EFFICACY OF NASAL RESISTANCE TECHNIQUE ON GLOTTAL ADDUCTION IN YOUNG PHONO-NORMAL INDIVIDUALS

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CERTIFICATE

This is to certify that this dissertation entitled **"Efficacy of nasal resistance technique on glottal adduction in young phono normal individuals"** is a bonafide work submitted as a part fulfilment for the Degree of Master of Science (Speech-Language Pathology) of the student with the Registration Number: P01II22S123018. 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.

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CERTIFICATE

This is to certify that this dissertation entitled **"Efficacy of nasal resistance technique on glottal adductionin young phono normal individuals"** has been prepared under my supervision and guidance. It is also been certified that this dissertation has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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DECLARATION

This is to certify that this dissertation entitled **"Efficacy of nasal resistance technique on glottal adductionin young phono normal individuals"** is the result of my own study under the guidance of Dr. R Rajasudhakar, 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 the award of any other Diploma or Degree.

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Chapter I

Introduction

The larynx is one among the organs human possess where the vocal folds lies within the larynx. The vibration of vocal folds makes up our voice. When the structure or function of vocal folds gets disturbed, voice quality is affected, leading to dysphonia. Speech-language pathologists (SLPs) play a crucial role in the treatment of dysphonia. By providing therapy using various techniques and strategies, SLPs help individuals with dysphonia to regain their ability to produce voice efficiently.

According to Stemple et al. (2018), the approaches of voice therapy can be categorized under five major headings. They include hygienic voice therapy, symptomatic voice therapy, psychogenic voice therapy, physiologic voice therapy, and eclectic voice therapy. The selection of a particular voice therapy approach depends on the specific needs of the clients as well as the clinician's theoretical orientation.

Among the physiological approaches, vocal function exercises, resonant voice therapy, and semi occluded voice therapy exercises are the main voice therapy techniques used by clinicians. All of these exercises have been shown evidence in the literature. Speech-language pathologists endorse multiple variants of the SOVTs in their clinical setups to ameliorate dysphonia. In general, as the name suggests, the SOVT exercises involve partial occlusion of the vocal tract.

Titze (2006) identified the major types of SOVT techniques available in the literature. The long list includes partially covering the mouth with a hand while speaking, complete closure followed by the opening of the mouth before vocalization, lip trills, tongue trills, and raspberries. He also identifies the y-buzz technique given by Lessac (1967), resonance voice therapy given by Verdolini-Marston et al. (1995), and bilabial voiced fricative under SOVT.

Flow resistance straws and nasal consonants are the other two SOVT techniques mentioned by Titze (2006). Apart from the above variants, Radhakrishnan in 2022 introduced a novel SOVT approach named as Nasal Resistance (NR) technique. The procedure of this technique involves occluding the nostrils partially by fingers. No other techniques reported in the literature share similarities with the NR technique. However, a study conducted by Konrot et al. in 2022 discussed about the nasal tube in water exercise. Later study employed nasal consonants while keeping a nasal tube in water resembles the nasal resistance as described by Radhakrishnan (2022).

Nasal Resistance Technique

Humming is considered to be helpful in both voice therapy as well as voice training (Cooper, 1971; Gregg, 1997; Miller, 1996; Verdolini-Marston et al., 1995; Yiu & Ho, 2002). NR technique involves offering manual resistance at the level of nostrils while humming. The intended purpose of it is to increase the glottal adduction. During the technique, two levels of resistance would be felt in the vocal tract. 1st at the level of the nasal cavity, the small lumen creates the natural resistance. Second at the level of nostrils using thumb and index finger (Radhakrishnan, 2022).

The single study available in the literature on NR technique was carried out by Radhakrishnan in 2022, where the study considered 34 vocally healthy adult females. The participants were asked to perform four techniques. These included steady modal phonation, straw phonation, humming, and NR technique. The order of performing these techniques was randomized. While performing the techniques, electroglottogram (EGG) contact quotient and jitter values were taken. Results showed maximum contact quotient (CQ) for the NR technique and minimum CQ for humming among the four prescribed techniques. It was also found that jitter values were lesser for NR technique compared to straw phonation and steady modal phonation (Radhakrishnan, 2022).

Study conducted by Konrot et al. (2022) involved phonation in water for 5 minutes with a submersion depth of 5 cm. The task was carried out in two ways by all the 34 participants with normal voices. The first was through nasal route using a tube attached to the nostril by a nasal pillow mask. The authors termed it as Semi occluded nasal tract exercise (SONTE). The second was through oral route using a tube identical to the one used for the first task. Acoustical, aerodynamic, and EGG measures were taken before and after the task. Pre-post comparison indicated no significant difference in the temporal and spectral parameters except for amplitude perturbation values. Amplitude perturbation decreased following the exercise in both conditions. There was an increase in mean SPL values after both exercises. Oral and nasal SOVT techniques were found to increase peak inspiratory flow (PIF). The increase was more for nasal route compared to oral route. The CQ values were found to have no significant differences in the pre-post comparison. However, the jitter and periodicity values showed a significant difference and they were found to have a reciprocal interaction as well. From their obtained results, the authors concluded that SONTEs would be as effective as SOVTEs in their application. However, the authors recommend additional research to gain a complete picture of the utility of the mentioned technique. The authors also recommend changing or altering the tube submersion depths, body mass index, gender, implementation period, and long-term effects in this regard.

Glottal adduction

The physical impact of SOVT technique on the human laryngeal system and the scientific underpinning was explained by Titze in 2006. It is understood from his explanations that the SOVT techniques increase the inertance in the vocal tract and lead to reduced phonation threshold pressure increasing the efficiency of vocal fold vibration (Kang et al., 2019). For this reason, SOVTs are often used with hyper functional voice disorders. However, clinicians also use SOVT techniques in the case of hypofunctional voice disorders. Straw phonation using a small diameter is a well-accepted technique in this regard. The NR technique which is newly introduced, is also thought to be an exercise of a similar kind (Radhakrishnan, 2022). Both the straw phonation with small diameter and NR technique, can be discussed in terms of their impact on glottal adduction.

Electroglottograph (EGG) helps us to understand glottal contact better. During phonation, vocal folds come into contact at the bottom first and go on zipping up upwards along its length. The separation of the vocal fold also starts from the bottom and ends at the top. The duration of time vocal folds come in contact is referred to as contact quotient (CQ). The duration of time vocal folds are apart is known as the open quotient (Pinto & Hijleh, 2021).

Although there are numerous variations of SOVT exercises, each has a limited body of literature. This is dearth of literature makes it difficult for speech language pathologists to make well-informed decisions, limiting evidence-based practice when addressing management of hypofunctional voice disorders. Manually offering Nasal Resistance (NR) at the nostrils during humming is an innovative way to improve glottal adduction. Radhakrishnan's preliminary research gives cause to endorse this approach for hypofunctional voice issues. Although the former study using the NR technique on 34 vocally healthy adult females showed an increase in Contact Quotient (CQ) and a reduction in EGG jitter during the task, it remains unclear whether this technique has any lingering effects or carry over effects on the vocal system. Additionally, information about the appropriate dosage and specific tasks for this technique are still lacking. Considering that ethnocultural differences can affect individuals' voices, it is essential to implement this technique with the Indian normophonic adult population before applying it to a clinical setting. Therefore, the present study aimed to address this knowledge gap.

Objectives of the study

The objectives of the present study are;

1. To compare CQ and EGG jitter before, during, and after 5 days of 5 minutes of NR humming technique training.
2. To compare CQ and EGG jitter before, during, and after 5 days of 10 minutes of NR humming technique training.
3. To compare CQ and EGG jitter parameters between 5 minutes and 10 minutes of NR humming training.

Chapter II

Review of Literature

Voice production mechanism

The acoustically perceived human voice is the consequence of complicated fluid-structure-acoustic processes that interact intricately with one another. Anatomical qualities of the lungs, larynx, and vocal tract has an important role to play in voice production (Zhang, 2016). Thus, an integrated approach involving physiology, vibration of the vocal folds and acoustics are very much essential in understanding voice production and voice control. Especially in clinical care of voice disorders, a sound understanding of what physiological change affects the output is paramount. This helps in justifying the altered voice quality and thus indicating its possible remedial measures (Kreiman & Sidtis, 2011). From the clinical point of view, such information act as the torch bearer in predicting the voice outcomes of care given to the patient as part of voice management, thus improving diagnosis as well as treatment.

Voice problems occur when a person's voice quality changes. The change can be in terms of pitch or loudness which are found to be erroneous for their age, gender, cultural background, or geographical location (Aronson & Bless, 2011; Boone, 2010; Lee et al., 2004). Irrespective of other’s views, if one finds his/her voice to be not suitable for their daily demands, it is termed as voice problem (ASHA, 1993; Casper & Leonard, 2006; Stemple et al., 2018; Verdolini & Ramig, 2001).

Prevalence of voice problems described in the literature ranges from 0.98% to 38.4% in the United States (Bhattacharyya, 2014; Cohen et al., 2012; Lyberg-Åhlander et al., 2019; Roy et al., 2004). Research indicated that up to 30% of general population experience voice complaints at least once during their lives (Roy et al., 2005). Huston et al. conducted a survey on vocal disorders and voice use in 2024. In the study, 20% of the 1522 respondents representing the sample population of the United States reported having an abnormal voice condition at some point of time in their lives. Approximately 60% of this subset sought medical attention for their voice, with 12.6% having a current condition and 9.5% reporting a reoccurring vocal issue. From the findings of the study, authors reported that one out of every five Americans surveyed, had a vocal problem (Huston et al., 2024). In spite of accommodating very large population, there are limited information available regarding the prevalence of voice disorders in India. In the literature focusing on professional voice users, prevalence of voice disorders varies from 17.4% to 89% (Devadas et al., 2017, 2020; Jayakumar et al., 2022; Joshi et al., 2020; Menon et al., 2021). This discrepancy can be due to changes in research methods and population investigated. A preliminary cross-sectional survey done by Sheyona and Devadas in the year 2022 on voice users who are non-professionals and work in various educational institutions present in Manipal, a city in Karnataka state, reported a lifetime prevalence of 21.6%. Also, 4.9% of the participants reported voice disorder on the day of the survey (Sheyona & Devadas, 2022). The authors proposed for a larger scale study to understand the epidemiology of voice disorders in a better manner in India.

