NORMATIVE SCORE FOR NASOMETER IN KANNADA

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A dissertation submitted in part fulfillment for
the degree of **M. Sc., (Speech Language pathology)**
University of Mysore,
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**ALL INDIA INSTITUTE OF SPEECH AND HEARING,
MANASAGANGOTHRI, NAIMISHAM CAMPUS
MYSORE- 570006.**

MAY- 2005

CERTIFICATE

This is to certify that this dissertation entitled **"NORMATIVE SCORE FOR NASOMETER IN KANNADA** " is the bonafide work in part fulfillment for the degree of Master of Science (Speech Language Pathology) of the student **(Reg. No. L0380006).** This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other university for the award of any other diploma or degree.

Place: Mysore
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Dedicated To
My Family
Who Shaped My Life

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CHAPTER - I

INTRODUCTION

Speech is the key to human existence. It bridges the difference and helps to give meaning and purpose to life. To understand the nature and function of speech, it is necessary to know the mechanism involved in the production of speech. Speech production is a process where the concepts, ideas and feelings are converted into linguistic code: linguistic code into neural code: neural code into muscular movements and finally muscular movement leads to acoustic signal (Ainsworth, 1975). Hence speech is just a particular type of acoustic signal and its production can be explained in terms of source signal and resonance of the vocal tract. During speech or singing, it is necessary to open and close the passage way connecting the oro pharynx with the naso pharynx, depending on the specific speech sounds to be produced. This mechanism leads to nasality or nasal resonance in the speech production. Nasality is one of the important parameter in the perception of normal speech, as well as disordered speech.

Cleft lip and cleft palate are the congenital conditions seen in 1 in 700 live births. It is often associated with multiple problems such as feeding problem, hearing disorders and psychological problems. Communication disorder is one of the common problems seen in this population in which delay in language acquisition, hypernasality and articulatory errors are associated. Velopharyngeal dysfunction is the main cause, which leads to nasality in speech. Normal velopharyngeal function varies according to the characteristics of the speech produced. Factors such as vowel height, consonanat type, proximity of nasal sounds, utterance length, speaking rate and tongue height can affect velopharyngeal patterns.

Nasality is the common problem in subjects with repaired / unrepaired cleft palate, which affects the speech intelligibility. Nasal resonance is not only seen in disordered speech, even normal speech also consist some amount of nasality. Example: Among the Indian languages, Malayalam has got more nasal resonance than any other languages.

Nasality can be assessed by subjective as well as objective methods. Perceptual judgment of nasality is done using various rating scales. These rating scales have used different rating points ranging from five point scale to nine point scales. The judges for these rating scales were from trained speech pathologists to clients themselves. Since this is a subjective task, standard data / normative data cannot be established due to many disadvantages associated with this method. Hence, standard objective methods are essential to asses the velopharyngeal dysfunction and to provide guidelines for suitable rehabilitation method.

Over the years, various objective methods have been developed for assessing the nasality. These methods can be classified as direct and indirect methods. Direct objective methods such as Nasendoscopy and Video fluoroscopy are widely used to evaluate the velopharyngeal dysfunction, which has greater reliability. However, Nasendoscopy is invasive and Videofluoroscopy exposes clients to radiation. Additionally, these techniques must be conducted by medical settings, and thus are not always available to speech language pathologists.

Accelerometer (vibration detector) was one of the instrument, which was widely used by speech language pathologist to measure the intra oral and nasal pressure. Later, the concept of “nasalance” was introduced by Fletcher et al. (1978). It is the ratio of nasal acoustic energy to the sum of nasal plus oral acoustic energy multiplied by hundred, which was widely accepted.

There are various acoustic and aerodynamic techniques have been developed to measure the nasalance (Flectcher et al., 1989 and Warren et al., 1993). TONAR (The Oral to Nasal Air Pressure Ratio) is one among them. This instrument involves positioning two microphones (one to pick up the nasal energy and the other to pick up the oral energy) separated by a wooden plate. This method has got several limitations, like the position of the microphones, the quality of the separating chamber and calibration of the equipment. This technique is not a real time analyzer and the use of this instrument for analyzing in running speech was not well accepted due to the above limitations.

The need for a reliable, objective measure of speech nasality with high levels of content validity was largely met with the commercial introducing of the Kay Nasometer in 1986. It employs non-invasive measurement techniques and can also be used outside medical settings. Nasometer assesses the nasality of speech by measuring the acoustic output from both the nasal and oral cavity by using two microphones, separated by an acoustic shield that rests on the upper lip, which is mounted on a head set which gives appropriate position for the microphones. Additionally it is a personal computer based device that can be easily installed and can measure the nasality at any point of the sample.

The introduction of the Nasometer led to research into its ability to detect abnormal nasality in clinical population with optimal efficiency of test sensitivity and specificity (Dalston et al., 1991a, 1991b & 1991c; Hardin et al., 1992 and Watterson et al., 1993). Extensive studies on the device's validity have generally shown high levels of correspondence between listener judgments and measures made by device (Flectcher, 1976, 1978; Dalston and Warren, 1986; Hardin et al., 1992). In addition to research directed to a direct clinical application of Nasometer measurements, there have been investigations into factors that influence nasalance measures in normal speech. These studies have shown that nasalance of normal speech is sensitive to phonetic composition of the speech stimulus (Watterson et al., 1996), native language (Anderson, 1996), age and gender (Van Lierde et al., 2003). However, the findings are not universally consistent.

Need for the Study

Assessment of resonance disorders in speech has been traditionally proved to be a difficult perceptual task for speech pathologist. Perceptual ratings of speech nasality are susceptible to problems that influence their reliability for example rating scale used, clinical exposure of the judges on nasality, and the presence of other speech characteristics that may mask the perception of nasality (Fletcher et al., 1989). In children with velopharyngeal inadequacy, accurate assessment of the disorder is critical. Hence in order to select the treatment, the need for a reliable, objective measure of speech nasality with high levels of content validity was largely met with the Nasometer. It employs non-invasive measurement techniques and can be used easily in outside medical setups. Nasometer validity has generally shown high levels of correspondence between listener's judgments of speech nasality and the nasalance measures made by devices (Hardin et al., 1992). These studies have shown that nasalance of normal speech is sensitive to the phonetic composition of the speech stimuli, native language, regional dialect age and gender. This makes the strong need for establishment of regional norms as there are very few standardized normal nasalance scores for normal speakers in Indian languages.

Aim of the Study

- To develop normative data on nasalance: maximum nasalance, minimum nasalance and nasalance deviation in Kannada language for oral and nasal sentences for children and adults.
- To study the effect of age and gender differences on nasalance scores in Kannada speaking children and adult population.

CHAPTER - II

REVIEW OF LITERATURE

Assessment of nasality disorders in speech is a traditionally proved to be difficult perceptual task for speech pathologist. Perceptual ratings of speech nasality are susceptible to many problems that influence the results. Children with velopharyngeal inadequacy are suggested for surgery or speech therapy as a treatment option. Hence an accurate assessment of the nasality is critical, as this provides valuable information for the suitable treatment. So use of instrumentation has become an important part of the assessment and treatment of individuals with velopharyngeal dysfunction.

To assess and study nasalization and disorders of nasalization, speech language pathologist and otorhinolaryngologists relay on a combination of direct and indirect assessment procedures (Shprintzen & Bardach, 1995). Direct methods of visualization of the velopharyngeal valve include multi view Video fluoroscopy and Nasopharyngoscopy, where as indirect or non-visualizing procedures are illustrated by the mirror test and aerodynamic and acoustic investigations (Van Lierde et al., 2001).

Speech language pathologist prefers the indirect methods, since it is a noninvasive method and does not require additionally the medical professional support. Moreover the action of the velopharyngeal mechanism is not easily observed visually. In addition the acoustic effects of improper velar action are sometimes difficult to monitor visually. Therefore, there is a need, in the field of speech pathology for convenient and reliable systems to monitor velar action during speech, both to give the clinician a measure of such action and to provide a means of feedback for the person trying to improve velar control.

