CERTIFICATE

This is to certify that the dissertation entitled

AN OBJECTIVE MEASUREMENT OF NASALITY

is the bonafide work in part fulfilment for the degree of Master of Science {Speech & Hearing), of the student with Register No. M 8701

19/5/89
Director
All India Institute of Speech & Hearing
Mysore - 570 006

CERTIFICATE

This is to certify that this dissertation entitled

AN OBJECTIVE MEASUREMENT OF NASALITY

has been prepared under my Supervision and guidance.

Dr. N.P. NATARAJA
Guide

DECLARATION

This dissertation is the result of my own study undertaken under the guidance of Dr. HP. Nataraja, Header and Head, Dept. of Speech Science, All india insutitute of Speech and Hearing, Mysore, and has not been submitted ear/ier at any University for any other Diploma or Degree.

Mysore **Reg. No. M 8707**
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CHAPTER - I

INTRODUCTION

Human society relies heavily on the free and easy interchange of ideas among its members. This speech is suitable for widespread use under the constantly changing and varied conditions of life. It is suitable because it remains functionally unaffected.

The voice quality is one of the most important characteristics of speech. Among the characteristics of voice quality of voice is one of the poorly defined term and which needs lots of research to quantify it as well as to define. The quality of voice is greatly affected by presence of nasality. Of the various deviations and deficiencies exhibited by individuals with cleft of the lip and palate, the most important are those involving the process of speech communication. Individuals with cleft palates exhibits a voice deviation usually referred to as "Nasality" Eckelman and Baldridge (1945), Vanriper and Irwin (1958).

Nasal consonants are found in virtually every language and nasalized vowels in about one out of five (Ferguson (1963), Maddieson, (1984). So the nasal resonance is a highly distinctive, readily perceived acoustic quality which may be mixed with orally produced sounds to invoke specific phonetic contrasts. The penetrating quality of nasality as an acoustic property is unacceptable to listeners when it is injected dominantly and nonphonetically into speech.

Despite its easily recognized presence, the degree of excessive nasality in speech has been shown to be difficult to establish perceptually Bracdford, Brooks and Shelton (1964), Cunihan and Cullinan (1970), Watterson and Emanuel (1981).

When nasal resonance exceeds some as yet undetermined level, it is noticed. At some point above this level of detection it is perceived as abnormal. The voice is then judged as "Hypernasal". Different listeners vary in where they would locate the boundaries between normal, noticeably nasal and hypernasal voice quality Fletcher (1972). Perhaps because of the variable possibly fluctuating, baseline listeners apply in judging perceived nasality, establishing normal limits for this voice quality has presented a serious challenge in diagnosis and management of cases with nasality.

Some attempts have been made to measures this objectively using instruments. The ultimate purpose of instrumentation is to improve management accuracy and repeatability in difficult diagnostic and treatment task.

Hypernasality is the most commonly seen voice problem in cleft palate and others. Both its presence and magnitude are important diagnostically and therapeutically. The measurement of these facets of nasality has occupied clinical and experimental interest for several decades, several attempts have been to develop different methods to measure nasality. Among them are tried by Fletcher and Bishop (1970) is one. They compared acoustic output from the nasal and oral chambers of TONAR - II and judgement ratings of nasality in a passage spoken by 20 subjects with velopharyngeal insufficiency. They found that there was agreement between the judgemental scores and the instrumental ratings.

Fletcher (1978) examined the relationship between perceived nasality and nasalance scores by Nasometer. He found that correspondingly higher agreement between the instrumental scores and subjective ratings, suggest that the perceptual and instrumental observation had a common basis.

But he also reported that the instrumentation provided explicit information with respect to certain ranges of nasal resonance that were particularly difficult for listeners to resolve. The gaining of experience prior to judging of nasality. Otherwise the listeners are only capable of identifying two extremity that is "Normal" and "Abnormal". Where as in the midrange where listeners to listener variability was high.

Need for the study :-

There is no idle instrument available for the measurement of the nasality with meaningful differentiation of the degree of nasal resonance. So the present study was carried out to find the efficacy of the Nasometer instrument based on principles of instrument used by Fletcher (1978). And check whether is it possible to use this instrument for the routine clinical assessment by developing a standard nasalance scale.

Statement of the problem :-

The problem was to find an instrument which can be use to measure nasality and determine the relationship between nasality rating by judges and objective measurement.

Hypothesis :-

(1) There is no significant difference in nasalnace scores between speech samples of normal subject :-

(1) Normal vowels (nonnasal) /a/, /i/, /u/.

(2) Nasalized vowels /a/, /i/, /u/.

(3) Denasalized vowels /a/, /i/, /u/.

(4) Between Nasal sentences and Nonnasal sentences.

(2) There is no significant difference in Nasalance scores between normal males and females.

(3) There is no significant correlation between subjective rating and objective rating of artificially produced nasality by normal subjects.

(4) There is no significant correlation between subjective rating and objective rating of nasality in cleft palate cases.

Implication :-

(1) Provides information about the efficacy of the instrument.

(2) Provides information for differentiation of the degree of nasal resonance.

(3) This information is helpful in diagnosis of cases with nasality. It is also helpful in training of cleft palate subjects.

Limitation :-

(1) Only 30 normal subjects were taken for the present study.

(2) Only four cases with nasality were considered for the study.

Recommendation :-

(1) This study can be conducted with large number of subjects of different age groups.

(2) The instrument can be used clinically for diagnosis and treatment of nasality.

CHAPTER - II

REVIEW OF LITERATURE

Nasalization is important in relation both to phonetic and phonologies some consonants are produced nasaly and in the phonological systems of some languages the nasalization of vowels is phonologically significant. It is also important because excessive nasalization is frequently considered to constitute or contribute significantly to a speech disorder.

Nasalization may be said to have occurred when the coupling between oral and nasal cavity is increased sufficiently to produce a perceptually significant change in the speech signals.

Moll (1961); The nasal cavities are very complexily shaped convoluted cavities whose acoustic characteristics are correspondingly complex. Moreover, the interaction between the pharyngeal-oral tracts and the nasal cavities is complexily related to the extent of coupling between them. When the velopharyngeal port is sufficiently open, some of the sound energy will be transmitted via this opening through the nasal cavities and to the outside air. Thus, there may be two transmissions channels instead of just one, and the manner in which the energy is divided between these two channels is related not only to the extent of the velopharyngeal opening, but also the articulatory configuration of the oral cavity eg. the degree of constriction caused by elevation of the tongue, the amount of lip opening etc., consequently this division of energy will be the variable function of frequency. Stated some what more exactly, the division of sound energy between the two channels will be related to the opposition to the flow of energy through each. When concentrated with oscillating signals such as sound, this opposition to energy transmission is correctly termed as impedance [rather than resistance as it would be dealing with a steady flow]. And it is characteristic of the impedance of transmission channel that it varies with frequency. Since the greater proportion of energy will be transmitted through the channel having the lesser impedance. The division of energy between the two channel will be inversely proportional to the ratio between their respective impedances. This ratio will vary not only for different vowels but it will be a variable function of frequency also.

Normal velopharyngeal function :

X-ray studies have indicated that, in normal individuals displacement of velum upward and backward contributes to closure of the velopharyngeal.

Bzoch K.R, Gerber TM, Aoba T (1959), studied 44 normal young adults during production of /p/, /b/, /f/, /w/ and /m/ and reported that the velum is highest at its middle segment and that its third quadrant meets the posterior wall of the pharynx in sealing the velopharyngeal port. They reported that, usually, the midpoint of contact between the velum and the posterior pharyngeal wall was 3 to 4 mm below the palatal plane. The highest point contact was approximately at the palatal plane and the highest point of the velar eminence was 4 to 5 mm above the palatal plane. Mazaheri M.Milliad R.T. Erickson D.M. (1964) found velopharyngeal contact to be below the palatal plane is eight of ten normal subjects.

Velopharyngeal closure, as observed in the sagittal view from lateral X-ray films, is completed before onset of phonation and is maintained until the person produces wither a normal consonant or a vowel adjacent to a nasal consonant. Even though velopharyngeal closure is maintained through out the oral portion of an utterance, the velum moves upward and downward in coarticulation with other articulators (Moll 1960). This motion appears to be normally programmed so that closure is firmer for those sounds which require greater intraoral air pressure (Lubker 1975).

Variation in velar displacement in different speech contexts has been of special interest to speech pathologists. Dickson and Maue-Dickson (1980) and warren and Hoffman (1961) found from cineradiographic research that the velum did not malntatin firm contact with the posterior wall during the production of isolated sound.

Vowel articulation and nasality :

Moll (1962) studied velar height, extent of contact between velum and posterior pahryngeal wall, and gap between velum and posterior pharyngeal wall for four different vowels produced by 10 normal adults. Data were obtained from cineflouragraphic film exposed at 24 frames per second. The vowel /i/,/x/,/u/, and /e/ were studied in isolation and CVC syllable produced in the carrier phrase, "say again" each syllable was initiated or arrested with fricatives, plosives, affricatives, the liquid and the nasal appeared in either the releasing or arresting of each syllable.

Closure was not always achieved for vowels, opening observed on 30 percent of the isolated vowels, 13 to 15 percent of the vowels in oral consonant contexts, and 89 percent of the vowels in /n/ context, Velar height, which may be measured regardless of velopharyngeal closure, was greater for vowels in nonnasal contexts. Velar heights were lowest in nasal contexts (8.4 mm) and ranged from 11.6 mm for the context free from consonants to ;12.3 mm for /dz/. Velar height for the high vowels /i/ and /u/ averaged 12.4 mm each compared to 10.5 mm for /x/ and 10.6 mm for /a/. Difference between high and low vowels were statistically significant. Where as the difference among the high vowels were not. Data for extent of velopharyngeal contact were similar in pattern to those for velar height.

Distance between the Velum and posterior wall was studied only for vowels in nasal context because most of the measures other context were zero. That in, the velopharyngeal port was closed. Mean gap were 2.45mm for /i/, 2.03mm for /u/, 4.6mm for /x/ and 4.0mm for /a/. High vowels were not significantly different from one another neither the low vowels.

These data suggests that the functions of the velum varies systematically with context. According to Moll (1962) the variability velar height with tongue height determines vowel position may reflect the influence of the plutoglossal muscle which connects the two structures. Different vowels may require different degree of velopharyngeal closure hypernasality.

In another cineradiographic study Moll and Shriner (1967) reported that the Velum is elevated above its resting position for nasal consonants. The distance the velum moves between nasal consonants and vowel decreases as the rate of syllable production increases. Velar swing also increases with increase in rate of production of strings of /l/ syllable. The velopharyngeal port opens between syllables produced at one and two syllables per second, as it remains closed when syllables are produced at rate of four per second.

Consonantal production and Nasality :

In a study using a cinefluorography at 150 frames per second, Moll and Daniloff (1971) reported that some contact between the velum and the posterior pharyngeal wall was observed in normal young adults speakers during all oral movements in NC, NCC, NCCC and NCN context. The last context sandwiched the oral consonant between two nasal consonants. Two of their subjects did not close on /w/ or /l/ when they occurred in NVC contexts. In most NVC sequences movement of the Velum towards the closure began during the nasal consonant, during movement toward the vowel, or during vowel production other articulatory effects observed are, in CN and CCN sequences, the Velum moved towards opening just before or as the tongue tip moved towards the alveolar contact for /h/. They noted that in CVVN sequences, velar opening, which they associated with the nasal consonant, occurring as many as two vowels before the nasal even though a word boundary occurred with in sequence.

