IMMEDIATE EFFECTS OF LARYNGEAL MANUAL THERAPY ON VOICE QUALITY IN INDIVIDUALS WITH MUSCLE TENSION DYSPHONIA

HIMA NAIR

Register No: 17SLP011

A Dissertation submitted in part fulfilment of degree of

Master of Science (Speech-Language Pathology)

University of Mysore, Mysuru

ALL INDIA INSTITUTE OF SPEECH AND HEARING

MANASAGANGOTHRI

MYSURU - 570006

MAY 2019

CERTIFICATE

This is to certify that this dissertation entitled "***Immediate Effects of Laryngeal Manual Therapy on Voice Quality in Individuals with Muscle Tension Dysphonia***" is a bonafide work submitted in part fulfillment for the degree of Master of Science (Speech-Language Pathology) of the student Registration Number: 17SLP011. 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 the award of any other Diploma or Degree.

Mysuru

May 2019

Dr. M. Pushpavathi

Director

All India Institute of Speech and Hearing

Manasagangothri, Mysuru-570006

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Mysuru

May 2019

Dr. Pebbili Gopikishore

Guide

Assistant Professor in Speech Pathology

All India Institute of Speech and Hearing

Manasagangothri, Mysuru-570006

DECLARATION

This is to certify that this dissertation entitled "***Immediate Effects of Laryngeal Manual Therapy on Voice Quality in Individuals with Muscle Tension Dysphonia***" is the result of my own study under the guidance of Dr. Pebbili Gopikishore, Assistant Professor in Speech Pathology, Department of Speech Language Pathology, All India Institute of Speech and Hearing, Mysuru, and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysuru Registration No. 17SLP011

May 2019

Acknowledgment

First and foremost I would like to express my sincere thanks to the Almighty for the life and opportunity he had given me to choose this field and serve the needy.

I would express my sincere gratitude to Dr. M Pushpavathi (Director) for permitting me to conduct my dissertation.

Next, I would like to thank my guide Dr.Pebbili Gopikishore. Without him, my dissertation would not have been possible. He took great efforts to motivate me to reach greater heights. He guided my work to be excellent without considering the time factor.

My grandparents and parents extended their fullest support to realize my ambition.

And also I would like to extend my thanks to Dr.Vasanthalakshmi, Dr.Santhosha, and Dr.Shijith Kumar for their valuable inputs.

Last but not the least, my friends were the greater walls of support whenever I was in tight corner.

My thanks to all the individuals who co-operated and participated in my study.

In short I thank all my well wishers who helped me in achieving success.

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CHAPTER I

INTRODUCTION

Vocal Hyperfunction is one of the most prevalent disorders of the voice. Vocal hyperfunction is a condition in which an individual's laryngeal muscles exhibit increased muscle contraction n(Morrison & Rammage, 1993). Individuals with this issue tend to also use extrinsic laryngeal muscles as well as superficial neck muscle in a very similar manner. One such disorder exhibiting vocal hyperfunction is Muscle tension dysphonia (MTD), a "functional voice disorder" where there is excess or dysregulated muscle activity causes a forced, laborious voice quality and this increased tension occurs in the absence of any structural changes to the vocal fold or any neurogenic disease of the larynx. MTD is a condition where "the excessive muscular tension in laryngeal and perilaryngeal areas or muscle misuse is associated with phonation. Various synonyms have been used for this entity like hyperkinetic dysphonia, musculoskeletal tension dysphonia, hyperfunctional dysphonia, mechanical voice disorder, functional hypertensive dysphonia, muscle misuse dysphonia, laryngeal isometric dysphonia, laryngeal-tension fatigue syndrome" (Morrison, Nichol & Rammage, 1986).

Several causative factors may account for the presence of excessive musculoskeletal tension which is as follows: Psychological or personality factors may cause tension. According to Aronson (1990), factors such as 'anxiety, anger, irritability, impatience, frustration, and depression' may be responsible for hypercontraction. 1) Psychological distress contributes to responses in the nervous system that leads to hypertonicity of the voluntary musculature (Morrison & Rammage, 1993). 2) Technical misuse of the vocal mechanism, particularly extensive and extraordinary vocal commands may lead to the development of excessive musculoskeletal tension and MTD (Morrison & Rammage, 1993). The poor technical use of the phonatory mechanism may include factors such as lack of coordination between respiratory, phonatory, resonatory and articulatory gestures, extreme or insufficient laryngeal valving; improper control of pitch or loudness (Morrison & Rammage, 1993). 3) Excessive musculoskeletal tension may be a learned adaptation after infection in the upper respiratory tract or other physiological triggers such as gastroesophageal reflux disease, allergic reactions and asthma (Morrison & Rammage, 1993; Roy, Ford & Bless, 1996) and 4) Excessive musculoskeletal tension may be a compensatory adaptation for some underlying organic or neurologically based dysfunction (e.g., vocal fold lesions, vocal fold paralysis or paresis) (Roy et al., 1996).

The characteristics of MTD include insidious musculoskeletal tension which may be the cause of the voice disorder (Morrison & Rammage, 1993; Roy et al., 1996). Participants with MTD tend to have secondary pathological conditions generally associated with vocal hyperfunction and abuse (nodules, polyps, etc) (Morrison & Rammage, 1993). Persons exhibiting muscle tension can show signs of excessive muscle activity in the head or neck. Their responses on case history forms often relate to the occurrence of stress, anxiety, depression, and high vocal demand, accompanying general complaints of being overloaded both physically and emotionally. Other characteristics consistent with MTD may be head or hand tremors, abnormal breathing patterns, visible tightness in the neck or jaw region, abnormal facial expression and gaze, and inconsistency of voice characteristics (Stemple, 1993). Dietrich, Verdolini Abbott, Gartnner-Schmidt and Rosen (2008) cited depression and stress as two most common features in participants with MTD seeking care in their voice clinic.

Expected vocal profile in individuals with MTD includes hoarseness as a chief symptom, with other features such as breathiness and harshness of voice. The frequent hard glottal attack is a common feature with the majority of vowels that occur initially in words being produced with forced onset. Low pitched voice with muffled throaty quality reflects false vocal fold approximation. Pitch breaks occur in MTD, particularly when the speaker attempts to increase loudness, as the result of increased vocal fold tension. Voiceless segments may also be present, particularly when higher vocal notes occur in speech or singing and this is accompanied by delayed VOT. Muscle tension results in fatigue hence vocal stamina is reduced and the vocal notes tend to be unstable (Morrison et al., 1986).

Muscle tension dysphonia can be diagnosed based on the examination by an Otolaryngologist/ Phonosurgeon and a Speech-language pathologist. An Otolaryngologist/ Phonosurgeon's examination would include a videolaryngoscopy or videostroboscopy. Voice evaluation by Speech-language pathologist includes the case history, oral peripheral examination; qualitative measurement of the respiratory system, phonatory system, resonatory system and quantitative measures like aerodynamic measures, acoustic measures. In addition, various clinical, radiological, and electromyographical assessment methods have been used to measure laryngeal muscular tension in individuals with MTD. The commonly used methods for assessment and treatment of MTD in voice clinics includes case history, observational techniques, and palpation. The radiography as well as the sEMGcan also be used as an assessment methods to diagnose MTD. Through assessment of muscle activity using sEMG one can obtain the neurophysiological data for quantifying the degree of MTD.

The voice therapy for MTD includes the therapist working on various aspects such as 'posture, breathing, phonation, articulation and working on muscle tension', by using laryngeal maneuvers. The voice therapy and vocal hygiene works hand in hand in the management of MTD. Vocal hygiene is to eliminate the vocal misuse or abuse by the individual whereas voice therapy would work on reversing the factors causing the tension and letting the individual use the normal physiology as used earlier. Hence the voice therapy would let the individual using overcompensation or decompensation to overcome it and prevent organic lesions associated with abnormal voice usage (Van Houtte, Van Lierde, & Claeys, 2011). The voice therapy for MTD includes the clinician working on the individuals voice by improving the posture, regulating the breathing pattern, relaxation technique to decrease the tension around the shoulder and neck, particular vocal exercises designed to distribute the workload to the specific muscles, and laryngeal maneuver to lower the tension in and around the laryngeal muscles (Van Houtte et al., 2011)

Need of the study

The abnormally elevated muscle tension being the etiology and major clinical feature in MTD, several studies have been conducted to verify the efficacy of voice therapy approaches that target at the relaxation of the laryngeal muscles. Among the relaxation approaches, laryngeal manual therapy has been consistently revealed to be an effective approach. However, the generalization of the findings of these studies is confined due to several of the methodological issues. The studies reported had not utilized the LMT in unison and has been used in combination with several other approaches in an eclectic manner making it challenging to attribute the outcomes to the LMT. Further, the generalization is questionable owing to the accuracy of the outcome measures used in these studies. For instance, Roy et al. (1996), Roy, Bless, Heisey and Ford (1997) and Mathieson, Hirani, Epstein, Baken, Wood and Rubin (2009) used the LMT approach in unison in individuals with MTD, however, the outcome measures were restricted to perturbations, formants, and perceptual scales. The multiparametric measures such as acoustic voice quality index have been shown to be superior to that of single parameters in documenting the therapeutic outcomes. Therefore, considering the dearth of studies investigating the efficacy of LMT in individuals with MTD using robust outcome measures, the current study is taken up with the aim of documenting the immediate effects of LMT on Acoustic voice quality index (AVQI) value in individuals with MTD.

Aim of the Study: The present study was taken up to investigate the immediate effects of laryngeal manual therapy on voice quality in individuals with muscle tension dysphonia.

Objective of the study

1. To document the AVQI in individuals with muscle tension dysphonia.
2. To investigate the immediate effects of laryngeal manual therapy on voice quality in individuals with muscle tension dysphonia as observed on AVQI.

CHAPTER II

REVIEW OF LITERATURE

The primary objective of voice therapy in individuals with MTD is to reduce the habitual patterns of tensed voice usage and facilitate the coordination among the subsystems of voice production. Various voice intervention techniques have been reported in the literature. Some of the widely investigated approaches for the management of MTD include the Semi-Occluded Vocal Tract exercises (SOVT)(Guzman et al.,2016) , nasal and frequency modulations (Verdolini, Burke, Lessac, Glaze, & Caldwell,1995), Vocal Function Exercises (Stemple, 2000), Respiratory exercises along with phonoarticulatory method (Liang et al., 2014) and different forms of manual therapy (Aronson,1990; Roy & Leeper, 1993; Roy et al., 1996; Mathieson et al., 2009).

