and pre-post training phases as seen from Table 6.

Further, comparison was made to identify the differences in the parameters among each gender for pre- and post- training phases.

Table 7 lists the comparison between pre and post training for each parameter among male participants using t test.

Table 7

t and p value for pre-and post- training of male participants

Parameters	**t value**	**Significance level (p)**
AVQI	-4.76	.00*
CPPs	0.62	.54
HNR	1.47	.16
SHIMMER LOCAL	3.37	.00*
SHIMMER dB	1.26	.23
SLOPE LTAS	0.32	.75
TILT LTAS	-2.50	.02*

Note. * p value <0.05

Values from table 7 reveals that AVQI and other parameters such as Shimmer local and tilt LTAS has significant difference ($p<0.05$).

Table 8 lists the comparison between pre and post training for each parameter among female participants using t test.

Table 8

t and p value for pre-and post- training of female participants

Parameters	**t value**	**Significance level (p)**
AVQI	-3.91	0.00*
CPPs	2.55	0.02*
HNR	1.63	0.13
SHIMMER LOCAL	1.67	0.12
SHIMMER dB	-.32	0.74
SLOPE LTAS	-1.56	0.14
TILT LTAS	-4.99	0.00*

Note. * p value <0.05

Values from table 8 reveals that AVQI and other parameters such as CPPS and tilt LTAS has significant difference (p<0.05).

In general, the results indicated the following:

The main effects (between subjects and within subjects) and the interaction effects across phases and participants were determined using mixed ANOVA. Results indicated significant main effects i.e. within subject effects in the parameters such as AVQI, CPPs, HNR, Shimmer local and tilt LTAS, thus, demonstrating an impact on few parameters post vocal training.

Further, the parameters, HNR, Shimmer local, Shimmer dB, slope LTAS, tilt LTAS showed a significant difference between male and female participants. However, the interaction effects were not statistically significant.

As there were significant main effects in the gender, further investigation among each gender for pre- and post- training phases were determined using t-test, which revealed changes in the AVQI measure and few other parameters of AVQI.

CHAPTER V

DISCUSSION

The principle aim of the current study was to investigate the effects of SOVT frication exercise /v/ on voice using AVQI measurement.

The objectives of the study involved:

- To find out the long term effect of SOVT frication exercise /v/ in young phononormals using Acoustic Voice Quality Index (AVQI).
- To compare the AVQI Pre and Post frication exercise training.
- To check for gender differences, if any, and document the same.

Considering the objectives of the study, the conclusions drawn from the test results are discussed under the following subheadings:

i. Gender effects
ii. Effects of pre- and post- training in male participants
iii. Effects of pre- and post- training in female participants

i. Gender effects

On analysis of the data for male and female participants, results revealed that there were significant changes in five acoustic parameters between the male and the female participants.

The AVQI score revealed no differences between male and female participants, which is similar to the normative study done by Latoszek et al., (2019). The CPPs is measured by the distance between the first rahmonic's peak and the point on the regression line which has equal quefrency through the smoothed cepstrum also revealed no differences in the values between male and female participants, however this contradicts to the normative studies by Jayakumar et al., (2020) and Shabnam and Pushpavathi (2021) in which there was significant increase in the value of CPPs for male participants.

Harmonic to Noise Ratio provides an information regarding the the amount of additive noise in the voice signal which occurs due to the turbulent airflow generated at the level of glottis was found to be greater for female participants than the male participants which can be attributed to the physiological and structural variations, and is in accordance to the previous studies (Benoy et al., 2017 and Shabnam, & Pushpavathi, 2021).

In studies conducted by Jayakumar et al., (2020) and Shabnam, et al., (2021) to establish normative data on phononormal population, Shimmer dB and tilt LTAS were found to be more for male participants than female participants. Likewise, similar results were obtained for Shimmer dB and tilt LTAS in the current study.

Shimmer local was found to be more for male than female participants and is in contradiction to results of Jayakumar et al. in 2020, who reported that there were no changes in Shimmer local between male and female participants. In addition, slope LTAS showed increased values for female participants than male participants which contradicts to the study by Shabnam et al., (2021) who reported that there were no gender differences. These differences in the results may be attributed to the total number of participants considered for the current study.

ii. Pre- and post- effects in male participants

In male participants, the values of AVQI has significantly increased post vocal training phase.