Kuchn (1976) studied the velopharyngeal/function of two normal individuals uttering VCNV, VNCV syllables with the phrase "say again" using cineradiography. The camera was operated at 100 frames per second. His findings were as follows.

1. Subjects tended to drop the velum and show a large velopharyngeal opening on the /l/ in /a/na/.
2. One subject dropped the velum on /s/ in /asha/.

3. The velum remained higher for nasal consonants in high vowel than in low vowel contexts.

4. One subject moved the tongue tip before the palace for some /s/ sounds in /say/, where as the other subjects always began velar movement "well in advance of tongue tip movement for the /s/ sounds.

He also found that the information about the speed of articulatory acts (1) Velar movement was decreased during more rapid speech. (2) the velum generally moved more slowly than the tongue. (3) The farther a structure had to move, the faster it tended to move. (4) Speakers with large structures tended to move their articulators farther and faster than individuals with smaller structure. Kuchn (1976) reported that measures of velocity, time distance varied considerably from speaker to speaker and from context to context. The pattern of Velar movement was similar for each subject from context that even similar in place of articulations. The displacement Velum to contact the pharyngeal walls in a major component of normal velopharyngeal closure.

Kunzel (1976) used velography to study velar height in normal German speakers. He found velar heights to be a greater for oral consonants than the vowels. He also reported greater heights for plosives than for liquids. He also reported greater heights for plosives than for liquids.

He found velar height to be greater in voiceless than in voiced plosives, for example in /lapn/ the release in oral, while /lapm/ in nasal.

Iglesias et al (1980) obtained lateral still X-ray films and frontal tomograms simultaneously as normal speakers sustained /z/, /n/, /i/, /u/, /a/ and /x/. Velar displacement was measured. Displacement was significantly greater for /z/ and the high vowels than for the low vowels and for /n/, and it was greater for the low vowels than for /n/, difference between front and back vowels were not significant.

In summary, during speech, the Velum moves upward and backward contacting the posterior wall of the pharynx a bit below palatal plane. This motion usually begins prior to the onset of an utterance is ended. However, the velum moves up and down in keeping with context (coarticulation with the tongue or achieving greater closure in keeping with aeromechanical requirements) even though closure is maintained. The elevated velum during speech as viewed in a sagittal X-ray film in characterized by an eminance of knuckled appearance. The extent of Velar displacement decreases with increased speech rate. The Velum is higher in high vowels than in low vowels and higher in consonants, requiring intraoral air pressure, than in vowels. There is variability among subjects in Velar function.

Bzoch (1959) Nasalization in normal speech in important. It contributes to the quality of voice. Other wise the voice will be sounding muffled. Since the nasal cavities are also important resonator. These resonators have a greater effect on the quality of voice.

Speech Problems due to Nasal resonance :

As explained earlier nasal resonance is essential for normal speech, to be used when ever required. However, sometimes it may become more or less or may not be available even for normal production of speech. These conditions lead to speech problems, which can be considered as nasal resonance problems can divided mainly into two categories, one characterised by too much of nasal resonance and the other by too little or no nasal resonance. The term hyper and hypo-rhinolalia have been used in the past. And the excessive nasality and insufficient nasality have also been commonly used terms.

Hypernasality is excessive, thus undesirable, amount of perceived nasal cavity resonance in speech. Vowel production in the English language is characterised by oral resonance with only slightly nasalized component. If the oral and nasal cavities are open to one another by lack of velopharyngeal closure, the laryngeal tone will receive heavy resonance within the nasal cavity. Only the nasal sounds such as /m/ /n/ /n/ should receive the degree of nasal prominence produced by an open velopharyngeal port. But in cases with hypernasality along with the nasal sounds other sounds also get resonated in the nasal cavity.

Both organic and functional factors have been identified as leading to hypernasality. Basically all these lead to incomplete velopharyngeal port i. e., either due loss of tissue or sensory loss or just learnt habit.

Denasality or hyponasality is the lack of normal nasal resonance for nasalized phonemes like /m/ /n/ and others. In the strict sense therefore denasality can be categorized as an articulation substitution disorder. Generally, denaslity also affects the vowels as normally vowels also get some part of nasal resonance. A common example of denasal voice is the voice that of a person suffering from severe cold. Insufficient nasality is due to nasal obstruction by enlarged adenoids or other growths.

The other type nasality is known as assimilative nasality. In this condition the vowels occurring adjacent to nasal consonants appear nasal. It would appear that the velopharyngeal port opens too soon and remains too long in that condition. Therefore, the vowels proceeding and following would get greater degree of nasal resonance than normal.

Pitch and intensity have considered to affect the degree of naslity. The data on variation in nasality with changes in vocal pitch in cleft palate individuals are not completely definitive. It does appear that nasality may decrease slightly when the subjects are instructed to increase the pitch level. There appears to be no consistent relationship between degree of pitch inflection and nasality in cleft palate subjects.

Sherman and Goodwin (1954) studied between pitch and nasality in functional cases of nasality. They concluded that there was " little evidence to support the hypothesis that there is a relationship between pitch level and perceived nasality". They further qualify their conclusion by stating that lowering the pitch level may be accompanied by a decrease in nasality in some individuals.

Greene (1960) after a study of several hundred cases of cleft palate found that the high pitch voice of females may get away with more nasal escape than deeper male voices. This was also noted by Renfrew (1957). Froeschels (1957) advises judicious experiment with the elevated pitch and the increased intensity to reduce nasality.

Some clinicians (Westlake and Rutherford,1966) have noted that a lower than average pitch level is associate with naslity. Others (Hess,1959; Froeschels,1957) have recommended raising the habitual pitch to reduce nasality. Still others (Van Riper,1954; Gray and Wise,1959) have recommended lowering of the habitual pitch as a way of reducing the naslity.

There are reports that subjects with severe nasality speaks at a lower intensity level than the normal or with mild nasal quality. Findings of Hess (1959) are compatible with those of Williamson (1944) who reports a decrease in nasality with increase in vocal intensity in functionally nasal speakers. Weiss (1954) reports negative correlation between measures of average overall SPL and nasality ratings. Hess (1959) investigated the relationship between the nasality and vocal intensity in cleft palate subjects and repoted that there was a decrease in perceived naslity with increase in SPL. Counihan and Counihan (1972) studied the relationship between the vocal intensity and rated nasality using sustained isolated vowels. When the recorded vowels were played back to the judges at a constant intensity level, the rating were found to be related to the type of vowel. According to Hess (1960) normal males display a similar trend but normal females evidence a trend towards a higher mean rating at the highest than at the lowest intensity level. Further a decline in mean rating with increased intensity was seen in the cleft palate females. So it is possible that the relationship between the nasality ratings and vocal intensity differs for both males and females.

Asthana (1977) found that cleft palate subjects had significantly less nasality at the high pitch level than at the habitual pitch. The degree of perceived naslity was significantly less at higher intensity levels. When pitch or intensity was lowered no significant change in nasality was perceived. Thus the type and degree of relationship between nasality and pitch and intensity remain inconclusive.

Measurement of severity of nasality is dependent upon listeners judgement. Although the human ear is admittedly the final detector and arbiter of nasality, it is not necessarily mean that the judgement made by the listeners are valid. There is evidence to show that the judgement of nasality may be influenced by such factors as proficiency of articulation, vocal pitch and intensity levels, the type of speech sample judged, difference in the background of judges and instructions given to judges dictate the criteria by which the judgements are made (Lubker,1971).

in order to enhance the validity of nasality ratings attempts have been made to eliminate the contaminating effect of 'irrelevant' speech dimensions by judging nasality in tape recorded speech samples played backwards. This procedure has been questioned on the grounds that the acoustic cues associated with consonant production may form an important part of nasality of the cleft palate speakers.

There is a reason to believe that nasality as a perceptual construct is poorly defined. This lack of definition is illustrated by the variety of descriptions of nasality used. Nasality may not be a single quality disturbance. Some have differentiated between the muffled nasal quality associated with an open velar port and a dialectal nasality characterized by accentuation of higher frequency harmonics. The later type had been believed to result more from adjustment of pharyngeal wall tension and tongue posture than from the velar inadequacy. It is also possible that different voice quality disturbances exist in the same speakers. Shanks (1962) reports presence of nasal and denasal speech features in a single speaker. In addition it is apparent that a perceptually different voice quality can occur when velar inadequacy is accompanied by nasal obstruction. These findings suggest that the perception of nasality which is dependent upon listeners judgement is a complex phenomenon and attempts to explain nasal speech through perceptual measures themselves may be limited.

But it must be noted that the measurement of nasality is essential for both diagnosis and therapy with cases of nasality. The measurement of nasality may provide information regarding the possible causative and maintaining factors of nasality, to take decision regarding the line of treatment and to decide the time at which intervention has to be made and to evaluate different surgical and therapeutic measures and their efficiency.

Measurement of Nasality :

The methods of measuring nasality can be considered as (1) direct measures and (2) Indirect measures. The direct measures are those measures which directly measure the nasality, such as TONAR. The indirect measures are those which provide information about structural abnormality like velopharyngeal incompetency, which give an indirect clue about the presence of nasality. But the validity of these measures are questionable.

The direct measures :

The direct measures are those which directly measure the nasality. They are oral nasal sound pressure, acoustic, aero-mechanical and oral - nasal air flow measures.

Oral and Nasal sound pressure measures:

In an effort to understand the exaggerated nasal resonance phenomenon a number of Investigators have undertaken studies to measure the correlates of nasality objectively. Although analysis of the acoustic spectrum of the nasal speech have provided data regarding the shift in formant energies that are associated with nasal tract coupling, the variability among the speakers and the vowels produced by the same speaker have detered the identification of the consistent spectrum pattern that defines the presence and degree of nasal speech.

One acoustic measure that may be useful in differentiating normal from nasal speakers and related degree of perceived nasality have been derived from the use of probe tube microphone assembly (Bryan,1963). This apparatus permits simultaneous recording of the oral (actually oral plus nasal) and nasal speech signals. An identical apparatus is used to record the nasal signal, except that the nasal condensor microphone is modified by addition of a probe tube and its adaptor. The probe tube is inserted a short distance into the least occluded nasal meatus. Oral and nasal signals thus recorded are introduced into a graphic level recorder to obtain measurement of sound pressure levels. Because the probe tube microphone is located within the nasal cavity and oral microphone some distance from the lips, greater nasal than oral sound pressure are usually obtained during speech.

While various measures of sound pressures have been employed in studies of nasal speakers the measure most typically used is that of the different in decibels between oral and nasal sound pressures.

The reliability of this measure in different types speech samples produced by normal and cleft palate group was studied by Richards (1966). The investigator reported that the mean sound pressure difference obtained both the groups in repeated production of speech samples were highly reliable. The difference among means for repeated trials seldom exceeded one decibel. Intra subject variation was some what greater. The maximum change in sound pressure differences for individual subjects repeating the same speech item was on the average four to five dB. A few subjects displayed parked inconsistency from trial to trial. Changes as great as 14 dB for vowels, 28 dB for CVC syllables and 9 dB for sentences were obtained. These data indicate that the mean sound pressure difference obtained for both cleft palate and normal group were highly reliable, but that substantial variation could occur in the productions of the same speech items by individual subjects.