The SOVT exercises involve phonation with a narrowing at supraglottic point along the vocal tract. This narrowing is assumed to facilitate interaction between vocal fold vibration (sound production) and the vocal tract (the sound filter), and to produce resonant voice. Various activities involving the semi-occluded vocal tract such as lip trills, tongue trills, straw phonation are used for this purpose. Guzman et al. (2016) investigated the effect of phonation into tubes submerged in water and tubes in air. They investigated the air pressure variables and vocal fold adduction in individuals with different voice conditions. Forty-five participants with four different vocal conditions were included for this study: individuals diagnosed with normal voice and without voice training, individuals with normal voice with voice training, individuals with muscle tension dysphonia, and individuals with unilateral vocal fold paralysis. Participants phonated into different kinds of tubes (drinking straw, 5 mm in inner diameter; stirring straw, 2.7 mm in inner diameter; silicon tube, 10 mm in inner diameter) with the free end in air and in water. Aerodynamic, acoustic, and electroglottographic signals were captured simultaneously. Mean values of the glottal contact quotient (CQ) measured by electroglottograph, fundamental frequency, subglottic pressure (Psub), oral pressure (Poral), and transglottal pressure were considered. The investigation revealed that all exercises had a significant effect on Psub, Poral, transglottal pressure, and CQ ($p < 0.05$). Phonation into a 55-cm silicon tube submerged 10 cm in water and phonation into a stirring straw resulted in the highest values for CQ, Psub, and Poral were compared with baseline for all vocal status. Poral and Psub correlated positively. Authors concluded that most variables improved with SOVT regardless of the vocal status of the participants. This implies the importance of proper instructions in voice therapy, as the expectations of therapy outcome naturally are different for individuals with different types of voice disorders.

Another approach reported in the literature for the management of MTD is nasal and frequency sound modulation. The resonant voice is a 'continuum of oral sensations and easy phonation building from basic speech gestures through conversational speech'. The therapy goal is to achieve the strongest, "cleanest" possible voice with least effort and impact between the vocal folds to minimize the likelihood of injury and maximize the likelihood of vocal health. The individual with dysphonia is constantly instructed to monitor the "feel" and to concentrate on the auditory feedback. In the study by Ogawa, Hosokawa, Yoshida, Iwahashi, Hashim, and Inohara (2014), the immediate effects of humming and subsequent um-hum phonation were investigated on the computed parameters of electroglottographic (EGG) signals in 21 individuals with MTD and 20 phononormic individuals. Acoustic and EGG signals were recorded while the participants performed humming with and without gliding. The perceptual analysis was performed by three laryngologists using the GRBAS rating scale. The MTD group showed a decrease in both perceptual vocal roughness and acoustic perturbation parameters following both the humming tasks. The perturbation parameters of EGG signals and the standard deviation of the contact quotient (CQ) also exhibited significant decreases associated with either of humming or um-hum phonation in both groups. The CQ exhibited significant increases following humming alone in the MTD group and the combination of humming and um-hum phonation in both groups. The authors opined that the combination of humming without pitch changes and subsequent um-hum phonation have the immediate effect in adjusting the regularity of vocal fold vibration and augmenting the degree of glottal contact in individuals with MTD participants as well as phononormic speakers whereas, humming alone increased the degree of glottal contact in individuals with MTD.

Vocal Function Exercises (VFE) is a physiological voice therapy approach reported in the literature for the management of MTD. It consists of a series of systematic voice exercises designed to strengthen and balance the laryngeal musculature, improve vocal fold adduction, and coordinate the subsystems of voice production. Nguyen and Kenny (2009) evaluated the treatment effects of vocal function exercises on muscle tension dysphonia (MTD). The study included forty female primary school teachers from Northern Vietnam, diagnosed with MTD. They were randomly allocated into a treatment group (n=22), which used a full vocal exercise protocol (FE) and a control group (n=18) which was treated with a partial vocal exercise protocol (PE). The treatment duration was for two 20 minute sessions per week for four weeks for both the groups. Acoustic and perceptual data were used as primary outcome measures. Acoustic parameters included were frequency and amplitude perturbation, the harmonics-to-noise ratio (HNR), the mean fundamental frequency of the broken and rising tones, and parameters representing pitch movement in the rising tone. Perceptual analyses were performed on pre and post-treatment samples of the sustained /a/ sound using anchor vocal samples. Self-report data, collected via a post-treatment questionnaire, was used as a secondary outcome measure. Significant changes in perturbation, HNR, and perceptual data were observed in the FE group but not in the PE group. The FE group showed increased size and speed of pitch change. Participants from both groups showed positive changes in some tonal parameters after treatment. However, the magnitude of change and the number of participants with positive changes were larger in the FE group. The authors attributed the positive effect of FE to the increase in phonation volume, a decrease in airflow rate at high pitches, and an increase in maximum phonation time. More stable vocal fold vibration, reflected by the decrease in post-treatment jitter and shimmer in the FE group, which was not observed in the PE group. The study concluded that vocal function exercises are an effective treatment approach for MTD.

Respiratory exercises along with phonoarticulatory method include the following five components: exercise with a convex and concave abdomen; exercise for controlling the diaphragm with a convex abdomen; rapid breathing exercise; relaxation exercise for the muscles at the base of the tongue and throat; and a reciting vocal exercise. Liang et al. (2014) used these exercises on 21 female participants with MTD for one hour once a week for 12 weeks. Following 12 weeks of voice training, the median subglottal pressure and mean aerodynamic power were decreased and the median maximum phonation time was significantly increased compared to the baseline measurements. The authors concluded that the ‘respiratory exercises along with phonoarticulatory method' is an effective treatment method for in individuals with MTD individuals. They further stated that the aerodynamic analysis can effectively evaluate the status of vocal functioning in individuals with MTD before and after training.

Manual therapy in the management of muscle tension dysphonia

Manual therapy in the management of MTD has been used since the beginning of 1990 by Aronson. The manual circumlaryngeal techniques such as Circumlaryngeal manual therapy (CMT) proposed by Aronson (2010), laryngeal manual therapy (Mathieson et al., 2009) and voice massage (Leppanen, Ilomaki, & Laukkanen, 2010) have been shown to be particularly effective, and purportedly result in rapid and sustained improvements in the quality of phonation in individuals with MTD (Roy & Leeper, 1993; Roy et al., 1997; Mathieson et al., 2009). The following section describes various manual therapies reported in the literature for the management of MTD.

Laryngeal Manual Therapy (LMT) proposed by Matheison et al. (2009) is one of the manual therapy approaches that involve specific laryngeal maneuvers to reduce the muscle tension in individuals with MTD. LMT involves palpatory evaluation followed by manual therapy. For palpatory evaluation, the individual is made to sit comfortably with head and shoulder in neutral position. The clinician would stand behind the participant and evaluation will be carried out by using the index, second and third finger of both the hands. The palpation would be carried out with an examination of the sternocleidomastoid (SCM) followed by palpatory evaluation of thyroid lamina and hyoid bone. LMT would begin by massaging the SCM from the point that was least tensed on palpatory evaluation to the point of most tense. Once the muscle seems to have a lesser tension, the consideration would be given to the supralaryngeal area. The supralaryngeal area is kneaded from midline to the lateral side of the mandible. These steps are followed until the muscle tension is reduced. Improvement of the vocal quality and decrease in the pain indicates a reduction in the tension in the laryngeal area and the efficacy of the therapy.

Manual circumlaryngeal therapy (MCT) is another approach proposed by Aronson (1990) and was extensively researched by Roy and colleagues (1993, 1996, 1997) for the reducing the muscle tension in individuals with MTD. The CMT involves circular pressure applied over the hyoid bone, within the thyrohyoid space and over the posterior borders of the thyroid cartilage, followed by depression of the larynx by applying pressure to the superior border of the thyroid cartilage. The kneading and sustained pressure begins superficially and the depth of massage is gradually increased. Many of the studies and articles by Roy and colleagues (Roy & Leeper., 1993; Roy et al., 1997; Roy & Ferguson 2001) are not conducted in the recent past hence the validity of the same has to be revaluated. The differences and similarities between the LMT and MCT are given under the Table 1.

Voice massage is a Finnish method consisting of ‘holistic manipulation of muscles related to voice production' involving the respiratory, laryngeal and articulatory muscles (Laukkanen, Leppanen, Tyrmi & Vilkman, 2005). The technique includes ‘strokes, kneading, friction and intercostals pull, with the goal of increasing the mobility of the ribcage while breathing and to avoid excessive tension in the various muscles used in the voice production’. Leppanen et al. (2010) have shown the voice massage as an effective treatment approach for the management of MTD.

Table 1

Comparison of the Laryngeal Manual Therapy and Circumlaryngeal Manual Therapy.