Several methods have been reported to assess nasality by using instruments. Followings are some of the methods that are used.

- Measuring the low frequency, primarily subsonic and including zero frequency, components of the airflow through the nose or nose and mouth simultaneously, often with a measure of the intra oral pressure.
- Accelerometer is one of the instrument, which is placed (vibration detector) on the nose to detect sound passing through the nose.
- Measuring the sound (acoustic pressure waveform) emitted from the nose and mouth respectively with microphones placed above and below the barrier, analyzing the acoustic properties of the radiated speech to detect the acoustic properties associated with nasalization (Baken, 1987).
- Analyzing the acoustic properties of the radiated speech to detect the acoustic properties associated with nasalization (Baken, 1987).

But, the above-mentioned equipments and methods had several limitations like, lack of proper calibration of the equipment, standardization of procedure and lack of normative data**.**

Nasalization can be measured in different units. e.g. nasality (subjective), nasalance ratio and nasalance (objective). Fletcher et al. (1974) have coined the term nasalance to describe various measures of the balance between the acoustic energy at the nares, (An) and the acoustic energy at the mouth, (Ao) during voiced speech. This balance between An and Ao can be expressed as a simple ratio, An/Ao to yield a measure that can be referred to as a nasalance ratio (NR) or it can be expressed as a percentage. An/Ao + An to yield a measure that can be referred to as % Nasalance (% N). Each measure contains the same information, but with a different scale. Recent measurements of nasalance have been reported in the % nasalance form.

In 1986, Kay Elemetrics introduced an addition to the instrumental devices available to clinicians working with patients who manifest velopharyngeal impairments. This device known as a Nasometer, is a microcomputer-based instrument that provides the user with a numeric output indicating the relative amount of nasal acoustic energy in subject's speech. This computer-based instrument employs microphones on either side of a sound separator plate, which rests on the upper lip. The signal from each microphone is filtered and digitized by custom electronic module. Band pass filter is also one of the important instrumentation of Nasometer. Band-pass filters (two in number) consist of cascaded low pass and high pass 4- pole Butterworth filters, with -3 dB points of 350 Hz and 650 Hz respectively. Thus energy below about 300 Hz and above 750 Hz would be significantly attenuated. Attenuated components would therefore include the voice fundamental frequency component (especially for adult male voices) and formant energy above the first formant for most vowels (Rothenberg, M., 1999). The data are then processed by computer and accompanying software.

A numeric ratio of nasal acoustic energy to the sum of nasal plus oral acoustic energy in calculation multiplied by 100 and expressed as a nasalance score. Therefore the output of their instrument provides the percentage score that reflects the relative amount of nasal energy in a subject's speech

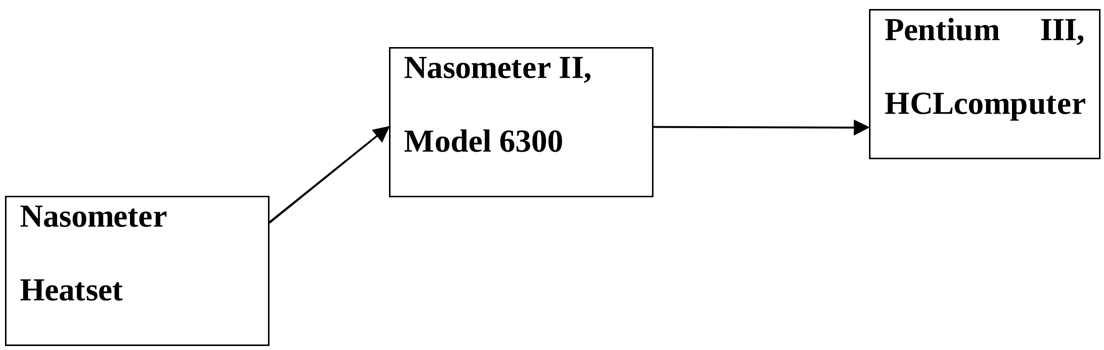

Figure 1: Schematic representation of the instrumentation of Nasometer measurement.

Since the Nasometer was first introduced, several studies have been reported the usefulness of the Nasometer in the assessment of resonance problems associated with velopharyngeal and nasal obstruction. Since its introduction the Nasometer has been utilized by a number of investigators in an attempt to determine its utility in the assessment of clients at risk for manifesting velopharyngeal dysfunction. Most studies reported to have suggested that the Nasometer is a clinically useful tool. (Dalston, 1990; Parker et al., 1989; Seaver and Dalston, 1990; Dalston et al., 1991 a,b,c; Harpaman, 1991)

Following section deals with studies related to correlation between perceptual judgment and objective measurement, establishment of normative data for nasalance score in different languages, variation of nasalance scores across age and gender, and the effect of different stimuli on nasalance scores.

I. Correlation between Perceptual Judgment and Objective Measurement

Correlations between perceptual ratings of nasality and nasalance scores reported in the literature varied from 0.02 to 0.82 (Sweeny et al., 2004). Dalston et al. (1991 a) examined the correspondence between nasalance scores obtained during production of nasal sentences (standard passage) and judgments of hypo nasality assigned by a single trained listener for 76 subjects with a cleft palate. A Pearson correlation of – 0.65 was obtained when all subjects were included in the analysis. When they eliminated those subjects with perceived hypo nasality who also exhibited audible nasal emission, a correlation of – 0.87 was obtained using a nasalance. Cut off score of 50 to reflect the presence (or) absence of clinically significant hypo nasality the authors found that the scores for 90% of all patients accurately reflected clinical judgments of hyponasality.

In a comparison study, Dalston et al. (1991 b) examined the correspondence between nasalance scores obtained during production of the zoo passage and judgments of hyper nasality obtained from a single trained listener for 117 patients. A correlation of 0.82 was reported. The authors also used the indices of sensitivity and specificity to examine the accuracy of a predetermined nasalance cutoff score of 32 in categorizing patients with and without clinical significant hypernasality.

Paynter et al. (1991) studied 30 English-speaking subjects in the age range of 7 to 64 years using Nasometry material (zoo passage). They found that mean nasalance scores for the zoo passage were compared to listener judgments for the presence or absence of hyper nasality, a screening test sensitivity of 0.78 and a specificity of 0.60 were obtained. Only 66% of the categorizations accurately reflected listener judgments. A screening test sensitivity of 1.00 and a specificity of 0.85 were obtained when the mean nasalance scores obtained during the nasal sentences passage were compared to listener judgments for the presence or absence of hyponasality. Eighty-six percent of the categorizations based on nasometry data accurately reflected listener judgments. This suggests a poor correspondence between nasalance score and listener judgments of hyper nasality.

Hardi et al. (1992) examined 74 subjects in which 51 subjects were subjects with cleft palate and 23 being normal subjects. Twenty-nine of the 51 subjects with cleft palate had undergone pharyngeal flap surgery. Nasal sentences and zoo passage were used as stimuli. Predictive analyses were performed to assess the sensitivity specificity and efficiency of the Nasometer as a screening instrument. The over all relationship between perceptual judgments of hypernasality and nasalance score was good for the non flap subjects when the nasalance cut off score of 26 was used. A sensitivity of 0.87 and specificity of 0.93 were obtained. The correspondence between nasalance scores and clinical judgments of hyponasality was also good for nonflap subjects when the nasalance cut off score 50 was used. A sensitivity of 0.60 and specificity of 0.97 were obtained. Efficiency of nasometry was poor for the flap subjects.

Nellis et al. (1992) studied 16 subjects with cleft palate in the age range of 8 to 18 years. All the subjects had undergone pharyngeal flap surgery before nasometry testing. They used 7 short sentences some of which contain nasal sounds and some of which contain oral sounds. They used 6- point scale. Ten graduate students rated the degree of nasality in the sample. They did not found a significant correlation between nasalance scores and listener rating of hyper nasality. This results were attributed to indicate a "primarily hyponasal population".