Sound Pressure measures and oral nasal coupling:

As sound pressure differences are related to variations in the degree of oral nasal coupling it might be expected that cleft palate and the normal speaking group differ with respect these measures. Counihan and Pierce (1965) studied a group of 40 persons with cleft palate and reported a mean sound pressure difference of 30 dB, 32 dB and 32 dB for vowels, CVC syllable and sentences respectively.

There is a general agreement amongst studies that the magnitude of the oral-nasal sound pressure difference varies according to the vowel produced for both cleft palate and normal speaking group. Studies on normal speakers indicates greater mean sound pressure for high vowels than for the low vowels. And the existence of an inverse relationship between the magnitude of the sound pressure difference measures and the oral intensity level is reported by Summer (1965), who found that the mean sound pressure difference for normal decreased from 35 to 28 dB as oral intensity is raised from 57 to 84 dB. Studies of vowels produced by persons with cleft palate and normal speaking group reveals consistently greater mean sound pressure difference for females than males. The difference between the means for the sexes are inversely related to the reported difference in the relative power of male and female voices.

The effects of consonant contexts on the sound pressure difference in vowels for both normal and cleft palate speakers are studied by Small (1972). Vowels in consonant context display lesser sound pressure difference than vowels in isolation. Nasal consonant environments however associated with greatly elevated sound pressure difference for vowels in nasal environment is about 13 dB greater than for vowels either in plosive or fricative contexts. High vowels are associated with greater mean sound pressure difference than low vowels.

Sound pressure measures and Nasality judgement:

The usefulness of oral nasal sound pressure differences as an index of perceived nasality was first reported by Weiss (1964), who studied a group made up primarily of functionally nasal speakers. This investigation reported of a very high correlation between sound pressure difference and nasality ratings of connected speech. He concluded that the listeners judgement of the severity of nasality is related to the difference in decibels between nasal and oral sound pressure level. Therefore, it may be said that there is relationship between these two measures. But studies on cleft palate speech show that the relationship between these measures is greater in connected speech than in either CVC syllables or isolated vowels.

Although the size of the correlation reported in studies of cleft palate group had not confirmed the high degree of relatipnship cited by Wiess (1964), further studies were warranted.

Oral and nasal air flow and air pressure measures:

Although disturbance of the oral structures have been implicated as the sources of misarticulations in cleft palate speakers, it is apparent that an inability to impound and regulate the oral breath stream is the primary cause of defective sound production.

Instruments that measure air pressure and flow provide a reasonably direct way of assessing the patency of velar value and the utilization of the breath stream in the production consonants and vowels.

More recently breath pressure ratios obtained in the use of the oral manometer have been employed to evaluate the velopharyngeal adequacy. In this procedure oral breath pressure measured during a maximum respiratory effort with nostrils open is expressed as a ratio of breath pressure measured with the nostrils occluded. If readings under the two conditions are of equal magnitude a high breath pressure ratio is obtained, indicating adequate velar valving. If the readings are low with the nostrils open, lower ratios are obtained, implying less than complete closure.

Measures obtained with the instrument described above yields essentially static estimates of the velar functions. Collectively they have the following limitations: 1. They do not permit measurement of air pressure or flow from the nose and mouth simultaneously or continuously, 2. They lack the the sensitivity to detect the fast variation in flow rate during running speech, 3. they require subjective judgement of dial reading that may affect the precision of measurement, 4. they do not offer a permanent record of data and 5. they do not yeild direct data concerning the air pressure and flow phenomenon that occurs during speech. Advances in the design of flow meter systems have provided the researchers and clinicians with air flow and air pressure transducers that overcomes many of the limitations of the previous instruments. The two flow meters that have been used with success in the investigation of speech are :1. Pneumotachograph, (designed by Flesch,1960) and 2. the warm wire anemometer, (devised by King, 1914).

Measurement of air pressure and flow :

The pneumotachograph measures airflow on the theory that the volume of air passing through in straight tube in proportional to the difference in pressure between two points in that tube.

The use of sensitive instruments to measure oral and nasal air pressure flow in the study of articulation and speech physiology in relatively recent. Problem related to differences in methods of measurements make direct comparison of results in different studies difficult. Considerable work remains to be done in defining the procedures by means of which airflow and air pressure data are extracted and in resolving problems associated with instrumentation and calibration before definitive statements can be made about many features of speech articulation and physiology. There is, nevertheless, reason to assume that airflow and air pressure measurements will add measurably to the armament of researchers interested in speech phenomena.

Aeromechanical measurement :

Warren and DuBois technique :

Measurement of nasal airflow and of the difference in air pressure above and below the velopharyngeal port may be used to estimate both the area of the velopharyngeal orifice, if any during the production of stop consonant and the resistance of the port to airflow.

Measurement of nasal pathway resistance and its importance are discussed below. The determination of the area of the orifice depends upon the use of an equation that was applied by warren and DuBois (1964) is as follows :

$$A = \frac{V_n}{K\sqrt{\frac{2\,(P_1 - P_2)}{D}}}$$

Where

A is area in cm2.

Vn is nasal airflow in cubic centimeters.

P1 and P2 are oral and nasal air pressure in dynes.

D is density of air (0.001 $Gm/\Delta m^3$)

K is a correction factor (0.65)

In practice, the pressure - sensing tubes used to pick up oral and nasal air pressure are coupled to a single differential pressure transducers which forwards to the recorder the difference between the two pressures that value is expressed in centimeter of water. The pressure value is multiplied by 980 to convert to dynes. The area may then be determined by entering the appropriate values in to the formula and performing the needed calculation. The correction factor of 0.65 was obtained by warren and DuBois through use of a model of the vocal tract with known velopharyngeal orifices. Clinical use of this correction factor is based on the assumption that the velopharyngeal segment of the speech analogue designed by warren and DuBois and fashioned on an adult model is similar in form to the patient's mechanism.

Warran (1979) noted that, in contrasting the analog, oral cavity and the nasal pathway dimensions was approximated from cephalometric data obtained from normal adults. Information such as the cross sectional area of the analogue were constructed to offer resistance to airflow similar to that observed in normal person and individual with cleft palate.

The resistance of the passage between two pressure sensing tubes is calculated by dividing oral nasal differential air pressure by nasal airflow and moving the decimal point three places to the right. The resistance is expressed in centimeters of water per liter per second.

$$R = \frac{\Delta P}{V_n}$$

Where

R is resistance expressed in centimeter of water /liter /second.

AP is oral - nasal difference.

Vn is nasal airflow.

Although this formula is used to measure laminal flows. Which we donot have in velopharyngeal assessment, it provides adequate estimates of resistance. If the measurement are always obtained at a given rate of nasal airflow, commonly resistances is measured at 250 and 500 cm H2O/L/S. If one of the pressure sensing tubes used to measure oral - nasal differential air pressure is placed in the nares, the resistance measured reflects the influence of the velopharyngeal port and the nasal pathway combined. Isshiki et al., (1968) wrote that any resistance calculated in the sum of the resistance present - those of the velopharyngeal port, the nasal pathways and the pneumotachometer itself. The latter two resistance are usually small, but they are factors in the results obtained when the velopharyngeal port is open even a small amount.

Equipment :

Warren's system, that is for measuring velopharyngeal area, is that the airflow through the nose is captured by a face mask or a catheter, and passed through a pneumotachometer attached to a differential pressure transducer. The transducer responds to the difference in air pressure on the two sides of the pneumotachometer. The drop in pressure across the screen is proportional to the airflow and may be entered into the formula for determining the area and resistance. The differential pressure transducer converts pressure to an electrical signal, which is recorded on a oscilloscopic recorder or an oscilloscope.

Oral and nasal air pressure are obtained by placing pressure sensing tubes in the nose and mouth. These tubes are connected to a second differential pressure transducer which responds to the difference between the two pressures. This signal is recorded on a second channel of the oscillographic recorder and this differential pressure is entered into the formula. To measure oral air pressure, in contrast to oral -nasal differential air pressure, one side of the transducer is left open and no tube is placed in the nose.

A concise description of several problem presented by Muller and Brown (1980) they indicated that calculating of orifice areas for ports of the same size but of different geometric configurations may differ slightly from one another. Muller and Brown also indicated that the area estimate will be influenced by the shape of the entry and exit to the port, the presence or absence of a distant periodic component to the flow, and the nature of the flow, that is, whether turbulent, laminar or transitional. Other variables that may influence estimates of velopharyngeal area and nasal pathway resistance include the biomechanical of the tissue of the pertinent structures and changes in those tissue and in respiratory pressure initiated by muscle activity.

PERCI :

Warren (1979) introduced an instrument called PERCI (palate efficiency rating computed instantaneously) for use in velopyaryngeal mechanism'during speech. It is cheaper than the aeromechanical system he used in research, but provides information that agrees with that derived from the more complex systems.

No claim is made that the PERCI is sensitive to differences in velopharyngeal opening /s/ less than 10mm2. The study of patient with marginal velopharyngeal competence is especially important. The clinical needed of the patients are less clear than are those of the patients with unquestionable in competence. The marginal group included individuals who had velopharyngeal area between 0 and 10mm2, their needs will not be well -served by the PERCI.

HONC (Horii oral nasal coupling). Horii (1980) has deviced an electric system for producing the ratio of nasal to oral accelerometer out put (similar in principle of sound pressure ratio) during running speech. The HONC index is a relative scale, with a value of 1 ie., (HONC = 1) representing maximum nasalization HONC ratio can be compared across speakers. And the value 0 ie., (HONC =0) indicates denasalization. In evaluating denasality, a fully oralized sound can be used as a base line reference.

Indirect measures :

(1) Articulation tests :

Leakage of air through an incompetent port would be expected to interfere with high - pressure consonants and produce perceptible nasality. Conversely inadequate nasality will distort nasalized sounds like /m/, /n/.

(2) Radiological measures

(3) Cephalometrics

(4) Tomography

(5) Cine-vedioflouroscopy

(6) Ultrasounds

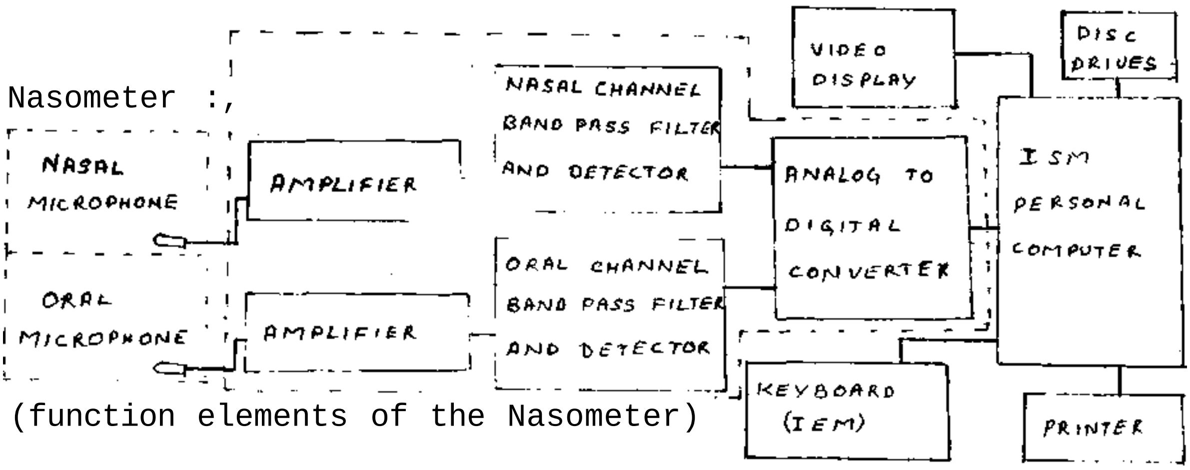
(7) Endoscopy

TONAR :

Fletcher (1970) advanced the study of oral and nasal sound intensity measure as indices to hypernasality through the development of an instrument which in named TONAR (the oral - nasal acoustic ratio). This instrument includes lead chamber to separate the nose from mouth. A microphone packed in fiberglass is contained in each chamber. Each microphone leads to its own tunable filter network. These networks have identical band widths and frequency ranges are capable of processing frequencies between 50 and 20,000 Hz. The system locks on the resonant frequency in the nasal chamber and at the same time tracks the same frequency band in the oral channel (Warren 1973). The instrument points out voltages associated with the nasal and oral signals and also a trace reflecting the ratio of the voltages from the sound detected in the oral and nasal chamber.