This increase in the AVQI value (Mean=4.25, SD=0.55) can be attributed to the change in the glottal adductory forces after the vocal training. Similarly, in a study which implemented SOVT exercises (water-resistance and straw phonation exercise) on individuals with dysphonia, findings revealed the value of AVQI increased post treatment but was not statistically significant. Thus, revealing no change in AVQI post SOVT treatment (Meerschman et al., 2019).

However, Shimmer local (Mean=6.53, SD=1.50) reduced in its value showing a positive impact of the fricative exercise on voice. Similar findings were reported by Meerschman et al. (2017) who implemented SOVT exercises (nasal consonants and straw phonation) on 30 speech language pathologist for a period of 6 weeks.

Further, there were no significant changes in the other parameters of voice such as CPPs, Shimmer dB, Shimmer local, HNR, Harmonic to noise ratio, Shimmer dB and slope Long Term Average Spectrum. This lack of change might be attributed to the small sample size or the relatively short treatment period.

In the current study, Tilt LTAS reduced (Mean= -10.96, SD=0.42) post- treatment which is contradictory to the finding of Meerschman et al. (2017). This differences in the outcome of the current study to that of any previous studies can be attributed to the physiological differences among the SOVT training exercises chosen (Maxfield et al., 2015).

From a physiological point of view, Laukennen (1992) revealed that the increased occlusion force during the production of the fricative /b:/ for the vocal training had an impact on the glottal activity. Thus, the force of the occlusion at the anterior area of the vocal tract and the sound pressure level during the vocal training phases of the /v/ fricative might also be one of the reasons for such changes in the AVQI parameters.

iii. Pre- and post- effects in female participants

In female participants, the value of AVQI (Mean=3.78, SD=0.46) has significantly increased by approximately 0.52 post vocal training phase. This increase in the AVQI value can be attributed to the change of the glottal adductory forces after the vocal training. However, studies reveal that when using AVQI as a follow-up tool, the difference between two AVQI scores has to be a minimum of 0.54 to be considered as an absolute change in voice quality and not attributed to any measurement or test-retest variability error (Barsties & Maryn, 2013).

The CPPs, which is considered as the smoothed version of the Cepstral peak prominence contributes majorly in the AVQI value, it is the distance measured between the first rahmonic's peak and the exact point on the regression line which has equal quefrency through the smoothed cepstrum. The more periodicity in the voice signal, higher would be the value of CPPs. In the current study, results reveal that the CPPS (Mean=12.71, SD=0.62) and tilt LTAS (Mean= -10.31, SD=0.57) reduced after the training, which contradicts to the findings reported in the study by Meerschman, et al. (2017). These changes in the acoustic parameters of voice could be attributed to the occlusive effort in the production of the fricative /v/ produced by the participants during the vocal training (Laukennen, 1992).

Further, there were no significant changes in the other parameter of voice such as Harmonic to noise ratio, Shimmer dB, Shimmer local and slope Long Term Average Spectrum. This lack of change can be attributed to the small sample size or the relatively short treatment period.

In summary, the SOVT frication exercise /v/ for a period of 21 days has had an impact on the acoustic parameter of voice such as increase in AVQI score, reduced CPPS and tilt LTAS, which can be attributed to the increased occlusive effort taken by the participants during the /v/ production. Further, there was a decrease in the Shimmer local values, suggesting stability in the vocal fold movements. These changes in the parameters can be attributed to the adjustments in the physiology of the vocal musculatures after the SOVT frication training.