Feature	**LMT**	**MCT**
Palpatory Evaluation	Before LMT	During the process of intervention
Manual Intervention	1) Bimanual and unimanual 2) Pads of index, middle and third finger 3) Working from areas of greatest muscle resistance, guided by patient's tolerance of the intervention 4) More prolonged attention to areas of greater muscle resistance	1) Unimanual 2) Thumb and index finger 3) Working from areas of least muscle tension to areas of greatest muscle tension, guided by patient's tolerance of the intervention 4) Sites of focal tenderness, modularity, or tautness given more attention
Order of structures targeted	1) SCMs 2) Supralaryngeal area 3) Hyoid bone 4) Larynx	1) Hyoid bone 2) Thyrohyoid space 3) Larynx 4) Medial and lateral suprahyoid musculature as necessary
Methods	1) Circular massage of SCMs (bimanual) 2) Kneading of supralaryngeal area (unimanual) 3) Massage of the hyoid bone 4) Bimanual depression of the larynx with fingers on the superior border of the thyroid cartilage 5) Larynx moved laterally by alternate application of bimanual digital pressure	1) Circular pressure to hyoid bone 2) Procedure repeated within the thyrohyoid space 3) Repeated over posterior borders of the thyroid cartilage 4) Larynx pulled down with fingers over the superior border of the thyroid cartilage and moved laterally occasionally

Table taken from Mathieson et al. (2009)

Efficacy of manual therapies in the management of muscle tension dysphonia

Roy and Leeper (1993) studied the effects of the manual laryngeal musculoskeletal tension reduction technique (CMT) for the treatment of functional voice disorders. The effect of this technique was studied by analyzing the acoustic as well as perception measures of vocal function. Seventeen individuals with functional dysphonia participated in the study. For perceptual evaluation, sustained vowel production of /a/, a central portion of standard rainbow passage was taken from 17 individuals before and after the treatment. Four clinically certified Speech language pathologists with extensive experience were employed in assessing the perceptual quality of the voice in these individuals. The voices were rated on a seven point equal appearing interval scale where one indicated normal voice quality and seven indicated a severe voice quality. For acoustic analysis, the researchers measured jitter, shimmer, and signal to noise ratio before and after the therapy for connected speech and sustained vowel context.

Results of perceptual evaluation indicated a statistically significant reduction in the severity of dysphonia. Results of the acoustic measures of jitter, shimmer, and signal to noise ratio (SNR) showed an improvement in both connected and sustained vowel context following the management session. For connected speech jitter, shimmer and SNR showed statistically significant changes post-treatment. However, in terms of sustained vowel context, only SNR showed significant changes post intervention. The authors in this study did not attribute the change in voice to 'the reduction in laryngeal musculoskeletal tension or lowering of the position of larynx' as in Aronson (1990). Instead they explained that there could be both psychological and physiological factors implicated in the pathology of functional dysphonia and speculated that muscle tension will be variable based on the individuals pathology that is either psychological or physiological. However, based on the virtue of the short-term voice improvement, clinical efficiency of this approach and the lack of evidence, the authors claim that some consideration could be given to the improvement in voice using the CMT.

Roy et al. (1996) studied the role of manual laryngeal tension reduction technique in the diagnosis and management of muscle tension dysphonia and spasmodic dysphonia. The assessment was done by focal palpation of larynx to determine the extent of laryngeal elevation, focal tenderness, effect of voice on applying the downward pressure and the extent of persistent improvement in voice following the circumlaryngeal massage in one individual with muscle tension dysphonia, one with spasmodic dysphonia and one individual with both spasmodic dysphonia and MTD. The manual tension reduction procedure was undertaken according to the technique of Aronson (1990) in these three individuals. In this case study, for the individual with muscle tension dysphonia, after circumlaryngeal massage tension and pain reduced and a normal voicing quality was established with the patient reporting relief of tightness and pain. A one-month long reassessment indicated no recurrence of pain or tension. In the second case with spasmodic dysphonia, three consecutive sessions of circumlaryngeal massage were successful in alleviating the tenderness in the laryngeal region. However, only a transient improvement in voice was stabilized and the patient was further referred for Botox injection. In the third case, i.e. the individual with both spasmodic dysphonia and muscle tension dysphonia, a week-long program of CMT twice daily helped establishing the normal voice quality. However, the individual encountered difficulty in stabilizing these improvements beyond the therapy room and was instructed in self-administration of these manual techniques. This study in MTD and SD serves as a evidence in establishing the efficacy of manual laryngeal techniques for proper diagnosis and ensuring the appropriate treatment for both MTD and SD.

Roy et al. (1997) investigated the short term and long term treatment outcomes of CMT for 25 individuals with functional dysphonia. A pre-therapy and post-therapy audio recording of connected speech and sustained vowel were subjected to perceptual and acoustical analysis to assess immediate and long term effect of a single treatment session. Twenty-five individuals were subjected to multiple recordings one recording during the pre-therapy, an immediate follow-up recording, a second follow-up recording, and a third follow-up recording. For the perceptual evaluation, four Speech-language pathologists were required to rate the voice samples on a seven point equal appearing interval scale where one indicated normal voice and seven indicates severe voice disorder. The perceptual evaluation was rated across all the time points. The speech sample was subjected to acoustic evaluation and the frequency, jitter, shimmer, and SNR parameters were compared across different treatment time points. The result of perceptual and the acoustic measures indicated gradual improvement in the treatment outcome and also supported short-term maintenance of voice with a fewer report of recurrences in the early follow-up phase. These results extended the work of Roy and Leeper (1993) confirming the clinical utility and efficiency of manual techniques for the treatment of muscle tension in individuals with functional dysphonia. This investigation also revealed that short-term results of circumlaryngeal therapy are impressive but the long term results found in the study were robust and has to be further researched upon to speculate the long term effect across the larger population in individuals with functional dysphonia.

Van Lierde, De Ley, Clement, De Bodt, and Van Cauwenberge (2004) performed a pilot study to document the outcome of vocal quality after a well-defined LMT program. The study included four Dutch professional voice users with a persistent moderate, or severe muscle tension dysphonia who were studied pre-treatment (1 week before LMT) and post-treatment (1 week after completion) of manual therapy (25 sessions). These participants had received several months of traditional voice therapy, without any success. To quantify and compare the effect of LMT, for this objective and subjective assessment techniques were used. Perceptual voice assessment included a perceptual rating of the voice using the GRBAS scale. Furthermore, the vocal quality in this population was modelled using the Dysphonia Severity Index (DSI). All of the participants selected for LMT showed improvement in perceptual vocal quality and DSI values. The use of LMT in professional voice users with persistent moderate-to-severe muscle tension dysphonia, especially in some participants who have not responded to traditional voice therapy, is supported by this pilot study. The authors hypothesized that the use of a mixture of different classic voice therapy with repeated laryngeal manipulation appears to be very helpful and motivating for professional voice users with persistent moderate-to-severe muscle tension Dysphonia. It was also noticed that following the LMT, several complaints of muscle hypertonicity with painful palpation, the laryngeal tension of pain, globus pharyngeus, and difficulties with singing were diminished or even disappeared. The authors speculated that the success of LMT in these participants could be due to the increased proprioceptive feedback.

Dromey, Nissen, Roy, and Merrill (2008) aimed at studying the effects CMT in 111 women with primary MTD. The outcome measures considered were the frequency of formants and transition slopes of two diphthongs (/eI/, /aI/); auditory perceptual analysis through customized visual analog scale and the speaking time ratio (ratio of the total duration of spoken segments to the total sample duration). The results revealed a significant increase in the slope of second formant transitions indicating positive effects of voice therapy on vocal tract changes and articulatory activity. Also most marked and a statistically significant decrease was reported in perceptual severity following the treatment. The speaking time ratio was increased significantly following the treatment and the authors attributed this to the less fragmented or more continuous speech with therapy. Based on the findings, the authors emphasized the interconnected nature of the laryngeal and articulatory activity and concluded that the impact of the voice disorder might extend beyond the larynx in this population. However, the authors acknowledged the limitations of the study such as its retrospective nature of data collection and the availability of limited tokens of speech sample for analysis and recommendations were made for further studies using fully randomized control.

Mathieson et al. (2009) aimed to determine the acoustic measures sensitive to the LMT treatment and to find the treatment effects of LMT in 10 individuals with MTD in the age range of 19 to 55 years. The measures considered were an acoustic analysis of sustained speech and spontaneous speech using Speech Studio software, formant frequency analysis using *Praat* (Paul Boersma and David Weenink) and vocal tract discomfort scale, which is a self-rating scale that allows the participants to record the frequency and severity of their vocal tract symptoms. The recordings were obtained before each participant's LMT session (one session), immediately after the session and then a follow-up measure after one week. The results revealed that the acoustic parameter relative amplitude perturbation (RAP) in the connected speech was found to be a sensitive measure compared to other parameters. The frequency of the formants F 1 and F 2 did not reveal a marked change following treatment. Further, the frequency of 'throat dryness, tickling, soreness, tightness, and irritability' changed significantly from pre-therapy to one-week post-LMT. The severity of the symptoms tight, dry, tickling, and sore sensations were reduced significantly following LMT. Based on the findings, the authors concluded that LMT could be used as a method of therapy in the treatment of hyperfunctional voice disorders. The authors acknowledged the limited participants and the outcomes based on the single voice therapy session in the study and recommended for further studies considering larger sample size.

In an attempt to investigate the effectiveness of an eclectic voice therapy programme consisting of voice massage, voice training, and voice hygiene program, Leppanen et al. (2010) conducted a study on Finnish female primary school teachers. The outcomes were evaluated based on ratings obtained using self-reported rating scales for the symptoms of vocal fatigue before, six months and 12 months after the administration of three types of interventions. All participants (n=90) with the mean age of 15 years, performing 24 teaching hours on average per week were divided equally into three groups and were given a voice hygiene lecture (3 hours), voice massage treatment (5x1 hour sessions) for nine weeks and another group voice training (5x1 hour sessions) over two months. The participants answered a questionnaire over the Internet concerning symptoms of vocal fatigue. The sum score of symptoms decreased significantly in all three groups through the period of investigation. The authors attributed the improvement in the voice quality to the better understanding regarding the importance of voice rest, voice use, and relaxation of voice by the participants. There were no significant differences across the groups receiving three types of voice therapy, and this can be due to the wide individual variation within the groups. These variations are results of differences in their learning strategies and psychological factors. Overall, all three interventions improved the teacher's vocal well-being over the long term. Similar positive findings when comparing the effects of Voice Massage, a voice hygiene lecture and voice training have been investigated by Laukkanen et al. (2009).

Van Lierde, De Bodt, Dhaeseleer, Wuyts and Claeys (2010) compared the effectiveness of vocalization with abdominal breath support and CMT in individuals with MTD. The study included 10 participants (four females and six males with a mean age of 58 years ranging from 18 - 65 years) with MTD. The vocal quality before and after the intervention was measured using the dysphonia severity index. The repeated-measures ANOVA revealed a significant difference in the overall vocal quality following CMT and not following the vocalization with abdominal breath support. The authors attributed the improvement following CMT to the direct decrease of laryngeal tension as all the 10 participants involved in the study exhibited laryngeal elevation and increased the tension of the extrinsic and intrinsic laryngeal muscles, which contributes to the occurrence of MTD. The authors concluded that the CMT could be an effective treatment technique for individuals with an elevated laryngeal position, increased laryngeal muscle tension, and for different types of muscle tension dysphonia.

