RELATIONSHIP BETWEEN NASALANCE AND ACOUSTIC VOICE QUALITY INDEX (AVQI)

Reshma O.

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This Dissertation is submitted as a part of fulfillment

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All India Institute of Speech and Hearing

Mansagangothri Mysore – 570006

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CERTIFICATE

This is to certify that this dissertation entitled **'Relationship between Nasalance and Acoustic Voice Quality Index'** is the bonafide work submitted in part fulfillment for the Degree of Master of Science (Speech language pathology) of the student with Registration No: **18SLP026** 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.

Dr. M. Pushapavathi

Director

All India Institute of Speech and Hearing,

Manasagangothri, Mysuru- 570006.

Mysuru

July2020

CERTIFICATE

This is to certify that this dissertation entitled **'Relationship between Nasalance and Acoustic Voice Quality Index'** has been prepared under my supervision and guidance. It is also certified that this has not been submitted earlier to any other University for the award of any other Diploma or Degree.

10-07-20
Mysuru

Dr. T. Jayakumar
Guide
Associate Professor is speech Sciences
HOD- Dept. of Speech Language Sciences
All India Institute of Speech and Hearing
Mysuru - 6

DECLARATION

This is to certify that this Master's dissertation entitled **'Relationship between Nasalance and Acoustic Voice Quality Index'** is the result of my own study under the guidance of Dr. T. Jayakumar, Associate Professor in Speech Sciences, Department of Speech Language Sciences, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier in other University for the award of any Diploma or Degree.

Mysuru, **ReshmaO**

July2020 RegNo:18SLP026

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Chapter-I

Introduction

The sound produced by human for communicating the information/thought/ideas/ is referred as voice (Zhang, 2016). Voice is the laryngeal transition of the air from lungs, directed by the organization of the vocal tract (Michael &Wendahl, 1971). It is the aspect of speech that yields the speaker with the vibratory signal upon which speech is carried out. It provides the melody of our speech and gives expression, feeling, idea and mood to our day to day articulation. Voice production requires involvement from various subsystems including resonance.

Resonance is the alteration of phonated sound through selective amplification of certain frequencies as opposed to others. This modification is decided by the size and appearance of the vocal tract cavities (pharyngeal, oral and nasal cavity) (Kummer, 2011a). Pharynx and nasal cavity is the main resonating chamber for voice. Nasal cavity continues from the nostrils to pharynx. It is important in resonance by opening or closing of velopharyngeal port. The various sinuses in the cranium are also important for voice modulation. Velopharyngeal valve or port is achieved by the contact of velum and pharyngeal wall and it will be opened for nasal consonants and vowels.

Velopharyngeal closure is an important process for voice/speech production; it is the utmost main function of the velopharyngeal sphincter which consists of palatal muscles along with the superior constrictors of both sides. The sphincter is enclosed anteriorly by the velum, laterally and posteriorly by lateral and the posterior pharyngeal wall respectively. The sort of closure pattern is regulated by the active participation of each wall during articulation of voice / speech. VPD is a state in which that valve does not close steadily and totally while producing oral sounds (Kummer, 2011d; Cardamone, 1989). Velopharyngeal insufficiency (VPI) could make the speech hyper nasal which results in behavioral and psychological effects. Those individuals who have hyper nasalized speech /voice will be regarded as less intelligent, interesting, pleasing, and attractive. Such understandings can negatively affect the social life of the child although his articulatory production is correct.

While conversing or singing, it is important to open and close the passage way which connects the oro-pharynx with that of the naso-pharynx, which depends on the production of specific sounds being processed. This procedure leads to nasalized speech production. While perceiving a speech, be it a normal one or a disordered one, nasality is an important parameter. Nasality is a perceptual characteristic, where judgment regarding degree of nasality is made by competence of listener. Although, nasality gives information of the degree of the velopharyngeal incompetence, it is confounded by variety of factors. Nasality is perceptually affected by vocal pitch and intensity and therefore, becomes utmost essential for a speech language pathologist to evaluate effectively and manage the complex symptoms (Lubker,1971).

Individual with cleft palate, velo-pharyngeal insufficiency/inadequacy exhibit resonance disorder, which affects speech intelligibility. Nasality can be explained in terms of clinical components of resonance disorder such as hyper nasality, hypo nasality, and nasal emission. Hyper nasality occurs when there is increased nasal airflow during vocal production. Hypo nasality may be explained as lack of appropriate nasal air during vocal production.

Fletcher et al., (1974) have coined the term nasalence to describe various measures of the balance between the acoustic energy at the nares. Nasalence is utilized as an acoustic measure to supplement perceptual assessment of nasality when assessing resonance disorders. It gives the ratio between nasal and combination of nasal and oral acoustic energy in the production of speech and changes according to the degree of nasality. There is a high correlation between nasalence and perceived nasality and the test–retest reliability is high. It has been used in several clinical and research applications mainly in speakers with cleft lip and palate and other resonance disorders. Thus, nasalence is regarded as a powerful instrumental measurement in assessing resonance disorders. It is commonly used by SLP to validate a perceptual assessment and for giving extra quantitative measurement.

Nasometer is a powerful tool which involves non invasive measures and could be practiced out of the medical setting. Nasometer has two microphones which is on an acoustic shield (placed on the upper lip) captures the acoustic signal output from the nose and mouth to evaluate the nasality (Fletcher, 1970). Moreover, it is a PC based device, easily installed and used in an acceptable clinical setting. Nasometry was designed primarily for the assessment of hyper nasality and includes hardware for the analog filtering of the signals using a bandwidth filter of 300 Hz with a centre frequency of 500 Hz. The analog speech is sampled at 120Hz and nasalence is computed from the DC component of the signal. The instrument has been used for the assessment, rehabilitation and for the research purpose.

Speech of a specific language or different languages depends upon the frequency of nasal and oral consonants in that language. Despite that, other phonemic/phonetic attributes of a specific language also plays a role which includes structure of a syllable (Tachimura et al., 2000) and vowel nasalization (Bullen, 1942; Kantner& West, 1960: Bell-Berti, 1980: Solé, 1992: Falé & Hub Faria, 2008). A Japanese research done by Tachimura et al., (2000) on nasalence revealed that the syllable structure causes a predominance of vowels within words, when it is compared with that of English or any other Western languages, which sequentially, reduces nasalence as there are more oral sounds in the nasalence equation. While in some other languages such as French, Portuguese and American English, vowel nasalization becomes a feature of those languages by Chen (1997), Falé & Hub Faria(2008) and Bell-Berti(1980). So, consonants are being made with higher velar position than oral vowels in American English (Bcll-Berti, 1980) and vowels being either oral or nasal in French and European Portuguese (Chen, 1997: Falé& Hub Faria, 2008).Studies on nasalance scores were also done in Indian languages by Nandurkar (2002), Sunitha et al. (2005) and Jayakumar (2005) using oral and nasal sentences as stimuli in Marathi, Tamil and Kannada languages respectively.