Various authors have come up with different classifications of voice disorders. In which, a former binary classification of voice disorders into hyper functional and hypo functional is worth noting (Froeschels, 1943). The hyper and hypo functioning is with respect to laryngeal musculature. Based on the etiology, voice can be classified into functional and organic as well (Brodnitz, 1966). Functional voice disorders refer to conditions where vocal abuse or misuse is the primary cause of voice problems. In such cases, excessive breath pressure and/or muscular contractions along with hyper functional phonation are predominantly present. Prolonged hyperfunction can lead to weakening of vocal system resulting in hypofunctional voice as well, for example, myasthenia laryngis reported by Jackson (1940) wherein the voice problem is understood analogous to writer's cramp in which there is fatigue after prolonged usage (Jackson, 1940). In contrast to functional voice problems, organic voice disorders are thought to be the result of changes of laryngeal structures, loss of tissues and or neurological impairments (Brodnitz, 1966).

Voice treatment

Historically, Speech language pathologists began caring for the voice in the 1930s as a result of efforts to improve normal voice quality. Ever since then, many therapy techniques used to train the ideal voice has evolved. These include improving vocal hygiene, therapy that detects and alters vocal symptoms, therapy that addresses the psychogenic components of the voice problem, and therapy that investigates and improves the underlying physiology of the voice disorder using direct voice exercises. The majority of voice treatments are eclectic, incorporating elements from all voice therapy approaches (Stemple, 2005).

Physiological approaches include vocal function exercises, resonant voice therapy, and semi occluded voice therapy (SOVT) exercises. Even though other exercises are present, these are considered to be the prominent ones (Radhakrishnan, 2022). In general, as the name suggests, the SOVT exercises involve partial occlusion of the vocal tract. In a systematic review (Yiu et al., 2017) on resonant voice therapy, conducted by two independent reviewers based on the published papers from 1974 to 2014 using the keywords ‘‘Humming, Resonance, Resonant Voice, Semi-occluded or closed tube phonation’’ found nine such studies in the available database systems. Two of them were randomized controlled trials. The remaining seven were judged to be observational studies. Several resonant voice therapy variants were discussed in the above study which includes Lessac-Madsen Resonant Voice Therapy, Y-Buzz, Resonance Therapy, and Humming. The authors assigned a moderate degree of quality to the evidence supporting exercises based on SOVT principles in general.

However, as the majority of the research lacked a comparison group, the improvement in voice cannot be attributed only to the resonance voice. The review clearly demonstrates a dearth of quality research on resonance voice therapy, which attribute as reason for "moderate" degree of confidence. Most studies used small sample numbers and were limited to a single clinical population, gender, or occupational category. There was a lack of studies based on multicentre care as well, thus making it not clear whether the results can be generalized if done by different clinician as well (Yiu et al., 2017).

Mechanism of SOVT

Since its introduction, SOVT exercises have been utilized in voice treatment for two primary reasons. One is to lessen extra muscular tension in the vocal tract while the other being to have resonant quality (Laukkanen et al., 1996; Titze, 2006). During the exercise, impedance matching between the glottis and supraglottic cavity occurs. This makes velocity between supraglottic air pressure and flow in-phase. It thus feeds energy back into the glottis and hence aids in adduction (Andrade et al., 2014). Furthermore, glottal shape in adduction also changes during SOVT. In the normal way, tight adduction at the top and loose adduction at the bottom resulting in a convergent glottal shape happens. However, in SOVT, pattern changes to rectangular shape with equal adduction from top to bottom. Thyroarytenoid muscle contraction aids in vocal fold adduction. Thus "squaring up" effect happens at the level of vocal folds, that led to lowering the phonation threshold pressure (Titze, 2006).

Although there are numerous variations of SOVT exercises, each has a limited body of literature. This dearth of literature makes it difficult for speech language pathologists to make well-informed decisions, limiting evidence-based practice. Differences in SOVT exercises can be in terms of number and placement of constriction offered. The length as well as diameter of the straw (if used), and tube-water/straw-water depth also contributes to variations found in SOVT (Radhakrishnan, 2022). The implementation and physiology will differ with each version. Titze (2006) analyses the various SOVT approaches according to their occlusion effect and naturalness. From biggest effect and least natural to smallest effect and most natural, they can be classified. Tiny diameter stirring straw, which is highly resistant followed by larger diameter drinking straws which provide less resistance fills the first two positions. Then voiced fricatives involving bilabial or labiodental place of articulation, Lip or tongue trill, nasal consonants and the vowels (in specific /u/ and /i/) comes in the order (Titze, 2006).

Studies on SOVT

Andrade et al., (2014) investigated various SOVT exercises using various parameters. From the Electroglottography, authors measured contact quotient (CQ), range of contact quotient (CQr). Acoustically, Fundamental frequency (F0), range of fundamental frequency, and F1-F0 difference were found. EGG signals were acquired using the Laryngograph equipment. Speech Studio software was also used to measure the relative vocal fold contact area. To capture audio signals, Laryngograph headband microphone used. It was placed 5 cm away from the side of the mouth.

The SOVT exercises examined were LaxVox (soft silicone tube with 25 cm in length and 9mm diameter internally) and straw (12.5 cm long and 4 mm diameter internally) phonation. Lip and tongue trills, humming by placing handover-mouth, and tongue-trill combined with hand-over-mouth were also included. As a control exercise, comfortable Phonation was used. The authors categorized the exercises into two categories. The first group of activities had only one source for vibration, namely the vocal folds (hand over mouth, humming, and straw phonation). Whereas the second group of exercises had a secondary source of vibration (lip trill, tongue trill, and lax-vox).

Based on the data gathered, the authors discovered that exercises with a single vibratory source had no statistically significant difference in CQr value from the control exercise. Whereas the exercise with a supplementary source of vibration showed a statistically significant change in CQr values. The only exercise that yielded statistically significant (lower) CQ values in comparison to comfortable phonation was lip trill. An increase in F0 was seen, although the difference was not statistically significant. The fundamental frequency range was found to be greater and statistically significant for the second group, indicating that the first set of vibrations was "steady" while the second set was "fluctuating". The F1-F0 acoustic parameter revealed substantial differences in results between the two groups. The authors concluded that, the exercises in group two may be more appropriate for patients with excessive extrinsic laryngeal muscles tension. They attribute this to their stronger massage effect on glottis (due to increased CQr values) compared to group one. However, it should be noted that these results were acquired alone when normal persons performed the activity, rather than as part of a therapeutic plan for dysphonic individuals.

Meerschman et al. (2024) studied the effects after SOVT exercise using straw (21 cm long with 5 mm diameter) phonation (SP) for a short span of time in air and water. Authors evaluated these therapy effect on vibration of vocal folds and activity at the level of supraglottic region in patients having dysphonia. Instantaneous changes in the vocal fold vibrations and patients' supraglottic activity "during" the tasks were also investigated. A strobovideolaryngoscopy (SVL) was used for the same purpose.

Twelve adults with voice disorders including eight women who are twice in number compared to that of men (four in number) with average age of 52 years participated in the study. They were randomly allocated in to two groups. Namely, SP in air or SP in water (2cm deep under water). Participants conducted a rigorous SVL just before, during, and after a 15-minute therapy session. Three laryngologists performed the visual-perceptual ratings. They were blindfolded and did it in random order. Voice-Vibratory Assessment with Laryngeal Image rating form for stroboscopy was used for the same.

The vibrational amplitude of vocal folds decreased during SP in water, whereas it increased during SP in air. The authors conclude that this is due to insufficient supraglottic pressure during the SP in air task. After the session, there was no difference in vibrational amplitude for SP in air modality. However, SP in the water modality showed an increase in vocal fold vibrational amplitude. This shows a transfer of vocal efficiency. Nevertheless, since the number of participants were less and the specific voice abnormalities varied among individuals, generalizing the results warrants caution.

Guzmán et al. (2016) evaluated how the phonation into tubes varies between air and water by measuring different parameters during the phonation task. For the same purpose, air pressure and vocal fold adduction measures were taken from patients with various voice disorders. The study was conducted on forty-five participants. The participants were divided into four groups: First two being normal with and without receiving voice training and the other two being individuals with muscle tension dysphonia, unilateral vocal fold paralysis, respectively.

Participants were requested to phonate into various types of tubes. They included straw used for drinking (5mm in inner diameter), straw used for stirring (inner diameter-2.7mm) and silicon tube (inner diameter-10mm). Phonation were under two conditions: one in air and another in water. The glottal contact quotient (CQ) was measured simultaneously with EGG (model 6103, KayPENTAX). Aerodynamic measurements included subglottic pressure (Psub), oral pressure (Poral), and trans glottal pressure. Phonatory Aerodynamic System was used for their measurement. Fundamental frequency (F0) using a condenser mic integrated into the PAS system (AKG Acoustics, Vienna, Austria) was also measured.

All exercises significantly impacted Psub, Poral, trans glottal pressure, and CQ. Phonating through silicon tube which is 55cm long and kept in ten-centimetre depth of water using a stirring straw produced the largest CQ value. Also, it had the most Psub, and Poral values relative to the baseline among all the vocal states. The authors concluded that, regardless of the participants' vocal status, most parameters followed a consistent pattern with significant individual variability. Some of the study's drawbacks include a small number of participants in each group, no gender-specific divides, no consideration of air flow measures, and the exclusion of patients with phono traumatic vocal fold injuries.