Anhaiya et al. (2014) conducted a study to evaluate the effect of two different intervention in teachers with voice complaints. The authors compared the effect of manual perilaryngeal massage and traditional vocal training in professors with voice complaints. Forty-two professors were randomized into two groups. Peri laryngeal manual massage was given to group 1 and vocal training to the group 2. The effect of both the therapy techniques was assessed based on self-perceived vocal and pain evaluation symptoms report cervical muscle tension. The evaluation of perceptual auditory and acoustic voice analysis was carried out and both groups indicated improvement in the vocal symptom. However, no difference was found with intervention with respect to the self-assessment questionnaire and acoustic analysis. Statistical analysis between the two groups regarding age, gender, and teaching experience did not reveal any differences among them. This indicates that both the intervention techniques improved the wellbeing and voice quality and in place of traditional therapy any intervention could be used based on the symptoms and vocal requirements.

Reimann, Siqueira, Rondon, Brasolotto, and Silverio (2016) investigated the immediate effect of laryngeal manual therapy in alleviating musculoskeletal pain, change in voice and change in sensation in individuals with and without functional dysphonia. The study included 30 individuals in the age range of 18 to 45 years. They were sorted into two groups with 15 in the dysphonic group and 15 in the control group. The individuals answered pain questionnaire and their voices were recorded as sustained vowel and continuous speech. The perceptual analysis was done by three speech language pathologist specialized in voice who rated the voice based on the general voice quality, roughness, breathiness, tension, and instability. Acoustic analysis was carried out using multidimensional voice program by Kay Pentax for the vowel /a/ and they have analysed the fundamental frequency, jitter, shimmer and noise to harmonic ratio. The results of the study indicated reduced pain intensity in individuals with dysphonia improvement in the perceptual quality and acoustic analysis indicated changes in the jitter of individuals without vocal complaints and stability of frequency. In terms of sensation individual with and without behavioural dysphonia indicated positive changes in terms of production of voice. The authors concluded that even though the result indicated positive alterations, but a more controlled, randomized study evaluating the long term changes of voice are required to evaluate the role of LMT in voice changes.

Silverio, Brasolotto, Siqueira, Carneiro, Fukushiro and Guirro (2015) investigated the effect of transcutaneous electrical nerve stimulation (TENS) and laryngeal manual therapy in 20 women with bilateral vocal nodules. The two techniques were compared in relation to the laryngeal symptom, pain and vocal quality after the administration of these therapy techniques. Twenty women with bilateral vocal nodules were divided into two groups of 10 volunteers where group 1 was subjected to TENS application and group two underwent LMT; these groups received 12 sessions of treatment twice a week lasting 20 minutes each after treatment the initial assessment was repeated. The results indicated that with TENS there was a significant improvement in the voice and effort to speak symptoms and it also lowered the frequency of pain in individuals. The perceptual evaluation only showed changes in the strain parameter after TENS. In individuals who underwent LMT, they reported betterment in the symptom of sore throat lowering of pain in the neck as well as easier production of voice. The authors explained TENS more as a complementary treatment method than LMT and can be used in cases with severe muscle tension.

To summarize, the studies by Mathieson et al. (2009) and Roy et al. (1997) were each based on one treatment session of either LMT or CMT. Although Van Lierde et al. (2010) also used only one treatment of CMT during the baseline measures, their participants had undergone abdominal breath support therapy immediately prior to the CMT. The authors acknowledged, therefore, that there was a prospect of aggregate effect resulting in enhanced voice quality, although they supported their argument that this was unlikely. Although literature indicates that the multiparametric measures such as DSI and Acoustic voice quality index (AVQI) are robust and reliable outcome measures, limited number of these studies had documented their outcome using these measures. For instance, studies by Van Lierde et al. (2004) and Van Lierde et al. (2010) had utilized the multiparametric measure DSI for documenting the therapeutic outcomes.

Application of Acoustic voice quality index as an outcome measure

As an outcome measure, sustained vowels show a lessened variation within the speech signal due to prosodic and voicing factors and permit ease of standardization of the sample. Continuous speech is a more usual speaking behaviour, and is the environment in which perceptual decisions regarding the appropriateness of quality of voice are made (Carding, Carlson, Epstein, Mathieson & Shewell, 2000). However, given the fact that acoustic qualities of sustained phonation, as well as connected speech varies, including a connected speech sample, can serve the function of increasing the ecological validity of the analysis. (Wolfe, Cornell & Fitch, 1995; Zraick, Wendel & Smith-Olinde, 2005). Thus arises a necessity to incorporate even connected speech sample within the acoustical analysis so that the sample used to diagnose will be more similar to that of the individual's habitual speaking voice (Reynolds et al., 2012).

Maryn, Corthals, Van Cauwanberge, Roy and De Bodt (2010) introduced a technique to measure the severity of overall dysphonia involving sustained phonation, as well as connected speech. They analyzed 13 acoustic measures (based on fundamental frequency perturbation, amplitude perturbation, spectral and cepstral analyses) from the concatenated samples of the sustained vowel as well as connected speech. Following this, the stepwise multiple linear regression analysis was applied and a six-variable acoustic model for the multiparametric measurement of overall voice quality of the concatenated samples were derived called Acoustic voice quality index (AVQI). The AVQI uses the parameters smoothed cepstral peak prominence (CPPS), harmonics-to-noise ratio (HNR), shimmer local (SL), shimmer local dB (ShdB), the slope of the long-term average spectrum (slope) and tilt of the trendline through the long-term average spectrum (tilt). Thus AVQI is constructed as AVQI =

2.571*(3.295- 0.111*CPPS - 0.073*HNR - 0.213*SL + 2.789*ShdB - 0.032*Slope + 0.077*Tilt). The authors reported that a score of 2.95 or below obtained on AVQI identified the sample to be normophonic for Dutch speakers. The authors reported a positive association between the AVQI and the perceptual dimension of overall dysphonia, in which the higher the AVQI score is associated with higher dysphonia severity and vice versa. The correlation across AVQI and the perceptual dimension of overall dysphonia was found to be 0.78, which demonstrates a high concurrent validity for AVQI (Maryn, De Bodt & Roy, 2010).

AVQI was identified as stable across different phonetic and linguistic structures across several languages such as English, Dutch, French, German, Japanese, Korean, Lithuanian, and Kannada even though it involves continuous speech as one of the measures that contribute to it (Maryn et al., 2010a, 2010b, 2014; Reynolds et al., 2012; Barsties & Maryn, 2012, Hosokawa et al., 2017). Also, recent studies revealed a strong correlation of AVQI with the GRBAS scores as well as that of CAPE-V for Korean (Maryn, Kim, & Kim, 2016) as well as for Lithuanian (Uloza et al., 2017) languages (Table 2).

Reynolds et al. (2012) revealed that AVQI has high diagnostic accuracy in terms of its application to the pediatric voice. They found that, AVQI correlates with GRBAS scale and that AVQI is an appropriate measure for evaluation and diagnosis of dysphonia in children. Similarly, AVQI has been used to document the effects of voice therapy on voice quality in a variety of population including children (Reynolds, Meldrum, Simmer, Vijayasekaran & French, 2016), and adults with several voice disorders (Hosokawa et al., 2017, Uloza et al., 2017).

Table 2

Summary of AVQI scores across different languages reported in the literature.

Language	Author	Threshold of the AVQI values
English	Reynolds et al., (2012)	3.46
	Maryn et al., (2014)	3.25
Dutch	Maryn et al., (2010)	2.95
	Barsties & Maryn., (2015)	2.80
French	Maryn et al., (2014)	3.07
German	Barsties & Maryn.,(2012)	2.70
Japanese	Hosokawa et al., (2017)	3.15
Finnish	Kankare et al., (2015)	2.35
Lithuanian	Uloza et al., (2017)	2.97
Kannada	Benoy & Jayakumar (2017)	3.00
	Sheshashri & Gopikishore (2018)	3.36
Malayalam	Benoy & Jayakumar (2017)	3.03

In a recent study D'haeseleer, Meerschman, Claeys, Leyns, Daelman, and Van Lierde (2016) attempted to profile the voice of theatre artists using AVQI. The study included 26 theatre actors and their voice samples were recorded before and after a one and a half hour long analysis. The results indicated that the vocal quality, measured by the AVQI, did not change after a theater performance but indicated a mean AVQI of 3.48 concurs with a mild dysphonia. Thus, in the present scenario of voice sciences, AVQI demonstrates an incipient role as a promising voice measurement tool in the quantifying of quality of voice and to document the treatment related outcomes.

Therefore, considering the dearth of studies systematically documenting the efficacy of LMT in individuals with MTD and the accuracy and ecological validity of the AVQI as an outcome measure, the current study was an attempt to investigate the immediate short-term effects of LMT in individuals with MTD on objective voice quality as measured by the AVQI.

Chapter III

METHOD

Participants

For this study, a pre-test - post-test control design was used. Twenty individuals with MTD were recruited for the study. These individuals were selected based on the diagnosis of MTD by a team consisting of Speech-language pathologist and an Otolaryngologist/ Phonosurgeon. The demographic details and clinical findings of the participants are given under Table 3. The following inclusion and exclusion criterion was considered to recruit the participants.

Inclusion criteria

- The participants diagnosed with MTD based on the voice evaluation by a Speech-language pathologist and videolaryngoscopic /stroboscopic evaluation by an Otolaryngologist/ Phonosurgeon.
- The participants in the age range of 19 to 45 years were considered so as to avoid the effect of extraneous variables such as puberty and aging.

Exclusion criteria

- The participants with active vocal tract related infections, or history of the chronic obstructive pulmonary disorder, asthma or any other respiratory tract infection were excluded from the study.
- The participants with any associated communication disorders such as hypernasality, dysarthria, velopharyngeal dysfunction were excluded from the study.

Table 3

Demographic details and clinical findings of the participants.