Like nasality, Voice also evaluated objectively as well as subjectively in many ways. Subjective evaluation includes perceptual ratings of voice on various parameters like roughness, breathiness, resonance, loudness etc. Objective measurements include acoustic, aerodynamic and physiologic parameters using instruments. The quantitative or instrumental evaluations can be invasive or non-invasive. Non invasive methods include recording and the subsequent analysis of the quantified values by the examiner or by the instrument itself. The most common objective approach is the acoustic analysis.

Acoustic analysis is the method used for the interpretation of the voice. The assessment of the different parameters of the vocal signal may be carried out by individual instruments developed for a specific purpose or progressively by software packages, which can evaluate each parameter and then incorporate the data acquired in relation to these individual aspects. An acoustic analysis profile emerges from that, which indicates the extent to which each parameter deviates from normative values and which acts as a baseline for treatment progress.

For objective assessment of the voice quality, several acoustic measures are used in the literature. However, the use of different discrete acoustic parameters will not represent the disorder's impacts on the multi-dimensional aspects of the voice. It has also been discovered that most of these single acoustic parameters have restricted validity (Awan & Roy,2006)

Various researchers have therefore attempted to develop a multiparametric protocol to explore speech quality, and to check between different types of voice and different dysphonia severity levels. (e.g., Awan & Roy, 2006; Ma &Yiu, 2006;Wuytset al., 2000; Yu et al., 2001).Several researchers stated that the utilization of multi-parameter protocol combining different parameters would be preferable to assess the voice quality rather than using single parameter in various studies in the literature.).

The Acoustic Voice Quality Index (AVQI), developed by Maryn et al., 2010 which is a multiparametric tool intended to quantitatively evaluate the total voice quality, which is based on 6 acoustic parameters and is the outcome of a stepwise multiple linear regression study of 13 acoustic steps to work out the most stable combination that gives a single number predicting the extent of dysphonia severity, which ranges from zero to ten. The lower the value, the less is the dysphonia and the more the quality of the voice. It’s all measures are analyzed using Praat software which is a free computer based software.

Maryn et al (2010) mentioned 6 advantages of taking a sustained vowel for analysis:

1. It demonstrates relatively stable phonation, with less variability in frequency, variations in sound pressure levels and time variations, thus easing acoustic measurements.
2. Unvoiced phonemes are not involved in sustained phonation, and hence it is not affected by voice onset/offset times, or by any frequency variations and variations in sound pressure level.
3. Not dependent of any linguistic or idiosyncratic factors.
4. Perturbation measures are easily measured when using sustained vowels.
5. It can be produced effortlessly and permits for a standardized measure.
6. Linguistic load is not required and is therefore unlikely to differ among other variables based on accent pertaining to a region or cognitive level.

The parameters of AVQI are, (a) smoothed cepstral peak prominence, (b) harmonics-to-noise ratio, (c) shimmer local, (d) shimmer local dB, (e) slope and tilt of the long-term average spectrum. Considering these parameters,
AVQI = 2.571*(3.295-0.111*CPPS - 0.073*HNR - 0.213*SL + 2.789*ShdB - 0.032*Slope + 0.077*Tilt). Individuals who scored 2.95 or below on AVQI are considered to be normphonic (Marynet al., 2010).

Reynolds et al., (2012) found AVQI as having high degree of diagnostic correctness when its application to the pediatric voice is considered. Ever since its genesis, AVQI was calculated using a combination of *SpeechTool* (used to derive CPPS) and *Praat*(used to measure HNR, ShL, ShdB, Slope, & Tilt) which was a tedious process. However, with the implementation of CPPS within Praat, AVQI could be determined by the use of *Praat* software alone. A study by Maryn&Weenink (2015) established that the $CPPS_{Praat}$ is a hugely justifiable estimation of the $CPPS_{SpeechTool}$. It was also found that the two AVQI methods were found to be akin, thus elevating the clinical practicality of both methods for measuring the severity of dysphonia.

A recent study was done by Madill (2018) aimed at examining the effect of nasality on CPP and HNR**.** The results revealed significant lower CPP values when the task phonation turned from vowels to nasalized vowels and then to nasal, and correlation was found for CPP and nasalence. Also, HNR values were higher with nasals than with vowels. CPP had better correlation than HNR with nasalence.

Another study done by Ahn(2002) aimed at investigating the effect of nasality ob the acoustic voice quality, to analyze the relation between both. No statistical significant differences were seen in shimmer, HNR, jitter, and NNE. However, as the nasalence score increased jitter increased though not significant.

Another study done by Park et al., 2009 aimed at conducting a correlation analysis between pitch, nasalence, and voice quality parameters. They used two software's i.e. Nasal View and Dr. Speech 4.5. The results indicated a correlation between fundamental frequency and acoustic quality parameters, but no correlation between fundamental frequency and nasalence and there was a correlation between nasalence and voice quality parameters.

A study was done by Yang et al., in 2014 and this study aimed at assessing CPP of vowels and also to compare the obtained values between patients who had VPI after cleft palate surgery and normal's using acoustic analyzer. The results revealed that the CPPs decreased in VPI speakers both before and even after the surgery. No significant difference was found between the experimental group after attending the therapy and the control group.

A cross linguistic study done in 2016 tested whether nasalized consonants and vowels have breathier quality of voice when compared to oral consonants in 3 Yi (Loloish) languages. Oral vs. nasal vowels and consonants were analyzed using EGG and other acoustic analysis. The results revealed that nasal sounds are breathier when comparing to their oral counterparts.

1.1 Need of the study

AVQI was developed by Maryn et al., (2010) for European normal participants and dysphonic subjects. In the due course it is emerging as a potential voice measurement tool to assess the voice quality and monitor changes due to therapeutic management as well. However, there are only few studies done on various factors affecting voice quality to validate the AVQI. Therefore, there is a need to evaluate AVQI on nasalized voice quality. Literature shows that few sub parameters of AVQI shows correlation with nasalence. Therefore, the current study attempts to make an understanding towards the measure of AVQI on individuals with normal voice quality as well as on individuals with nasalized voice quality in the Indian context and to correlate findings of both AVQI scores and nasality.

1.2 Aim of the study

The aim of study is to explore the relation between AVQI and its sub parameters with nasality or nasalence score in Indian population.

1.3 Objectives of the study

- To determine the AVQI scores for individuals with normal voice quality in the Indian population.
- To determine the AVQI scores for individuals with nasalized voice quality in the Indian population.
- To determine the correlation between AVQI scores and Nasalence scores.