CHAPTER VI

SUMMARY AND CONCLUSION

Various Evidence Based Treatment protocols established in the arena of voice rehabilitation focuses on implementing efficient voice usage and economic vocal output. Semi-occluded vocal tract exercises (SOVT) among these protocols have been used predominantly as a warm up strategy and therapeutic tools in clinical voice disorders. SOVT exercises involve tasks with the use of materials such as straws, cup and tasks without the use of materials such as lip/tongue trills, fricatives, nasal consonants and vowels. However, the target of all these SOVT exercises focuses on creating a narrow vocal tract near the lips or tongue tip, thus matching the impedance between the vocal folds and the supraglottic regions. During this activity, there is a fluctuation in the intraoral pressure, which is different for each SOVT exercise. This fluctuation in the intraoral pressure due to the combined vibration at the level of vocal folds as well as the vibration at the distal end of the vocal tract, imparts a massage like effect on the laryngeal musculatures. Usage of the voiced fricative /v/ is one such treatment aspect which emphasizes on reducing the phonatory stress by creating a direct impact on the physiological functioning of the vocal fold. Wherein the fricative /v/ has a change in the intra oral pressure of approximately being 0.429 Kpa in males and 0.344 Kpa in females as per evidence from literature.

Further, for the purpose of measuring the treatment outcome as a part of evidence based practice, enormous assessment procedures and parameters are utilised. However, there is a current trend in the use of multiparametric acoustic voice evaluation, which has led to the usage of a linear regression model of voice parametric tool named Acoustic Voice Quality Index (AVQI). AVQI is a multivariate 6 factor analysis model developed by Maryn et al., (2010), which provides a severity index for concatenated sample of sustained vowel and phonation task in range of 0-10. However, the role of AVQI on post behavioral voice treatments, especially using SOVT exercises is less researched.

The aim of the current study focussed on determining the effects of 21 days of SOVT frication exercise- /v/ on voice and documenting the changes using AVQI measurement. The participants of the study included a total of 24 young adult male and female participants in the age range of 20-30 years. The baseline recording of the sustained vowel phonation and continuous speech was obtained one day prior to the onset of the treatment protocol of 21 days. All the participants completed approximately 15 minutes each of SOVTE fricative exercise of /v/ twice a day continuously for 21 days. The participants were instructed on the details of the exercise and were reminded regularly on a daily basis through calls and WhatsApp messages. Computerised Speech Lab (CSL) 4500 model (KAY PENTAX, New Jersey, USA) was used for audio recording of the stimuli of all the participants and Praat (version 6.1.16) software was utilized for analysis of the recorded data for both pre- and post- training phases recordings. Statistical analysis using the Mixed ANOVA and paired t- test were done. Results revealed differences in slope LTAS, tilt LTAS, HNR, Shimmer dB and Shimmer local between male and female participants in general. Pre- and post- training revealed increased AVQI value for both male and female participants, reduced values of CPPs in female participants, reduced Shimmer Local for male participants and reduced tilt LTAS for male and female participants. Few hypotheses for the lack of progress in few parameters are possible such as 3 weeks of practice might be too short to experience a change by the participants, possible increased occlusive effort taken by the participants during the fricative /v/ training or possible difficulty of the participants in projecting the skills and modulating it in a vocally demanding tasks such as speech.

Clinical Implication of the study

- The current study provides a basis to the literature of long term effects of using fricative /v/ for the vocal exercise and its impact on the vocal functioning.
- It is to be considered as a novel study which has involved the usage of the fricative /v/ as a long term vocal treatment approach.
- The current study provides an insight and evidence regarding the impact of the SOVT frication exercise /v/ on the multidimensional acoustic parameter AVQI.
- The current study also reinforces the findings of other relevant studies involving various tasks of SOVT exercises such as improvement in Shimmer parameter of voice after 21 days of vocal training.

Limitations and future directions of the study

- Direct monitoring of the participants for the fricative /v/ training or possible difficulty in using the technique could not be done and such measures may have influenced the findings of the study.
- The study consisted of smaller sample size of 24 participants, thus, replicating the same in a larger population would create a support to the findings.
- Understanding the impact in the vocal folds during the frication exercise versus other SOVT exercises using electroglottographic measure would provide another dimensional view to speculate the change in vocal physiology.

REFERENCES

Alves, M., Krüger, E., Pillay, B., Van Lierde, K., & Van der Linde, J. (2019). The effect of hydration on voice quality in adults: a systematic review. *Journal of Voice*, *33*(1), 125-e13.