Studies also differ in using number of listeners and this may have been one source of variance. Perceptual judgments of nasality were made by a listener in a study conducted by Dalston et al. (1991 b) and by a panel of listeners in a study by Paynter et al. (1991). In addition, different rating scales have been used to assess nasality. Paynter et al. (1991) used the 9- point scale in which, +5 indicated sever hypernasality and -5 indicated severe hyponasality (Paynter et al. 1991), and Dalston, et al. (1991 b) study used a 6- point equidistant scale. Furthermore, in the study by Dalston et al. (1991 b), the perceptual judgments of nasality were made during clinical assessments using a different speech sample from that used in nasometric analysis.

Despite this variability in results, the general consensus is that the Nasometer is a useful clinical tool for informing the assessment and diagnosis of nasality problems when used in addition to a perceptual assessment.

Watterson et al. (1996) compared nasalance scores and hypernasality ratings obtained from a group of 25 children. Hyper nasality was judged on a 5- point scale by a panel of ten speech language pathologist. The Pearson correlation coefficient between the perceptual and instrumental assessments was low (0.49) and fairly low level of sensitivity (0.71) and specificity (0.55). Results revealed the poor correlation between perceptual judgments and instrumental analysis.

Overall relationship is stronger if the perceptual ratings of hyper nasality are correlated with speech stimuli devoid of nasal consonants and if perceptual ratings of hyponasality are related to speech stimuli loaded with nasal consonants (Sweeney et al., 2004).

II. Development of Normative Data across Various Languages

Since the Nasometer was introduced in 1986, several articles have appeared in the literature on developing the normative data in various languages. These studies indicated that nasalance scores vary across languages. (Anderson, 1996; Van Doorn and Puecell, 1998; Van Lierde, 2001; Whitehill, 2001; Nandurkar, 2002; Van Lierde et al., 2003; Sweeney et al., 2004; Sunitha et al., 2005).

Anderson (1996) conducted a study to establish normative data in Spanish-speaking women using Nasometer 6200. Forty subjects in the age range of 21 to 43 years (mean age 26.5) were considered. They included three types of stimuli: (i) Sentences containing nasal consonants (ii) A reading passage with both oral and nasal consonants. (iii) A reading passage with oral consonants. Comparisons across these stimuli were made. Results indicated the significant difference in mean nasalance score across the nasal sentences. The over all mean nasalance score for nasal sentences was 62% with SD of 7.76. Though, the Spanish-speaking group values obtained in this study fall within the range of values reported for English-speaking females by Seaver, (1991), possible cross-cultural difference in perception of nasality and normal resonance was also evident in this study. It is possible that individuals from different cultural groups vary in perception of nasality. Although very little data are available in the area of cross cultural perception of resonance, the evidence reports suggests the differences.

Van Doorn and Puecell. (1998) assessed 245 normal children (123 females, 122 male) in the age range of 4years to 9years 3month without any associated problems. Mean nasalance scores were obtained for two speech passage (zoo passage and nasal sentences) that are used as standards for Nasometer (model 6200) testing. In addition the nasalance data were analyzed for gender and age dependence parameters. A mean score of 13.1 (SD 5.9) was obtained for the zoo passage, and a mean of 59.6 (SD 8) for the nasal sentences were obtained. They concluded that these normative nasalance data for children who speak Australian English will provide important reference information for clinicians who assess nasality disorder of resonance.

Van Lierde (2001) conducted a study to obtain normative nasalance score for normal adult Flemish speakers. He studied 58 healthy young Flemish adults with normal oral and velopharyngeal structure and function. The Nasometer (Model 6200) was used to obtain nasalance scores for the three reading passages. These three reading passage were designed specifically for use with the Nasometer. These passages were on oronasal passage, an oral passage and a nasal passage. The nasalance data were also analyzed for gender dependence, using student's 't' test for each reading passage. Normative nasalance data were obtained for the oronasal text (33.8%), the oral text (10.9%) and the nasal text (55.8%). Furthermore, statistically significant cross-linguistic nasality differences were also observed. The English and Spanish languages were found to have more nasalance than the Flemish language.

Whitehill (2001) established a normative data using Nasometer (Model 6200) in Cantonese language. She considered 141 Cantonese-speaking women who were undergraduate students as subjects and four types of speech stimuli were (i) oral sentences, (ii) nasal sentences and (iii) oral paragraph and an oral-nasal paragraph. Mean value for oral sentences was 16.79 (SD 5.9), nasal sentences 55.67 (SD 7.38), oral paragraph 13.68 (SD 7.16) and oral-nasal paragraph was 35.46 (SD 6.22) . There was a significant difference in mean nasalance scores for oral versus nasal materials. Session to session reliability was within 5 points for over 95% of speakers for the oral stimuli but for less than 76% of speakers for the nasal and oral-nasal stimuli. Mean score for the Cantonese nasal materials were lower than previous reports of English speakers even though the proportion of nasal consonants in the Cantonese sample was higher than the proportion in the English nasal sentences (40.9% Vs 35%) suggests the influence of other factors, like higher degree of vowel nasalization in English than in other languages (Mayo et al., 1996).

Nandurkar (2002) studied 10 children with cleft palate and 10 normal children whose mother tongue was Marathi. Speech material consisted of eight Marathi monosyllabic words consisting of the pressure consonants. Results showed that normal children scored 7-12% of nasalance in monosyllable stimulus and cleft palate children obtained significantly high score. She concluded that Nasometer was reasonably accurate in distinguishing between normal and hypernasal speech samples. Correlation coefficient computed between the instrument measurement and the perceptual judgments of nasality indicate moderate correlation between the two measures. Due to small number of sample results were not generalized, and the reliability measures is also not consisted.

Van Lierde et al. (2003) conducted a study to obtain a normative score and age related changes. He evaluated 33 children (18 males and 15 Females) with the age range of 7 years to 13 years, and 58 adults (30 women and 28 men) in Flemish language. Three different types of stimuli were used (oral, oronasal and nasal text) along with that three sustained phonation of vowel / a /, / i /, / u /, and the consonant / m / also were taken, Kay Nasometer (Model 6200) was used to collect the data. Results revealed the normative nasalance value for oral (11.3), oronasal (31.9) and nasal text (51.6). They also found that normative for / a / (6.4), / i / (19.6), / u / (9.6) and / m / (94.4). They compared the nasalance value with 58 adult data, which had been obtained in a previous study to find the effect of age on nasalance score.

Sweeney et al. (2004) conducted a study to obtain normative data on nasalance values for Irish speaking children, and to find the differences in nasalance score across gender. Seventy children (36 girls and 34 boys, aged between 4 to 13 years) with normal articulation, resonance, and voice were assessed. Mean nasalance score were obtained for normal speaking children during the repetition of 16 test sentences that were categorized according to the consonants type with in the sentences (high pressure consonants, low pressure consonants, nasal consonants). Children repeated each of the 16 test sentences individually. The sentence were presented in groups according to consonant type, refer to as a sentences categories. Data was collected and analysed using the Kay Nasometer (Model 6200.3). Nasalance scores were obtained for the total speech sample and each sentence sentences category. Normative nasalance score were obtained for total speech sample (26% with SD of 5), high-pressure consonants sentence (14% with SD of 5), low-pressure consonants sentences (16% with SD of 6), and a nasal consonant sentences (51% with SD of 7). Authors were also compared the normative data established for American English and found that normal nasalance score was lower in the Irish study, compared with the American and Australian studies of nasalance score. Analysis of the high pressure and low pressure category nasalance score may inform the differential diagnosis regarding hyper nasality and nasal air flow error. But this differentiation was not well established by this study

Sunitha et al. (2005) conducted a study to establish the normative data in Tamil speaking individual. In the first phase, ten meaningful sentences using the various sound classes in Tamil were developed. These were repeated by 120 children (60 boys and 60 girls) in the age range of 5 to 15 years. The data was analyzed using the Kay Nasometer (Model 6500) and the results revealed that girls showed higher nasalance value than boys. The results showed the normative for oral stimuli (9-15%), nasal stimuli (58-62%), and predominately oral stimuli (20-40%). The nasalance cut-off ranged between 13% and 17% across the gender and age for Tamil language. With the availability of the ten standard sentences and age-gender norms were established. In this study the reliability measures has not been included.