Chapter II

Review of literature

The human speech is generated by vocal cord vibrations, which is amplified by cavities of mouth, throat, and nose in the vocal tract. The type of resonant voice quality where the resonance occurs through the nose is referred to as nasality. There are no specific muscles in the nasal cavity to adjust the shape of the cavity. Hence, the sound passing through the cavity is considerably affected by the swelling or shrinking of the mucous membrane. To explain physiologically, the lowering of the velum (soft palate) allows air to proceed along the nasal cavity to bring nasality in the produced utterances. The velopharyngeal port serves to vary the degree of acoustic coupling between the nasal and oral cavities. The velum can be raised to prevent the oral and nasal coupling, or it can be dropped to allow a coupling. During the time of lowering, the primary source of output is the oral cavity only, but the sound quality gets a nasal characteristic. The coupling allows a certain degree of nasality, which is acceptable, but severe nasality is not considered pleasing. She also commented, if no sound flows through the nose, then the perceived sound is possibly an "unacceptable white tone" (Gregg, 1998 &1999).

The nasal tract has its resonant frequencies and nasal formants as the oral tract. With the coupling, the amplitude of the resonant formant frequencies are reduced and the bandwidth and the frequency increases, House and Stevens (1956). The first formant frequency for the nasal consonant usually occurs at around 300Hz, and they're antiformants at around 600Hz. The main characteristics of the spectral properties of the nasal sounds is at around 200Hz to 2500Hz, thus giving more energy concentration on the low frequency regions and little energy to the anti formants Lieberman land Blumstein, 1988.

For objective evaluation of the voice quality, several acoustic measures that include frequency related measures (e.g., Fo, habitual Frequency, range of frequency, etc.) amplitude related measures (e.g., habitual intensity, extent, and fluctuation of intensity, etc.), perturbation related measures (e.g., jitter, shimmer, etc.), as well as harmonics related measures (e.g., HNR, etc.), have been extensively applied by several researchers (Dejonckere & Lebacq, 1996; Hirano et al., 1988; Rabinov et al., 1995; Picirillo et al., 1998; Wolfe et al., 1995).

Acoustic measures of voice quality provide the clinician with an accurate, precise, and quantitative profile of the characteristics of voice being investigated. It has the upper hand over the perceptual evaluation of voice because they are least subjective and, therefore, a better reliable method to profile the vocal functioning. Also, acoustical measures tend to provide the clinicians with uniformity in the diagnostic examinations across the practicing clinicians and various clinics.

One recently developed method to quantify the degree of dysphonia is the Acoustic Voice Quality Index (AVQI) (Marynet al., 2010). To develop AVQI, Maryn and colleagues used combined samples of the sustained vowel and connected speech. They analyzed 13 acoustic measures. After that, they applied multiple linear regression analysis, from which a 6-variable model for the multiparametrical assessment of overall voice quality of the samples was attained. This consisted of a equal combination of time, frequency, and quefrency domain measures and cepstral measure being the main altruist to the prediction of voice quality).

The parameters used for AVQI are, CPPs, HNR, SL, ShdB, Slope and tilt of LTAS. Thus AVQI is constructed as AVQI = 2.571*(3.295-0.111*CPPS - 0.073*HNR - 0.213*SL + 2.789*ShdB - 0.032*Slope + 0.077*Tilt) (Marynet al., 2010). If the score is 2.95 or below on AVQI, the sample is identified as normal for Dutch speakers (Marynet al., 2010). According to Marynet al., (2010), the reported sensitivity and specificity values of AVQI were 0.85 and 1.0 respectively.

In the research done by Soh et al., (2005), the Cepstrum Method was utilized to analyze the vocal tract transfer function. For the assessment of nasal resonance, the VT transfer function and the source spectrum is taken. This research aimed at collecting quantitative data on the acoustic instrumentation for measuring hyper nasality. 87 normal subjects and 46 individuals with VPI have taken part in this study. The vowel /i/ was used to evaluate the severity of hyper nasality. The acoustic characteristics were identified using Spectral and Cepstral studies. A significant difference is showed in cepstral analysis for quefrency and amplitude. The quefrency of VPI population was higher than that of the normal population, while the amplitude of VPI groups was higher than that of the normal groups. The results might have significance in the assessment of nasal resonance.

Marynet al., (2010) found a positive strong relation between AVQI and the overall dysphonia. Therefore, when the AVQI score is more, the overall voice quality will be distorted more and vice versa. The obtained r value was 0.78, which demonstrates a high concurrent validity (Marynet al., 2010).

A study was done by Yang et al., in 2014 and this study aimed at assessing CPP of vowels and also to compare the obtained values between patients who had VPI after cleft palate surgery and normal's using acoustic analyzer. The results revealed that the CPPs decreased in VPI speakers both before and even after the surgery. No significant difference was found between the clinical group after attending the speech therapy and the control group. Lower values of CPPs were found in the clinical group prior to surgery and prior to speech therapy when compared to the control group, which could be described due to compensation of the body for the reduced intraoral pressure and due to the habituated articulation.

A study done by Gonzalez(2015)focused to analyze how the main acoustic voice parameters, including shimmer, pitch and jitter, vary significantly between person with repaired cleft palate and normal children. Participants were separated into two groups, clinical group which consists of 14 patients with unilateral RCLP and persistent or residual VPI and control group, which consists of 14 age and gender matched normal healthy subject. In subjects with VPI, hyper nasality and nasal emission were perceptually assessed. Videonasopharyngoscopy was used to evaluate the size of the gap in subjects with VPI. Acoustical voice analysis was done, which include F0, shimmer, and jitter which were compared among both the groups. The findings showed that F0 in male patients was substantially more than male controls. For subjects with VPI, shimmer was significantly higher, regardless of gender. In addition, significantly higher shimmer values were obtained for patients with moderate VPI regardless of age.

The research performed by Bhagban (2016) measured and compared temporal nasalization patterns in three vowel contexts in Persian children with and without cleft palate. The participants were separated into two groups. One group involved 14 children with repaired cleft palates along with or without cleft lip with mild to extreme hyper nasality and the other group consisted of 14 children without cleft palate within age range of 4 - 12 years. In three vowel contexts the nasal onset interval, nasal offset interval, and total duration of nasalization were collected from acoustic waveforms and spectral measures. The ratio of the nasalization duration was measured to reduce the impact of different rate of speech in the both groups. Acoustic signals that display the overall substantial temporal variations in children with CLP and without CLP and across the vowel contexts ($P < 0.000$) imply overall nasalization duration. Longer durations of nasalization in children with cleft palates relative to children without cleft palates indicate the deviant temporal trends in children with cleft palates. For children with a cleft palate, the duration of nasalization showing temporal patterns of oral-nasal acoustic impedance may influence perception of hyper-nasality.

A study done by Dodderi et al., (2016) explored to note voice low tone to high tone ratio (VLHR) values. They used phonation samples of participants with the cleft palate before and after surgery. The participants were 30 children within the age range of 8-15 years with a congenital cleft palate. Sustained vowels (/a/,/i/ and /u/) were taken for the study. Recordings were done at their comfortable pitch and loudness level in a sound proof room by using a handheld dynamic microphone. To extract the values of VLHR for the recorded data before and after the surgery, Praat software was used. VLHR values reduced significantly after surgery. It was inferred that the VLHR parameter could be utilized as a measure to assess nasality and it can be contained in the regular assessment protocol.