A second version of this equipment is TONAR II provides a reinforcement panel. This instrument can be used a biofeedback training device, light bulbs on the reinforcement panel are illuminated automatically as the patients oral - nasal ratio achieves a level selected by the clinicians.

Nasometer :,



(function elements of the Nasometer)

The TONAR II instrument was replaced by the Nasometer. The Nasometer is similar in principle to TONAR II but significantly different in structure, function and practice features.

It consists of three major subunits.

(1) A sound separator

(2) Electronic circuit for frequency band limiting and processing the microphone signals and transmitting them to a computer.

(3) A personal computer for receiving data, processing the information, calculating the nasalance values and displaying the nasalance scores along with other parameters in printed or graphical (e,g., " Nasogram") form.

Sound separator :

The sound separator assembly consists of a metal plate or baffle, headgear to support the baffle and two microphones that transduce the separated nasal and oral acoustic signals. Anthropomorphic data were obtained, so it would fit a wide range of faces and in particular that of a young adult.

During use, the plate is oriented perpendicular to the frontal plane of the face and centred on the prolabium approximately midway between the nose and the upper lip.

The acoustic amplitude of the signal from the nose and mouth is transduced to proportional electrical signals by the microphones mounted above and below the separator plate. The microphones are unidirectional close speaking and dynamic. They have a 50 to 15,000 Hz frequency response with a -66 dB sensitivity. The unidirectional response characteristic of these microphones increases the acoustic separation of the nasal and oral signals and helps reject potentially contaminating environment noise. Under this condition the nasal - oral signal separation is about 25dB.

The advantage of the current design include natural speech acoustic with out injection of competing cavity resonances and with out impedance loading present in a more closed systems. It also allows the talkers to self monitor their speech with less distortion.

Software :

The Nasometer is microcomputer based and software driven. This permits several features that are not available in TONAR II.

The major function of the software includes data acquisition, data editing and analysis, stimulus presentation display generation, file management and various utilities.

Interpreting nasalance measures :

Fletcher (1978) examined the relationship between perceived nasality and instrument measures of nasalance through series of comparison between instrumentally derived and listeners judgement scores. 70 cleft palate children's speech samples were randomized and 20 listeners served as judges. They were asked to mark the severity of nasality in a 5 point scale ie., "Normal" , "Mild", "Moderate", "severe ", "Very severe". He found that the listeners perceptual ratings become more closely aligned agreement with the instrumentally derived nasalance scores systematically increased. That is greater precision in listeners observation lead to correspondingly higher agreement with the instrumental scores, suggesting that the perceptual and instrumental observation had a common basis. The final correlation of 0.91 between nasality and nasalance scores suggest that for the most purposes the instrument measures may be used as a valid estimate of the degree of nasality likely to be deprived of pooled observation from listeners judgement.

Patterns of nasalance :

The nature of the measurement procedure dictates that the degree of nasalance in speech will be proportional to the acoustic energy of the signal as it exists from the nasal and oral chambers. This proportion is controlled by the physical characteristics of the oral and nasal chambers, the integrity of the velopharyngeal value, postures of the lip and tongue and by the phonetic demands of the sound spoken. Each of the multidimensional factors influences the graphical pattern.

CHAPTER III

METHODOLOGY

The purpose of the study was to find the efficiency of the Nasometer developed using a personal computer in, objectively, measuring the nasality and to relate the measurement with the subjective ratings of nasality. Further it was also intended to develop norms for normal and nasal speech samples to be used clinically in evaluating cases with nasality.

Fletcher (1978) has described a Nasometer developed using a personal computer (and two microphones and A/D convertor) with appropriate software. Based on this principle a personal computer (PC/XT) has been modified into a nasometer. To put this Nasometer into clinical use the present study was undertaken.

INSTRUMENT

The Nasometer consists of three units. They are

1. Sound separator,
2. A/D convertor with necessary filters and computer interface and
3. Personal Computer (PC/XT, Wipro).
4. Software

The Sound separator, is a plastic plate with two microphones with same specifications, that transduce the separated nasal and oral acoustic signal. The plate was cut to fit into the configuration of the area below the nostrils and above the upper lip (Photograph - 1) of different age groups so that the voice signals oral and nasal cavities are separated.

The signal received by the microphones are filtered and amplified by two different but identical amplifiers and fed a 12 bit A/D convertor. From there the digitized signals are fed to computer for further processing by the programme nasal'.

The software is basically used for acquisition of data, data analysis and display generation i.e., the nasometer is a software driven system. The data is acquired at a rate of 8 KHz from both channels(nose and Mouth outputs) and digitized. Then they are analyzed for intensity of the signal and displayed on the screen separately i.e..signal from nose as well as mouth (Figure -1). The averaged values of both signals are taken and then the ratio Nasalance' is determined by using the formula :

$$\text{Nasalance} = N / N+O \times 100$$

Where N= Nasal output, 0 = oral output.

Subjects :- Thirty normal subjects were taken in the present study. The group included fifteen males and fifteen females. The age range was from twenty Years to twenty eight Years. All subjects had normal voice which was appropriate to their age and sex with out any vocal pathology.

Group II :- Four subjects with nasality were also taken in the present study (ie., 3 with cleft palate and 1 with velopharyngeal incompetency). No attempts was made to control the sex , age and cause for the nasality of the group. The group included 2 males and 2 females. The age range was from seven Years to fifteen Years. The subjects did not had any other problem except for hypernasality.

Speech samples :- (1) Phonation of /a/, /e/, /i/ Three times each with normal phonation, with instruction to open velopharyngeal port (nasalization of vowels) and with occluding nasal openings.

(2) Five sentences with out nasal sounds.

(3) Five sentences with maximum number of nasal sounds.

(4) For, the younger group who were unable to read, three standard sentences were used.

Procedure :-

Part A :-Objective evaluation

Step 1 :The subject was asked to sit on a chair and instructed in the following manner.

Photograph-1 NASOMETER.

"After keeping the sound separator between nose and mouth (photography -1) phonate the vowel /a/, /i/, /u/ continuously in your normal speaking voice with out any variation". He was also instructed not remove the sound sep ator during testing.

The nasalance value was taken into consideration only when the out put on the screen was continuous.

The nasalance value was taken for each vowel (/a/, /e/, /u/), thrice and the mean of nasalance score was calculated for each vowel.

Step 2 :-

The subject was asked to phonate the vowels /a/, /i/, /u/ in a nasalized voice with out any variation. The subject was also instructed not to remove the sound separator during testing.

The nasalance score as mentioned in step 1 was calculated.

Step 3:-

The subject was asked to phonate the vowels /a/, /i/, /u/ with nares occluded using a clip (photography 1) with out any variation. The subject was also instructed not to remove the sound separator during testing.

The nasalance score was calculated as mentioned in step 1.

Step 4 :-

Nasal sentences written on flash cards were presented to the subjects and were asked to read by keeping the sound separator between nose and mouth on the upper lip.

And nasalance score for each sentences were calculated once and the mean nasalance score was obtained.

Step 5 :-

Non nasal sentences written on flash cards were presented to the subjects and were asked to read by keeping the sound separator between nose and mouth on the upper lip.

And nasalance score for each sentences were calculated once and the mean nasalance score was obtained.

After finding out the mean for each items separately for each subject these scores were divided on a 5 point scale depending on nasalance score.

0 - 15	- denasal
15 - 30	- noraml
30 - 45	- mildly nasal
45 - 60	- moderately nasal
60 - 75	- severely nasal
75 - above	- very severely nasal

And each item was assigned numbers depending upon the severity that if it is denasal - 0, normal - 1, mild - 2, moderate - 3, severe - 4, very severe - 5. So these nasalance scores were also converted into single number by using this nasalance scale for easy comparison with that of the subjective rating.

Part - B :-

Subjective evaluation :-

All speech samples were submitted for subjective rating by judges. They are phonation of /a/, /i/, /u/ with noraml voice, with instruction to open velopharyngeal port, and with occluded nares, the nasal sentences and non nasal sentences were also presented.

Speech samples of males, females and cases have been randomized separately. Before presenting for the subjective evaluation. Each item in phonation was presented three times and each sentences (nasal and non nasal) were presented for rating.

Three listeners served as judges of these speech samples. These three judges were post graduate students of speech and hearing.

They were asked to rate the severity of nasality by using point five point scale after hearing each sample for

They made markings in a response sheet depending upon the severity of nasality as they perceived,

denasal - 0

nasal - 1

mild - 2

moderate - 3

severe - 4

very severe - 5

To obtained the judgement, the recorded speech samples were played in a sound free room at a constant intensity. Rest periods of 5 to 10 minutes were given during rating sessions.

The part of the speech samples were rated after period of 48 hours for the purpose of reliability check.

Method of analysis :-

Correlation between the objective and subjective ratings, inter and intra judge reliability were determined using computer programmes for all the speech samples.

Further 'T - Test' was also administered to find out significance of difference between different types of speech samples.

CHAPTER IV

RESULTS AND DISCUSSION

In the present study thirty normal subjects (15 males and 15 females) and four subjects with nasality were taken to check the efficacy of the instrument and to find the relationship between subjective rating and objective rating of nasality and thus to establish norms.

Objective scores :

The analysis of the objective scores showed that there was variation in the nasalance scores depending on the speech samples used. Table 1 provides, the nasalance scores found for different individuals 30 normals (males and females) and four cases with nasality for different speech samples.

The difference in nasalance scores were found to be significant for some of the speech samples. Table [la, lb, lc], [2a, 2b, 2c], [3a, 3b, 3c] indicate, nasalance scores, mean, standard deviation and correlation between speech samples of males, females and cases.

Significant difference in nasalance scores between speech samples of males were found in the following.

(1) Nonnasal /i/ and nonnasal /u/.

(2) Nonnasal /a/ and nasalized /a/.

(3) Nonnasal /a/ and denasalized /a/.

(4) Nonnasal /i/ and nasalized /i/.

(5) Nonnasal /i/ and denasalized /i/.

(6) Nasalized /i/ and denasalized /i/.

(7) Nasalized /i/ and nonnasal /i/.

(8) Nasalized /a/ and nasalized /a/.

(9) Nasalized /i/ and nasalized /u/.