There is evidence that the nasalance scores varies across dialects also (Seaver et al., 1991; Van Doorn & Purcell, 1998; Nichols, 1999). Seaver et al. (1991) conducted a study to obtain normative data for 140 normal adults from four different geographical regions of North America. Subjects were asked to read these three types of stimuli (nasal sentences, rainbow & zoo passage). The mid-Atlantic speakers were found to have significant higher nasalance scores on all three reading passage. The results indicated the significant differences in nasalance score across various dialects of English. The nasalance scores indicated the little difference for three of the four regional speech patterns.

Van Doorn & Purcell (1998) provided normative data for 245 Australian English speaking children. Mean nasalance value for zoo passage and the nasal sentences were about two nasalance points lower than previously reported normative value for American

English speaking children (Fletcher et al., 1987). Mean value for zoo passage was slightly higher than a previous report of Canadian children (Leeper et al., 1942), but similar for the nasal sentences. The author attributed these differences to dialectal variation and highlighted the need for developing normative data across dialect variation.

Nichols (1999) aimed to obtain normative data and comparison among two populations in Mexico with a total subject of one fifty using Nasometer (Model 6200). Three groups of subjects were considered (children, old children, and adults) with age range of 6 to 8 years, 11 to 13 years, and 20 to 40 years respectively. The investigator used 10 nasal and 10 non-nasal sentences. The reliability of the measures was demonstrated to be very high (0.87 to 0.95). Significant differences among two different Mexican populations were found. The mean value for oral sentences 17.02 (SD 6.72) and nasal sentences 55.28 (SD 6.00) was established.

Van Lierde (2001) compared the normative nasalance resonance in the speech of young Flemish adults with north Dutch, regions of North America and Atlantic provinces of Canada. Cross linguistic comparison using independent 't' test showed that Canadian (nasalance score 37.1 %) and North American data (nasalance score 36%) differ significantly from the Flemish data (nasals score 33.8%). But a significant difference was not evident between Flemish and North Dutch.

III. Effect of Gender on Nasalance Score

There is some controversy regarding gender differences in mean nasalance scores in normal speakers. Mean nasalance score also vary across gender. Gender related differences in nasalance value can possibly be related to basic structural and functional differences across gender. The resonance of voice is influenced by the size, shape and surface of infraglottal and supraglottal resonating structures and cavities. Previous studies found that female speakers have significantly higher nasalance scores than male speaker on passage containing nasal consonants (Seaver et al., 1991; Van Lierde et al., 2001; Fletcher, 1978; Hutchinson, 1978). Fletcher, (1978) reported higher nasal value for normal men on nasal sentences. But Hutchinson, (1978) reported higher nasal value for women on three reading passages.

Seaver et al. (1991) found the differences in nasalance scores between men and women. Female subjects exhibited significantly greater nasalization compared to male. The results were attributed to increased respiratory effort and increased nasal cross-sectional area in female and also due to filter characteristics of the Nasometer.

Van Lierde (2001) found nasalance scores for oronasal text and nasal texts were higher for the female subjects. The female speakers exhibited significantly higher nasals score than male speakers on the passages containing oro-nasal texts (female nasalance score 36.1%, male nasalance score 31.5%) and the nasal texts (female nasalance score 57.4%, male nasalance score 54.2%). But no significant difference was found for the oral texts (female nasalance score 11.6%, male nasalance score 10.2%). No statistically significant differences were found across gender for oral passage. The data suggest that the female subjects exhibited higher nasalance score for oro-nasal passage. The results were due to basic structural and functional differences across gender. These data suggests that the female subject exhibited significantly more nasalance when regarding to stimuli included nasal consonant and when obviously coordinate opening and closing function of velopharyngeal mechanism worked. A large number of laryngeal and velopharyngeal anatomical, physiological and aero dynamical sex-related differences may affect the functioning of resonance system. The mechanisms for velopharyngeal valuing have been found to differ for men and women.

McKerns & Bzoach (1970) investigated the mechanism for velopharyngeal valving in 40 normal young adults using lateral cinefluorography and found significant difference across gender. The basic orientation of velum to pharynx in men can be described in terms of an acute angel and that of human more approximately in terms of right angel. Velar length and height is greater in men but the amount of contact is less and the inferior point of contact is most usually above palatal plane. But in female, the above findings were reported to be reversed. But this finding was contradicated by Litzaw and Dalston. (1990) who reported no significant relationship between nasal cross-sectional area and nasal score from reading of the nasal sentences.

Many studies reported that a significant difference was not evident in nasalance scores across gender (Trindade et al., 1997; Van Doorn & Purcell, 1998; Sweeney et al., 2004; Van Lierde et al., 2003).

Trindaale et al. (1997) compared the nasalance values across gender. Based on the results, they opined there is a statistically significant differences found in the nasalance scores across gender, the differences were only 2 scalar points and therefore the difference was of no clinical significant. Nichols, (1999) also reported higher nasalance value for the female speaker (7%) compared to male speaker (6%). The difference was not significant.

Whitehill (2001) compared the nasalance score across gender. The results indicated there was no significant difference in nasalance for the nasal sentences, oral sentences or oronasal passages. However a significant difference in nasalance was noted for the oral sentences.

Van Lierde et al. (2003) evaluated 33 children (15 girls and 18 boys) in Flemish language. Three different types of stimuli were used. (oral, oronasal and nasal text). They recorded children producing sounds and the read three texts. They compared the nasal resonance data from the children with those of 58 adults that have been obtained in a previous study. Results suggested that women had higher scores than men during the production of the /u/ in the oro nasal text and the nasal text. But it was not statistically significant.

Sweeney et al. (2004) evaluated 70 normal Irish children with age range of 4 years to 13 years. Children repeated each of the 16 sentences individually. The sentences were presented in groups according to consonant type (High pressure, low pressure and nasal consonant). Normative nasalance scores were obtained for three groups of sentences. The group mean nasalance score for boys was 26% (SD 4.18), and the group means nasalance score for girls was 27% (SD of 4.12). There was no significant difference in nasalance scores between males and female speakers.

IV. Effect of age on Nasalance Score

Very limited studies have been done on the effect of age on nasalance scores. Trindade, (1997) studied three groups of speakers: Children younger than 11 years, adolescents (11 to 17 years), and adult (above 17 years). The results revealed that children had significantly lower nasalance scores during the production of non nasal passage for normal Brazilian Portuguese speakers. There was no statistically significant difference in scores between children and adolescents. Similar results were also reported by Fletcher et al. (1989).

Nichols (1999) reported the minimal difference between adults (4%) and younger children (5%) for nonnasal passage. Even though the small difference was seen, it was significant. The result was in agreement with Santos Terron et al. (1991) who reported lesser average nasalance for non-nasal materials increases as the age increases.

Whitehill (2001) reported no significant correlation between age and mean nasalance score. But this result was attributed to small sample considered for the study.

Van Lierde et al. (2003) reported that adults had significantly higher nasal resonance scores for the vowels /a/ /i/ /u/ and when the reading stimuli included nasal consonants, They also suggested that age-related differences in nasal resonance scores were not based on obvious alterations in velopharyngeal function, but more related to developmental change in speech mechanisms and differences in speech programming. When comparison of nasal resonance score of male and female adults were compared with those of male and female children, age had a significant effect on the vowel /a/ across the gender. Their results corroborate the findings of Seaver et al. (1991) and Leeper et al. (1992) who reported higher nasal resonance score for adult than children.