Studies on Humming

Humming is a soft-onset vocalization method that slows down vocal fold adduction (Iwahashi et al., 2017). It also enhances proprioceptive feedback by vibrating the nasal and facial bones (Andrade et al., 2016). Owing to its easiness to learn and implement, it assists speech language pathologists in achieving vocal projection and resonance balance in their patient population, especially if individuals struggle to master other SOVT techniques (Zenari et al., 2023).

In a study of women with vocal hyperfunction, humming enhanced phonation four seconds after emission (Andrade et al., 2014). Another study carried on individuals with mass lesions on vocal folds (eg. nodules, polyps, and cysts) found improved voice quality and acoustic measurements as a result of humming for three seconds (Vlot et al., 2017).

A review of literature on humming as an exercise based on SOVTE principles revealed immediate positive effect of humming on various parameters in individuals with muscle tension dysphonia. These includes improved acoustic signal quality along with increase in glottal closure. An increase in regularity of vocal fold contact, and supraglottic compression degree were also found. The results were found to be similar in non-dysphonic individuals. Indicating potential benefit of humming in improving the voice quality (Zenari et al., 2023).

Ogawa et al. (2014) studied the immediate effects of humming as well as um-hum phonation (pitch glide up incorporated with humming) on 21 individuals with muscle tension dysphonia. Twenty non-dysphonic people were chosen as controls. In their study, each participant was given three different phonation tasks namely, natural phonation, humming with no pitch shifts, and um-hum phonation.

Acoustic and EGG data were gathered while subjects carrying out tasks. The parameters identifying aberrant vocal fold vibrations were found along with the parameters indicating extent of glottal contact. These were then compared across the tasks. Acoustic recordings were taken with an electret condenser microphone which is head-mounted and having omnidirectional polar pattern. The mic was positioned laterally, 2 cm away from the participant's mouth. EGG electrodes were attached to the participant's neck near the bilateral thyroid cartilage lamina using Velcro strap. Recordings were done in a soundproof room. The GRBAS scale was used to evaluate perceptual abilities.

Perceptual disturbance and roughness characteristics were shown to be reduced in MTD patients. In both groups, a decreasing trend was found in the perturbation parameters of EGG signals during humming or um-hum phonation. CQ standard deviation also showed a similar trend. In addition, CQ increased dramatically in MTD group after humming alone. In both groups, increase in CQ noted when humming and um-hum phonation exercises used together. These findings indicate an immediate effect of normal humming without any pitch changes, followed by um-hum phonation, on adjusting regularity of vocal fold vibration. It can also be found that, these exercise aids in the extent of vocal fold contact in MTD patients as well as nondysphonic individuals. In patients with MTD, humming alone is found to be sufficient to increase the extent of glottal contact. However, study did not talk about the CQ values during normal phonation after the humming and um-hum phonation. Hence, the generalization effect of humming and um-hum phonation on vocal fold contact and regularity of vocal fold vibration on normal and regular phonation is not known.

Vlot et al. (2017) studied people with organic dysphonia (OD) to see if humming could reduce the irregularity in the vibration of vocal folds. The authors used electroglottography (EGG) as well as laryngeal high-speed digital imaging (HSDI) as the outcome measures. The study included 49 dysphonic patients with benign mass lesions on the vocal folds. An equal number of healthy persons with normal voices served as the control group. Perturbation parameters for acoustic (Ac) and EEG data were determined from both the groups during natural phonation (phonating /e/ for more than 3 seconds) and humming (for more than 3 seconds).

Furthermore, during the performance of two tasks, EGG and HSDI video capture using laryngofiberoscopy was done on 11 patients with OD and same number of healthy speakers having normal voice. Estimation as well as correlation of EGG perturbation measures and the glottal area waveforms (GAW) from the HSDI were made. Data was collected using a head mounted electrets condenser microphone and an EGG device. Monochrome high-speed camera having HSDI system with xenon light source was also used. The results showed an improved EGG perturbation parameters in both groups for humming task. Compared to control group, majority of the OD patients had lower perturbation parameter values in EGG. The GAW analysis found moderate correlations between perturbation parameters of period and amplitude. These findings suggest that humming can improve voice quality in OD patients by stabilizing vocal fold oscillation. However, study did not include a task involving humming with pitchgliding, which could have provided further information about the physiological changes that occur when humming with pitch changes.

Furthermore, the results were based on a single task performance, but learning about it as part of a voice training regimen could have shed light on its genuine clinical relevance.

Nasal consonants as SOVT

Nasal consonants are produced with semi-occlusion of the vocal tract that has long been utilized in vocology but may not be frequently associated with the new term SOVT. These includes /m/, /n/ & /ŋ/. The oral constriction can be at the lip level, alveolar level, or at the velar site. During the production of nasal sound, velar port is opened. Thus, the nasal airway acts as the upper part of vocal tract, with the nostrils providing semi-occlusion (Dargin et al., 2016). These treatments are designed to improve resonant voice perception and retention. The activities of SOVT exercise with nasal consonants begin with humming, then move on to speech sounds incorporated semi occlusions. At the later stage of therapy, spontaneous and habitual speech will be focused (Kapsner-Smith et al., 2015).

Meerschman et al. (2017) investigated the effects of resonant voice training. Authors compared nasal consonants with straw phonation. Study was carried out on prospective occupational voice users who were having normal voice. Randomized control group design with multigroup pretest-posttest was utilized for the study. Thirty students pursuing speech-language pathology course whose age ranging 17-22 years were assigned into three groups randomly, namely, resonant voice training (n = 10), straw phonation (n = 10), or control (n = 10). To assess the participants' voices before and after training, a voice assessment protocol was used, which included both subjective and objective measurements.

Acoustic measurements were performed using the Computerized Speech Lab's MultiDimensional Voice Program (MDVP). Microphone placement was 15 cm from the lips and inclined at 45 degrees. The aerodynamic measurements were obtained using a dry spirometer. The vocal range profile (VRP) was established by the Computerized Speech Lab using a microphone positioned similar to that for MDVP.

Resonant voice training as well as straw phonation groups underwent practice for six weeks, with two 30-minute sessions per week. Training with nasal consonants started with emphasizing sensory feedback along with forward focus associated with phonation of /m/, /n/, and /ŋ/. In the next stage, nasal sounds were combined first with rounded and unrounded vowels and then with consonants. Pitch as well as loudness activities were taught and practiced in following sessions, including pitch glides, loudness changes, emphasis, and melodies. Second phase of training began with session 7, focusing on nasal sounds embedded speech. This was then shifted to ordinary open-mouth phonation. Training was carried out in a hierarchical manner starting from simple and moving to complex (word, phrase, sentence, and text levels, in this order, resonance gradually reduces). The last three sessions focused on spontaneous speech. Throughout each session, the experimenters provided verbal instructions and various examples along with corrective feedback whenever necessary.

The straw phonation group phonated /o/ and /ɔ/ vowels with a 21 cm long drinking straw having a diameter of 5mm. Participants discovered the increased airflow resistance during phonation. Pitch as well as loudness activities were introduced in session 2 and repeated in later sessions. These included pitch glides, emphasis, and melodies similar to nasal consonant exercise group. Beginning with session 7, a smaller and shorter stirring straw with 2.5 mm diameter and 11.5 cm length was used. Usage of small and short stirring straw was to increase inertive reactance of the vocal tract. The second part of the training sessions (from session 7 onwards), emphasized the transition to regular open-mouth phonation. In this stage, words, phrases, sentences, and paragraphs were uttered with and without a straw to ensure correct intonation and articulation.

For any of the outcome variables measured, there were no significant time-by-group interactions observed. This indicates, an indifference in evolution across time span in all three groups. The training group focused on resonant voice showed a significant improvement in dysphonia severity index. Whereas, the straw phonation group improved in intensity range. Based on their findings, the authors concluded that both SOVTEs are effective in enhancing voice of prospective occupational voice users. They also suggest to utilize their cumulative effect.

One of the study's limitation is that participants were not blinded to the study's objective. The control group received no sham training as well. Additionally, subjective vocal measurements should have been tailored to the target audience. Since the Voice Handicap Index was designed for dysphonic patients, this study might have failed to notice significant self-report data. Visual analogue scales, like the Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V), could be more sensitive than the ordinal GRBASI scale. As those scales are better at recognizing auditory-perceptual distinctions in SLP student population. Larger sample sizes and effect of long-term findings would be more useful in future studies of this nature.

Nasal Resistance (NR) technique

Manually offering NR at the nostrils during humming is an innovative way to improve glottal adduction. A search carried out in PubMed, Scopus, Cochrane Library found two studies related to Nasal Resistance voice therapy. One conducted by Radhakrishnan (2022) and another study carried out by Konrot et al. (2022).

Radhakrishnan's preliminary research gives cause to endorse this approach for hypofunctional voice issues. During the technique, two levels of resistance were felt in the vocal tract. First, the limited lumen in the nasal cavity generates natural resistance. Second, at the level of the nostrils, using the thumb and index finger. When this method was utilized while humming, CQ rose across a wide range of subjects. As a result, author stated that this approach can help patients with inadequate glottal contact (Radhakrishnan, 2022).

Radhakrishnan (2022) studied the effect of the nasal resistance (NR) method on glottal adduction in phono normal participants. The author described it as a potential novel therapy strategy for glottal closure. Thirty-four apparently healthy adult females in the age ranging from 19 to 32 years with mean age: 23.82 years participated in the study. Subjects were instructed to complete four exercises in random order. Two among these were phonation in steady mode and phonation using a straw. Humming and NR method phonation were the other two exercises. EGG measurements involved determining CQ and jitter during the middle of the four mentioned tasks for at least ten EGG cycles using Pentax Medical's EGG Model 6103 (New Jersey, USA) were obtained.