American Speech-Language-Hearing Association. (2004). Evidence-based practice in communication disorders: An introduction. https://www.asha.org/policy/TR2004-00001/

Andrade, P. A., Wood, G., Ratcliffe, P., Epstein, R., Pijper, A., & Svec, J. G. (2014). Electroglottographic study of seven semi-occluded exercises: LaxVox, straw, lip-trill, tongue-trill, humming, hand-over-mouth, and tongue-trill combined with hand-over-mouth. *Journal of Voice*, *28*(5), 589-595. https://doi.org/10.1016/j.jvoice.2013.11.004

Aronson, A. E., & Bless, D. M. (2009). *Clinical voice disorders* (4th ed). *Thieme*.

Barsties, B., & Maryn, Y. (2013). Test-retest-variabilität und interne konsistenz des acoustic voice quality index. *Hno*, *61*(5), 399-403. https://doi.org/10.1007/S00106-012-2649-0

Barsties, B., & Maryn, Y. (2015). The improvement of internal consistency of the Acoustic Voice Quality Index. *American Journal of Otolaryngology, 36*(5), 647-656. https://doi.org/10.1016/j.amjoto.2015.04.012

Benoy, J. J., & Jayakumar, T. (2017). Acoustic Voice Quality Index (AVQI) and Perceptual Measures in Indian Population (Unpublished Master’s Dissertation), University of Mysore, Mysuru.

Boone, D. R., McFarlane, S. C., Von Berg, S. L., & Zraick, R. I. (2014). *The Voice and Voice Therapy* (9th ed.). Pearson.

Boersma, P. (2019). Praat, a system for doing phonetics by computer [Computer program]. Version 6.1.16, retrieved 20 June 2020 from http://www.praat.org/

Chan, R. W., & Titze, I. R. (2006). Dependence of phonation threshold pressure on vocal tract acoustics and vocal fold tissue mechanics. *The Journal of the Acoustical Society of America*, *119*(4), 2351-2362. https://doi.org/10.1121/1.2173516

Cielo, C. A., Lima, J. P. D. M., Christmann, M. K., & Brum, R. (2013). Semioccluded vocal tract exercises: literature review. *Revista CEFAC, 15(6)*, 1679-1689. https://doi.org/10.1590/S1516-18462013005000041

Croake, D. J., Andreatta, R. D., & Stemple, J. C. (2017). Immediate effects of the vocal function exercises semi-occluded mouth posture on glottal airflow parameters: a preliminary study. *Journal of Voice*, *31*(2), 245-e9. https://doi.org/10.1016/j.jvoice.2016.08.009

Dodderi, T., Philip, N. E., & Mutum, K. (2018). Prevalence of voice disorders in the Department of Speech-Language Pathology of a tertiary care hospital of Mangaluru: A retrospective study of 11 years. *Journal of Health and Allied Sciences NU*, *8*(03), 012-016. https://doi.org/10.1055/S-0040-1708757

Fairbanks, G. (1960). *Voice and articulation drillbook* (2nd ed.). Addison-Wesley Educational Publishers.

Fant, G. (1970). *Acoustic theory of speech production* (1st ed.). Mouton Publishers.

Hirano, M. (1981). *Clinical Examination of Voice* (1st ed.). Springer-Verlag.

Jayakumar, T., Benoy, J. J., & Yasin, H. M. (2020). Effect of Age and Gender on Acoustic Voice Quality Index Across Lifespan: A Cross-sectional Study in Indian Population. *Journal of Voice*. Advance online publication. https://doi.org/10.1016/j.jvoice.2020.05.025

Kaneko, M., Sugiyama, Y., Mukudai, S., & Hirano, S. (2020). Effect of voice therapy using semioccluded vocal tract exercises in singers and nonsingers with dysphonia. *Journal of Voice*, *34*(6), 963-e1. https://doi.org/10.1016/j.jvoice.2019.06.014

Kempster, G. B., Gerratt, B. R., Abbott, K. V., Barkmeier-Kraemer, J., & Hillman, R. E. (2009). Consensus auditory-perceptual evaluation of voice: Development of a standardized clinical protocol. *American Journal of Speech-Language Pathology*, *18*(2), 124–132. https://doi.org/10.1044/1058-0360(2008/08-0017)