The research done by Esen et al., (2016) aimed to explore the impact of glottal stop productions (GS) in children with cleft palates using different voice evaluation methods. 34 children with RCLP without any vocal fold abnormalities were taken for the study. They were divided into two groups on the basis of the results of articulation tests. The clinical group involved 17 children with glottal stop productions. The control group consisted of 17 children (age and gender matched) without having glottal stop productions. Acoustic analysis, pVHI, and perceptual analysis (GRBAS) was included in the voice evaluation protocol. Nasopharyngoscopy and the nasometer were used to check the status of velopharyngeal port for both the groups. Statistical analysis revealed significantly higher value for the overall pVHI score, subscales of the pVHI, F0, jitter, and in the clinical group. A difference in overall voice quality and roughness between both the groups was observed during audio-perceptual analysis. And also in the clinical group, more occurrences of significant VPI and higher nasalence values were obtained. The findings can mean that children with GS have different vocal quality characteristics than children who don't have this kind of development. The study suggested that a comprehensive therapeutic intervention, along with voice therapy techniques, should be provided to children with CLP who have glottal stops.

The aim of the research carried out by Yang (2018) was to investigate the spectral characteristics and to compare instrumental data collected from participants with cleft palates using an acoustic analyzer with instrumental data from normal children using LTAS analysis. The subjects were separated into two groups (clinical and control). To become fluent, all subjects were told to practice reading a sentence. Each recording had a length of almost 60 seconds duration. Using Praat software all samples were exposed to acoustic analysis. All recordings were acoustically analyzed using LTAS. The results revealed no significant difference between both the groups in the low-frequency region.

A significant difference was obtained between both the groups in the middle-frequency region for LTAS measurement. In the high frequency region, the clinical group had slightly lower energy distribution when compared to the control group in both genders. They also found an absence of flat region in the mid-frequency range in the clinical group when compared to the control group.

Chapter III

Method

The present study is aimed to find the relation between AVQI and nasalence among individuals with cleft lip and palate and normal individuals.

3.1 Participants

Twenty two individuals participated in the present study. First group of participants consisted of 15 individuals with nasalized voice quality. They are diagnosed as having hyper nasality secondary to cleft lip and palate by a speech language pathologist as well as an otolaryngologist/Plastic surgeon. The other group constituted of seven individuals with normal voice quality. All the participants in both the groups are within the age span of 12-40 years. The Group I constitute of individuals with nasalized voice quality and Group II consist of individuals with normal voice quality.

Table 3.1

Number of Participants and Age Range

	Group I	Group II
Participants	15	7
Age range (years)	12-40	12-40
Mean age range (years)	24.3	24.4

3.1.1 Participant selection criteria

The participants were selected based on the following criteria:

- Native speakers of Kannada language
- Participants with no UTI, asthma, and or any allergic conditions at the time of recording
- Participants, with no endocrinological issues.
- Participants with no long term exposure to alcohol and tobacco consumption; were precluded from this study

3.2 Stimuli

Sustained phonation of vowel /a: / for a minimum duration of 5 seconds, and continuous reading speech (using standard passages of Kannada (Savithri&Jayaram, 2005) (Appendix A) sample were used as stimuli for measuring AVQI in both the groups. The test material selected for this study consisted of sentences. Two lists of meaningful Kannada sentences (oral and nasal) developed by Jayakumar and Pushpavathi (2005) (Appendix B) were used for measuring AVQI in both the groups. The first list consisted of five nasal sentences whereas the second list consisted of five oral sentences. These are sentences routinely used for assessment al Unit of structural and oro- facial anomalies (USOFA) at All India Institute of Speech and Hearing, Mysore.

3.3 Instrumentation

The Nasometer II (6450) a microcomputer based system which is developed by Kay Elemetric, NJ was used for data collection. The nasometer headset consists of a baffle plate, on which two microphones are mounted to pick up nasal and oral acoustic energy, which is rested on the upper lip. The microphone collects the signal which is then filtered and digitized by the conventional modules and sends to the software for analysis. The software establishes nasalence using formulae, Nasalance = (Nasal/ Nasal + Oral x 100).

For the measurement of AVQI, Praat (version 5) is used. AVQI script (v02.01) developed Maryn & Weenik (2015), was used to estimate the AVQI score.

3.4 Procedure

3.4.1 AVQI:

Prior to the recording, the subjects were described of the procedure. An informed consent was taken. Following that, they were then told to sit straight in a comfortable way. To avoid breathing noise, there was a distance of 6cm between the microphone of the recorder and the mouth of the participant. The audio recordings were procured in a noise proof room using Olympus LS 100 digital voice recorder, and with a sampling frequency of 44.1 KHz and 16 bit resolution in .wav format, which was same for both the recording of sustained vowel and continuous speech. There were 3 trials of recording for sustained vowel and 2 trials of recordings for continuous speech. Best trial was considered for the analysis. For the purpose of reliability 10% of the data was collected twice and analyzed. The result showed that, the reliability coefficient was0.91.

*3.4.2 Nasalence***:**

Before beginning with the nasalence measuring procedure, the nasometer headset was calibrated according to the specifications given in the manual. The participants were explained about the experimental procedures. Following that, each subject was then told to sit comfortably on a chair. The nasometer headset was placed on each subject's head, with the baffle plate fitting snugly underneath the nares and according to the specifications provided in the instructor's manual. While the microphone placed both above and beneath the plate collected the acoustic signal. Adequate precaution was taken that the placement was adequately maintained throughout the process of data collection. Each participant was instructed to read at their habitual loudness level, and normal conversational rate. In case of any instances of coughs, or throat clearing, pauses etc, during the data collection, the sample was recorded again and the extraneous sample was excluded from analysis. Each participant was asked to read five nasal sentences followed by five oral sentences in their mind for familiarization with the stimuli prior to the recording. Later, the stimulus was displayed in front of the participants and each participant wasmade to read five nasal sentences followed by five oral sentences and was recorded and saved for analysis separately. For the purpose of reliability 10% of the data was collected twice and analyzed. The result showed that, the reliability coefficient was 0.91.

3.5 Analysis

3.5.1 AVQI:

The obtained audio recordings of sustained vowel and continuous speech were subjected to objective analysis using *Praat* script to attain AVQI. Script for obtaining AVQI (v02.02) published by Maryn &Weenik (2015), that contained the formula, AVQI= 9.072 - 0.245*CPPS - 0.161*HNR - 0.470*SL + 6.158*ShdB -0.071*Slope + 0.170*Tilt was used. The stable middle 3 second portion was extracted for sustained vowel /a: / and the third to fifth sentences of the paragraphs were used for continuous reading speech sample. The samples obtained in .wav format were renamed as 'sv' (sustained vowel) and 'cs' (continuous speech) to be provided into the AVQI script as suggested by Maryn*et al.,* (2010) and Maryn&Weenik (2015).