To compare the CQ and jitter outcome measures of each phonatory task, one-way repeated measures ANOVA followed by appropriate post-hoc testing was performed. Analysis revealed significant difference in the mean CQ across all tasks. Among them, humming had the lowest CQ values and NR method found to have the highest CQ values. Although straw phonation had a greater CQ than steady phonation, jitter was significantly reduced using the NR technique. During straw phonation, jitter was found to be not significantly different compared to modal phonation.

The author presented the findings as early proof that the NR technique could increase CQ with less jitter compared to straw phonation with a 2 mm diameter. However, the study's findings were exclusively based on the recordings made while performing the task activities. As a result, it is impossible to comment on the transfer of findings to normal phonation when used as a therapeutic method. Furthermore, the study's subjects consisted of only females and were in limited numbers. These could be considered as limitations of the aforementioned study.

Konrot et al. (2022) studied the efficacy of semi-occluded nasal tract exercises (SONTE). The procedure involved enlarging the nasal cavity. This was done attaching a silicone tube (35cm long with outside diameter 9mm). Nasal Pillow Mask was used to fit the tube to the nasal cavity of the participants. Participants were then instructed to conduct water resistance exercises at a depth of 5 cm. To assess their immediate effects, acoustic, electroglottographic (EGG), and aerodynamic data were collected. Simultaneous recording of acoustic and EGG parameters were done prior to exercise while the participants sustained vowel /ʌ/ phonation.

Aerodynamic examination included measuring oral and nasal peak inspiratory flow (PIF) rates (the largest instantaneous airflow obtained during forced inspiration from the nose or mouth), vital capacity (VC), and maximum sustained phonation (MSP). Both SONTE as well as SOVTE exercises involved 5 minutes of /ɔ/ oral phonation in water at a tube depth of 5 cm. It also involved 5 minutes of sustained nasal /m/ phonation (i.e., humming) in water at the same tube depth. Between sessions, 15 minutes of pure voice rest was advised. While doing the exercise, only EGG recordings were recorded.

On average, each participant took 1.5 hours to complete the procedure. Acoustic measures were taken with a Kay-PENTAX Computerized Speech Lab (CSL) using a condenser microphone. The microphone's frequency response covers 20 Hz to 20 kHz. The microphone was positioned 15 cm away from the participant at a 45-degree angle and zero azimuth.

The time and frequency domain characteristics showed no significant difference before and after the training. Amplitude perturbation quotient (APQ) was the only exception from this. APQ decreased after both exercises. Post exercise comparison showed no significant difference in aerodynamic parameters. However, there was a significant increase in the average SPL values. Increased oral and nasal peak inspiratory flow rates were found post the exercise in both the conditions. Among the two, SONTEs had the most effect than the SOVTE. The CQ parameter showed no significant difference between in SONTE and post-SONTE. The same trend of CQ was observed in-SOVTE and post-SOVTE measurements as well.

However, the jitter and periodicity parameters differed significantly between the preliminary evaluation, during SONTE, post SONTE, during SOVTE, and post SOVTE. The median values of post-SONTE jitter measure were lower than the median values in-SONTE and SOVTE jitter measure. Based on the findings, the authors believed that SONTEs would be just as effective as SOVTEs in their application. However, the authors recommend additional research to provide a complete picture of the technique's utility. Suggested variations include, changing submersion depths of the tube, body mass index and gender of the participants, implementation period, and long-term impacts.

Glottal adduction and EGG

The physical impact of SOVT exercises on the human vocal system and the scientific underpinning was explained by Titze in 2006. It is understood from his explanations that the SOVT techniques increase the inertance in the vocal tract and lead to reduced phonation threshold pressure there by increasing the efficiency of vocal fold vibration (Kang et al., 2019).

For this reason, SOVTs are often used with hyper functional voice disorders. However, clinicians also use SOVT techniques in the case of hypofunctional voice disorders. Straw phonation using a small diameter is a well-accepted technique in this regard. The NR technique which is newly introduced, is also thought to be an exercise of SOVT in nature (Radhakrishnan, 2022). Both the straw phonation with small diameter and NR technique, can be discussed in terms of their effect on glottal adduction.

Electroglottography (EGG) is a low-cost, non-invasive method for detecting vocal fold vibratory activity during voice production. Philippe Fabre introduced it approximately sixty-five years ago. The procedure involves sending a high-frequency (usually in Megahertz) and low-Ampere current between two electrodes that is placed on either side of the thyroid cartilage (Herbst, 2020). Electrodes will be inserted so that current flows roughly perpendicular to the glottis. Changing the vocal fold contact area (VFCA) during vibration causes changes in admittance, which results in a proportionate (demodulated) EGG signal (Hampala et al., 2016).

Earlier publications showed an inverted EGG waveform with VFCA going negative. However, according to recent studies, the EGG signal is expressed so that an increase in VFCA correlates to an increase in positive number. In the late 1980s and early 1990s, EGG gained prominence for scientific and therapeutic applications and was thought to be in its "golden era" (Herbst, 2020).

The EGG contact quotient (CQ) is a critical quantitative analysis metric for the EGG signal. It has been employed in several scientific studies as well. The CQ compares the duration of vocal fold contact to the corresponding glottal cycle. Reinsch and Gobsch first proposed the concept, which was further improved by Lecluse in his dissertation work on excised larynges and EGG (Herbst, 2020). Increased vocal fold adduction is often associated with higher closed quotients (Scherer et al., 1995). Research also indicates that transitioning from "breathy" to "pressed" phonation could be differentiated based on CQ values (Kankare et al., 2012).

Need for the study

Without glottal adduction, the voicing will not be possible. Inadequate adduction would lead to breathy voicing as well. Different aspects of the SOVT techniques were found to have a specific influence on the adduction of vocal folds. These include the number of constrictions offered, the length of the straw, the diameter of the straw, and how deep the straw is kept underwater (Radhakrishnan, 2022).

Even though the preliminary study done using the NR technique on 34 vocally healthy adult females showed increased Contact quotient (CQ) and reduced jitter during the performance of the task, it is still unknown whether the technique has a lasting effect on the vocal system. Information regarding the dosage and specific tasks to be used is also unclear. Given the fact that ethnocultural differences can have an impact on individual's voices, implementation of the specified technique on Indian population before practicing it on clinical population is very much warranted. The present study, therefore intends to fill the knowledge gap in this regard.

Aim of the study

The present study aimed to determine the efficacy of the NR humming technique on glottal adduction in young normophonic adult individuals.

Objectives of the study

The objectives of the present study are;

1. To compare CQ and EGG jitter before, during, and after 5 days of 5 minutes of NR humming technique training.
2. To compare CQ and EGG jitter before, during, and after 5 days of 10 minutes of NR humming technique training.
3. To compare CQ and EGG jitter parameters between 5 minutes and 10 minutes of NR humming training (2 different dosages).

Chapter III

Method

Participants

The study involved 20 healthy adults with normal voices, who were divided into two groups of 10 participants each. Equal number of males & females participated in each group. Participants were selected using convenient sampling. A multi-group time series design was employed for the study. The following criterion were used for the enrolment of participants in the study;

Inclusion criteria

- Participants were in the age range of 18 to 35 years.
- Participants were considered based on the voice quality of participants using GRBAS perceptual voice rating scale (Hirano, 1981), where the overall grade 'G' was zero.
- The Voice Handicap Index-10 (VHI-10) questionnaire (Rosen et al., 2004) was administered, and participants with a score of less than 11 were included in the study.
- Participants with no history of nasal septal deviation-related issues were selected.

Exclusion criteria

- Participants with a past habit or present history of smoking and alcohol consumption were eliminated from the study.
- Participants with any history of diagnosis of voice disorders or other laryngeal pathologies were not included in the study.

- Participants with acute respiratory infections at the time of the study were eliminated.
- Participants who engaged in voice usage for professional activities (e.g., singing, teaching, dubbing) for more than 2 hours daily were not considered for the study.
- Participants with a past or present history of hormonal therapy were eliminated.
- Any participants who had recently participated in any kind of voice therapy were excluded from the study.

Instrumentation and parameter extraction

The electroglottography (EGG) of the Computerized Speech Lab (CSL) model 6103 (Kay-Elemetrics, USA) software was used in the present study. The researcher measured contact quotient and EGG jitter values in the present study.

Procedure

The aim and objectives of the study were explained to the participants. Written consent was obtained from them. The entire data collection procedure was carried out in three phases, where the data collection procedure was adhered to AIISH ethical committee guidelines for Bio Behavioral Sciences for Human Subjects (AEC, 2009).

Phase 1: Baseline

Participants were made to sit comfortably on a chair in a noise free room. They were then asked to maintain a 90-degree upright posture with relaxed and stable neck positioning. Following adequate seating, the researcher explained electrode placement and provided instructions concerning EGG recording to the participants. The individuals were asked to indicate any discomfort felt during electrode placement, which was done on either side of the thyroid lamina or throughout the procedure. Participants were then asked to carry out phonation of /a/ vowel. For better understanding of the task, the researcher provided a small demonstration as well.

Once the above procedure was completed, the participants were called back after two days, and the EGG recording was repeated in the same manner. This was done to understand the amount of variability in EGG due to placement differences. Both the first & second EGG recordings were compared, and since a correlation was found between both recordings, the average of both was taken as the representative baseline.

Phase 2: NR Technique for five days

The participants were enrolled in the NR humming technique for five consecutive days. The investigator provided training on the NR technique once per day, and it was carried out on an individual basis while they performed the technique face-to-face. The researcher provided instructions regarding the steps involved in the technique, and the participants were asked to carry them out. Participants were divided into two groups based on the dosage of NR humming training. One group was given 5 minutes of training whereas second groups was given 10 minutes of NR humming training.