Majority of the studies suggested that language, dialect and the nature of the speech samples have a greater influence on nasalance scores than the age of speakers (Sweeney et al. 2004).

V. Effect of Stimuli

An initial step towards refining the use of nasometry as an objective measure of perceived nasal acoustic energy involves manipulating the speech sample used. Several speech samples and materials and reading materials (Rainbow passage, zoo passage) are included in the nasometry package for use in assessment of resonance disorders. A series of speech productions devoid of nasal consonants and oral consonants and oral pressure consonants might enable measurement of nasal acoustic energy that is clue only to voiced nasal resonance with out the effect of intentional nasal resonance associated with nasal consonants and with out unintentional effect of nasal turbulent airflow associated with pressure consonants production. Research has shown that the zoo passage (devoid of nasal consonants) is useful in identifying individuals with velopharyngeal dysfunction. Traditionally long passage such as zoo passage was used to assess nasalance. This paragraph contains a variety of oral consonants (plosives, fricatives, glides). The zoo passage has 83 syllables in length and presumably it is sufficiently long to obtain valid and stable measures of nasalance.

Carney & Sherman (1971) aimed to study the effects of three speech tasks upon the perception of nasality for 10 normal subjects and 10 subjects with cleft palate. The three speech tasks consisted of the production of: five isolated vowels, same vowels in consonant-vowel-consonant (CVC) syllables and same CVC in connected speech passage. The results indicate that for both groups, CVC syllables from a connected speech are judged to be less nasal than either isolated vowels or isolated CVC syllables. The variation with results were attributed this effect to co-articulation influences. Subjects with cleft palate are more nasal on high vowel than on low vowels, while subjects without cleft palate had more nasal on low vowels than on high vowels.

Dalston et al. (1990 b) found that, the nasalance scores for zoo passages was greater than 32% typically manifested aerodynamically determined velopharyngeal areas in excess of 0.10 square centimeters. It also revealed that those with zoo passage scores over 32% had speech that was judged to be characterized by at least mild to moderator hyper nasality.

Another frequently used material is Rainbow passage. This (contains 11% nasal consonants) is believed to represent the percentage of nasal consonants typical of conversational speech (Fletcher et al., 1989, Dalston & Seaver, 1992). Dalston & Seaver (1992) reported poor correlation between nasalance scores on the rainbow passage and perceptual judgments of nasality.

The Rainbow passage and zoo passage were also found to be too difficult semantically and syntactically for young children to repeat these passages (Watterson et al. 1993). Some simplified passage considered appropriate for children have been developed for use with the Nasometer (MacKay and Kummer, 1994). Several researchers used the passages as a speech sample (Dalton et al., 1991a, Seaver et al., 1991). Some of them used sentences (Sweeney et al., 2004; Van Lierde et al., 2003; Nichols, 1999; Van Lierde, 2001) and some of them used passage as well as sentences (Anderson, 1996; Van Doom et al., 1998; Whitehill, 2001).

Recently, many authors have proposed shorter stimuli. (MacKay and Kummer, 1994; Watterson et at, 1996; Awan, 1998), but short stimuli create the potential for vowel and consonants content to have a weighting effect on the nasalance score (Karnell, 1995; Watterson et al, 1999). Because the Nasometer is designed primarily to measure the acoustic energy in vowels, the vowel content of the short stimulus would be of particular concern (Fletcher et al, 1989). MacKAy and Kummer (1994) developed SNAP that (Simplified Nasometric Assessment Procedures Test) that provides data that support the contention that nasalance scores from short stimuli may be markedly influenced by vowel content. Form the SNAP Test, MacKAy and Kummer (1994) provide mean nasalance data for normal subject using variety of stimuli. The syllable repetition subtests require subjects to repeat a CV syllables, for 6 to 10 times (eg. Ti, ti, ti…) and data are provided for CV stimuli that differ only with respect to the vowel. The data show that nasalance score for stimuli with the high front vowel / i / are markedly higher than the low back vowel / a /.

Watterson et al. (1999) studied five English speaking normal children and 20 children at risk of velopharyngeal dysfunction whose mother tongue is English. Nasalance measures were compared for speech stimuli of 17-syllable passage, 6- syllable sentence, and 2- syllable word to scores obtained from a standard 44- syllable passage. All stimuli were devoid of nasal consonants. The results showed that the longer the stimulus, the stronger the association with the standard passage. The results also showed that comparable measures of nasalance can be obtained using stimuli as short as six-syllable sentence. Authors found that valid assessment of nasalance can be achieved with speech sample as short as six syllables.

Lewis et al. (2000) compared the nasalance scores with nine different speech stimuli with vowel content controlled. The subjects were 19 children with velopharyngeal dysfunction and 19 normal children. The stimuli consisted of five sentences and four sustained vowels. One sentence contained only high front vowel, one contained only high back vowel and so on. The result showed that high vowels were associated with significantly higher nasalance scores than low vowels for both sentence and sustained vowels. Difference was evident among front / back vowel contrasts. These natural difference in oral and nasal sound intensity would some in the direction of increased nasalance on high vowels would explain the findings. However, nasalance scores may be differed by the vowel content of the speech stimulus.

Overall, selection of the speech sample to be used for Nasometer testing has been shown to affect results.

Sentence repetition is considered to be an effective way of collecting a speech sample in children (Antanio & Scherer, 1995). In the evaluation of speakers with nasality and nasal airflow errors, Karnell (1995) has recommended the use of separate high-pressure consonant sentences and low-pressure consonant sentences when obtaining nasalance scores. He stated that when nasal turbulence is present, nasalance scores on high- pressure consonant sentences may be artificially high. The elevation of nasalance scores on high-pressure consonant sentences may become apparent in subjects with nasal emission, nasal turbulence, or both if separate nasalance scores are obtained for high-pressure consonants and low-pressure consonant sentences.

Sweeney et al. (2004) reported that separate analysis of the high-pressure and low-pressure category nasalance scores may inform the clinician's differential diagnosis regarding hypernasallity and nasal airflow errors, but it was not well established.

The above review of literature indicates the need of establishing normative data in different languages, which is useful for assessing resonance disorders. One of the main aim of the current study is to establishing normative nasalance scores for children and adults in Kannada language. Another aims are to compare the nasalance value across age and gender.

CHAPTER - III

METHOD

Subjects:

One hundred normal subjects were participated in the present study. Each subject was evaluated by an experienced speech pathologist to check, oral structure and function. Normal speech and language ability were also evaluated informally during five-minute conversation. Background information regarding medical history and hearing ability was collected. Children with normal hearing, normal orofacial structure and function, normal speech and language ability were considered for the study. All the participants were native speaker of Mysore dialect Kannada.

Subjects were divided into two groups. First group consists of 50 children (25 males, 25 females) in the age range of 5-10 (mean age 8.1years) years. Second group consisted of 50 adults (25 males, 25 females) in the age of 20-35 (mean age 26.1years) years. Most of the adult participants were in and around the institutional area. The inclusions and exclusion criteria was same as the criteria used for selection of children. Table 1 depicts the subject's details.

Sl.No	Age range	Male	Female	Total
1	5-10 years	25	25	50
2	20-35 years	25	25	50
Total		50	50	100

Table 1: Details of subject.

Stimuli:

Two sets of meaningful Kannada sentences were prepared. One set consisted of nasal sentences, which had predominantly nasal consonants and the other set was oral sentence, which consisted predominantly oral consonants. Each category consisted of 8 sentences. An experienced speech language pathologist whose mother tongue was Kannada selected these sentences. Sentences with in the immediate memory spans of young children were prepared for both sets of materials, and sentences were made simple, short, easy to remember and meaningful. The sentences selected were ranged in length from three to four words (6 to 10 syllables). Nasal and oral Sentences are given in the Appendix - I.