3.5.2 Nasalance:

For nasalence analysis, after each recording of nasal and oral sentences, the nasalence trace was tracked and saved on computer for further analysis. An average value of mean nasalence score for each subject was calculated by taking the average of three trails mean scores, displayed in theNasometer.

Chapter IV

Results

The present study was designed to check the relationship between AVQI scores (also its constituent parameters) and nasalence scores in individuals with cleft lip and palate and normal individuals. AVQI scores were obtained using Praat program and AVQI script. The nasalence was obtained using Nasometer for both groups.

Fifteen individuals with CLP constituted the clinical group and seven normal individuals without any underlying conditions constituted the control group. AVQI scores and Nasalence score of these individuals were subjected to statistical analysis. In clinical group, two subjects were outliers, so they were removed and a total of twenty participants were taken for the statistical analysis. The results are sub grouped into 3 sections.

- Correlation of parameters between Group I and Group II
- Correlation of parameters within Group I (Individuals with nasalized voice quality)
- Correlation of parameters within Group II(Individuals with normal voice quality)

Descriptive statistical analysis was done for AVQI scores and nasalence for individuals with nasalized and normal voice quality. The table 4.1 shows the mean and SD for AVQI scores and nasalence of both groups.

Table 4.1

Mean and SD of Individuals with Nasalized Voice Quality and Normal Voice Quality

	Group I (Individuals with nasalized voice quality)		Group II (Individuals with normal voice quality)	
	Mean	**SD**	**Mean**	**SD**
AVQI	2.601	1.438	3.720	0.605
CPPs	14.480	1.382	13.184	1.142
HNR	21.569	5.262	18.521	1.707
Shimmer Local	5.796	5.177	6.742	0.889
Shimmer local(dB)	.556	0.438	0.714	0.079
Slope of LTAS	-22.673	3.790	-19.821	3.965
Tilt	-10.943	0.781	-10.462	0.821
Nasalence	40.238	7.357	11.200	2.44

The mean AVQI values were better for Group I when compared to Group II. Higher CPP values were obtained for Group I than Group II. HNR values obtained for Group I was higher than that of Group II. For perturbation measures such as Shimmer local and Shimmer dB, the values obtained for Group I was slightly lower when compared to Group II. Slope of LTAS obtained for Group I was higher than that of Group II, whereas similar results for Tilt of LTAS were obtained for both the groups. Nasalence was significantly higher for Group I when compared to Group II.

4.1 Correlation of parameters between Group I and Group II

As the study is aimed to find the relation between nasalence and voice quality, each parameter is correlated with other parameter between the clinical group and the control group. The Karl Pearson product moment correlation ‘r’ was computed among the variables AVQI, CPPs, HNR, Shimmer local, Shimmer local(dB), Slope of LTAS, Tilt, and Nasalence scores. The data was interpreted as where a Pearson r value of

0<r<.3, a weak correlation, .3< r< .7, a moderate correlation and r>.7, a strong correlation.

4.1.1 Correlation between AVQI (with its constituent parameters) and Nasalance

There was no significant correlation, r = -0.432 found between AVQI and nasalence. However there was negative correlation between nasalence and AVQI. There was a significant positive correlation, r = 0.567 found between nasalence and CPPs. There was weak negative correlation, r = -0.319 found between nasalence and Shimmer local(dB), between r = -0.365 was found between nasalence and Slope of LTAS, also between r = -0.355 was obtained between nasalence and HNR. There was a no correlation, r = -0.248 found between nasalence and Shimmer local and (r = -0.195) between nasalence and Tilt of LTAS. Table 4.2 shows the Pearson product moment correlation ‘r’ between AVQI with its constituent parameters and nasalence. Figure 4.1 shows the differences between clinical as well as control group on AVQI scores and nasalence scores.

Table 4.2

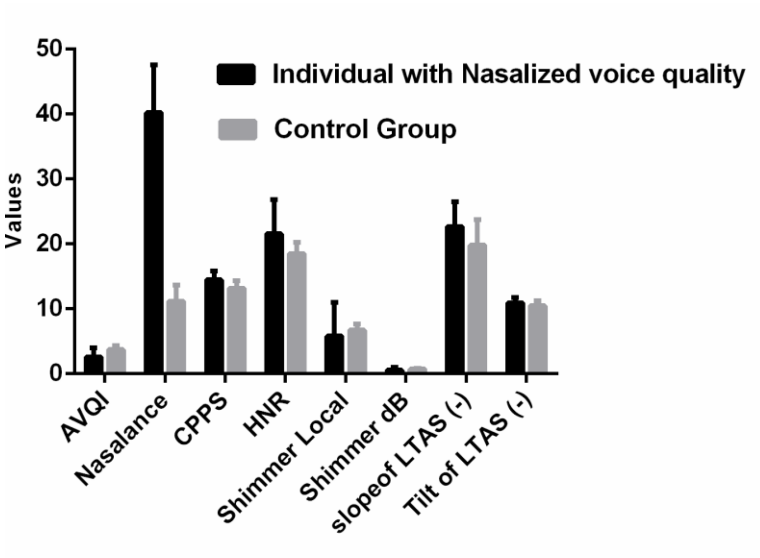
Pearson’s Product Moment Correlation for Individuals with Nasalized Voice Quality and Normal Voice Quality

Parameter	AVQI	Nasalence score	CPP	HNR	Shimmer Local	Shimmer Local(dB)	Slope of LTAS	Tilt of LTAS
AVQI	1	-0.432	-0.746#	-0.907#	0.754#	0.857#	-0.091	0.205
Nasalence score		1	0.567#	0.355	-0.248	-0.319	-0.365	-0.195
CPP			1	0.543*	-0.542*	-0.603#	-0.021	-0.243
HNR				1	-0.848#	-0.901#	-0.046	0.078
Shimmer local					1	0.974#	-0.202	-0.272
ShimmerdB						1	-0.174	-0.208
Slope of LTAS							1	-0.115
Tilt of LTAS								1

‘p’= <0.05*, ‘p’=<0.01#

Figure 4.1

Bar Graph Showing Differences in AVQI and Nasalance Between Individuals with Nasalized Voice Quality and Normal Voice Quality



4.2 Correlation of parameters within Group I

As the study is aimed to find the correlation, each parameter is correlated with other parameter within the clinical group is discussed below. The Karl Pearson product moment correlation ‘r’ was computed among the variables AVQI, CPPs, HNR, Shimmer local, Shimmer local(dB), Slope of LTAS, Tilt, and nasalence.

4.2.1Correlation between AVQI (with its constituent parameters) and Nasalance

There was no significant correlation, r = -0.196found between AVQI and nasalence. There was a significant positive correlation, r = 0.596 found between nasalence and CPPs and also a weak positive correlation (r = 0.304) was found between nasalence and Tilt of LTAS. There was a weak negative correlation, r = -0.396 found between nasalence and Shimmer local, similarly found between r = -0.354 nasalence and Shimmer local (dB).No significant correlation (r = -0.225) was found between nasalence and Slope of LTAS, similarly no significant correlation, r = -0.187 was obtained between nasalence and HNR.The table 4.3 shows the Karl Pearson product moment correlation ‘r’ between AVQI with its constituent parameters and nasalence.