NR Humming Technique training

The technique was conducted in the following manner, in accordance with the protocol mentioned by Radhakrishnan (2022):

- Participants were asked to sit comfortably.
- Participants were asked to take a deep breath and hum at a comfortable pitch and loudness.
- After monitoring the pitch and loudness at their comfortable level, participants were then asked to occlude the flow of air by gently placing their index and thumb fingers on each of their nostrils to offer resistance to the flow of air. The investigator provided latex-free gloves to the participants during this step to maintain hygiene.
- Participants were asked to match & produce the pitch and loudness of humming as like before occluding the nostrils.
- Once the participants successfully produced humming with nasal resistance, they were asked to prolong it for 5 seconds. After this introductory training, formal training was conducted.

For the five-day training, the steps given by Meerschman et al. (2019) were adapted to the NR technique. The number of trials varied for 5-minute and 10-minute dosages to fit within the time frame (the number of trials was doubled for the 10-minute training). The details of the NR technique, including the steps, number of trials, and duration, are depicted in table 1.

Table 1

NR humming training details

S. No.	Exercise Steps	Trials and breaks	Total duration
1.	Maintain correct body posture.		
2.	Start inhaling through the nose and hum for continuous 10 seconds.	3 Trials with 5 seconds break in between.	
3.	Participants were instructed as follows Hum for 3 seconds and start NR humming from then on for 10 seconds. 1. Rising the pitch for 10 seconds using NR humming 2. Pitch gliding for 10 seconds (from low to high and vice versa). 3. Hum familiar melodies (Happy Birthday melody) for 20 seconds using NR humming technique.	1. 3 Trials with 5-seconds break. 2. 3 Trials with 5 seconds break. 3. 3 Trials for each with 5 seconds of break. 4. 3 Trials with 20 seconds of break.	4.25 Minutes
5.	Continue humming with using NR technique for 10 seconds.	3 Trials for each with 5 seconds of break.	0.75 Minutes
			Total duration=5 minutes

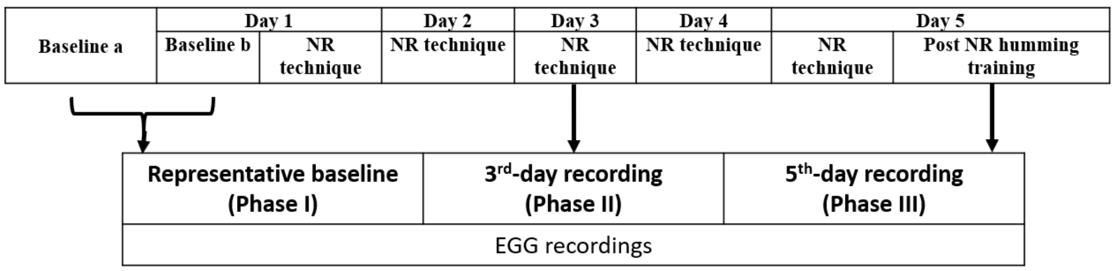
On completion of the third day of NR technique training, EGG recording was done during the training regimen. The EGG recording was carried out while the individual phonated vowel /a/.

Phase 3: Fifth day of NR technique

The participants underwent the NR technique for five consecutive days. EGG was recorded after the fifth day, which was the last day of the technique regimen. The 5^{th} day recording was done similarly to that of the 3^{rd} day recording. The schematic diagram (Figure 1) below represents all the phases and recording timelines involved in the study.

Figure 1

Phases and timelines of EGG recording



Statistical analysis

The mean, median, standard deviation, minimum and maximum values and inter quartile range of EGG CQ and EGG jitter were measured for both the dosage groups across three conditions (baseline, during, and post-training) using descriptive statistics. The normality test was done using the Shapiro-Wilk test. The results revealed normal distribution for CQ measure, whereas jitter values followed non-normal distribution. Also, the jitter values showed increased standard deviations than median values. Hence, for the analysis of CQ measure, parametric tests such as Mixed Repeated Measures ANOVA and independent two-sample ‘t’ tests were used, and for the jitter measure, non-parametric tests such as Mann-Whitney U test, Friedman's Two-Way ANOVA were chosen for between group comparison.

Chapter IV

Results

The objectives of the study were to (a) compare CQ and EGG jitter before, during, and after 5 days of 5 minutes of NR humming technique training, (b) compare CQ and EGG jitter before, during, and after 5 days of 10 minutes of NR humming technique training, and (c) compare CQ and EGG jitter parameters between 5 minutes and 10 minutes of NR humming training. The statistical tests were carried out for the above purposes using "Statistical Package for the Social Sciences" (SPSS) software (version 26.0).

1. Shapiro-Wilk's test of normality
2. Descriptive statistics
3. Mixed Repeated Measures ANOVA
4. Mann-Whitney U test
5. Friedman's Two-Way ANOVA
6. Independent two sample 't' test

Tests of Normality

Shapiro-Wilk's test is used to find whether the measured parameter follow the normality assumption. The results revealed that EGG CQ parameter fulfill the normality assumption (p value > 0.05), whereas jitter values did not (p value < 0.05). Also, the jitter values showed higher standard deviations as well. Hence, for the analysis of EGG CQ measure, parametric tests such as Mixed Repeated Measures ANOVA and independent two sample 't' tests were used and for the EGG jitter related measures, non-parametric tests such as Mann-Whitney U test, Friedman's Two-Way ANOVA were chosen.

Descriptive statistics

The EGG Recordings were done on four time points (1) baseline a, (2) baseline b, (3) on 3rd day of NR humming training, and (4) post 5th day of NR humming training. The EGG parameters (CQ & EGG jitter) were measured, & tabulated for both groups (five minutes and 10 minutes) across four time points. Using the SPSS software, the descriptive statistics like mean, median, standard deviation, minimum, maximum values & inter quartile range of the two parameters were extracted & compared within and between groups. Table 2 depicts the results of descriptive statistics across four time points.

Table 2

Descriptive statistics results of parameters extracted across time points

	Group	Mean	Median	SD	Minimum	Maximum	Interquartile Range
CQ Baseline a	5 min	44.16	44.08	4.86	34.16	51.98	4.76
	10 min	44.18	43.98	2.25	39.49	47.32	2.83
CQ Baseline b	5 min	44.02	44.21	4.41	35.84	51.84	5.39
	10 min	45.43	44.95	3.52	39.57	51.94	5.45
CQ 3rd day	5 min	46.16	45.23	4.16	39.62	52.00	6.64
	10 min	46.83	46.12	3.55	41.96	53.75	5.16
CQ Post 5th day	5 min	45.70	44.00	3.74	40.61	51.27	6.87
	10 min	47.47	47.48	3.88	41.53	54.82	5.76
EGG Jitter baseline a	5 min	0.70	0.66	0.32	0.32	1.39	0.44
	10 min	0.48	0.45	0.22	0.17	0.87	0.42
EGG Jitter baseline b	5 min	0.76	0.68	0.31	0.38	1.28	0.62
	10 min	0.41	0.35	0.18	0.24	0.92	0.13
Jitter 3rd day	5 min	0.90	0.46	0.86	0.29	2.91	0.96
	10 min	0.48	0.45	0.20	0.26	0.99	0.23
Jitter post 5th day	5 min	0.64	0.39	0.52	0.28	1.89	0.57
	10 min	0.47	0.46	0.14	0.28	0.73	0.24

*CQ = Contact quotient, EGG = Electroglottogram, min = minute, SD = standard deviation

From the above table, an increase in mean values of CQ can be seen on 3rd and 5th day compared to baseline values. Across all time points, 10-minute dosage group shows consistent higher values compared to 5 minutes dosage group. There is an increase in jitter values that can be noted from baseline to the 3rd day. This increase is more pronounced in the 5 min group compared to the 10 min group. There is a decrease in jitter values from the 3rd day to post the 5th day in both groups. At each time point (baseline, 3rd day, and post 5th day), the 5-minute dosage group tend to have higher mean values compared to the 10 minute dosage group.

The results of current study are discussed under the following sub-headings.

I. Baseline establishment.

II. Effect of NR humming technique training on CQ.

III. Effect of NR humming technique on EGG Jitter.

IV. Comparison of different dosages of NR Humming technique on CQ and EGG jitter.

I. Baseline establishment

Two baseline measurements (baseline a & baseline b) were taken prior to the NR humming training for both CQ as well as for EGG jitter. To have a representative baseline, & to nullify the electrode placement at different time points as a factor, both the baselines were compared. For this, dependent ‘t’ test is used for CQ and Wilcoxon signed-rank test was used for EGG jitter. Result of dependent sample ‘t’ test showed no significant difference between the two baseline CQ values of the participants ($t(19) = -0.999$, $p > 0.05$). Similarly, the results of Wilcoxon signed rank test results showed no median difference between the two baseline values of EGG jitter ($/Z/ = 0.075$, $p > 0.05$). Hence, averages of baseline a and baseline b were taken for further analysis as the “representative baseline”. The values of representative baselines are depicted in table 3.

Table 3

Descriptive statistics of representative baseline for CQ & EGG jitter

	Groups	Mean	Median	Std. Deviation	Minimum	Maximum	Interquartile Range
CQ baseline average	5 min.	44.10	44.23	4.56	35.00	51.91	4.84
	10 min.	44.81	44.91	2.55	39.53	49.63	2.37
EGG Jitter baseline average	5 min.	0.74	0.66	0.30	0.36	1.33	0.41
	10 min.	0.45	0.41	0.19	0.21	0.90	0.19

II. Effect of NR Humming technique training on CQ

The mean, standard deviation, minimum values, maximum values and interquartile range of CQ on baseline, during (3rd day) and immediately after 5th day (post 5th day) of NR humming training are depicted in the table 4.