(10) Denasalized /a/ and denasalized /u/.

(11) Denasalized /i/ and denasalized /u/.

(12) Nasal sentences and nonnasal sentences.

Speech samples where there was no significant difference :

(1) Nonnasal /a/ and nonnasal /i/.

(2) Nonnasal /a/ and nonnasal /u/.

(3) Nasalized /a/ and denasalized /a/.

(4) Nonnasal /u/ and nasalized /u/.

(5) Nonnasal /u/ and denaslaized /u/.

(6) Nasalized /u/ and denasalized /u/.

Speech samples where them was a significant difference in nasalance score among females :-

(1) Nonnasal /i/ and nonnasal /u/.

(2) Nonnasal /a/ and nasalized /a/.

(3) Nonnasal /a/ and denasalized /a/.

(4) Nasalized /a/ and denasalized /a/.

(5) Nonnasal /i/ and nasalized /i/.

(6) Nonnasal /i/ and denasalized /u/.

(7) Nasalized /a/ and nasalized /i/.

(8) Nasalized /i/ and nasalized /u/.

(9) Denasalized /a/ and denasalized /u/.

(10) Denasalized /i/ and Denasalized /u/.

(11) Nasal sentences and nonnasal sentences.

Speech samples, where there was no significant difference among females :-

(1) Nonnasal /a/ and nonnasal /i/.

(2) Nonnasal /a/ and nonnasal /u/.

(3) Nonnasal /i/ and denasalized /i/.

(4) Nasalized /a/ and nasalized /u/.

(5) Denasalized /a/ and denasalized /i/.

Comparision of nasalance scores of Females and males:

A comparison of nasalance score on each Speech samples of males and females were performed. The results were as follow :- (Table -4)

Statistically significant correlation were found in following variables between males and females :-

(1) Nonnasal vowel production /a/.

(2) Nonnasal vowel production /i/.

(3) Nasalized vowel production /a/.

(4) Nasal sentence production.

(5) Nonnasal sentence production.

Statistically there was no significant correlation found in the following variables :-

(1) Nonnasal vowel production /u/.

(2) Nasalized vowel production /i/.

TABLE-1(a) Nasalance scares (HALES)

Sl No.	Normal phonation /a/,	HI,	/u/	Nasalized phonation /a/,	/i/,	/u/	Denasalized phonation /a/,	/i/,	/u/	Nasal sentences	Non-nasal sentences
1.	12.34	22.45	15.70	41.25	65.84	52.32	15.34	14.16	11.21	63.75	18.20
2.	15.72	23.43	15.73	35.15	59.41	57.16	21.65	11.61	16.01	59.12	20.10
3.	17.35	23.31	17.28	43.12	64.34	53.44	19.12	19.75	13.82	68.16	17.20
4.	25.32	26.46	16.50	43.25	63.28	57.44	25.76	17.17	18.85	57.25	18.15
5.	14.02	35.15	23.10	38.25	70.23	42.31	15.98	14.42	18.20	62.15	22.45
6.	14.42	24.38	14.69	34.04	61.25	59.32	20.35	16.26	15.88	55.28	15.56
7.	15.72	35.25	16.64	40.21	65.50	58.37	19.25	17.56	17.25	57.35	18.85
8.	17.03	35.21	25.25	45.25	66.36	53.59	20.65	18.12	16.25	59.25	25.25
9.	17.35	47.17	24.21	45.25	73.10	58.36	22.56	21.15	17.75	63.25	23.25
10.	19.55	42.71	21.10	53.25	74.35	61.17	21.70	19.13	16.16	67.16	24.16
11.	20.05	24.26	17.13	45.50	57.25	57.25	24.13	18,19	16.26	62.26	22.02
12,	18.74	18.49	11.74	55.25	70.29	54.25	17.96	23.16	18.82	62.30	16.65
13.	20.24	33.21	20.13	71.20	62.13	60.15	24.75	24.26	23.12	69.14	20.25
14.	17.55	35.21	19.46	36.25	64.65	47.02	24.50	22.55	22.25	61.78	25.16
15.	19.55	40.25	21.71	54.25	73.32	53.21	21.70	18.16	16.16	67.05	23.84

TABLE-I(b) Nasalance score (HALES)

			Mean	Std. Deviation	Minimi	Maxmum
1.	Nonnasal	/a/	17.874	3.082	12.2	26.5
2.	Nonnasal	lit	31.951	8.830	18.49	48.15
3.	Nonnasal	Id	18.834	4.195	11.36	28.85
4.	Nasal	lit	45.286	10.380	33.93	74.41
5.	Nasal	in	68.467	5.975	54.91	80.34
6.	Nasal	/u/	55.549	5.869	39.09	71-24
7.	Denasal	ui	20.750	3.293	14.54	28.87
8.	Denasal	HI	17.412	3.504	10.01	25.26
9.	Denasal	lul	16.358	3.015	11.01	23.08
10.	Nasal sentences		61.870	6.382	49.03	77.91
11.	Nonnasal sentences		20.631	4.003	13.37	29.70

TABLE -1 (c) Nasalance scores (MALES)

Samples	T test scores	Probality	correlation	significance
1. Nonnasal /a/ and Nonnasal /i/	+10	0.000	0.20 !O	
2. Nonnasal /a/ and nonnasal /u/	- 1.3	0.20	0.09 (-)	
3. Nonnasal /i/ and nonnasal /u/	-14.44	0,000	0.79 (+)	+
4. Nonnasal *lil* and nasal /a/	-19.38	0.00	0.42 (+)	+
5. Nonnasal /a/ and denasal /a/	- 6.63	0.00	0.58 (+)	+
6. Nasal *lil* and denasal /a/	+16.48	0.00	0.29 (+) -	
7. Nonnasal /i/ and nasal *lil*	-33.68	0.00	0.57 (+)	+
8. Nonnasal /i/ and denasal /i/	+13.10	0.00	0.56 (+ 1	+
9. Nasal *HI* and denasal /i/	+61.61	0.00	0.41 (+)	+
10. Nonnasal /u/ and nasal /u/	-35.65	0.00	0.088 (+) --	

Samples	'T' test scores	Probality	correlation	significance
11. Nonnasal /u/ and denasal /u/	+ 3.82	0.004	0.305 (+)	
12. Nasal /u/ and denasal /u/	+40.23	0.00	0.024 (+)	-
13. Nasal /a/ and nasal /i/	-22.25	0.00	0.75 (•)	+
14. Nasal /a/ and nasal /u/	- 7.58	0.00	0.49 (+)	+
15. Nasal /i/ and nasal /u/	+13.99	0.00	0.45 (+)	+
16. Denasal /a/ and denasal /i/	+ 6.68	0.00	0.51 (+)	+
17. Denasal /i/ and denasal /u/	+ 2.78	0.007	0.707 (+)	+
18. Denasal /a/ and denasal /u/	+12.6	0.00	0.73 (+)	+
19. Nasal sentences and nonnasal sentences	+59.93	0.00	0.42 (+)	+

Note : + indicates significant correlation
- indicates insignificant correlation

TABLE -2(a) Nasalance scores (FEMALES)

SI No.	Noraal phonation /a/,	/i/,	/u/	Nasalized phonation /a/,	/i/,	/u/	Denasalized phonation /a/,	/i/,	/u/	Nasal sentences	Non-nasal sentences
1.	12.56	22.56	21.15	43.95	68.86	49.91	12.72	14.45	11.76	63.35	14.45
2.	28.25	23.35	20.65	51.56	59.95	52.25	20.92	16.90	18.96	68.88	23.35
3.	17.26	39.95	26.65	48.85	77.75	63.35	25.52	17.70	18.75	69.45	27.75
4.	16.90	40.10	14.45	48.86	64.75	62.56	21.12	16.65	16.65	71.76	21.16
5.	17.76	41.13	19.95	49.95	81.82	55.56	20.93	18.85	19.93	61.16	17.76
6.	18.80	49.91	15.15	54.45	64.46	59.45	18.86	25.92	16.12	53.35	21.98
7.	17.16	28.81	16.65	36.65	63.35	54.45	21.21	15.56	13.76	68.86	22.25
8.	17.90	27.92	16.62	37.76	54.42	52.26	18.72	16.62	10,17	62.25	21.16
9.	16.56	32.35	21.64	49.92	67.72	64.46	18.13	16.05	14.40	65.58	20.21
10.	16.96	32.26	21.16	35.52	78.82	59.95	18.13	16.05	8.93	65.56	17.76
11.	16.60	24.92	18.85	47.78	56.65	61.15	20.16	14.48	18.80	68.80	16.65
12.	21.20	36.65	25.25	49.92	73.35	61.36	21.12	16.65	18.80	63.32	23.35
13.	22.25	34.46	17.15	57.25	65.52	48.85 v	20.08	11.10	11.90	60.10	21.16
14.	19.95	37.75	19.95	47.72	81.12	64.46	20.44	13.30	14.90	67.70	19.90
15.	24.36	33.35	19.76	43.32	66.15	63.35	19.92	14.40	13.98	59.90	16.65

TABLE-2(b) Nasalance score (FEMALES)

			Mean	Std. Deviationi	Minimum	Maximumi
1.	Nonnasal	/a/	18.456	4.825	10.68	33.91
2.	Nonnasal	/i/	51.960	6.869	20.46	46.6
3.	Nonnasal	/u/	19.902	5.062	9.91	31.85
4.	Nasal	/a/	46.247	7.560	32.79	59.48
5.	Nasal	/i/	70.074	7.672	52.25	85.00
6.	Nasal	/u/	58.072	6.365	44.44	67.69
7.	Denasal	/a/	19.829	3.357	11.76	27.71
8.	Denasal	/i/	16.055	3.615	9.48	27.97
9.	Denasal	/u/	14.916	3.336	8.35	19.77
10.	Nasal sentences		61.443	7.366	32.87	76.13
11.	Nonnasal sentences		20.346	4.062	12.44	17.46

TABLE -2 (c) **Nasalance scores (FEMALES)**

Samples	T test scores	Probality	correlation	significance
1. Nonnasal /a/ and Nonnasal /i/	-11.04	0.000	0.048 (+) -	
2. Nonnasal /a/ and nonnasal /u/	- 1.55	0.12	0.20 (-) -	
3. Nonnasal /i/ and nonnasal /u/	+15.99	0.000	0.68 (+)	+
4. Nonnasal /i/ and nasal /a/	-28.19	0.00	0.50 (+)	+
5. Nonnasal /a/ and denasal /a/	- 2.31	0.026	0.575 (-)	+
6. Nasal /a/ and denasal /a/	+26.95	0.00	0.496 (+) -	
7. Nonnasal /i/ and nasal /i/	-34.42	0.00	0.483 (+)	+
8. Nonnasal /i/ and denasal /i/	+12.91	0.00	0.163 (+) -	
9. Nasal /i/ and denasal /i/	+42.12	0.00	0.04 (+)	+
10. Nonnasal /u/ and nasal /u/	-43.02	0.00	0.476 **(+)**	**+**