Age	Gender	Occupation	Severity dysphonia	Medical diagnosis
34	F	Doctor	Mild hoarse	MTD Type III
32	F	Nurse	Mild hoarse	MTD Type II
38	F	Teacher	Moderate hoarse	MTD Type III
45	F	Housewife	Mild breathy	MTD Type II
43	F	Housewife	Mild hoarse	MTD Type I
36	F	Teacher	Moderate breathy	MTD Type II
44	F	Lawyer	Moderate hoarse	MTD Type III
42	F	Housewife	Mild hoarse	MTD Type II
44	F	Housewife	Mild hoarse	MTD Type II
23	M	Student	Mild breathy	MTD Type I
33	F	Housewife	Moderate hoarse	MTD Type II
44	F	Social worker	Moderate hoarse	MTD Type II&III
20	M	Student	Mild breathy	MTD Type I
24	F	Student	Mild hoarse	MTD Type I
25	M	Student	Moderate breathy	MTD Type II
31	M	Teacher	Moderate hoarse	MTD Type III
31	F	Journalist	Mild hoarse	MTD Type III
43	M	Engineer	Mild breathy	MTD Type II
45	M	Teacher	Mild hoarse	MTD Type II
41	F	Housewife	Mild hoarse	MTD Type II

Procedure

Audio recordings for the measuring the Acoustic Voice Quality Index

Stimuli: The present study included the phonation of vowel /a/ as well as reading task as stimuli for measuring the AVQI. The standardized Kannada passage (Savithri & Jayaram, 2005) was used for the reading task.

Recording procedure: The recordings were obtained in a quiet room. The participants were instructed to sit comfortably in the chair and to phonate vowel /a/ and read the standardized Kannada passage at comfortable pitch and loudness. The recording was obtained using a table mounted microphone with mouth to microphone distance constantly maintained at 10 cm. The microphone was connected to the HP laptop with *Praat* 6.0.04 version software (Paul Boersma & David Weenink). The recordings were obtained at 44.1 kHz sampling frequency and 16-bit resolution. The sustained phonation of vowel /a/ was obtained for three trails, and the continuous speech task (reading of the standardized passage of Kannada) was obtained for two trails. These recordings were obtained before and after completion of a session of LMT. The recorded samples were saved in the .wav format in a separate folder.

Procedure for Laryngeal Manual Therapy

The participants of the present study were subjected to one session of LMT. The step by step LMT procedure as described by Matheison et al. (2009) was followed in this study. The palpatory evaluation was carried out before and after LMT as described by these authors.

Palpatory evaluation: During the palpatory evaluation, the participant was seated in an upright, low back chair and the clinician stands behind the participant. The palpatory evaluation described by Matheison et al.(2009) involves determining 'the degree of muscle resistance and the height of the larynx in the vocal tract'. The palpatory evaluation commences with inspecting the resistance of SCM and muscles of the supralaryngeal area, laryngeal resistance to lateral pressure and measuring laryngeal height. The inspected resistance was graded on a 1-5 rating scale with five being the highest resistance and one being the minimum resistance. The laryngeal height was determined based on the inspection of the vertical position of the larynx during phonation and was classified as either high held/ neutral/ lowered/ forced lowered.

Laryngeal Manual Therapy: The procedure of LMT as described by Matheison et al. (2009) commences with massaging the SCM from the point that was least tense to most tense. Once the muscle seemed to have lesser tension, the consideration was given to the supralaryngeal area. The supralaryngeal area was 'kneaded' from midline of the mandible to the lateral side of the mandible. These steps were followed until the muscle tension of the SCM and the supralaryngeal area was reduced. Improvement of the vocal quality and decrease in the pain indicates a reduction in the tension in the laryngeal area and efficacy of the therapy (Matheison et al., 2009).

Analysis: The recorded .wav files were opened in the *Praat* software (6.0.28 version). The steady middle portion of the sustained phonation of vowel /a/ for about three seconds was selected and renamed as 'sv' (sustained vowel) and similarly, the middle portion between the fourth to sixth sentences of the continuous speech task was selected and renamed as 'cs' (continuous speech). The'cs' and 'sv' files were opened in the *Praat* and the AVQI script (2.02 version)developed by Maryn et al. (2010) was 'run' to obtain the AVQI. The output window thus obtained depicts the graphical display of the waveform, spectrogram, spectrum, cepstrum and the AVQI value. The output window also displays the values of constituent parameters of AVQI (CPPs, HNR, Spectral slope, Shimmer local, Shimmer dB, and Spectral tilt). The screenshots of the steps involved in measuring AVQI are given under Figure 1 and 2. Figure 3 depicts the graphical AVQI output.

Statistical analyses

The obtained AVQI values across the participants were subjected to appropriate statistical analysis using the Statistical Package for Social Sciences

(Version 20). In order to verify the normality of the samples, Shapiro Wilk's test of normality was used. A descriptive statistics was used to deduce the average AVQI and its deviation from the average. To verify the effect of LMT on AVQI and its six constituent parameters, paired‘t' test was carried out. Further, Wilcoxon signed rank test was carried out to verify the significance of the difference between pre and post values of the palpatory evaluation.

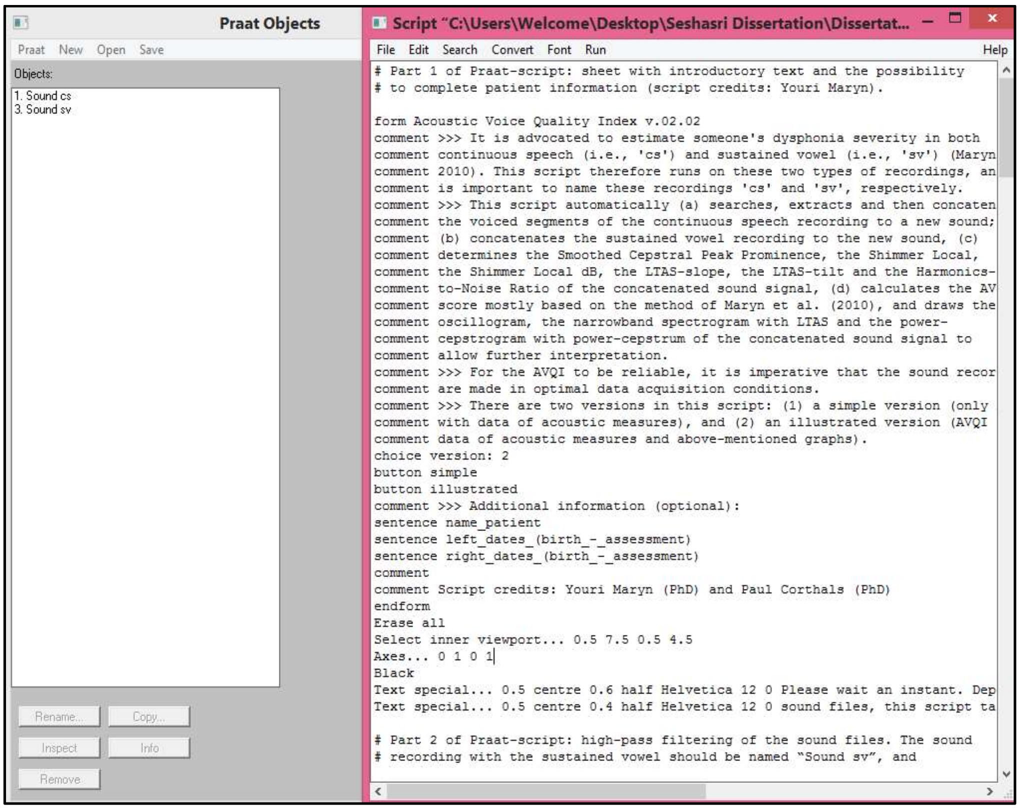

Figure 1. Screenshot revealing renamed audio samples and AVQI script in the*Praat* software

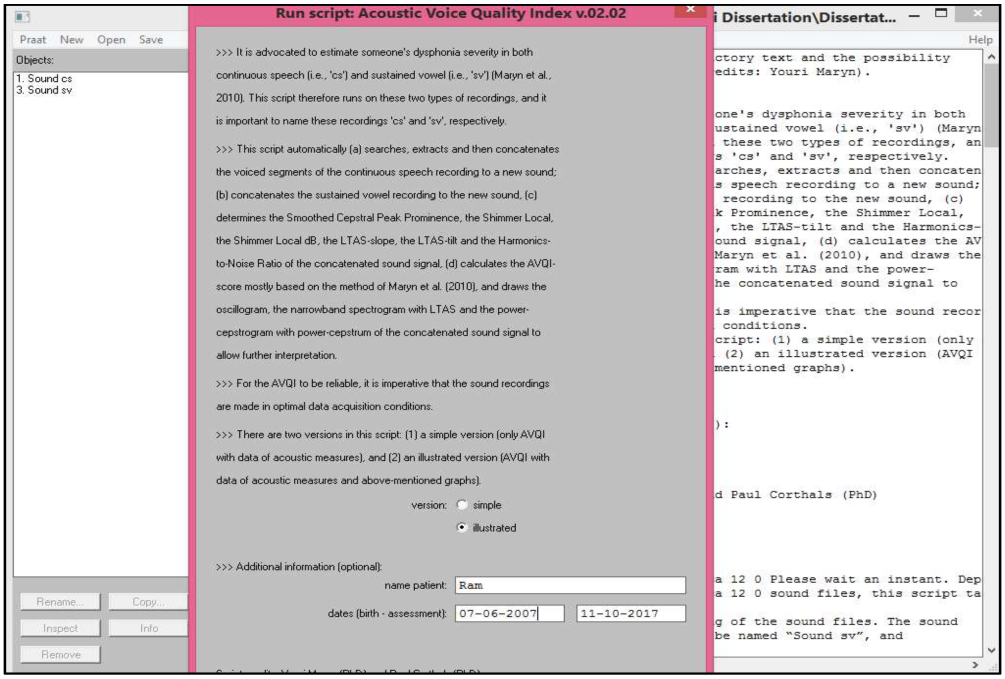

Figure 2. Screenshot revealing the option for the input of demographic data during the AVQI measurement.