Table 4

The mean, standard deviation, minimum values, maximum values and interquartile range of CQ across three time points

	Groups	Mean	Std. Deviation	Minimum	Maximum	Interquartile Range
CQ baseline average	5 min	44.10	4.56	35.00	51.91	4.84
	10 min	44.81	2.55	39.53	49.63	2.37
CQ 3rd day	5 min	46.16	4.16	39.62	52.00	6.64
	10 min	46.83	3.55	41.96	53.75	5.16
CQ Post 5	5 min	45.70	3.75	40.61	51.27	6.87
	10 min	47.48	3.89	41.53	54.82	5.76

From the above table, an increment in CQ can be observed on 3rd day as well as on 5th day when compared to the baseline. This is true for both the groups (5 minutes as well as 10 minutes groups). The increment is however seen slightly higher for the 10 minutes group compared to 5 minutes group.

Main effects and Interaction effects measured from Repeated measures ANOVA

Table 5 depicts the results of mixed repeated measures ANOVA. F- value (F) and p- value (p) of main effect as well as interaction effects are incorporated in the same table.

Table 5

Main effects and interaction effects of mixed repeated measures ANOVA on CQ

		F-value	p-value	Partial Eta Squared
CQ	Groups (5 minutes & 10 minutes)	0.537	0.473	0.029
	Time points (Baseline, 3rd day & post 5th day)	4.760	0.015	0.209
	Groups * Time points	0.317	0.730	0.017

From the above table, it can be observed that there is no main effect of dosage group of NR humming training ($F(1,18) = 0.537$, $p > 0.05$) and there is no interaction effect between dosage groups and time points ($F(2,36) = 0.317$, $p > 0.05$). However, there is a significant main effect observed across time points ($F(2,36) = 4.760$, $p < 0.05$). Hence, Bonferroni Pairwise comparison was performed on CQ values across time points (baseline, 3rd day, and post 5th day of NR humming training) to see any significant difference between the time points.

Bonferroni pairwise comparison of CQ values across time points

Bonferroni Pairwise comparison was done to compare CQ values across three time points i.e., baseline, 3rd day and post 5th day of NR humming training. There was no significant main effect of exercise dosage group noticed (Table 4) indicating that CQ is not significantly different between two groups. Hence comparison between two dosage groups at different time points was not performed. The result of the Bonferroni pairwise comparison is depicted in table 6.

Table 6

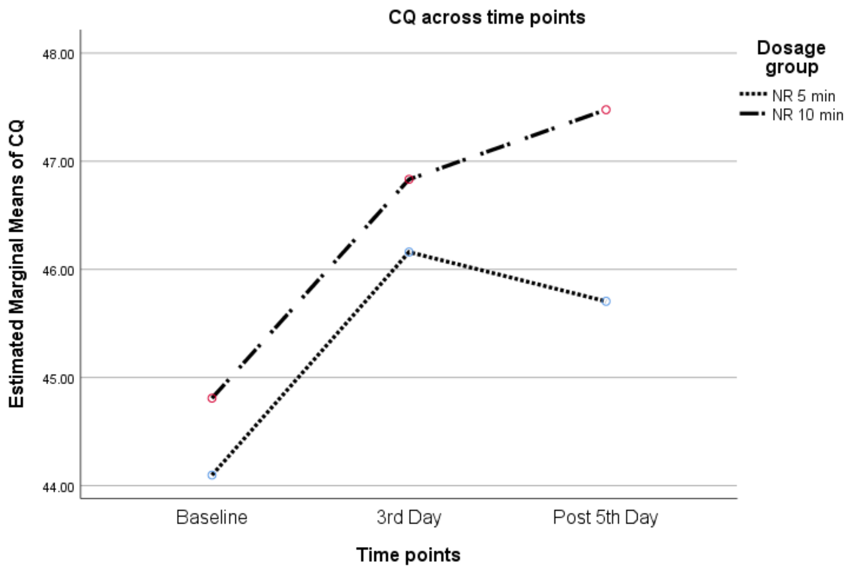
Bonferroni pairwise comparison results

	Time points	Time points	Mean difference	p-value
CQ	Baseline	3rd day	-2.04	0.03
		Post 5th day	-2.14	0.03
	3rd day	Post 5th day	-0.09	1.00

From the above table, it can be seen that, there is a significant increment in CQ values from baseline to 3rd day ($p < 0.05$). On comparing 3rd day and post 5th day, there is no significant increment in CQ noted ($p > 0.05$). However, when we comparing baseline with post 5th day CQ values, significant difference can be noted ($p < 0.05$). The changes of CQ values across time points can be better understood from figure 2.

Figure 2

Changes of CQ values across time points



From the above figure, it can be seen that there is an increase in CQ values after the commencement of NR humming training in both the dosage groups. The increment in CQ values were maintained across 3rd day as well as post 5th day of training. Further, the increase value of CQ was relatively higher for 10 min group than 5 min group, though there was no significant group difference found.

III. Effect of NR Humming technique on EGG Jitter

Mean, median, standard deviation and interquartile range of EGG jitter values across baseline, on 3rd day and on post 5th day for both the groups are depicted in the table 7.

Table 7

The mean, standard deviation, and interquartile range of EGG jitter across time points

	Groups	Mean	Median	Std. Deviation	Interquartile Range
Jitter baseline average	5 min	0.74	0.66	0.30	0.41
	10 min	0.45	0.41	0.19	0.19
Jitter 3rd day	5 min	0.91	0.47	0.86	0.96
	10 min	0.49	0.46	0.21	0.23
Jitter post 5	5 min	0.65	0.40	0.52	0.57
	10 min	0.47	0.46	0.14	0.24

From the above table, higher standard deviation values can be observed in comparison to median values of EGG jitter. Since the Shapiro-Wilk test of normality also indicated non-normal distribution of data (p value < 0.05), median would be better parameter to describe the EGG jitter values. There is a decrement in median scores of EGG jitter that can be observed from baseline to 3rd day and further to post 5th day compared to baseline in 5 minutes dosage group. Whereas an increment in median values can be seen in EGG jitter in 3rd day and post 5th day of NR humming training in 10 minutes dosage group when compared to baseline.

Since the data showed non-normal distribution, non-parametric tests such as Mann-Whitney U test, Friedman's Two-Way ANOVA were used for the analysis of EGG jitter measures.

Mann-Whitney U test results

Mann-Whitney U test was used to compare baseline, 3rd day and post 5th day EGG jitter values across two dosage groups (5 minutes & 10 minutes). The results are depicted in the below (table 8).

Table 8

Mann-Whitney U test results of EGG jitter across time points between two dosage groups

Time points	/Z/ value	p value
EGG jitter baseline	2.34	0.02
EGG Jitter 3rd day	0.83	0.41
EGG Jitter post 5th day	0.00	1.00

From the above table, it can be seen that, there is a significant difference in baseline EGG jitter values between the two dosage groups (/z/ = 2.345, $p < 0.05$). However, there is no significant difference seen in EGG jitter values on 3rd day as well as on post 5th day of NR humming training between the two dosage groups (/z/ = 0.832, $p > 0.05$ & /z/ = 0.000, $p > 0.05$, respectively).

Results of Friedman's Two-Way ANOVA

Friedman’s Two-Way ANOVA test was used to compare the EGG jitter values across the time points (i.e, baseline, 3rd day and post 5th day). The results are depicted in the below (table 9).

Table 9

Results of Friedman's Two-Way ANOVA of EGG jitter values, comparing across time points

Dosage groups	Total N	Test Statistic (χ^2)	Degree Of Freedom	p-value
5 minutes	10	3.80	2	0.15
10 minutes	10	0.00	2	1.00

From the above table, it can be observed that, there is no significant difference in terms of EGG jitter values across three time points (baseline, 3rd day and post 5th day of NR humming training) in both the 5 minutes as well as 10 minutes dosage groups (χ^2 (2) = 3.800, $p > 0.05$ & χ^2 (2) = 0.000, $p > 0.05$, respectively).

IV. Comparison of different dosages of NR Humming technique on CQ and EGG jitter

To find out the effect of different dosages of NR humming technique on CQ and EGG jitter, pre-post difference was estimated for both CQ as well as EGG jitter in both the dosage groups. This was then compared between the dosage groups using suitable statistical tests. Since the CQ followed normal distribution, independent sample 't' test was used to compare difference in CQ values between the two dosage groups. Similarly, since the EGG jitter was following a non-normal distribution, Mann-Whitney U test was used for comparing difference in EGG jitter values between two dosage groups. The results of the same are depicted in table 10.

Table 10

Independent sample 't' test results comparing pre-post difference in CQ values between the two dosage groups along with Mann-Whitney U test results comparing pre-post difference in EGG jitter values between two dosage groups

	Mean values		Test statistics (t)	df	p-value
Pre-Post difference in CQ	5 minutes	1.6070	-0.716	18	0.48
	10 minutes	2.6677			

Mann-Whitney U test results

	Median values		Test statistics /z/	p-value
Pre-post difference in EGG jitter	5 minutes	0.12	1.247	0.212
	10 minutes	-0.06		

From the above table, it can be seen that there is no significant difference in change in CQ after NR humming training between the two groups ($p > 0.05$). However, on analysis of mean values, more CQ value difference is observed for 10 minutes dosage group compared to 5 minutes dosage group (2.66 v/s 1.60). On comparing the median scores, there is less EGG jitter difference observed for 10 minute group when compared to 5 minutes group (-0.06 v/s 0.12). However, there is no significant difference observed between the two dosage groups on EGG jitter difference ($p > 0.05$).