Kim, J. S., Lee, D. W., Choi, C. H., Choi, S. H., Kim, J. S., Lee, D. W., ... & Choi, S. H. (2017). Effects of laryngeal massage and semi-occluded vocal tract exercises for patients with hyperfunctional dysphonia. *Communication Sciences & Disorders*, *22*(4), 806-817. https://doi.org/10.12963/csd.17434

Latoszek, B. B. V., Ulozaitė-Stanienė, N., Maryn, Y., Petrauskas, T., & Uloza, V. (2019). The influence of gender and age on the acoustic voice quality index and dysphonia severity index: a normative study. *Journal of Voice*, *33*(3), 340-345. https://doi.org/10.1016/j.jvoice.2019.06.014

Laukkanen, A. M. (1992). Voiced bilabial fricative/ß:/as a vocal exercise: an electroglottographic and acoustic investigation. *Scandinavian Journal of Logopedics and Phoniatrics*, 17(3-4), 181-189. https://doi.org/10.3109/14015439209098736

Laukkanen, A. M., Lindholm, P., Vilkman, E., Haataja, K., & Alku, P. (1996). A physiological and acoustic study on voiced bilabial fricative/β:/as a vocal exercise. *Journal of Voice*, *10*(1), 67-77. https://www.sciencedirect.com/science/article/pii/S0892199796800208

Laver, J. (1991). *The gift of speech* (1st ed.). Edinburgh University Press.

Lyberg-Åhlander, V., Rydell, R., Fredlund, P., Magnusson, C., & Wilén, S. (2019). Prevalence of voice disorders in the general population, based on the Stockholm public health cohort. *Journal of Voice*, *33*(6), 900-905. https://doi.org/10.1016/j.jvoice.2018.07.007

Maryn, Y. (2010). Acoustic measurement of overall voice quality in sustained vowels and continuous speech. (Unpublished Doctoral Dissertation) Ghent University, Ghent. https://biblio.ugent.be/publication/888156

Maryn, Y., & Weenink, D. (2015). Objective dysphonia measures in the program Praat: smoothed cepstral peak prominence and acoustic voice quality index. *Journal of Voice*, *29*(1), 35-43. https://doi.org/10.1016/j.jvoice.2014.06.015

Maryn, Y., Corthals, P., Van Cauwenberge, P., Roy, N., & De Bodt, M. (2010). Toward improved ecological validity in the acoustic measurement of overall voice quality: combining continuous speech and sustained vowels. *Journal of voice*, *24*(5), 540-555. https://doi.org/10.1016/j.jvoice.2014.06.015

Maryn, Y., De Bodt, M., & Roy, N. (2010). The Acoustic Voice Quality Index: toward improved treatment outcomes assessment in voice disorders. *Journal of* *communication disorders*, *43*(3), 161-174. https://doi.org/10.1016/j.jcomdis.2009.12.004

Maryn, Y., De Bodt, M., Barsties, B., & Roy, N. (2014). The value of the Acoustic Voice Quality Index as a measure of dysphonia severity in subjects speaking different languages. *European Archives of Oto-Rhino-Laryngology*, *271*(6), 1609-1619. https://doi.org/10.1007/s00405-013-2730-7

Maxfield, L., Titze, I., Hunter, E., & Kapsner-Smith, M. (2015). Intraoral pressures produced by thirteen semi-occluded vocal tract gestures. *Logopedics Phoniatrics Vocology*, *40*(2), 86-92. https://doi.org/10.3109/14015439.2014.913074

Meerschman, I., Van Lierde, K., Ketels, J., Coppieters, C., Claeys, S., & D'haeseleer, E. (2019). Effect of three semi-occluded vocal tract therapy programmes on the phonation of patients with dysphonia: lip trill, water-resistance therapy and straw phonation. *International journal of language & communication disorders*, *54*(1), 50-61. https://doi.org/10.1111/1460-6984.12431