Samples	T test scores	Probality	correlation	significance
11. Nonnasal /u/ and denasal /u/	+ 7.10	0.00	0.43 (+)	+
12. Nasal /u/ and denasal /u/	+43.31	0.00	0.16 (+)	-
13. Nasal /a/ and nasal /i/	-19.11	0.00	0.39 (+)	-
14. Nasal /a/ and nasal /u/	- 9.32	0.00	0.31 (+)	-
15. Nasal/i/ and nasal /u/	+10.75	0.00	0.44 (+)	+
16. Denasal /a/ and denasal /i/	+ 6.375	0.00	0.35 (+>	-
17. Denasal /i/ and denasal /u/	+11.91	0.048	0.658 1+)	+
18. Denasal /a/ and denasal /u/	+ 2.025	0.00	0.413 (+)	+
19. Nasal sentences and nonasal sentences	+54.98	0.00	0.782 (+)	+

Note : + indicates significant correlation
- indicates insignificant correlation

TABLE -3(a) Nasalance scores (CASES)

Sl No.	Normal phonation /a/, /i/, /u/			Nasalized phonation /a/,/i/, /u/			Denasalized phonation /a/, /i/, /u/			Non-nasal sentences 1	Non-nasal sentences 2	Nonnasal sentences 3
1.	31.73	48.85	48.85	58.85	71.71	67.75	15.50	14.83	17.76	58.92	61.10	57.95
2.	25.52	54.45	47.47	36.65	52.25	53.35	16.65	18.82	15.67	38.82	' 47.70	53.35
3.	25,92	52.28	43.38	32.25	48.81	49.92	17.92	14.45	13.35	38.82	43.35	47.95
4.	32.71	61.71	47.78	40.45	67.75	43.35	36.65	48.85	47.47	41.15	43.35	43.63

TABLE-3(b) Nasalance scores (CASES)

			Mean	Std. Deviation	Minimum	Maximum
1.	Nonnasal	/a/	32.791	8.210	23.58	49.69
2.	Nonnasal	/i/	58.022	12.133	46.25	77.14
3.	Nonnasal	/u/	47.701	3.424	42.65	53.36
4.	Nasal	/a/	42.696	12.033	33.73	64.73
5.	Nasal	/i/	65.906	10.450	51.08	78.85
6.	Nasal	/u/	57.134	7.365	49.81	67.41
7.	Denasal	/a/	17.178	2.289	13.98	21.45
8.	Denasal	/i/	18.914	4.164	14.41	26.63
9.	Denasal	/u/	17.223	2.079	14.79	21.98
10.	nonnasal sentence	(1)	39.978	8.871	31.13	53.36
11.	Nonnasal sentence	(2)	42.102	12.161	38.82	49.62
12.	Nonnasal sentence	(3)	43.170	12.212	37.71	55.57

TABLE -4 Nasalance **scores (FEMALES VS MEALES)**

Samples	T test scores	Probality	correlation	significance
1. Nonnasal /a/ and Nonnasal /a/	- 0.681	0.000	0.327 (+)	-
2. Nonnasal /i/ and nonnasal /i/	- 0.005	0.000	0.72 (+)	+
3. Nonnasal /u/ and nonnasal /u/	- 1.0S3	0.000	0.28 (+)	-
4. Nasal /a/ and nasal /a/	- 0.50	0.000	0.32 (+)	-
5. Nasal /i/ and nasal /i/	- 1.12	0.000	0.27 (+)	-
6. Nasal /u/ and nasal /u/	- 1.96	0.00	0.053 (+)	-
7. Denasal /a/ and denasal /a/	- 1.314	0.00	0.192 (+)	-
8. Denasal /i/ and denasal /i/	+ 1.807	0.00	0.074 (+)	-
9. Denasal /u/ and denasal /u/	+ 2.15	0.00	0.034 (+)	-
10. Nasal sentences and nasal sentences	- 0.379	0.0021	0.705 (+)	+
11. Nonnasal sentences and Nonnasal sentences	* 0.449	0.0042	0.654 (+)	+

Note : + indicates significant correlation
- indicates insignificant correlation

(3) Denasalized vowel production /a/.

(4) Denasalized vowel production /i/.

(5) Denasalized vowel production /u/.

It is clear from the above results tat there was a significant variation in nasalance scores for most of the stimulus materials. So from the above findings the hypothesis No-1 is rejected and conclude that there is a significant difference in nasalance scores between the speech samples of normal subjects.

Similar findings have been supported by Fletcher (1978) Nasometer provided explicit information with respect to certain ranges of nasal resonances. The mean scores from each set of data were subjected to analysis of variance. This analysis revealed that no significant age or sex effects on nasalance scores. But there was a significant difference in nasalance scores for different stimulus materials.

Hardy (1965) used the pressure and airflow during speech indicated that the oral pressure flow very for consonants and vowels as a function of voicing, manner of production position of the consonants in a sentence, vowel context.

In the present study there was clear difference in nasalance scores for the high vowels /i/ and /u/ and low vowel /a/. This difference is observed in nasalized, nonnasal and denasalized samples.

Moll (1962) has also reported similar results. He studied the velar height, extend of contact between velum and posterior pharyngeal wall for two vowels produced by two normal adults. Data was obtained from cineflourogrphic study. Velar heights for the high vowels /i/ averaged around 12.4 mm and it was 10.6 mm for /a/. Difference between high and low vowel was statistically significant. Distance between velum and the posterior wall, mean gap for /i/ were 2.45 mm and for /a/ it was 4.0.

Hawkins and Swisher (1978) used multielement transducer to study the movement of the lateral pharyngeal wall in them adult subject. They reported that a medial movement of 5mm for /a/ and a lateral movement of 10 to 12mm for /i/. Vaghun (1965) used a pressure air flow measure and found that vowels with lesser power such as /i/ and /u/ displayed greater flows than the more intense vowels such a /x/ and /a/. And also he explains that production of /i/ was accompanied by oral constriction. So air was directed towards the nasal cavity when compared to the production of /a/ where there was no constriction formation.

Fletcher (1961) noted that front vowels were judged to be more nasal than the back vowels and no systematic differences existed between the high and low vowels.

So from the above discussion it is clear that /i/ vowel shows high nasalance score than other vowels produced. So it can be said that the nasality depends on the vowel and is related to the constrictions formation in oral tract.

The present study also indicated that there was a marked difference between the nasal and nonnasal sentences.

Weiss (1964) who studied a group of functionally nasal speakers. This investigator reported of a very high correlation (0.945) between sound pressure differences, and nasality ratings of connected speech.

This present study indicates a statistically significant correlation between the nasal and nonnasal sentences, when compared to the other speech stimuli. So it is better to use connected speech for measuring nasality.

Comparison of Male and female groups:

The results indicated correlation only in specific speech samples that is nonnasal vowel production /a/, /i/, nasal vowel production of /a/, nasal sentence production and in nonnasal sentence production. This finding was supported by some researchers.

Mckenrns and Bzoch (1970) measured the angle formed by the posterior nasal spine, the superior point of, contact between the elevated palate and the posterior wall of the pharynx in normal males and females age between 19 and 32 years. They found that the angle to be more acute in males and more nearly right angle in females. They also found that the height of Velar elevation to be greater in men than in women but the extent of contact between the Velum and posterior pharyngeal wall to be less in men. The inferior print of the contact was usually above the palatal plane in the men but not in the women.

Kuehn (1976) studied the sagittal cineflourographs of one normal male and one normal female and reported that the male's palatal displacement followed a steeper path than did the females.

Seaver and Kuehn (1980) found, using cineflourographic system, that the women changed velar height more than the men. Tongue height appeared to be related to Velar height in males.

There are few researchers who did not find a significant difference between males and females.

Fletcher (1978) by using Nasometer found no significant difference either based on age or sex.

In the present study though there were differences between males and females in nasalance scores, the overall scores were not statistically significant. The comparison of mean values and minimum and maximum scores are provided in

Table. 4. Ho significant correlations were found in case of nonnasal vowel production of /u/, nasalization of /i/, denasal vowel production of /a/, /i/, /u/. Thus Hypothesis NO.2 is agreed upon. That is there is no significant difference between males and females in nasalance scores.

The nasalance scores obtained for different speech samples (males and females), were divided by using 5 point scale. Which can be used to classify in terms of severity. That is "Denasal", "Normal", "Mildly nasal", "Moderately nasal", "Severely nasal", "Very severely nasal" (refer Table 5a,5b,5c). The ranges were as follows:-

Denasal - 0-15 - 0

Normal - 15-30 - 1

Mildly nasal - 30-45 - 2

Moderately nasal - 45-60 - 3

Severely nasal - 60-75 - 4

Very severely nasal - 75 and above -5

So based on the objective scores, the single numbers were assigned for each individual speech sample. They are tabulated in Table 5a,5b,5c. Then the same were compared with that of the subjective ratings. By using spearsons method of correlation between nasalance scores and the ratings by judges were obtained. There was a high correlation.

Subjective ratings:-

Reliability check -

Interjudge and intrajudge reliablity were checked, by providing the part of the randomised samples (after 48 hours) for judgement by the same judges. Then this was compared with that of the earlier judgement by the same judges of the same speech samples. For finding out the correlation spearman's method was used. The results of the same is provided in Table no.6 there was a high positive correlation between the judgements made by different judges and also between two judgements made by each judge. But it was identified that there was a interchange of marking between normal and denasal. It may be because of the non coupling of the nasal of oral cavities even though the subjects were instructed to nasalize the vowels. However where all the scores were considered together a high positive correlation was found between the scores of subjective ratings.

All speech samples, which were evaluated objectively were randomised and they were presented for the subjective ratings. The judges were asked to rate the nasality by using 5 point scale (refer Table 7a,7b,7c). The results of the subjective rating of these judges were considered and the two ratings which were closely related, were taken for experiment that is the rating given by at least two judges were considered as score for that particular speech sample.

TABLE-S(a) Based on Nasalance scale (HALES)

Sl No.	Normal phonation /a/,	/i/	/u/	Nasalized phonation /a/,	/i/,	/u/	Denasalized phonation /a/,	/i/	/u/	Nasal sentences	Non-nasal sentences
1.	0	1	1	2	4	3	1	1	0	4	1
2.	1	1	1	2	3	3	1	0	1	3	• 1
3.	1	1	1	2	4	3	1	0	0	4	1
4.	1	1	1	2	4	3	1	1	1	3	1
5.	0	2	1	2	4	2	1	0	1	4	1
6.	0	2	0	2	4	3	1	1	1	3	1
7.	1	2	1	2	4	3	1	1	1	3	1
8.	1	2	1	2	4	3	1	1	1	4	i
9.	1	2	1	2	4	3	1	1	1	4	1
10.	1	2	1	3	4	5	1	0	1	4	1
11.	0	1	1	2	3	3	1	0	0	3	1
12.	1	1	0	3	4	3	1	1	1	3	1
13.	1	1	0	2	3	4	0	0	1	4	1
14.	1	1	0	2	4	3	0	0	1	4	1
15.	1	2	1	3	4	3	0	0	6	4	1

TABLE-5(b) Based on Nasalance scale (FEMALES)