Chapter V

Discussion

The present study aimed to investigate the efficacy of the NR humming technique on glottal adduction in normophonic young individuals under two training dosage conditions, i.e., 5 minutes and 10 minutes. CQ and EGG jitter values were obtained across four time points such as baseline a & b, 3rd day and post 5th day of NR humming technique. After establishing the representative baseline from the initial two baseline recordings, mixed repeated measures ANOVA was carried out to compare CQ values across baseline, third day, and post 5th day of NR humming training. The results indicated no significant main effect of two training dosages, indicating that five minutes and 10 minutes of training had similar effects on the CQ outcome measure. The significant main effect of three-time points indicated an increase in CQ values after the introduction of NR humming training in both groups.

Since the EGG jitter values did not follow normal distribution, the Mann-Whitney U test was done to compare baseline, 3rd day, and post 5th day values between the two dosage groups. The results indicated no significant difference between the two dosage groups in terms of EGG jitter values on 3rd day as well as on the 5th day of NR humming training. The two dosage groups had a significant difference regarding baseline EGG jitter values.

Further analysis was done using Friedman's test to investigate the effect of NR humming training on EGG jitter across three-time points. The results indicated no significant difference in EGG jitter values across baseline, third day, and post-5th day of NR humming training in both the dosage groups.

The results of the present study is discussed under three main headings;

1. Effect of NR humming technique training on CQ.
2. Effect of NR humming technique on EGG Jitter.
3. Effect of different dosages of NR Humming technique on CQ and EGG jitter.

1. Effect of NR humming technique training on CQ

CQ values were found to be higher on the third and fifth day of NR humming training compared to the baseline. The increase in CQ is observed after starting of NR humming training that can be attributed to its effect on the vocal mechanism in increasing the vocal fold contact area between the two vocal folds. The findings of the present study is consistent with Radhakrishnan's (2022) findings, who found that the NR humming exercise increased CQ while the task was being performed. Although no additional research exists on the novel NR humming approach as a therapy intervention technique in dysphonic individuals or phono normals, comparisons can be derived from past SOVT studies in which authors reported improved CQ while using SOVT procedures. For example, a study by Andrade et al. (2014) reports reduced CQ values only for lip-trill exercises, with all other SOVT exercises, CQ found to increase.

The above study by Andrade et al. (2014) also classifies SOVT techniques into two broader categories based on the number of vibratory sources, namely, SOVT exercise with a single source of vibration (e.g., hand-over-mouth, humming, and straw) and SOVT exercises with dual sources of vibration (e.g., tongue-trill, lip-trill, and LaxVox). The two sets of exercises are expected to cause different physiological effects on our vocal system, hence producing different therapeutic effects. One can draw parallels in the classification of SOVT exercises from Titze's, (2006) findings as well. Titze provided two spectrums of SOVT exercises. The first spectrum of SOVT exercises has the biggest effect and least naturalness (e.g., straw phonation with lesser diameter), and the other spectrum showcases the least effect but most naturalness (e.g., nasal consonants and vowels).

From these, it is evident that SOVT exercises can vary regarding the resistance they offer. Findings from the studies conducted by Meerschman et al. (2021) and Konrot et al. (2022) point to the above fact. Wherein, the former authors compared straw phonation in air against straw phonation when immersed in water; straw phonation when immersed in water showed increased vocal fold vibratory amplitude in strobovideolaryngoscopy (SVL) compared to straw phonation in air. The later study [i.e Konrot et al. (2022)] used a tube for phonation task through two modalities namely, oral and nasal. For the nasal modality, the tube was attached to the participant's nose. Results of Konrot et al. (2022) study showed no significant difference in CQ during and after the SOVT technique performance. The latter study is more valuable in the present study's context regarding the nature and similarity of the type of exercise as well. Similar to NR humming, the exercise of Konrot et al. (2022) study used a nasal tube for doing the SOVT exercise, thus calling it SONTE (Semi-occluded nasal tract exercise).

Study findings by Ogawa et al. (2014a) indicated humming with pitch glides increased the CQ values in normophonic individuals. Whereas the CQ values in MTD patients increased during humming even without pitch glide. The authors justify increased CQ during humming by attributing reduced back pressure in the vocal fold, and vigorous expiratory airflow happening while performing the task. Since the pitch and CQ are related as found by Paul et al. (2011), the pitch glide is assumed to contribute to the increased CQ further. The increased CQ found in MTD patients even without pitch gliding is justified as the MTD patients found to have more supraglottic compression in normal phonation compared to normophonic individuals Ogawa et al. (2014a). Releasing of this increased supraglottic compression during humming thus makes a greater impact on CQ in MTD compared to normophonic individuals. An earlier study conducted by Ogawa et al. (2014b) also points to similar findings wherein authors found reduced supra glottic compression by repositioning of false vocal folds which leads to increased CQ in MTD individuals on humming task. Former and later studies conducted by Ogawa et al., however, did not probe into the carryover effect of improved CQ of humming/humming with pitch glide in normal phonation. Results of the present study indicate that the increment seen during the NR humming task is even carried on to the phonation task after the training even with 5 minutes or 10 minutes of training.

Falling into the category of SOVT, it can be inferred that NR humming can fit into the more resistant variety of SOVT exercises. The effect of NR humming on the vocal system can be understood in the light of the explanation given by Titze (2006). According to his explanation, during the exercises, impedance matching occurs between supraglottic and subglottic cavities, creating a push-pull effect on vocal fold closure and opening, respectively. While placing the thumb and index finger on the nostril during NR humming exercise, obstruction of airflow during humming happens. It resembles the semi occluded vocal tract (oral tract along with nasal tract) in general and nasal tract in specific. Subsequently, a portion of energy gets reflected back to the oro-pharynx and larynx, particularly into the glottis where the pressure between the supraglottal and sub glottal regions becomes similar. This leads to impedance matching and creates push-pull effect. The push-pull effect, in turn, can change the vocal fold contact area (VFCA) during the vibration of vocal folds and result in a proportionate (demodulated) EGG signal. As explained by Titze for SOVT exercises, the inertial load effect during the NR humming helps the vocal folds achieve the vocal economy by facilitating self-sustained vibrations of vocal folds.

2. Effect of NR humming technique on EGG Jitter

No significant difference was found in terms of EGG jitter values across the time points in both 5-minute and 10-minute dosage groups. This is not in agreement with the findings of Radhakrishnan (2022) wherein the author observed a decrease in EGG jitter while performing the NR humming task. However, the reduction in EGG jitter might not have carried over to the phonation task after the NR humming task. Even though no other studies discussed the effect of NR humming on jitter, given the fact that EGG jitter is indicative of cycle-to-cycle variation in F0 during vocal fold vibration, studies on SOVTs showing variations in vocal fold vibrations after performing the task can be seen in the literature. For example, among the two types of SOVT techniques discussed by Andrade et al. (2014), single sourced SOVTs found to cause steady vibrations with lesser CQ range (CQr) and F1-F2 difference whereas dual sourced SOVT techniques found to produce fluctuating vocal fold vibration resulting in higher CQr and F1-F2 difference. The authors conclude that SOVTs with single source vibration lead to higher inertive reactance and promote an easy phonation (with lesser resistance). Whereas, SOVTs make use of secondary vibration leads to lesser inertive reactance and thus makes the phonation less easy (offering higher resistance).

The significant difference noted between baseline EGG jitter values of the two dosage groups was not expected. This can be attributed to variations in terms of physical factors, (such as reduced hydration) or environmental factors (eg., variations in humidity and temperature conditions), or behavioral patterns, such as excessive voice usage/stress and anxiety among the participants of the two groups. It can be inferred that, increased baseline values of EGG jitter in 5 minutes group could have played a role in posing a decreasing trend across time points. However, the difference in EGG jitter measures found between the two dosage groups was not significant on 3^{rd} day as well as post 5^{th} day of NR humming training.

2. Effect of different dosages of NR Humming technique on CQ and EGG jitter

There were no significant difference between the two dosage groups regarding pre-post changes in CQ values and EGG jitter (table 9). This is indicative of both the dosages of NR technique have similar impact on the human physiological system. However, the CQ increase was slightly higher for 10-minute group compared to 5-minute group. This concurs with the findings of Kang et al. (2019), wherein the authors investigated effect of 5 minutes & 10 minutes of SOVT exercise. They found differences in terms of vocal parameters after 5 minutes of SOVT training and the 10-minute dosage was found to cause lasting effects on the vocal system. However, generalization from the latter study to the present study warrants precaution as the former findings were just based on one-time performance of the tasks (for 5 min v/s 10min) and not as a regimen spanning over 5 days.

The results of the present study revealed several points of interests;

a) The study followed the NR technique proposed by the Radhakrishnan (2022) with the regimen suggested by Meerschman (2019) on 20 phono-normal young adults for two different doses i.e., 5 minutes and 10 minutes. The results of the present study did not find significant difference between two doses of NR technique on EGG CQ.
b) The study found significant increase in EGG CQ i.e., vocal fold closure or contact quotient from baseline to 3rd day of NR technique and baseline to 5th day of NR technique. The vocal fold closure improved after minimum of 3 days of NR technique with either 5 minutes or 10 minutes duration of training.
c) Further, the study found the impact of 10 minutes dose has relatively higher in vocal fold adduction compared to 5 minutes dose. However, in this present study, there was no significant difference on CQ value between the two dosages.
d) On comparing the EGG jitter values i.e., cycle to cycle variation in F0, the results of the present study reveals no significant difference in EGG jitter values from baseline to 3rd day as well as baseline to 5th day of NR technique training.
e) The present study reveals a negative trend in EGG jitter values on 5-minute dosage group. However, such a trend was not evident in 10 minutes group. This can be attributed to the higher baseline EGG jitter values of 5 minutes group compared to the 10-minute group. The significant difference in the EGG jitter values between the groups at baseline can be attributed to individual variations in terms of physical/environmental or behavioral patterns.