For children along with the selected material, syllable repetition was also considered, as children with the history of delayed speech and language or expressive language disorder may not be able to imitate or utter the sentence repetition. To evaluate their resonance normative data is essential on syllable repetition. This syllable was based on SNAP (Simplified Nasometric Assessment Procedures), which was developed by MacKay and Kummer (1994). It consists of front and back syllables of oral and nasal with three different vowel combinations.

		Vowel /a/	Vowel/i/	Vowel /u/
ORAL SYLLABLES	Front vowels	Pa	Pi	Pu
	Back vowels	Ka	Ki	Ku
NASAL SYLLABLES	Front vowels	Ma	Mi	Mu
	Back vowels	Na	Ni	Nu

Table 2: List of syllables repetition.

Instrumentation:

The Nasometer II, (6400) a microcomputer based system developed by Fletcher and Bishop (1973) and manufactured by Kay Elemetrics (1982) was used to record the data. The Nasometer consists of head set containing a sound separator with microphones on either side which detects oral and nasal components of the speech which rests on the subject's upper lip. The signal from each of the microphones is filtered individually and digitized by customized electronic modules. This software program was loaded to Pentium III computer. The resulting signal is a ratio of nasal**:** nasal plus oral acoustic energy in term of percentage (nasalance) multiplied by hundred.

$$\text{Nasalance} = \quad (\text{Nasal} / \text{Nasal} + \text{Oral}) \times 100$$

Procedure:

Initially to find the content validity of these sentences, sentences were given for perceptual judgment. Ten postgraduate speech language pathologists who had at least one-year experience in the field were considered as the judges in rating the nasality of the sentences. Eight sentences were given to them in each category and they were asked to rate the sentences according to nasality. Five points perceptual rating scale was used. Rating of '0' indicates of fully oral or no nasality, '4' consist of highly nasalized, for both the categories

The Nasometer was setup in a suitable quiet recording room. The instrument was calibrated prior to the experiment based on the instructions provided in the manual. The subjects were assessed and recorded individually. After selecting the subjects, they were seated comfortably, and the Nasometer headset was placed on the subject's head. The position of the Nasometer head set was adjusted and secured firmly in accordance with the manufacturer's instructions. In particular the angle of the metal sound bottle against the subjects face was checked throughout the recording to ensure that it maintained its position.

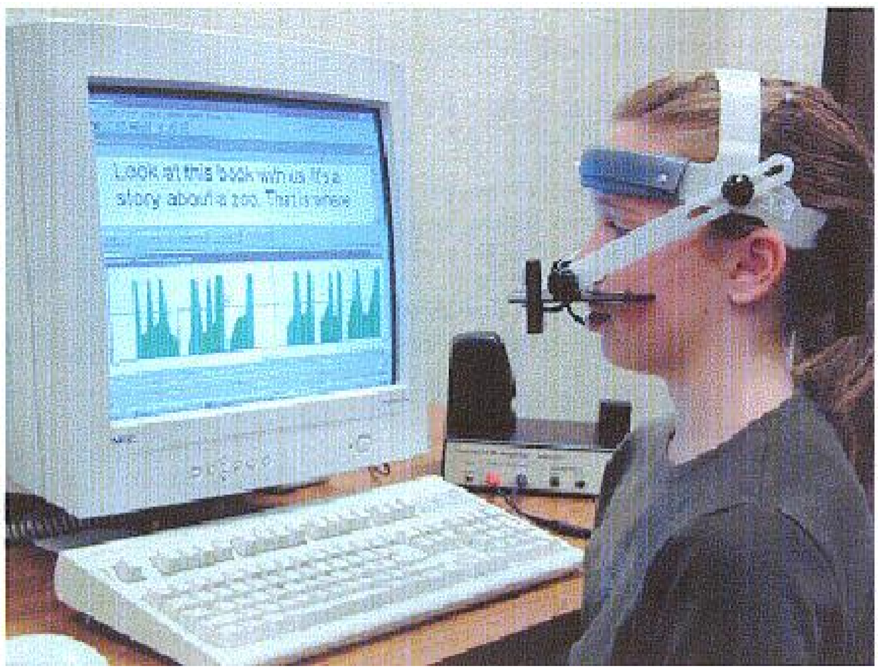

Figure 2: Picture of the Nasometer and headset position

Once the Nasometer head set was correctly positioned, the subjects were instructed to read the speech stimulus if he/she is a literate. In case of non-illiterate, they were asked to repeat speech stimulus (16 sentences) after the speech pathologist for a reliable output. After reading or repeating the sentence category, subjects were also asked to read or repeat the all sentences after 30 minuets for all the subjects for the purpose of test retest reliability. This reliability measure was followed for both the oral and nasal sentences category. At the end of each sentence, an interval of two seconds was provided, so that the instrument acquired the sentences with a separation, and it allowed for subsequent identification of different sentences for analysis.

For children additionally syllable repetition was used. Watterson, Lewis and Homan (1999) reported that comparable measures of nasalance can also be obtained using stimulus as short as six syllable sentences. Hence, children were asked to repeat the syllable minimum of six times. For experimental consistency, all the children were asked to repeat after the speech pathologist for the stimulus production. This also eliminated the need for practice for those children whose reading skill was still developing.

The nasalance trace was monitored continuously through out each recording to ensure that the data were being captured. Any extraneous events such as spontaneous coughs or repeated words were noted and marked with cursor for later removal from the recorded trace. In conditions where the subjects made an error during sentence repetition, retrial was taken and correct version was included for data collection. After the completion of each speech sample, the nasalance trace was stored in a computer file for further analysis.

Data Analysis:

Data was obtained for all the eight sentences in each category. The data files for all speech samples were subjected to a screening process to ensure that no inaccurate data were included in calculations of population mean. The extraneous data in these files were isolated between two cursors and deleted using the delete between cursors" function in the calculate menu of the Nasometer. Once the data files had been screened for the entire subject, the mean, maximum, minimum nasalance for each sentences (16 sentences) in each category were calculated. Mean value of each sentences were correlated with the perceptual judgments. Using the Nasometer statistical function, these scores were then recorded in a separate sheet form suitable for subsequent statistical analysis using "SPSS" program package. Descriptive statistics, independent "t" test and two way ANOVA (Analysis of variance) were used for analysis.

CHAPTER – IV

RESULTS AND DISCUSSION

RESULTS

The present study aimed at establishing the normative scores for Nasometery (Model 6400.II) in Kannada language for children and adults. The data was analyzed for children and adult separately using descriptive statistic, independent t test, and two way ANOVA using SPSS software (version, 10.0) package.

I Test -retest reliability:

Test retest reliability was assessed by making the subjects to utter all the sentences after 30 minutes. Results indicated good reliability for each sentences (app >90%) across age and sentence category. Reliability for the individual sentences is given in the following table.3. Reliability measures are expressed in alpha coefficient.

Order of the sentences	Children		Adult	
	Nasal	Oral	Nasal	Oral
Sentence 1	0.97	0.94	0.95	0.98
Sentence 2	0.95	0.96	0.82	0.90
Sentence 3	0.95	0.94	0.98	0.92
Sentence 4	0.97	0.94	0.89	0.94
Sentence 5	0.94	0.96	0.97	0.95
Sentence 6	0.98	0.97	0.77	0.88
Sentence 7	0.93	0.97	0.92	0.98
Sentence 8	0.95	0.96	0.97	0.99

Table 3. Test-retest reliability of sentences

II. The correlation of perceptual and objective assessment:

Although good reliability (Alpha coefficient) was established among the eight sentences, only a correlation of 66% was found between the perceptual judgment and the objective judgment. Based on objective method five sentences were selected which had a high nasalance score for nasal sentences and low nasalance for oral sentences, by the objective method. These sentences were further correlated with the perceptual method. Hence, these five sentences were considered for final analysis. The results of the descriptive analysis are depicted in Figure 3a, Figure 3b, Figure 4a, and Figure 4b. The sentences, which are shown in yellow color bar, were eliminated for the further analysis.