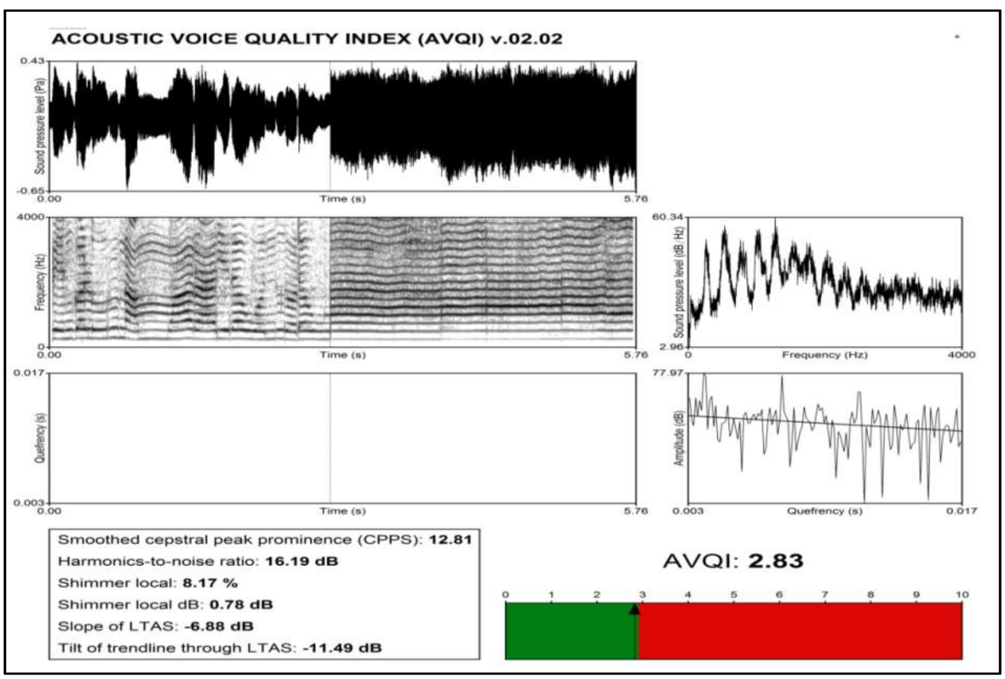

Figure 3. Graphical output of the Acoustic Voice Quality Index.

Chapter IV

RESULTS

The present study involved measuring the AVQI in individuals with MTD before and after a session of LMT. The obtained data in terms of the AVQI and its constituent parameters was subjected to various statistical analyses to verify the normality of the data, and verify the significance of the difference between pre and post AVQI values. The results thus obtained are presented in the following sections.

Normality of the data

Shapiro Wilk's test was done to determine the normality of the data. Results revealed that all the parameters followed the normal distribution with $p > 0.05$.

Acoustic Voice Quality Index in individuals with muscle tension dysphonia before and after laryngeal manual therapy

The mean and standard deviation of AVQI before the session of LMT are given under Table 4 along with graphical representation in *Figure 4*.The results indicated an average AVQI value of 5.50 with a standard deviation 0.88 in individuals with MTD. The average AVQI value reduced to 4.89 with standard deviation at 1.02 following a session of LMT. Table 5 shows the mean and standard deviation of the constituent parameters of AVQI before the session of LMT and similarly the Table 6 shows mean and standard deviation of the constituent parameters of AVQI following a session of LMT. The pre and post constituent parameters of AVQI is depicted in *Figure 5.*

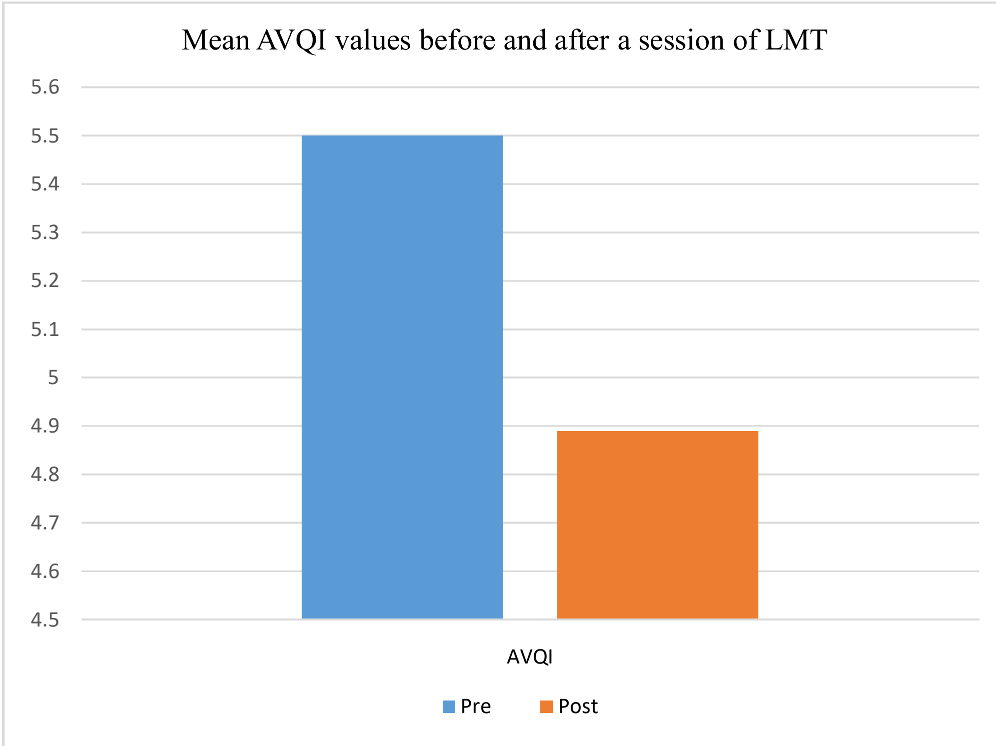

Figure 4 Mean acoustic voice quality index in adults before and following a session of LMT.

Table 4

Mean and standard deviation of acoustic voice quality index in adults with voice therapy before and after LMT.

Acoustic Voice Quality Index (AVQI)	
Before LMT	After LMT
5.50(±0.88)	4.89(±1.02)

Table 5

Mean and standard deviation values of the constituent parameters of AVQI in individuals with MTD.

CPPs (dB)	HNR	Shimmer local(%)	Shimmer(dB)	Slope(dB)	Tilt(dB)
9.82 (±1.62)	13.77 (±3.92)	11.05 (±4.19)	1.06 (±0.29)	-20.15 (±6.30)	-10.23 (±1.22)

Table 6

Mean and standard deviation values of the constituent parameters of AVQI in individuals with MTD following one session of LMT.

CPPs (dB)	HNR	Shimmer local(%)	Shimmer (dB)	Slope(dB)	Tilt(dB)
10.82 (±1.68)	15.03 (±3.62)	10.15 (±4.40)	0.972 (±0.31)	-19.98 (±5.04)	-10.12 (±1.11)

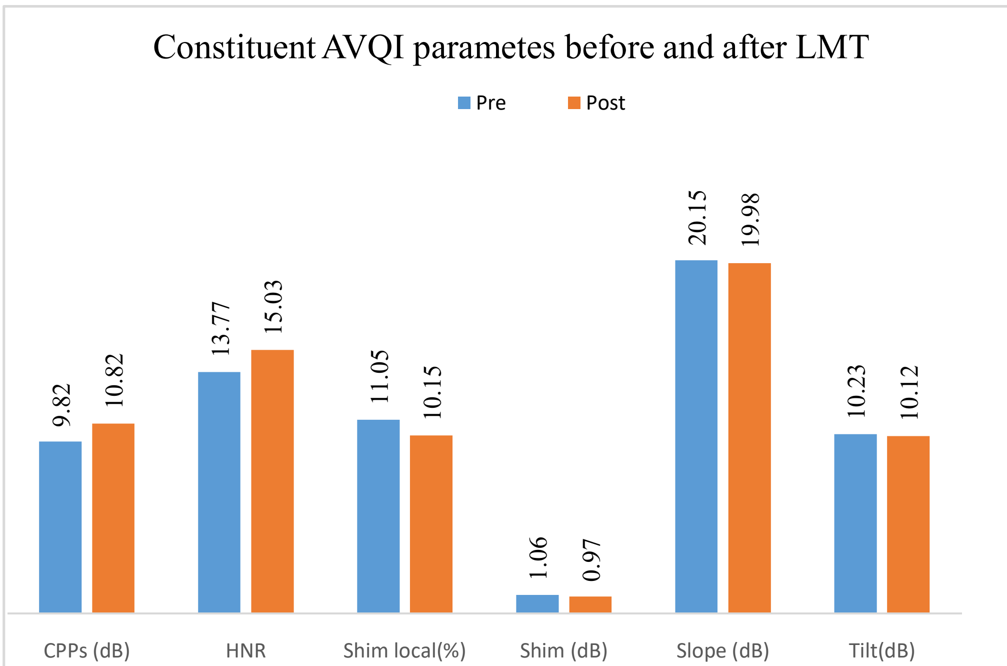

Figure 5. Mean values of constituent parameters of AVQI before and after a session of LMT.

Effect of Laryngeal manual therapy on Acoustic Voice Quality Index

The results of paired 't' test revealed a significant effect of LMT on the AVQI and CPPs (Table 7). The result indicated a significant effect of LMT only on the AVQI when [t (18) = 3.57, $p< 0.05$] and CPPs [t (18) = -3.93, $p< 0.05$]. The results, however, did not reveal any significant main effect of LMT on other constituent parameters ($p> 0.05$).

Table 7

Effect of LMT on AVQI and its constituent parameters as measured by paired 't' test.

Parameter	t	*p*
AVQI	3.57	0.02*
CPPs	-3.93	0.01*
HNR	-1.99	0.06
Shimmer Local	1.15	0.26
Shimmer dB	1.65	0.11
Slope	-0.20	0.83
Tilt	-0.52	0.60

**p <0.05 indicative of statistically significant effect.*

Table 8

/Z/ and /p/ value for the palpatory evaluation.