Chapter VI

Summary and Conclusion

Voice disorders significantly impact an individual's functioning, which has led to a growing emphasis on effective management among professionals in this field. Speech-language pathologists began addressing voice care in the 1930s. Since then, numerous therapy techniques have evolved to train the ideal voice. These techniques include improving vocal hygiene, and therapies addressing the psychogenic components of voice problems (indirect), and those that use direct voice exercises to investigate and improve the underlying physiology of the voice disorder, and therapies that identify and alter vocal symptoms. Most voice treatments are eclectic, incorporating elements from all these approaches. Physiological approaches to voice therapy include vocal function exercises, resonant voice therapy, and semi-occluded vocal tract (SOVT) exercises. As the name suggests, SOVT exercises involve partially occluding the vocal tract. Various SOVT exercises are discussed in the literature, such as partially covering the mouth with a hand while speaking, complete closure followed by opening the mouth before vocalization, lip trills, tongue trills, and raspberries. Additionally, the y-buzz technique by Lessac (1967), resonant voice therapy by Verdolini-Marston et al. (1995), and bilabial voiced fricatives are categorized under SOVT exercises. Other techniques include flow resistance straws and nasal consonants.

In addition to the aforementioned variants, Radhakrishnan introduced a novel SOVT approach in 2022 called the Nasal Resistance (NR) technique. This procedure involves partially occluding the nostrils with the fingers. No other techniques reported in the literature share similarities with the NR technique. Researchers found that the NR technique increased contact quotient (CQ) and reduced jitter during a preliminary study of 34 vocally healthy adult females, but they did not determine whether the technique had any lasting effects on the vocal system. Additionally, information regarding the dosage and specific tasks to be used for NR technique is unclear. Considering the potential impact of ethnocultural effects on individual voices, it is crucial to implement this technique with an Indian population who are phononormals before applying it to clinical populations. Therefore, the present study aimed to fill this knowledge gap.

The study involved 20 healthy adult individuals with normal voices, divided into two groups of 10 participants each. The first group received 5 minutes of NR humming training, while the second group received 10 minutes of training. Both the group received the respective dose of training for 5 consecutive days. A multi-group time series design was used for the study. Participants in this study were selected based on specific inclusion and exclusion criteria. Inclusion criteria included being aged between 18 and 35 years, having an overall grade 'G' of zero in GRBAS scale, scoring less than 11 on the Voice Handicap Index-10 (VHI-10) questionnaire, and having no history of nasal septal deviation-related issues. Exclusion criteria comprised of individuals with a history of smoking or alcohol consumption, diagnosis of voice disorders or other laryngeal pathologies, acute respiratory infections during the study period, engagement in professional voice usage exceeding 2 hours daily (e.g., singing, teaching, dubbing), past or present hormonal therapy, or recent participation in any form of voice therapy. Participants underwent NR humming technique training for five consecutive days following baseline voice assessment. Each day, the investigator provided individual training sessions on the NR technique as per Radhakrishnan's protocol. The training followed the steps outlined by Meerschman et al. (2019), adapted specifically for the NR technique. The number of practice trials varied depending on whether participants received the 5-minute or 10-minute dosage, with the number of trials doubled for the 10-minute sessions to accommodate the extended duration. The Computerized Speech Lab (CSL) model 6103 software from Kay-Elemetrics, USA, was used to capture Electroglottography (EGG) data and its parameters. The researcher measured contact quotient and EGG jitter values at four time points: baseline A, baseline B, on the third day of NR humming training, and post the fifth day of NR humming training.

The Shapiro-Wilk's test of normality was employed to assess the distribution of the data. The results indicated that measurements related to Contact Quotient (CQ) were normally distributed, while EGG jitter values exhibited non-normal distribution. Additionally, EGG jitter values showed higher standard deviations compared to CQ measurements. Hence, parametric tests were used for CQ related measures and non-parametric measures were used for EGG jitter measures. To establish a representative baseline, both baselines were compared using statistical tests. A dependent t-test was employed for Contact Quotient (CQ), revealing no significant difference between the two baseline values. Similarly, the Wilcoxon signed-rank test showed no median difference in electroglottography (EGG) jitter values between baseline A and baseline B. Consequently, baseline A and B averages were found and used as the "representative baseline" for further analysis.

A mixed repeated measures ANOVA was conducted to examine the main effects and interaction effects of CQ parameter. The analysis revealed no main effect of the dosage group for NR humming training and no interaction effect between dosage groups and time points. However, a significant main effect was observed across time points. Consequently, a Bonferroni pairwise comparison was performed on CQ values across the time points (baseline, 3rd day, and post 5th day of NR humming training). The Bonferroni pairwise comparison indicated increased CQ values after the commencement of NR humming training in both dosage groups. This increase was observed on the 3rd day and post-5th day of training. Significant increases of CQ parameter were noted from baseline to the 3rd day and from baseline to post-5th day, while no significant difference was observed between the 3rd day and post-5th day. The Mann-Whitney U test was used to compare EGG jitter values at baseline, on the 3rd day, and post-5th day across the two dosage groups (5 minutes and 10 minutes). The results showed a significant difference in baseline EGG jitter values between the two dosage groups. However, no significant difference in EGG jitter values was observed between the groups on the 3rd day or post-5th day of NR humming training. Friedman's Two-Way ANOVA test was used to compare EGG jitter values across the time points (baseline, 3rd day, and post-5th day) for both dosage groups (5 minutes and 10 minutes). The results indicated no significant differences in EGG jitter values across the three time points (baseline v/s 3^{rd} day; 3^{rd} day v/s 5^{th} day; and baseline v/s 5^{th} day) in either of the dosage group.

To evaluate the effect of different dosages of the NR humming technique on CQ and EGG jitter changes, pre-post differences (post 5^{th} day measure minus baseline measure) were calculated for both CQ and EGG jitter in each dosage group. These differences were then compared between the groups using appropriate statistical tests. Since CQ values followed a normal distribution, an independent sample t-test was used to compare the differences in CQ values between the two dosage groups. In contrast, since EGG jitter values followed a non-normal distribution, the Mann-Whitney U test was used for comparing differences in EGG jitter values between the groups. The results indicated no significant difference in the change in CQ values after NR humming training between the two dosage groups ($p > 0.05$). However, analysis of mean values showed a greater difference in CQ for the 10-minute dosage group compared to the 5-minute group. When comparing median scores for EGG jitter values, a decreasing trend was observed in the 5-minute group, while a slight increasing trend was seen in the 10-minute group. Nevertheless, these differences were not statistically significant between the two dosage groups.

The results of the present study concluded that NR humming provided beneficial effects on the CQ parameter of the voice, observed with both 5-minute and 10-minute dosages indicating increased adduction of vocal folds. These changes suggest that both durations of the exercise help to achieve vocal economy by facilitating favorable interactions between the vocal source and the vocal tract filter. However, the lack of significant differences in EGG jitter values after NR humming training indicates that EGG jitter might not be sensitive enough to detect subtle changes in the voice or further studies with a more significant number of participants and comparable baselines are warranted in this regard.

Clinical implications of the study

The present study results highlights several significant clinical implications, which are as follows:

- Either 5 minutes or 10 minutes dose of NR technique resulted in improving the vocal fold adduction even with 3 days of practice among normophonic adults. This suggests the voice therapists to imply this NR technique for individuals with dysphonia.
- More participants required to draw definite conclusion about EGG jitter or may require more dose beyond 10 minutes of NR humming training.

- The rationale of NR technique resembles the rationale of SOVT exercises where it enhances the self-oscillation of vocal fold vibration with minimal effort & improves vocal fold adduction. Thus, the results encourages voice clinicians to consider stepwise program of NR technique as designed in the study in individuals with hypo functional voice disorders.
- The study's results indicate beneficial impact of NR technique on electroglottographic parameters with 5 minutes as well as 10 minutes of NR humming doses. This finding suggests that the NR humming technique can produce significant effects within a short duration, making it a valuable technique for efficiently meeting the vocal requirements of voice patients.

Limitations of the study and the future directions

- Sample size

  The present study utilized a smaller sample size. Replicating this study with a larger sample size would provide more robust evidence, enhancing the generalizability of the findings.
- Lack of acoustic and aerodynamic analysis

  The study did not include acoustic and aerodynamic analyses. Incorporating these analyses would offer a more comprehensive understanding of the effects of NR technique, given the multi-dimensional nature of voice.
- Phono-normal subjects

  The study was conducted with phono-normal individuals. Investigating the impact of these exercises on clinical populations, such as those with hyperfunctional or hypofunctional voice disorders, would have greater clinical relevance and application.

- Age and gender considerations

  Age and gender-specific factors were not incorporated in the study. Including individuals across various age groups and comparing between genders would provide valuable insights into the potential effects of these variables on the physiological impact of the NR humming technique.

- Experimenter bias

  The same experimenter was involved in both the pre and post assessment and training phases, which may probably have introduced experimenter bias. Employing different experimenters, blind to the different phases of the study, would mitigate this issue and ensure more objective results.

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APPENDIX A

ALL INDIA INSTITUTE OF SPEECH AND HEARING: MYSORE-6
DEPARTMENT OF SPEECH-LANGUAGE SCIENCES

TITLE OF DISSERTATION: Efficacy of nasal resistance technique on glottal adductionin young phono normal individuals.

INFORMED CONSENT FORM

I have been informed about the aims, objectives, procedure of the study and the approximate time of testing. Data collection involves recording the electroglottographic analysis by placing electrodes in the neck region. The recorded sample will be kept confidential for ensuring the anonymity. The outcome of the study will help in understanding the impact of the voice exercises on voice and will help the professionals in the field of communication sciences and disorders in the clinical and research settings. Furthermore, I have been assured that there will not be any financial commitment on my part during the course of this study.

I,____, the undersigned, give my wholehearted and voluntary consent to be a participant for this study.

Signature of the participant   Signature of the Investigator