Table 4.3

Pearson's Product Moment Correlation for Individuals with Nasalized Voice Quality

Parameter	AVQI	Nasalence score	CPP	HNR	Shimmer local	Shimmer Local(dB)	Slope of LTAS	Tilt of LTAS
AVQI	1	-0.196#	-0.698#	-0.910#	0.797#	0.875#	-0.365	0.039
Nasalence score		1	0.596*	0.187	-0.396	-0.354	-0.225	-0.304
CPP			1	0.515	-0.604*	-0.639*	0.191	0.008
HNR				1	-0.880#	-0.904#	0.190	0.248
Shimmer local					1	0.983#	-0.292	-0.467
ShimmerdB						1	-0.366	-0.377
Slope of LTAS							1	0.16
Tilt of LTAS								1

'p'= <0.05*, 'p'=<0.01#

4.3 Correlation of parameters within Group II

As the study is aimed to find the correlation, each parameter is correlated with other parameter within the control group is discussed below. The Karl Pearson product moment correlation 'r' was computed among the variables AVQI, CPPs, HNR, Shimmer local, Shimmer local(dB), Slope of LTAS, Tilt, and nasalence scores.

4.3.1 Correlation between AVQI (with its constituent parameters) and Nasalance

There was significant positive correlation, r = 0.731found between AVQI and nasalence. There was a significant positive correlation, r = 0.793 found between nasalence and Shimmer local(dB), similarly a positive correlation (r = 0.411) was found between nasalence and Slope of LTAS. There was a significant negative correlation, r = - 0.646 between nasalence and HNR, similarly there was a negative correlation, r = -0.461 found between nasalence and CPPs. No correlation, r = 0.232 found between nasalence and Shimmer local, similarly no significant correlation (r = -0.296) was found between nasalence and Tilt of LTAS.

The table 4.4 shows the Karl Pearson product moment correlation ‘r’ between AVQI with its constituent parameters and nasalence.

Table 4.4

Pearson’s Product Moment Correlation for Individuals with Normal Voice Quality

Parameter	AVQI	Nasalence score	CPP	HNR	Shimmer local	Shimmer Local(dB)	Slope of LTAS	Tilt of LTAS
AVQI	1	0.73	-0.771*	-0.733	0.719	0.892#	0.22	0.393
Nasalence score		1	-0.461	-0.646	0.232	0.793*	0.411	-0.296
CPP			1	0.313	-0.587	-0.522	-0.95	-0.455
HNR				1	-0.502	-0.905#	-0.542	-0.16
Shimmer local					1	0.694	-0.353	-0.743
ShimmerdB						1	0.275	0.143
Slope of LTAS							1	-0.711
Tilt of LTAS								1

‘p’= <0.05*, ‘p’=<0.01#

Spearman's rho correlation coefficient was also performed and the results obtained were similar to the values obtained from Karl Pearson moment correlation coefficient.

4.4 Group mean comparison between Group I and Group II

MANOVA was carried out to check the groups mean comparison of individuals with nasalized voice quality and individuals with normal voice quality. Statistical analysis revealed that there was a notable difference for AVQI mean between both the groups, however it was not statistically significant. But significant difference was observed between both the groups for nasalence and also for CPP. The overall results of group mean comparison on individuals with nasalized voice quality and individuals with normal voice quality are summarized in table 4.5

Table 4.5

Results of MANOVA for Group Mean Comparison Between Individuals with nasalized Voice Quality and Normal Voice Quality

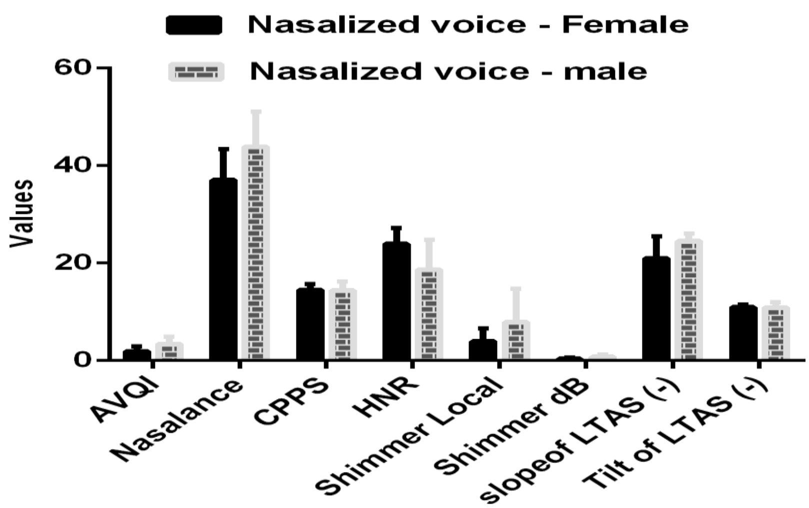
Parameter	**F**	**sig**	**Partial Eta squared**
AVQI	3.792	0.067	0.174
CPPs	4.474	0.049	0.199
HNR	2.175	0.158	0.108
Shimmer local	.225	0.641	0.012
Shimmer local dB	.866	0.364	0.046
Slope of LTAS	2.498	0.131	0.122
Tilt of LTAS	1.666	0.213	0.085
Nasalance score	100.755	0.000	0.848

4.5 Effect of gender on AVQI and Nasalance

Since the control group consists of only female participants, the gender effect was not obtained between the groups. However the effect of gender within the clinical group is obtained through a bar graph due to less number of participants. The results reveal that AVQI, nasalence, Shimmer local and Slope of LTAS show higher value for males.HNR shows higher value for females. CPP, Shimmer dB and Tilt of LTAS shows no difference between genders. Graph 4.2 shows the gender effect within the clinical group which consists of individuals with nasalized voice quality

Figure 4.2

Bar Graph Showing gender Differences in AVQI and Nasalence in Individuals with Nasalized Voice Quality



Chapter V

Discussion

The current study is to establish AVQI scores for individuals with normal voice quality and individuals with nasalized voice quality. It was also aimed to explore the relation between AVQI and nasalence. The data for the study was obtained from 20 native Kannada speakers.

Mean and standard deviation of AVQI

The mean value obtained for AVQI for individuals with normal voice quality and nasalized voice quality in this study is 3.72 (±0.605) and 2.601 (±0.143) respectively. This is lightly high values when comparing the AVQI values in the literature in Indian languages (AVQI=3.03 for Kannada and Malayalam (Jesnu, 2017))

Relation between AVQI and Nasalence

The results of the current study revealed that there was no significant correlation, but a weak negative correlation($r = -0.432$) found between AVQI scores and nasalence scores. Therefore, from the results obtained, we can infer that when nasality increases the AVQI scores decreases i.e. as the nasality increases, the voice quality becomes better. This might be due to the oral articulation is synchronized with the velar movement in a way that prominently attenuates nasal acoustic characteristics; the corresponding compensatory articulation can be aimed at reducing hyper nasality. No published data is available for the effect of nasality on AVQI values.