Parameter	Z	*p*
Sternocleidomastoid-R	-3.804	.000*
Sternocleidomastoid-L	-3.825	.000*
Supralaryngeal area	-3.274	.001*
The resistance of the larynx to the lateral digital pressure	-3.819	.000*

**p <0.05 indicative of statistically significant effect.*

Immediate effects of laryngeal manual therapy as observed on palpatory evaluation

Following the LMT, the tension in the sternocliedomastoid and supralaryngeal muscles and resistance of the larynx to the lateral digital pressure was observed to be reduced. The Wilcoxon signed-rank test revealed that the change in these palpatory measures following the LMT was statistically significant at $p < 0.05$ (Table 8).

CHAPTER V

DISCUSSION

This study was aimed to document the immediate effects of a session of LMT on AVQI. The study was carried out by performing the LMT on 19 individuals with MTD and by documenting the outcomes through pre-post AVQI measures. The following section describes the variation in AVQI following a session of LMT in individuals with MTD.

Acoustic voice quality index in individuals with muscle tension dysphonia

In the present study, the baseline average AVQI value of participants with MTD was 5.50 with a standard deviation of 0.88. This value is higher than that of the phononormic individuals reported in several studies (Maryn et al., 2010a, 2010b, 2014; Reynolds et al., 2012; Barsties & Maryn, 2012, Benoy et al., 2014; Hosokawa et al., 2017). These normative studies were conducted across various languages including English, Dutch, Finnish, French, German, Japanese, Lithuanian, Kannada, and Malayalam and the normative value in these studies ranged from 2.80 to 3.46. It is evident that the AVQI value obtained by the participants with MTD in the present study is markedly deviate from the reported reference AVQI values. Hence, confirming that the participants of the present study were dysphonic with respect to the AVQI.

Reynolds et al. (2012) reported that an AVQI value of greater than 3.46 is associated with dysphonic voice. Similarly, Hosokawa et al. (2017) and Uloza et al. (2017) reported that an AVQI value of greater than 3.15 and 3.48 respectively is associated with dysphonic voice quality. Therefore, the baseline AVQI value of 5.50

in the participants of the present study confirms the presence of the dysphonic voice in them.

Immediate effects of laryngeal manual therapy as documented using Acoustic voice quality index

The average AVQI value following one session of LMT in individuals with MTD decreased from 5.50 at baseline to 4.89 with a standard deviation of 1.02. This difference in the baseline and post-therapy AVQI values was found to be statistically significant on the paired ‘t’ test. The decrease in the AVQI value postLMT indicates the improved voice quality of participants with MTD. It is possible that the relaxation in the laryngeal and perilaryngeal muscles following the LMT procedure had contributed towards alleviating the abnormal physiology associated with the laryngeal musculoskeletal tension. According to Boone and Mc Farlane (2000), the hyperfunctional voice disorders such as the MTD is associated with excessive phonatory effort. Mathieson et al. (2009) presumed that the extrinsic laryngeal muscles that raise the larynx also affect the way in which the vocal folds vibrate by altering the length, tension, and stiffness of the vocal folds and contribute towards the disturbed voice quality. Thus, relaxing the laryngeal and perilaryngeal musculature through various steps involved in the LMT such as massaging the sternocleidomastoid and kneading the supralaryngeal muscles would have improved the overall vocal fold vibration, consequently improving the quality of voice. This improved quality of voice in the present study is reflected in the post-therapy AVQI values of the participants.

With respect to the constituent parameters of the AVQI, the smoothened cepstral peak prominence(CPPs) was the only parameter that changed significantly following a session of LMT. Cepstrum is the indication of the degree of harmonic organization in a signal and has been reported to be a stable parameter that reflects the voice quality (Hillenbrand & Clark, 2009). The relaxed larynx and vocal tract of participants of the present study with MTD, following the LMT, could have improved the glottal source function, thus improving the harmonic organization of the voice and subsequently the enhancing cepstral peak prominence.

AVQI has been established as a sensitive tool in documenting the therapeutic outcomes in individuals with dysphonia (Reynolds et al., 2012; Maryn et al., 2010; Hosokawa et al., 2017 and, Uloza et al., 2017). CPPs is also reported to be a good measure for detecting dysphonia and for objectively evaluating the degree of severity of voice alterations, especially if voice samples are used in connected speech (Delgado-Hernandez, Leon-Gomez, Izquierdo-Arteaga, Llanos-Fumero., 2018). Hence, the significant changes in AVQI and CPPs in this present study indicate a positive outcome of the LMT in individuals with MTD.

Immediate effect of LMT on laryngeal muscles as examined on palpatory evaluation

The results reveal that the perilaryngeal muscle tension and position of the larynx measured on palpatory evaluation has significantly reduced following a single session of LMT in individuals with MTD. The scale used for palpatory evaluationis characterized by the high reliability and accuracy in terms of assessing perilaryngeal muscle tension and the position of the larynx (Matheison et al., 2009). Therefore, the significant changes in the palpatory ratings in the present study following LMT indicate improvement in relaxation in the overall laryngeal and perilaryngeal musculature. This finding in coherence with the improvement observed in the objective voice quality measured through AVQI. The improvement in palpatory measures post-LMT could be attributed to the direct impact of LMT on the function and position of the larynx. Similar findings were reported by Mathieson et al. (2009) through the application of LMT in individuals with MTD.

In summary, although the post-LMT AVQI values in the present study did not reach the normative value reported across various studies, considering the short term intervention yet statistically significant change in the AVQI towards positive direction indicates the LMT as a promising treatment modality for MTD. Therefore, future studies in this direction with a long-term intervention and controlled designs are warranted. The present study has inherent drawbacks in terms of the absence of a control group and palpatory evaluation being performed by the experimenter herself, which needs to be controlled in future studies. Further, it is to be noted that the findings of the study are based on short-term intervention and immediate outcome measures, therefore, caution may be maintained in interpreting the results and future studies are recommended with follow-up measures to verify the maintenance of the therapeutic gains.

Chapter VI

SUMMARY AND CONCLUSIONS

Muscle tension dysphonia is a condition in which phonation is associated with excessive muscular tension in laryngeal and perilaryngeal muscles. The characteristics of MTD include insidious musculoskeletal tension which may be the cause of the voice disorder. Participants with MTD tend to have secondary pathological conditions generally associated with vocal hyperfunction such as nodules and polyps. Persons exhibiting muscle tension shows visible signs of increased muscle activity in the head and neck. MTD includes hoarseness as a chief symptom, with other features such as breathiness and harshness of voice.

Muscle tension dysphonia can be diagnosed based on the examination by an Otolaryngologist/ Phonosurgeon and a Speech-language pathologist. An Otolaryngologist/ Phonosurgeon's examination would include a videolaryngoscopy/ videostroboscopy to identify the glottic and supraglottic features and classify the condition as one of the subtypes of muscle tension dysphonia. A Speech-language pathologist evaluates the voice via the case history, oral peripheral examination; qualitative measurement of the respiratory system, phonatory system, resonatory system and quantitative measures like aerodynamic measures, acoustic measures.

The literature suggests the usage of indirect as well as direct approaches to correct muscle tension in individuals with MTD. The voice therapy for MTD involves the clinician working on the individual's voice by improving the posture, regulating the breathing pattern, relaxation technique to decrease the tension around the shoulder and neck, specific vocal exercises designed to distribute the workload to the appropriate muscles, and laryngeal maneuver to reduce tension in and around throat and laryngeal muscles.

As abnormally elevated muscle tension being the etiology and major clinical feature in MTD, several studies have been conducted to verify the efficacy of voice therapy approaches that target at the relaxation of the laryngeal muscles. Among the relaxation approaches, laryngeal manual therapy has been consistently revealed to be an effective approach. However, the generalization of the findings of these studies is confined due to several of the methodological issues. The studies reported had not utilized the LMT in unison and has been used in combination with several other approaches in an eclectic manner making it challenging to attribute the outcomes to the LMT. Further, the generalization is questionable owing to the accuracy of the outcome measures used in these studies. The multiparametric measures such as acoustic voice quality index have been shown to be robust and ecologically valid in documenting the therapeutic outcomes. Therefore, considering the dearth of studies investigating the efficacy of LMT in individuals with MTD using robust outcome measures, the current study was taken up with the aim of documenting the immediate effects of LMT on Acoustic voice quality index (AVQI) in individuals with MTD.

Twenty individuals diagnosed with MTD based on the assessment by a team of Speech-language pathologist and Otolaryngologist/ Phonosurgeon were recruited for the study. The participants of the present study were subjected to one session of LMT. The step by step LMT procedure as described by Matheison et al. (2009) was followed in this study. The palpatory evaluation was carried out before and after LMT as described by these authors. The LMT used involves massaging both the sternocliedomastoid muscles, kneading the supralaryngeal muscles, and lowering of the larynx.

For measuring the outcome of LMT, the sustained phonation of vowel /a/ (sustained vowel‘sv’) and reading of the standardized Kannada passage (continuous speech‘cs’) was obtained in a quiet room before and after completion of a session of LMT. The ‘cs’ and ‘sv’ files were opened in the *Praat* software (6.0.28 version) and the AVQI script (2.02 version) developed by Maryn et al. (2010) was ‘run’ to obtain the AVQI. The output window thus obtained depicts the graphical display of the waveform, spectrogram, spectrum, cepstrum and AVQI value.

The results indicated an average AVQI value of 5.50 with a standard deviation 0.88 in individuals with MTD. The average AVQI value reduced to 4.89 with standard deviation at 1.02 following a session of LMT indicating a marked improvement in the voice quality. This pre-post difference in the AVQI value is also shown to be statistically significant at $p<0.05$. In terms of the constituent parameters of AVQI, the CPPs was significantly different between the pre and post conditions.

Although the post-LMT AVQI values in the present study did not reach the normative value reported across various studies, considering the short term intervention yet statistically significant change in the AVQI towards positive direction indicates the LMT as a promising treatment modality for MTD. It is possible that the relaxation in the laryngeal and perilaryngeal muscles following the LMT procedure had contributed towards alleviating the abnormal physiology associated with the laryngeal musculoskeletal tension.

The present study has inherent drawbacks in terms of the absence of a control group and palpatory evaluation being performed by the experimenter herself, which needs to be controlled in future studies. Further, it is to be noted that the findings of the study are based on short-term intervention and immediate outcome measures, therefore, caution may be maintained in interpreting the results and future studies are recommended with follow-up measures to verify the maintenance of the therapeutic gains.