Sl No.	Normal phonation /a/	/i/	/u/	Nasalized phonation /a/	/i/	/u/	Denasalized phonation /a/	/i/	/u/	Nasal sentences	Non-nasal sentences
1.	0	1	1	2	4	3	0	0	0	4	1
2.	1	1	1	3	3	3	1	1	1	4	1
3.	1	2	1	3	4	4	1	1	1	4	1
4.	0	2	0	3	4	4	1	1	1	3	1
5.	1	2	1	3	5	3	1	0	1	3	1
6.	1	1	1	3	4	7	1	1	1	4	1
7.	1	1	1	2	4	3	1	0	0	3	1
8.	1	1	0	2	3	3	1	1	1	5	1
9.	1	2	1	2	4	3	1	0	0	4	1
10.	1	2	1	2	5	3	1	0	1	4	1
11.	1	1	1	3	3	3	1	1	1	4	1
12.	1	2	1	3	4	3	0	0	0	4	1
13.	1	1	1	2	3	4	0	0	0	4	1
14.	1	1	0	2	4	4	0	0	1	4	1
15.	1	1	1	2	4	4	0	0	0	3	1

TABLE-5(c) Based on Nasalance scale (CASES)

Sl No.	Normal phonation /a/,	/i/,	/u/,	Nasalized phonation /a/,	/i/,	/u/	Denasalized phonation /a/,	/i/,	/u/,	Nonasal sentence 1	Non-nasal sentence 2	Nonnasal sentence 3
1.	2	3	3	3	4	4	1	0	1	3	3	3
2.	1	3	3	2	3	3	1	1	1	2	3	3
3.	1	3	2	2	3	3	1	0	0	2	2	3
4.	3	4	3	2	4	3	2	3	3	2	2	2

TABLE -6 Intrajudge relibility check (correlation) (after 48 hours)

I Judge	Between I time rating and II time rating	0.948
II Judge	Between I time rating and II time rating	0.914
III Judge	Between I time rating and II time rating	0.932

lnterjudge relibility check (correlation) (after 48 hours)

1 time rating of nasality	Between I judge and III judge	0.93
1 time rating of nasality	Between I judge and II judge	0.92
1 time rating of nasality	Between II judge and III judge	0.83
II time rating of nasality	Between II judge and III judge	0.80
II time rating of nasality	Between I judge and II judge	0.89
II time rating of nasality	Between I judge and III judge	0.70

The analysis of subjective rating indicated that the judges did not had any difficulty in identifying the two extremes, that is "normal and very sever nasality". In the midrange where listener to listener variability was high and interjudge agreement was low, where as the instrumentation provided particularly meaningful differentiation of the degree of nasal resonanace.

And another finding was that the judges often judged the denasal sound as the normal one.

Power(1967) has found that the nasality rating may be influenced by such factors, proficiency of articulation, vocal pitch, intensity, the type of speech samples judged difference in judges sophistication that dictates the criteria by means of which such judgement are made.

So, possibly the judgement was made for the functionally nasalized samples might have affected the ratings in the midrange.

So it is clear that the subjective ratings cannot provide a classification based on the severity as it is possible by Instrumentation which provides rating. The instrumentation provided particularly meaningful differentiation of the degree of nasal resonance.

TMLE-7(a) Subjective ratings (MLES)

Sl No.	Normal phonation /a/,	/i/,	/u/	Nasatized phonation /a/,	/i/,	/u/	Denasalized phonation /a/,	/i/,	/u/	Nasal sentences	Non-nasal sentences
1.	1	1	1	3	3	3	t	1	1	3	1
2.	2	1	1	4	3	3	1	0	1	4	1
3.	0	1	t	2	4	4	0	1	0	3	1
4.	1	2	1	3	4	4	1	1	1	3	1
5.	1	1	1	3	4	3	1	2	1	4	1
A.	1	1	0	3	4	4	1	1	1	3	1
7.	1	1	1	1	3	4	1	0	0	3	1
8.	1	2	0	2	4	4	0	1	1	5	1
9.	0	0	1	2	3	3	1	1	1	3	1
10.	1	1	1	2	4	4	1	1	1	3	i
11	1	1	0	1	3	4	1	0	1	4	0
12.	1	2	0	3	4	4	1	1	1	4	1
13.	1	1	2	1	3	4	2	1	0	3	1
14.	1	1	3	3	3	4	1	1	0	4	1
IS.	0	1	2	1	2	4	1	1	1	4	0

TMLE-7(b) Subjective rating (FEMLES)

Sl No.	Normal phonation /a/,	/i/	/u/	Nasalized phonation /a/,	/i/ ,	/u/	Denasalized phonation /a/,	/i/ ,	/u/	Nasal sentences	Mon-nasal sentences
1.	1	1	0	3	3	3	0	0	0	3	1
2.	1	1	2	3	4	3	1	0	1	5	1
3.	0	2	1	3	5	3	1	1	0	4	1
4.	1	2	1	3	4	4	1	1	1	4	1
S.	1	1	1	3	3	4	1	2	1	3	1
A.	1	1	0	3	5	3	1	1	1	3	1
7.	1	1	1	1	3	3	1	1	0	4	1
8.	0	2	1	2	4	3	0	1	1	4	1
?.	0	0	1	3	4	3	0	1	0	3	1
10.	0	1	1	2	4	4	1	0	0	3	1
11.	1	1	0	1	3	3	1	1	0	3	1
12.	1	2	1	3	4	4	1	1	1	2	1
13.	1	0	1	1	2	3	1	i	0	3	1
14.	1	1	2	1	3	4	1	1	0	4	1
15.	1	t	2	2	2	3	2	1	1	3	1

TABLE-7(c) Subjective rating (CASES)

Sl No.	Nonal phonation /a/,	/i/,	/u/	Nasalized phonation /a/,	/i/,	/u/	Denasalized phonation /a/,	/i/,	/u/	Nonasal sentence 1	Non-nasal sentence 2	Nonnasal sentence 3
1.	3	3	3	3	4	4	1	2	0	4	3	4
2.	1	3	3	2	3	3	2	0	1	2	4	3
3.	1	3	3	3	3	3	0	0	2	3	3	4
4.	2	4	4	3	4	3	3	3	4	2	4	2

Comparison of Instrumental ratings and subjective ratings:

The correlation between perceived nasality and instrumental measures of nasalance score through a series of comparisons.

Nasalance score & Nasalance scale.

Nasalance score & Rating by judges.

Nasalance scale & Rating of nasality.

This comparisons were done for males, females and cases and combination of males and females (since there were no significant difference between males and females in nasalance scores).

Males:

Significant correlation between objective and subjective ratings have been found for the followings.

1. Nasalance score and nasalance scale high positive correlation (+0.706) for nonnasal phonation of /a/,/i/,/u/.

2. Nasalance score and nasalance scale there was a high positive correlation (+0.847) for functionally nasal phonation of /a/,/i/,/u/.

3. Nasalance scale and rating of nasality there was a significant correlation (+0.55) for functionally nasal phonation of /a/,/i/,/u/.

4. Nasalance score and nasalance scale there was a high positive correlation (+0.57) for denasalization vowel

5. Nasalance scale and rating of nasality there was a significant relationship (0.46) for denasalized vowels

6. Naslance scale and rating nasality, there was a high positive correlation (+0.88) for denasalized vowels

7. Nasalance score nasalance scale, there was a high positive correlation (0.90) for nasal and nonnasal sentences.
8. Nasalance score and rating by judges, there was a high positive correlation (0.78) for nasal and nonnasal sentences.
9. Nasalance scale and rating of nasality, there was a high positive correlation (0.85) for nasal and nonnasal sentences.
Table - 8 presents the details of this data.
The correlation was not significant for the following :
1. Nasalance score and rating by judges there was no significant correlation (0.121) for nonnasal and normal phonation of /a,/i/,/u/.
2. Nasalance score and rating of nasality there was no significant correlation (0.28).
Females:

Table - 9 presents the results of the nasal scores obtained and the subjective ratings.Significant correlation between objective and subjective ratings have been found for the following.
1. Nasalance score and nasalance scale, there was a significant positive correlation (0.64) for phonation of nonnasal vowels /a,/i/,/u/.

2. Nasalance score and rating of nasality, there was a significant positive correlation for phonation of nasal vowels /a,/i/,/u/.

3. Nasalance scale and rating of nasality, there was a high positive correlation (0.86) for phonation of nasal vowels /a,/i/,/u/.

4. Nasalance scale and rating of nasality, there was a significant positive correlation (0.39) for phonation of nasal vowels /a,/i/,/u/.

5. Nasalance score and nasalance scale, there was a high positive correlation (0.69) for phonation of denasalized vowels /a,/i/,/u/.

6. Nasalance score and nasalance scale, there was a high positive correlation (0.90) for nonnasal and nasal sentences.

7. Nasalance score and "rating of nasality, there was a high positive correlation (0.89) for nonnasal and nasal sentences.

8. Nasalance scale and rating of nasality, there was a high positive correlation (0.95) for nonnasal and nasal sentences.

Correlation was not significant between objective ratings and subjective ratings of nasality among females:

1. Nasalance score and ratings of nasality was not significant (0.35) for /a/,/i/,/u/ nonnasal phonation.

2. Nasalance scale and ratings of nasality was not significant (0.10) for /a/,/i/,/u/ nonnasal phonation.

3. Nasalance score and ratings of nasality was not significant (0.26) for /a/,/i/,/u/ denasalised phonation.

Females and Males (combined): (Refer Table 10)

Correlation between objective ratings and subjective ratings of nasality. Since there was no statistically significant difference in nasalance scores of males and females. The effort was made to find the correlation, assuming to increase the number of subjects.

The correlation was significant for the following :

1. Nasalance score and nasalance scale there was a significant correlation (0.69) for nonnasal vowel phonation of /a/,/i/,/u/.

2. Nasalance score and nasalance scale there was a high significant correlation (0.829) for nasalized vowel phonation of /a/,/i/,/u/.

3. Nasalance scale and rating of nasality there was a significant correlation (0.371) for nasalized vowel phonation of /a/,/i/,/u/.

4. Nasalance scale and rating of nasality there was a significant correlation (0.48) for nasalized vowel phonation of /a/,/i/,/u/.

5. Nasalance score and nasalance scale there was a significant correlation (0.64) for denasalized vowel phonation of /a/,/i/,/u/.

6. Nasalance score and nasalance scale there was a significant high positive correlation (0.91) for nasal and nonnasal sentences.

7. Nasalance score and rating of nasality there was a significant high positive correlation (0.82) for nasal and nonnasal sentences.

8. Nasalance scale and rating of nasality there was a significant high positive correlation (0.89) for nasal and nonnasal sentences.

The correlation was not significant for the following :

1. Nasalance score and rating of nasality there was no significant correlation (0.24) for nonnasal phonation of vowels /a/,/i/,/u/.

2. Nasalance scale and rating of nasality there was no significant correlation (0.13) for nonnasal phonation of vowels /a/,/i/,/u/.

3. Nasalance score and rating of nasality there was no significant correlation (0.25) for denasalized phonation of vowels /a/,/i/,/u/.

4. Nasalance scale and rating of nasality there was no significant correlation (0.26) for denasalized phonation of vowels /a/,/i/,/u/.

Cases :

Three cleft Palate and 1 case with soft palate paralysis with nasality. Correlation between objective scaling and subjective ratings were also checked. When compared to that of normal subjects, the cases had high correlation between objective scaling and nasality ratings by judges for both vowels as well as sentences used.

The results are (presented in Table - 10 also) as follows :

I Nonnasal phonation of /a/, /i/, /u/.

(1) Nasalance score and nasalance scale, there was a high positive correlation (0.89).

(2) Nasalance score and ratings of nasality, there was a high positive correlation (0.89).

(3) Nasalance scale and nasality rating, there was a high positive correlation (0.71)

II Nasalized phonation of /a/, /i/, /u/.