Meerschman, I., Van Lierde, K., Peeters, K., Meersman, E., Claeys, S., & D'haeseleer, E. (2017). Short-term effect of two semi-occluded vocal tract training programs on the vocal quality of future occupational voice users: "Resonant Voice Training Using Nasal Consonants" Versus "Straw Phonation". *Journal of Speech, Language, and Hearing Research*, *60*(9), 2519-2536. https://doi.org/10.1044/2017_JSLHR-S-17-0017

Menezes, M. H., Ubrig-Zancanella, M. T., Cunha, M. G. B., Cordeiro, G. F., Nemr, K., & Tsuji, D. H. (2011). The relationship between tongue trill performance duration and vocal changes in dysphonic women. *Journal of Voice*, *25*(4), e167-e175. https://doi.org/10.1016/j.jvoice.2010.03.009

Menon, U. K., Raj, M., Antony, L., Soman, S., & Bhaskaran, R. (2019). Prevalence of voice disorders in school teachers in a district in South India. *Journal of Voice*, 35(4), 1-8. https://doi.org/10.1016/j.jvoice.2019.07.005

Nemr, K., Simoes-Zenari, M., Cordeiro, G. F., Tsuji, D., Ogawa, A. I., Ubrig, M. T., & Menezes, M. H. M. (2012). GRBAS and Cape-V scales: high reliability and consensus when applied at different times. *Journal of Voice*, *26*(6), 812-e17. https://doi.org/10.1016/j.jvoice.2012.03.005

Oates, J. (2009). Auditory-perceptual evaluation of disordered voice quality. *Folia Phoniatrica et Logopaedica*, *61*(1), 49-56. https://doi.org/10.1159/000200768

Pavela Banai, I. (2017). Voice in different phases of menstrual cycle among naturally cycling women and users of hormonal contraceptives. *PLoS One*, *12*(8), e0183462. https://doi.org/10.1371/journal.pone.0183462

Pestana, P. M., Vaz-Freitas, S., & Manso, M. C. (2017). Prevalence of voice disorders in singers: systematic review and meta-analysis. *Journal of voice*, *31*(6), 722-727. https://doi.org/10.1016/j.jvoice.2017.02.010

Reynolds, V., Buckland, A., Bailey, J., Lipscombe, J., Nathan, E., Vijayasekaran, S., ... & French, N. (2012). Objective assessment of pediatric voice disorders with the acoustic voice quality index. *Journal of Voice*, *26*(5), 672-e1. https://doi.org/10.1016/j.jvoice.2012.02.002

Ribeiro, V. V., de Oliveira, A. G., da Silva Vitor, J., Ramos, A. C., Brasolotto, A. G., & Silverio, K. C. A. (2019). Effectiveness of voice therapy associated with electromyographic biofeedback in women with behavioral dysphonia: randomized placebo-controlled double-blind clinical trial. *Journal of Voice*, *33*(3), 381-e11. https://doi.org/10.1016/j.jvoice.2017.12.015

Roy, N., Merrill, R. M., Gray, S. D., & Smith, E. M. (2005). Voice disorders in the general population: prevalence, risk factors, and occupational impact. *The Laryngoscope*, *115*(11), 1988-1995. https://doi.org/10.1097/01.mlg.0000179174.32345.41

Ryan, E. B., Giles, H., & Sebastian, R. J. (1982). An integrative perspective for the study of attitudes toward language variation. *Attitudes towards language variation: Social and applied contexts,* 1, 19.

Sampaio, M., Oliveira, G., & Behlau, M. (2008). Investigation of the immediate effects of two semi-ocluded vocal tract exercises. *Pró-Fono Revista de Atualização Científica*, *20*, 261-266. https://doi.org/10.1590/s0104-56872008000400010

Shabnam, S., & Pushpavathi, M. (2021). Effect of Gender on Acoustic Voice Quality Index 02.03 and Dysphonia Severity Index in Indian Normophonic Adults. *Indian Journal of Otolaryngology and Head & Neck Surgery*, *73*, 1–8. https://doi.org/10.1007/s12070-021-02712-8

Sheyona, V., & Devadas, U. (2020). The Prevalence and Impact of Voice Problems in Nonprofessional Voice Users: Preliminary Findings. *Journal of Voice*. Advance online publication. https://doi.org/10.1016/j.jvoice.2020.06.010