CPPs and Nasalance

The results of the current study revealed that a significant positive correlation(r = 0.567) was obtained between CPP and nasalence. The results of the study is in accordance with the study done by Watts (2015) revealed that the nasal sentence being characterized by a high CPP and LH (spectral tilt in the form of a low-to-high spectral energy ratio). These results are possibly indicative of the high spectral energy of low frequency which is accentuated during nasal resonance. Such results support the idea that clinicians should understand how supraglottal articulation and the patterns of supraglottal resonance interact to alter the acoustic properties of speech with the glottal sound source. The articulation characteristics of different speech sounds impact the sound spectrum in ways that can affect both acoustic voice measurements and perceptual voice quality judgments. The oral articulation is synchronized with the velar movement in a way that prominently attenuates nasal acoustic characteristics; the corresponding compensatory articulation can be aimed at reducing hyper nasality (Rong, 2009). Conversely, a study done by Madill (2018) aimed at examining the effect of nasality on CPP and HNR**.** The results revealed significant lower CPP values when the task phonation turned from vowels to nasalized vowels and then to nasal, and, negative correlation was found between CPP and nasalence. However, in the present study, a positive correlation was found between CPP and nasalence. It might be because of the effect of stimulus; here in the current study, both phonation and connected speech were taken into account, whereas in the previous mentioned study only phonation was taken into account. Further research is needed with ample amount of sample size to evaluate the relation between CPP and nasalence.

HNR and Nasalance

The results of the current study revealed a weak negative correlation(r = -0.355) between HNR and nasalence. Although not significant, the mean of HNR is higher in the individuals with nasalized voice quality than the control group which is in accordance to the study done by Madill (2018) which revealed that the HNR values were higher with nasals than with vowels. The resonating conditions of the vocal tract tend to be less affected by HNR. As vocal tract and velopharyngeal port modifications tend to play an important role in deciding voice quality, it may be possible that periodicity will increase as a result of the vocal tract's impedance effect on laryngeal configuration as the vowel to nasal phonation changes. Ogawa and colleagues have shown that nasal resonance has significantly lower perturbation and standard deviation of Fo, suggesting more stable phonation. This increase of HNR value in nasal phonation does not have clinical importance due to the wider HNR spectrum. In practice, HNR is calculated from prolonged vowels and not from connected speech and in these conditions, it should be chosen as a measure of laryngeal activity and vocal fold vibration. Another study done Park et al., in 2009 aimed at conducting a correlation analysis between pitch, nasalence, and voice quality parameters indicated that nasalence had strong correlation with HNR. Further studies are required to generalize the relation between HNR and nasalence.

Shimmer and Nasalance

The results of the current study revealed no significant correlation between perturbation measures and nasality (Shimmer local (r = -0.248) and Shimmer dB (r = -0.319)) can be ascribed to fact that perturbation measures tend to be highly variable and can be affected by methodological or subject related factors. It is known that some amount of voice perturbations is present even in normal voice and they are indicative of sudden changes in the aerodynamic and neuromuscular events This results is in accordance with the study done by Ahn(2002) aimed at investigating effect of nasalence in acoustic voice quality and the results showed no statistically significant changes in shimmer along with other parameters. According to Orlikoff (1995), the perturbation measure of absolute shimmer magnitude is significantly influenced by the mean frequency and intensity of phonation. Zajac and Linville (1989) in their study intended at examining the relation between the voice perturbations and perceived nasality in children with VPI. The results of their study showed that the voice perturbations of children with hoarseness corresponded moderately with the nasality perceived. The authors discuss this finding of their study as an evidence for the link between the laryngeal and velopharvngeal events. They explain the findings on the basis of aerodynamic regulation. An open velopharyngeal port during the production of the vowel may cause changes in the flow rate and the transglottal pressures. An individual with VPI attempts to compensate for these changes by increasing the glottal resistance and thus would decrease the flow rate and thus would maintain the subglottic pressure required to sustain phonation. Thus these efforts at regulating the aerodynamic and neuromuscular processes, when the coupling of the oro nasal cavity is inappropriate may result in increased voice perturbations.

LTAS and Nasalance

The results of the present study revealed a weak negative correlation between nasalence and Slope of LTAS (r = -0.365) and no significant correlation between nasalence and Tilt of LTAS. The result of the current study is in accordance with study done by Yang in 2018 wherein there is no statistical significance between slope and tilt of LTAS with nasalence. The acoustic abnormalities observed in the subjects with cleft palate might be due to the existence of cleft palate, during the development of speech. It is related with the closing of vocal fold and abrupt release. Subjects with cleft palate may be aiming at regulating the active VT resistances as compensation. In addition to that, high glottal resistances during the production of voice would result in decreased air flow and thereby improves the regulation of sub glottal pressure which is important for continuous phonation. In their study, no significant difference was found in the low-frequency region among both the groups which revealed that the major variations in energy distribution in the persons with cleft palate are not in the low-frequency region. There was a great difference in the LTAS measurements between both the groups in the mid-frequency region. And also, it was observed that the energy distributed in the control group was higher than that of the clinical group in the high-frequency region. The results revealed an absence of flat region in the mid-frequency range in the clinical group when compared to the control group.

Group mean comparison between both groups

Statistical analysis revealed that there was a notable difference for AVQI mean between both the groups. Statistical analysis revealed that there was a notable difference for AVQI mean between both the groups, however it was not statistically significant. But significant difference was observed between both the groups for nasalence and also for CPP. The results of the present study is in accordance with the study done by Watts (2015) revealed that the nasal sentence being characterized by a high CPP and LH (spectral tilt in the form of a low-to-high spectral energy ratio).These results are possibly indicative of the high spectral energy of low frequency which is accentuated during nasal resonance. Such results support the idea that clinicians should understand how supraglottal articulation and the patterns of supraglottal resonance interact to alter the acoustic properties of speech with the glottal sound source. The mean of nasalence values group I was 40 and group II was 10, this might be the reason why the mean group comparison results showed very high value for nasalence.

Effect of gender on AVQI and nasalence

There were notable differences observed on AVQI values across gender groups in the present study. The results reveal that AVQI, nasalence, Shimmer local and Slope of LTAS show higher value for males. HNR shows higher value for females. CPP, Shimmer dB and Tilt of LTAS shows no difference between genders. HNR values for males was lower than female participants which is in accordance with a study by Goy et al., (2013) revealed that males have lower value of HNR compared to females due to the physical and structural variations present across the genders. There were statistical significance between nasalence scores across genders, p= 0.000, where female participants showed lower mean nasalence value than male participants. This might be because of the small sample size taken for the present study.