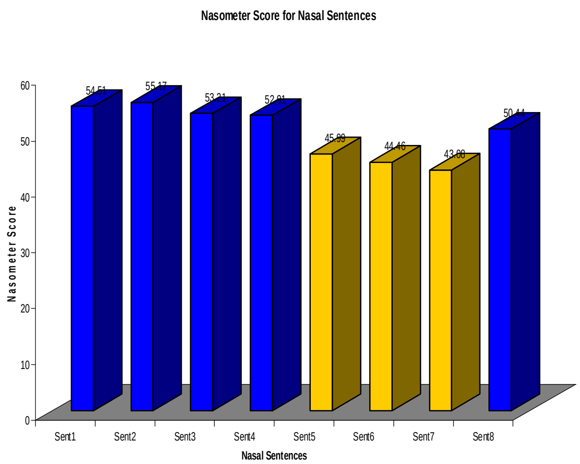

Figure 3 a**:** Descriptive analysis of nasal sentences in children.

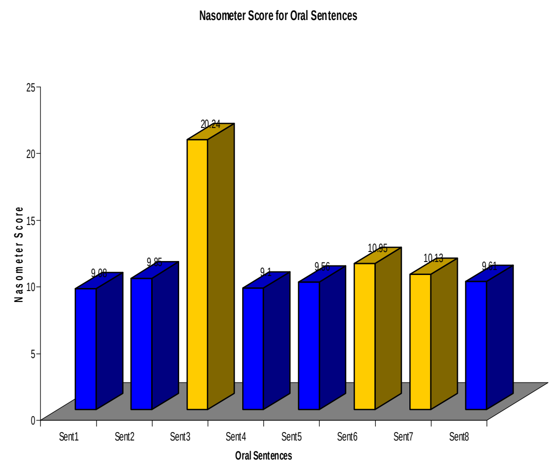

Figure 3 b**:** Descriptive analysis of oral sentences in children

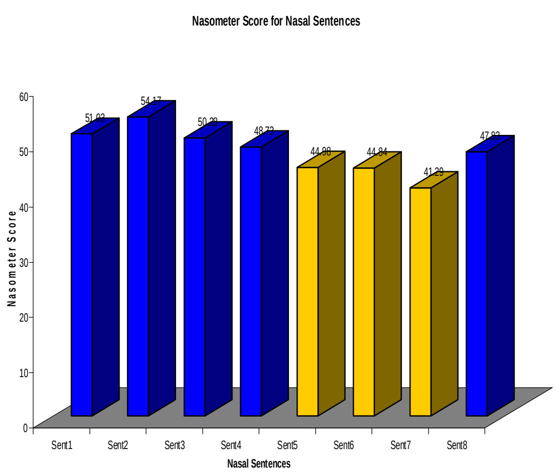

Figure 4 a**:** Descriptive analysis of nasal sentences in adults

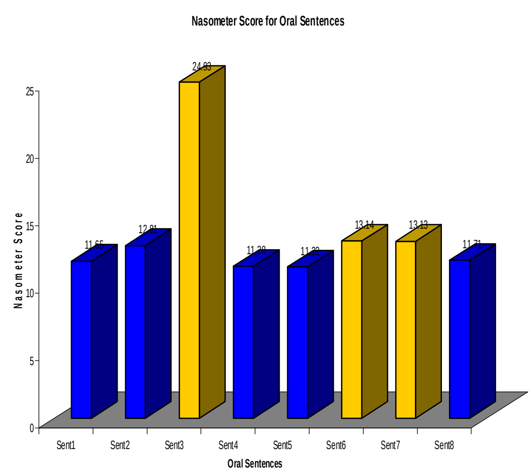

Figure 4 b**:** Descriptive analysis of oral sentences in adults.

III. Normative value for nasalance

Age group	Gender	Category (Sentences)	Mean (S.D)	Upper boundary	Lower boundary
Children	Male	Oral sentences	09.30 (3.9)	10.73	8.30
		Nasal sentences	50.96 (7.4)	52.24	48.93
	Female	Oral sentences	09.65 (4.1)	11.03	8.73
		Nasal sentences	49.85 (7.7)	51.37	47.95
	Male	Oral Syllable repetition	10.93(3.9)	11.81	8.92
		Nasal syllable repetition	67.02 (7.4)	69.01	66.71
	Female	Oral Syllable repetition	10.40 (4.2)	11.75	8.76
		Nasal syllable repetition	65.86 (5.8)	67.37	64.92

Table 4: Normative nasalance value for children

The above table 4 indicates the normative nasalance score for children across the gender. The scores for the syllable repetition is also depicted along with the S.D for, oral and nasal sentences. The upper and lower limit for oral and nasal sentences and the syllable repetition is also indicated in the table.

Age group	Gender	Category (Sentences)	Mean (S.D)	Upper boundary	Lower boundary
Adults	Male	Oral Sentences	08.77 (4.76)	10.07	8.08
		Nasal Sentences	48.27 (8.74)	50.16	46.78
	Female	Oral Sentences	14.69 (5.86)	15.57	13.72
		Nasal Sentences	58.22 (8.40)	59.71	56.72

Table 5: Normative nasalance value for adults

The above table 5 indicates the normative nasalance score for adults across the gender. The scores for the syllable repetition is also depicted along with the S.D for oral and nasal sentences. The upper and lower limit for oral and nasal sentences and the syllable repetition is also indicated in the Table.

VI. Effect of age and gender on nasalance score

(a) Comparison of nasal sentences score across age and gender

Age group	Gender	Mean	S. D
Children	Male	50.96	7.4
	Female	49.85	7.7
Adult	Male	48.27	8.7
	Female	58.22	8.4

Table 6: Nasalance scores for nasal sentences across gender and age

The above table 6 depicts the nasalance value for nasal sentences across gender and age. It shows that adults exhibited higher nasalance value for nasal sentences compared to children. Two way ANOVA was used to find the differences and the results indicated significant differences across gender and age groups for nasal sentences. The results are given in the following table 7.

Variables	df	F	Sig..Diff	Interpretation
Age group	1	15.349	0.000 **	Significant difference between children and adults for nasal sentences.
Gender	1	37.246	0.000**	Significant difference between males and females for nasal sentences.
Age group and Gender	1	58.155	0.000**	Significant difference between age group and gender for nasal sentences.

(** Significance at 0.001)

Table 7: Comparison of nasal sentences across age and gender

The above table 7 shows that there is a significant ($P < 0.001$) difference between children and adults as well as males and females. It also showed that there is an interaction effect present between age group and gender

To find the gender differences within each age group independent t- test was used. The results are given in the following table 8. The results indicated no significant difference across gender in children, but the significant difference was evident in adults for nasal sentencs.

Group	T	Df	Sig.Diff	P value	Interpretation
Children	1.148	248	.252	P> .05	No significant difference between males and females in children
Adults	9.141	248	.000	P< .001	Significant difference between males and females in adults

Table 8: Comparison of nasal sentences within age group.

(b) Comparison of oral sentences score across age and gender

Age group	Gender	Mean	S.D
Children	Male	9.30	3.9
	Female	9.65	4.1
Adult	Male	8.77	4.7
	Female	14.69	5.8

Table 9: Nasalance scores for oral sentences across gender and age

The above table 9 depicts the nasalance value for oral sentences across gender and age. It shows that adults exhibited higher nasalance value for nasal sentences compared to children. Two way ANOVA was used to find the differences and the results indicated significant differences across gender and age groups for oral sentences. The results are given in the following table 10.