Stemple, J. C., Lee, L., D'Amico, B., & Pickup, B. (1994). Efficacy of vocal function exercises as a method of improving voice production. *Journal of voice, 8*(3), 271-278. https://doi.org/10.1016/S0892-1997(05)80299-1

Thomas, G., de Jong, F. I., Cremers, C. W., & Kooijman, P. G. (2006). Prevalence of voice complaints, risk factors and impact of voice problems in female student teachers. *Folia phoniatrica et logopaedica*, *58*(2), 65-84. https://doi.org/10.1159/000089609

Titze, I. (2006). Voice training and therapy with a semi-occluded vocal tract: rationale and scientific underpinnings. *Journal of Speech, Language and Hearing Research*. 49(2),448-459. https://doi.org/10.1044/1092-4388(2006/035)

Titze, I. (2018). Major benefits of semi-occluded vocal tract exercises. *Journal of Singing*, *74*(3), 311-312.

Titze, I.R. (2001). Acoustic interpretation of resonant voice. *Journal of Voice*, 15(4), 519–528. doi:10.1016/S0892-1997(01)00052-2.

Vishali, P & Rajasudhakar. (2019). Acoustic Voice Quality Index (AVQI) in Tamil Language (Unpublished Master's Dissertation), University of Mysore, Mysuru.

Wilson, D. K. (1987). *Voice problems in children* (3rd ed.). Williams & Wilkins Publishers.

Wuyts, F. L., Bodt, M. S. D., Molenberghs, G., Remacle, M., Heylen, L., Millet, B., .& Heyning, P. H. V. D. (2000). The dysphonia severity index: an objective measure of vocal quality based on a multiparameter approach. *Journal of speech, language, and hearing research*, *43*(3), 796-809. https://doi.org/10.1044/jslhr.4303.796

Yiu, E. M. L., Lo, M. C., & Barrett, E. A. (2017). A systematic review of resonant voice therapy. *International journal of speech-language pathology*, *19*(1), 17-29. https://doi.org/10.1080/17549507.2016.1226953

APPENDIX A

अखिल भारतीय वाक् श्रवण संस्थान, मैसूरू - 570 006
ALL INDIA INSTITUTE OF SPEECH & HEARING: MYSORE – 6
वाक् भाषा विज्ञान विभाग/ DEPARTMENT OF SPEECH-LANGUAGE SCIENCES

<u>Informed Consent Form for Dissertation Data Collection</u>

Title: Acoustic Voice Quality Index in Young Phononormals using SOVT-Frication Exercise: Comparison of Pre-Post Training

Guide: डॉ. के. येशोदा / Dr. K. Yeshoda
एसोसिएट प्रोफेसर इन स्पीच साइंसेज / Associate Professor in Speech Sciences

Candidate: Sri Ranjani V (Reg. No: 19SLP029) II MSc (SLP), AIISH

I do hereby give consent to participate in the study titled "***Acoustic Voice Quality Index in Young Phononormals using SOVT- Frication Exercise: Comparison of Pre-Post Training***". I have been briefed about the purpose of the study which is as follows, *to investigate the effects of SOVT frication exercise on voice using AVQI measurement.*

I express my whole hearted consent to participate. I have also been informed about the approximate time of testing and understand that the procedure is purely unharming with research benefits only. I agree to cooperate with the investigator in this study and for the project/official communication in journals/magazines/newsletter and research purposes.

Furthermore, I have been assured that there will not be any financial commitment on my part during the course of this study. It has been further stated that my identity as a participant in this study will be strictly confidential and will not be divulged without my express consent.

Having read the above, I express my voluntary consent for my participation in this study.

Sl. No.	Name and address with phone #	Signature with date

APPENDIX B

Acoustic Voice Quality Index in young phononormals using SOVT- Frication exercise: comparison of pre-post training

LOG SHEET

Name: **Date of commencement:**

Trails	/v/ sustenance				Pitch glide of /v/ low to high and high to low										Happy birthday using /v/			
	1	2	3	4	1	2	3	4	5	6	7	8	9	10	1	2	3	4
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Day 3																		
Day 4																		
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