Chapter VI

Summary and conclusions

The voice characteristics in individuals with cleft lip and palate lave been explored at different levels like acoustic, aerodynamic, physiological and perceptually. Acoustic analysis of voice can supply objective data regarding vocal abnormalities. For cases of voice disorders these results can be used to track clinical course. Cleft lip and palate have a significant effect on vocal tract structure. Therefore speech quality can also be affected. However most of these studies are based on uni- parametric approaches. The present study aims to find the effect of nasalence on voice quality by correlating acoustic measures and nasalence. Here in the study, AVQI has been used wherein AVQI scores are correlated with nasalence scores to find the relationship.

The study included two groups, a clinical group which consisted of 13 individuals with nasalized voice quality and 7 individuals with normal voice quality as control group in the age range of 12-40years. All the participants in the clinical group were diagnosed with hyper nasality secondary to cleft lip and palate through clinical examination by SLP and plastic surgeon. Nasometer II, Model 6450 was used for obtaining nasalence scores. The stimuli used was five nasal and oral sentences developed by Jayakumar & Pushpavathi (2008) that were routinely used for assessment of individuals with CLP at Unit for structure and oro-facial anomalies, All India Institute of Speech and Hearing, Mysore. The participants were asked to read the stimuli at their habitual rate and loudness. Sustained phonation and reading sample were obtained and the corresponding AVQI measures were obtained. The samples were also subjected to perceptual analysis by 5 experienced speech language pathologists. AVQI measures and its constituent parameters were obtained using Praat software and AVQI script. Statistical analysis was carried using SPSS, 20, Descriptive statistics, MANOVA, Pearson's product moment correlation was carried out.

The normative mean value of AVQI for individuals with normal voice quality is 3.07 (±0.605) for individuals with nasalized voice quality is 2.601 (±0.143).The parameters AVQI, nasalence, shimmer local and Slope of LTAS showed higher value for males.HNR showed higher value for females. Pearson's moment correlation revealed that there was no significant correlation, but a weak correlation between AVQI and nasalence, a significant positive correlation between CPP and nasalence, a weak negative correlation between HNR and nasalence, a weak negative correlation between nasalence and both Shimmer local and Shimmer dB and no significant correlation between nasalence and both Slope of LTAS and Tilt of LTAS. This study result showed that better AVQI score for individual with nasalized voiced than normal voice quality. Also negative correlation was observed between AVQI and Nasalence was noticed. Few of the AVQI constituent parameters like CPP, Shimmer local, and Slop-LTAS also showed relation with nasalence. This may be due to the difference in the impedance effect of the vocal tract on laryngeal configuration and also due to the oral articulation is synchronized with the velar movement in a way that prominently attenuates nasal acoustic characteristics; the corresponding compensatory articulation can be aimed at reducing hyper nasality

Clinical Implications

- The study will help in understanding / validating AVQI
- This will help to understand the effect nasalence on voice quality measures.
- This will help in assessment and management of individuals with CLP &VPI.

Limitations

- The sample size considered is small and therefore, the scope for internal validity and generalization is limited in this study.

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APPENDIX A

Reading Passage in Kannada (Source: Savithri&Jayaram, 2005)

KANNADA PASSAGE

ಬೆಂಗಳೂರು ನಮ್ಮ ರಾಜ್ಯದ ಒಂದು ದೊಡ್ಡ ಊರು. ಈ ಊರನ್ನು ನಮ್ಮ ರಾಜ್ಯದ "ಬೊಂಬಾಯಿ" ಎನ್ನುವರು. ಇಂಡಿಯಾದ ದೊಡ್ಡ ನಗರಗಳಲ್ಲಿ ಇದೂ ಒಂದು. ಈ ಊರನ್ನು ನೋಡಲು ಜನರು ಬೇರೆ ಬೇರೆ ಊರುಗಳಿಂದ ಬರುವರು. ಇದಲ್ಲದೆ ನಮ್ಮ ರಾಜ್ಯದಲ್ಲಿರುವ ಬೇಲೂರು, ಜೋಗ್, ನಂದಿ, ಇವುಗಳನ್ನು ನೋಡಲು ಜನರು ಬರುವರು. ಈ ನಾಡಿನಲ್ಲಿ ರೇಷ್ಮೆಯನ್ನು ಬೆಳೆಯುವರು.

ಕೃಷ್ಣಾ ನದಿಯು ಸಹ್ಯಾದ್ರಿ ಪರ್ವತಗಳಲ್ಲಿ ಮಹಾಬಲೇಶ್ವರದ ಹತ್ತಿರ ಹುಟ್ಟುತ್ತದೆ. ಈ ಪ್ರದೇಶವು ರಮಣೀಯವಾದ ಸ್ಥಾನ. ಇದು ಮಹಾರಾಷ್ಟ್ರ, ಕರ್ನಾಟಕ ಮತ್ತು ಆಂಧ್ರಪ್ರದೇಶಗಳಲ್ಲಿ ಹರಿದು ಬಂಗಾಳ ಕೊಲ್ಲಿಯನ್ನು ಸೇರುತ್ತದೆ. ಇದಕ್ಕೆ ಉಪನದಿಗಳು ಹಲವು. ಕೊಯಿನಾ, ತುಂಗಭದ್ರಾ, ಘಟಪ್ರಭಾ, ಭೀಮಾ, ಮಲಪ್ರಭಾ– ಅವುಗಳಲ್ಲಿ ಕೆಲವು. ಕೊಯಿನಾ ನದಿಗೆ ಅಣೆಕಟ್ಟನ್ನು ಕಟ್ಟಿ ವಿದ್ಯುತ್ತನ್ನು ಉತ್ಪಾದನೆ ಮಾಡುತ್ತಾರೆ.

APPENDIX B

ORAL AND NASAL SENTENCES IN KANNADA (WITH IPA)

ORAL SENTENCES:-

ಕಾಗೆ ಕಾಲು ಕಪ್ಪು.	Ka:gɛ ka:lu kappu
ಗೀತ ಬೇಗ ಹೋಗು.	git̪a bɛga ho:gu
ದನ ದಾರಿ ತಪ್ಪಿತು.	d̪ʌna d̪a:ri t̪appit̪u
ಅಪ್ಪ ಪಟ ತಾ.	appa paṭa t̪a
ಬಾಲು ತಬಲ ಬಾರಿಸು	ba:lu t̪ʌbalʌ ba:risu

NASAL SENTENCES:-

ಮನು ಆನೆಯನ್ನು ನೋಡಿದ.	mʌnu a: nƐjannu no:d̪id̪a
ನವೀನ ಮನೆಯಿಂದ ಬಂದನು.	nʌvi:na mʌnƐjind̪a band̪ʌnu
ನಾನು ಆನೆಯನ್ನು ನೋಡಿದೆ.	na:nu a: nƐjannu no:did̪ɛ
ಮಂಗ ಮನೆಯ ಮೇಲಿದೆ.	maŋga manɛja me:lid̪e
ಮಾಮ ಮಂಡ್ಯದಿಂದ ಬಂದರು.	ma:ma mʌnd̪ja:d̪ind̪a band̪ʌru