(1) Nasalance score and nasalance scale, there was a high positive correlation (0.89).

(2) Nasalance score and rating of nasality, there was a high positive correlation (0.73).

(3) Nasalance scale and rating of nasality, there was a high positive correlation (0.83).

TABLE -8 Comparision 1between objective and subjective rating of nasality. (MALES)

		Correlation	Significance
Nonnasal /a/,/i/,/u/ phonation	Nasalance score and Nasalance scale	0.766	
Nonnasal /a/,/i/,/u/ phonation	Nasalance score and rating of nasality	0.121	-
Nonnasal /a/,/i/,/u/ phonation	Nasalance scale and rating of nasality	0.167	-
Nasal /a/,/i/,/u/ phonation	Nasalance score and Nasalance scale	0.847	++
Nasal /a/,/i/,/u/ phonation	Nasalance score and rating of nasality	0.25	-
Nasal /a/,/i/,/u/ phonation	Nasalance scale and rating of nasality	0.55	+
Denasal /a/,/i/,/u/ phonation	Nasalance score and Nasalance scale	0.56	+
Denasal /a/,/i/,/u/ phonation	Nasalance score and rating of nasality	0.41	+
Denasal /a/,/i/,/u/ phonation	Nasalance scale and rating of nasality	0.86	++
Nasal and nonnasal sentences	Nasalance score and Nasalance scale	0.97	++
Nasal and nonnasal sentences	Nasalance score and rating of nasality	0.91	++
Nasal and nonnasal sentences	Nasalance scale and rating of nasality	0.85	

Note :- (++) - Indicate high positive correlation
(+) - significant correlation
(-) - No significant correlation

TABLE -9 Comparision between objective and subjective rating of nasality. (FEMALES)

		Correlation	Significance
Nonnasal /a/,/i/,/u/ phonation	Nasalance score and Nasalance scale	0.696	+t
Nonnasal /a/,/i/,/u/ phonation	Nasalance score and rating of nasality	0.28	–
Nonnasal /a/,/i/,/u/ phonation	Nasalance scale and rating of nasality	0.35	–
Nasal /a/,/i/,/u/ phonation	Nasalance score and Nasalance scale	0.79	++
Nasal /a/,/i/,/u/ phonation	Nasalance score and rating of nasality	0.48	+
Nasal /a/,/i/,/u/ phonation	Nasalance scale and rating of nasality	0.40	+
Denasal /a/,/i/,/u/ phonation	Nasalance score and Nasalance scale	0.69	-
Oenasal /a/,/i/,/u/ phonation	Nasalance score and rating of nasality	0.36	-
Denasal /a/,/i/,/u/ phonation	Nasalance scale and rating of nasality	0.35	-
Nasal and nonnasal sentences	Nasalance score and Nasalance scale	0.98	++
Nasal and nonnasal sentences	Nasalance score and rating of nasality	0.96	++
Nasal and nonnasal sentences	Nasalance scale and rating of nasality	0.96	++

Note :- (++) - Indicate high positive correlation
(+) - significant correlation
(-) - No significant correlation

TABLE -10 Comparision between objective **and subjective rating of nasality.**
(CASES)

		Correlation	Significance
Nonnasal /a/,/i/,/u/ phonation	Nasalance score and Nasalance scale	0.89	++
Nonnasal /a/,/i/,/u/ phonation	Nasalance score and rating of nasality	0.59	+
Nonnasal /a/,/i/,/u/ phonation	Nasalance scale and rating of nasality	0.71	++
Masai /a/,/i/,/u/ phonation	Nasalance score and Nasalance scale	**0.89**	++
Nasal /a/,/i/,/u/ phonation	Nasalance score and rating of nasality	0.67	++
Nasal /a/,/i/,/u/ phonation	Nasalance scale **and** rating of nasality	0.83	++
Denasal /a/,/i/,/u/ phonation	Nasalance score and Nasalance scale	0.91	++
Denasal /a/,/i/,/u/ phonation	Nasalance score and rating of nasality	0.91	++
Denasal /a/,/i/,/u/ phonation	Nasalance scale and rating of nasality	0.91	++
Nasal and nonnasal sentences	Nasalance score and Nasalance scale	0.88	++
Nasal and nonnasal sentences	Nasalance score and rating of nasality	0.91	++
Nasal and nonnasal sentences	Nasalance scale and rating of nasality	0.87	++

Note :- (++) - Indicate high positive correlation
(+) - significant correlation
(-) - No significant correlation

TABLE -11 Comparision between objective and subjective rating of nasality. (Hales and females combined.)

		Correlation	Significance
Nonnasal /a/,/i/,/u/ phonation	Nasalance score and Nasalance scale	0.64	++
Nonnasal /a/,/i/,/u/ phonation	Nasalance score and rating of nasality	0.18	-
Nonnasal /a/,/i/,/u/ phonation	Nasalance scale and rating of nasality	0.13	-
Nasal /a/,/i/,/u/ phonation	Nasalance score and Nasalance scale	0.83	++
Nasal /a/,/i/,/u/ phonation	Nasalance score and rating of nasality	0.37	+
Nasal /a/,/i/,/u/ phonation	Nasalance scale and rating of nasality	0.45	++
Denasal /a/,/i/,/u/ phonation	Nasalance score and Nasalance scale	0.58	++
Denasal /a/,/i/,/u/ phonation	Nasalance score and rating of nasality	0.24	-
Denasal /a/,/i/,/u/ phonation	Nasalance scale and rating of nasality	0.26	-
Nasal and nonnasal sentences	Nasalance score and Nasalance scale	0.98	++
Nasal and nonnasal sentences	Nasalance score and rating of nasality	0.73	++
Nasal and nonnasal sentences	Nasalance scale and rating of nasality	0.93	++

Note :- (++) - Indicate high positive correlation
(+) - significant correlation
(-) - No significant correlation

III Denasalized phonation of /a/, /i/, /u/.

(1) Nasalance score and nasalance scale, there was a high positive correlation (0.91).

(2) Nasalance score and rating of nasality, there was a high positive correlation (0.91).

(3) Nasalance scale and rating of nasality, there was a high positive correlation (0.98).

IV Sentences :- (nonnasal and nasal)

(1) Nasalance score and nasalance scale, there was a high positive correlation (0.88).

(2) Nasalance score and rating of nasality, there was a high positive correlation (0.91).

(3) Nasalance scale and rating of nasality, there was a high positive correlation (0.87).

Analysis of the results of comparison between instrumental ratings and subjective ratings of males, females and cases with nasality indicate that

(1) A high positive correlation between nasalance scores and nasalance scale for all types of speech samples. So this nasalance scale can be standardized and it can be used for clinical purposes. The scale used is as follows.

0 - 15	-	Denasal
15 - 30	-	Normal
30 - 45	-	Mildly nasal
45 - 60	-	Moderately nasal
60 - 75	-	severely nasal
75 - above	-	Very severely nasal

This can be thus used to assess the severity of nasality present in a particular case.

(2) Among all the speech samples used, sentences had a high correlation with that of the subjective ratings. So, for the assessment purposes it is better to use continuous speech rather than phonation. Thus the hypothesis No 3 is agreed upon that there is no significant correlation between subjective ratings of nasality and objective scaling of artificially produced nasality by normal subjects.

(3) There was a correlation between the objective and subjective rating of the nasality scores of /a/, /i/, /u/ under nasal, denasal and normal condition. But they did not have high correlation.

(4) There was high positive correlation between subjective ratings and objective ratings for cases with nasality. Thus the hypothesis is rejected. That is "there was no significant correlation between subjective and objective ratings of nasality in cases".

Fletcher (1978) Examined the relationship between perceived nasality and instrumental measures of nasalance through a series of comparisons.

He reported that before they were asked to judge the nasality, they were given a prior auditory training for assessing nasality. Only after progressing through the training task, listener to listener agreement increased. He suggests that they were "tuning in" to a common acoustic elements in the spoken pattern. Of particular importance was that as the listeners perceptual ratings becomes more closely aligned, or agreed with the instrumentally derived nasalance scores systematically increased. That is, greater precision in listings lead to correspondingly higher agreement with the instrumental scores, suggesting that the perceptual and instrumental observation had a common basis.

So it is clear that the human ear is not "tuned in" for classifying the nasality based on the severity, without prior training. Which is case in the present study, particularly*" with reference to vowels used.

And it is important to note that the instrumentation provided explicit information with respect to certain ranges of nasal resonance that were particularly difficult for listeners to resolve. For example, in the midrange, when listener to listener variability was high and interjudge agreement was low in classifying and explicitly rating the responses, the instrumentation provided meaningful differentiation of the degree of nasal resonance in talker's responses.

A important aspect of above discussion is that, the listener or judges should have prior training just before sitting for assessing or rating of nasality. So, for the most purpose the instrumental measures may be used as a valid estimate of the degree of nasality.

The results of present study indicate that it is possible to measure the nasality (degree of nasality) objectively using the Nasometer.

CHAPTER - V

SUMMARY AND CONCLUSION

The nasal resonance is a highly distinctive readily perceived acoustic quality which may occur with orally produced sounds to invoke specific phonetic contrasts. The penetrating quality of nasality as an acoustic property is unacceptable to listeners when it is injected dominantly and nonphonetically into speech.

Despite its easily recognized presence, the degree of excessive nasality in speech has been shown to be difficult to establish perceptually (Bradford, Brooks and Shelton (1964), Watterson and Emamuel (1981). There was a great need for an objective measurement. Several instruments are available for measuring nasality. But there are several limitation with the instrument available for the measurement of nasality. The present study was carried out to find the efficacy of the Nasometer based on principles of instrument developed by Fletcher (1978) using computer. And to find out the possibilities of using this instrument for the routine clinical assessment by developing a standard nasalance scale.

In the present study thirty normal subjects (15 males and 15 females) and four subjects with nasality have been used. Each subject was asked to phonate the vowels /a/, /i/,

/u/ with normal voice, with instruction to nasalize the voice during phonation and with occluded nares. Sentences with maximum nasal sounds (nasal sentences), sentences with minimum or no nasal sounds (nonnasal sentences) were also used. And thus nasalance scores were obtained for each speech samples separately then this nasalance scores for each speech samples were compared with one another. And difference between males and females were also checked. These scores were converted into a single number by using nasalance scale, i.e., [0 - (0-15) - denasal, 1 - (15-30) - normal, 2 -(30-45) - mild, 3 - (45-60) - moderate, 4 - (60-75) - severe, 5 - above 75- very severe].

Then all the speech samples were randomized and were submitted for subjective rating by three judges. They were asked to judge the severity of nasality by using five point scale after listening each sample for three times. They made markings in a responses sheet depending upon the severity of nasality as they perceived, (denasal -0, normal -1, mild -2, moderate -3, severe -4, very severe -5).

The subjective ratings were then compared with that of the objective scaling of nasality. Conclusions have been made based on the results of this study.

(1) There was a significant variation in nasalance score for different stimulus materials used.

(2) There was no significant difference in nasalance scores between males and females on different stimulus materials used.

(3) Comparison of objective scaling and subjective rating of nasality showed that there was a high correlation between nasalance score and nasalance scale.

Nasalance scores of sentences had a high positive correlation with the subjective rating. No other samples showed such high correlation.

Thus the study has shown that the Nasometer can be used to measure the nasality objectively in a clinical setup.

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