REFERENCES

Anhaia, T. C., Klahr, P. da S., Ourique, A. A. B., Gadenz, C. D., Fernandes, R. A., Spagnol, P. E., … Cassol, M. (2014). Efeitos de duas intervenções em professores com queixas vocais. *Audiology - Communication Research*, *19*(2), 186–193.

Aronson, A. E. (1990). *Clinical voice disorders:* An interdisciplinary approach (3rd ed.). New York: Thieme.

Barsties, B., & Maryn, Y. (2012). The Acoustic Voice Quality Index. Toward expanded measurement of dysphonia severity in German subjects. *HNO, 60*(8), 715-720.

Barsties, B., & Maryn, Y. (2015). The improvement of internal consistency of the Acoustic Voice Quality Index. *American journal of otolaryngology*, *36*(5), 647-656.

Benoy, J. J. (2017). Acoustic voice quality index (AVQI) and perceptual measures in the Indian population, (May). Dissertation submitted to the University of Mysore.

Boone, D. R., & McFarlane, S. C. (2000). *The voice and voice therapy* (6th ed.). Boston: Allyn and Bacon.

Carding, P., Carlson, E., Epstein, R., Mathieson, L., & Shewell, C. (2000). Formal perceptual evaluation of voice quality in the United Kingdom. *Logopedics Phoniatrics Vocology*, 25(3), 133-138.

Delgado-Hernández, J., León-Gómez, N. M., Izquierdo-Arteaga, L. M., & Llanos-Fumero, Y. (2018). Cepstral analysis of normal and pathological voice in Spanish adults. Smoothed cepstral peak prominence in sustained vowels versus connected speech. *Acta Otorrinolaringologica Espanola*, *69*(3), 134–140.

Dietrich, M., Abbott, K. V., Gartner-Schmidt, J., & Rosen, C. A. (2008). The requency of perceived stress, anxiety, and depression in patients with common pathologies affecting the voice. *Journal of Voice*, *22*(4), 472-488.

D'haeseleer, E., Meerschman, I., Claeys, S., Leyns, C., Daelman, J., & Van Lierde, K. (2016). Vocal Quality in Theater Actors. *Journal of Voice.42*(3), 421-325

Dromey, C., Nissen, S. L., Roy, N., & Merrill, R. M. (2008). Articulatory changes following treatment of muscle tension dysphonia: preliminary acoustic evidence. *Journal of Speech Language and Hearing Research,51*(1), 196 - 213.

Guzmán, M., Castro, C., Madrid, S., Olavarria, C., Leiva, M., Muñoz, D., …Laukkanen, A. M. (2016). Air Pressure and Contact Quotient Measures During Different Semioccluded Postures in Subjects With Different Voice Conditions. *Journal of Voice*, *30*(6), 759.e1-759.e10.

Hillenbrand, J.M & Clark, M.J.(2009) The role of f0 and formant frequencies in distinguising the voices of men and women, *Attention, Perception & Psychophysics71*;1150.

Hosokawa, K., Barsties, B., Iwahashi, T., Iwahashi, M., Kato, C., Iwaki, S., ... & Ogawa, M. (2017). Validation of the acoustic voice quality index in the Japanese language. *Journal of Voice*, *31*(2), 260-e1.

Kankare, E., Barsties, B., Maryn, Y., Ilomäki, I., Laukkanen, A. M., Tyrmi, J., ... & Vilpas, S. (2015, August). A preliminary study of the Acoustic Voice Quality Index in Finnish speaking population. In PAN EUROPEAN VOICE CONFERENCE ABSTRACT BOOK (p. 218).

Laukkanen, A. M., Leppänen, K., Tyrmi, J., & Vilkman, E. (2005). Immediate effects of “voice massage” treatment on the speaking voice of healthy subjects. *Folia Phoniatrica et Logopaedica*, *57*(3), 163–172.

Leppänen, K., Ilomäki, I., & Laukkanen, A. (2010). A one-year follow-up study of self -evaluated effects of Voice Massage™, voice training, and voice hygiene lecture in female teachers. *Logopedics Phoniatrics Vocology,35*(1), 13-18. doi:10.3109/14015430903552360.

Liang, F. Y., Yang, J. S., Mei, X. S., Cai, Q., Guan, Z., Zhang, B. R., … Zheng, Y. Q. (2014). The vocal aerodynamic change in female patients with muscular tension dysphonia after voice training. *Journal of Voice*.

Lierde, K. V., Bodt, M. D., Dhaeseleer, E., Wuyts, F., & Claeys, S. (2010). The Treatment of Muscle Tension Dysphonia: A Comparison of Two Treatment Techniques by Means of an Objective Multiparameter Approach. *Journal of Voice,24*(3), 294-301.

Lierde, K. V., Ley, S. D., Clement, G., Bodt, M. D., & Cauwenberge, P. V. (2004). The outcome of laryngeal manual therapy in four Dutch adults with persistent moderate-to-severe vocal hyperfunction: A pilot study. *Journal of Voice,18*(4), 467-474.

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.

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.

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.

Maryn,Maryn, Y., Kim, H. T., & Kim, J. (2016). Auditory-perceptual and acoustic methods in measuring dysphonia severity of Korean speech. *Journal of Voice*, *30*(5), 587-594.

Mathieson, L., Hirani, S., Epstein, R., Baken, R., Wood, G., & Rubin, J. (2009). Laryngeal Manual Therapy: A Preliminary Study to Examine its Treatment Effects in the Management of Muscle Tension Dysphonia. *Journal of Voice,23*(3), 353-366.

Morrison, M. D., Nichol, H., & Rammage, L. A. (1986). Diagnostic criteria in functionaldysphonia. *The Laryngoscope*, *96*(1), 1-8.

Morrison, M. D., & Rammage, L. (1993). Muscle misuse voice disorders: description and classification. *Acta Otolaryngological (Stockh)*, *113,* 428–434.

Nguyen, D.D., & Kenny, D.T. (2009). Randomised controlled trial of vocal function exercises on muscle tension dysphonia in Vietnamese female teachers. *Journal of Otolaryngology- Head & Neck Surgery*, 38, 261–278.

Ogawa, M., Hosokawa, K., Yoshida, M., Iwahashi, T., Hashimoto, M., Inohara, H. (2014). Immediate effects of humming on computed electroglottographic parameters in patients with muscle tension dysphonia. *Journal of Voice, 28*, 733–741.

Reimann, A. P., Siqueira, L. T. D., Rondon, A. V., Brasolotto, A. G., & Silverio, K. C. A. (2016). Efeito imediato da terapia manual laríngea em indivíduos disfônicos.*CoDAS,28*(1),59.

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.

Reynolds, V., Meldrum, S., Simmer, K., Vijayasekaran, S., & French, N. (2016). Dysphonia in extremely preterm children: a longitudinal observation. *Logopedics Phoniatrics Vocology, 41*(4), 154-158.

Roy, N. (2008). Assessment and treatment of musculoskeletal tension in hyperfunctional voice disorders. *International Journal of Speech-LanguagePathology,10*(4),195-209.

Roy, N., Bless, D. M., Heisey, D., & Ford, C. N. (1997). Manual circumlaryngeal therapy for functional dysphonia: an evaluation of short- and long-term treatment outcomes. *Journal of Voice :11*(3), 321–331.

Roy, N. & Ferguson, N. A. (2001). Formant frequency changes following manual circumlaryngeal therapy for functional dysphonia: Evidence of laryngeal lowering? *Journal of Medical Speech-Language Pathology*, *9*, 169–175.

Roy, N., Ford, C. N., & Bless, D. M. (1996). Muscle tension dysphonia and spasmodic dysphonia: The role of manual laryngeal tension reduction in diagnosis and treatment. *Annals of Otology, Rhinology, and Laryngology, 105*, 851–856.

Roy, N., & Leeper, H. A. (1993). Effects of the manual laryngeal musculoskeletal tension reduction technique as a treatment for functional voice disorders: Perceptual and acoustic measures. *Journal of Voice*, *7*(3), 242–249.

Savithri, S. R., & Jayaram, M. (2005). Rate of speech/reading in Dravidian languages. AIISH Research Fund Project, AIISH.

Sheshashri & Gopikishore (2018) Acoustic Voice Quality Index in Kannada speaking children in the age range of 10 to 12 years(April) Dissertation submitted to the University of Mysore.

Silverio, K. C., Brasolotto, A. G., Thaís Donalonso Siqueira, L., Carneiro, C. G., Fukushiro, A. P., & Roberto de Jesus Guirro, R. (2015). Effect of Application of Transcutaneous Electrical Nerve Stimulation and Laryngeal Manual Therapy in Dysphonic Women: Clinical Trial. *Journal of Voice*, *29*(2), 200–208.

Stemple, J. C. (1993). Principles of voice therapy. *Voice therapy: clinical studies*.

Stemple, J. (2000). *Voice Therapy: Clinical Studies* (2nd Singular.ed.). San Diego, CA: 161.

Uloza, V., Petrauskas, T., Padervinskis, E., Ulozaitė, N., Barsties, B., & Maryn, Y. (2017). Validation of the acoustic voice quality index in the Lithuanian language. *Journal of Voice*, *31*(2), 257-e1.

Van Houtte, E., Van Lierde, K., & Claeys, S. (2011). Pathophysiology and treatment of muscle tension dysphonia: a review of the current knowledge. *Journal of Voice*, *25*(2), 202-207.

Verdolini-Marston, K., Burke, M. K., Lessac, A., Glaze, L., & Caldwell, E. (1995). Preliminary study of two methods of treatment for laryngeal nodules. *Journal of Voice, 9*, 74–85.

Wolfe, V., Cornell, R., & Fitch, J. (1995). Sentence/vowel correlation in the evaluation of dysphonia. *Journal of voice, 9*(3), 297-303.

Zraick, R. I., Wendel, K., & Smith-Olinde, L. (2005). The effect of speaking task on perceptual judgment of the severity of dysphonic voice. *Journal of Voice, 19*(4), 574-581.