Variables	df	F	Sig.Diff	Interpretation
Age group	1	28.29	0.000**	Significant difference between children and adults for oral sentences
Gender	1	54.73	0.000**	Significant difference between males and females for oral sentences
Age group and Gender	1	43.24	0.000**	Significant difference in interaction between age group and gender for oral sentences

(** Significance at 0.001)

Table 10: Comparison of oral sentences across age and gender

The above table 10 shows that there is a significant ($P < 0.001$) difference between children and adults as well as males and females. It also showed that there is an interaction effect present between age group and gender.

To find the gender differences within each age group independent t- test was used. The results are given in the following table 11. The results indicated no significant difference across gender in children, but the significant difference was evident in adults for oral sentences.

Group	T	Df	sig	P value	Interpretation
Children	0.682	248	0.496	$P > .05$	No significant difference between males and females in children
Adults	8.755	248	.000	$P < .001$	Significant difference between males and females in adults

Table 11: Comparison of oral sentences within age group.

Scatter plot was plotted for the performance of children and adults with respect to the oral and nasal sentences. The following Figures 5a, 5b and 6a, 6b depict the same.

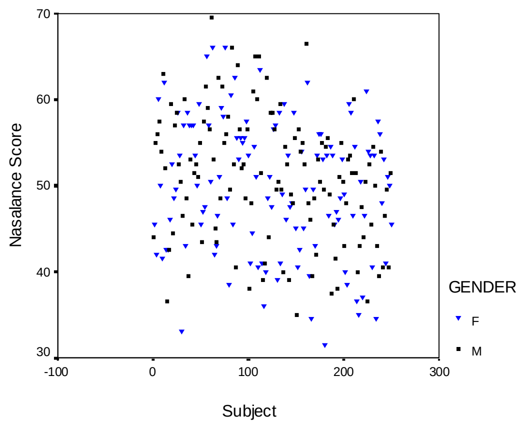

Figure 5a**:** Scatter plot for gender differences in children for nasal sentences.

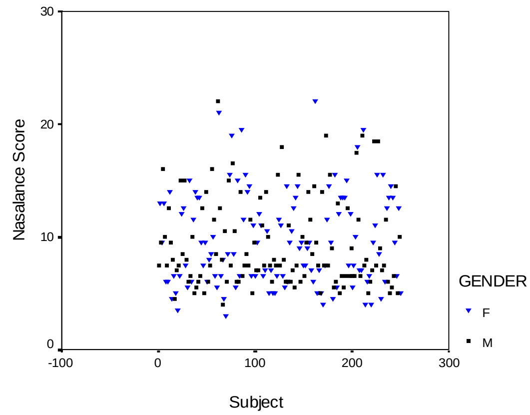

Figure 5b**:** Scatter plot for gender differences in children for oral sentences.

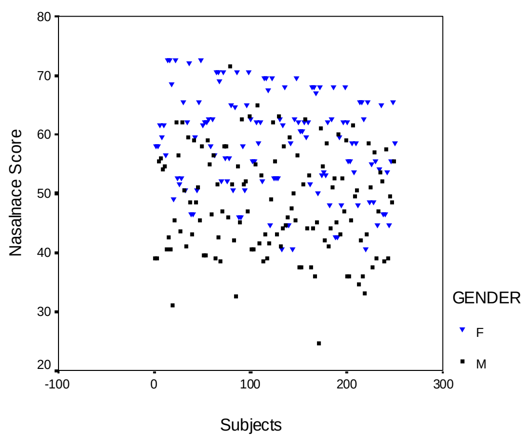

Figure 6a**:** Scatter plot for gender differences in adult for nasal sentences

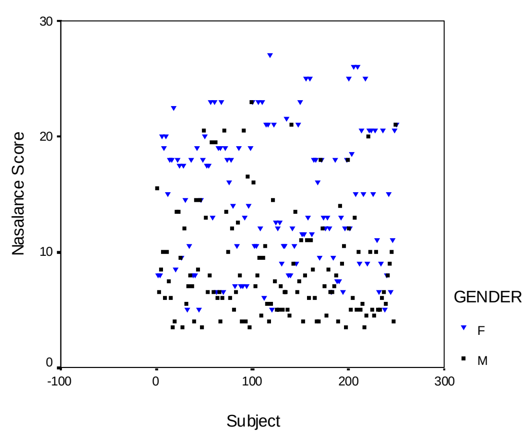

Figure 6b**:** Scatter plot for gender differences in adult for oral sentences

VII. Syllable repetition for children

(a) Nasal syllable repetition

For children who were not able to repeat the sentence, the syllable repetition found to be one of the better way to measure the nasalance. The following table 12 shows mean and S.D. deviation of nasal syllable repetition. One of the interesting finding obtained by this result was the higher nasalance value for the high vowel context (/ni/ and /mi /) compared to the other syllables.

Syllables	Mean	S. D
/ Ma /	55.20	9.07
/ Mi /	74.78	6.90
/ Mu /	64.06	9.11
/ Na /	58.72	12.50
/ Ni /	77.14	7.00
/ Nu/	68.76	9.00

Table 12: Mean value of nasal syllables

(b) Nasal syllable repetition across gender

To find the gender differences in the nasalance score, independent t test was used. Results did not reveal any significant differences across gender with respect to nasal syllable repetition.

Syllables	Gender	Mean	t value	df	P-value
Nasal syllable repetition	Male	67.02	0.617	48	1.166
	Female	65.85			

Table 13: Gender difference in the nasalance score of nasal syllables in children

The above-mentioned table 13 shows that there is minimal difference present between male and female subjects. But their was not statistically significant to confirm the gender difference in children with respect to nasal syllable repetition.

(c) Oral syllable repetition

The following table shows mean and S.D of the oral syllable repetition. As seen in the nasal syllables, oral syllables also exhibited higher nasalance value for the high vowel context (/pi/ and /ki /) compared to the other syllables.

Syllables	Mean	S.D
/ Pa/	8.14	2.60
/ Pi /	12.74	5.55
/ Pu /	7.58	3.28
/ Ka /	9.40	3.75
/ ki /	16.74	7.81
/ ku /	9.40	4.62

Table 14: Mean value of oral syllables

(d) Oral syllable repetition across gender

Table 15 depicts the results of oral sentences across gender. To find the differences in the nasalance score across gender, independent t test was used. Even though, males exhibited the higher nasalance value results did not reveal any significant differences across gender with respect to oral syllable repetition.

Syllables	Gender	Mean	t value	df	P-value
Oral syllable repetition	Male	10.93	0.459	48	0.648
	Female	9.65			

Table 15: Gender difference in the nasalance score of oral syllables in children

Summary of the normative nasalance result

The following table indicates the normative nasalance value for children and adults across sententence types. Since there was no significant difference across gender among children the mean value may be considered. For nasal sentences the nasalance value was 51.03 (7.02) and for oral sentences 9.08 (3.49). For syllable repetition task, nasalance value for nasal syllables 66.44 (6.63) and for oral syllables 10.66 (4.07).

In adults, significant difference was evident across gender. In males, for nasal sentences the nasalance value was 48.27 (8.74) and for oral sentences 8.77 (4.76) In females, for nasal sentences the nasalance value was 58.22 (8.40) and for oral sentences 14.69 (5.86).

Age group and gender		Nasal sentences score (SD)	Oral sentences score (SD)
Children		51.03 (7.02)	09.08 (3.49)
Syllable Repetition for children		66.44 (6.63)	10.66 (4.07)
Adults	Male	48.27 (8.74)	08.77 (4.76)
	Female	58.22 (8.40)	14.69 (5.86)

Table 16: Normative nasalance value

Over all

- There is no gender difference found in children nether in nasal sentences nor in oral sentences
- There is gender difference found in adult with nasal sentences as well as in oral sentences
- Adults had higher nasalance value compare to children
- Female had higher nasalance value compare to male.

DISCUSSION

The primary aim of the present study is to establish normative nasalance values for Kannada speaking children and adults for selected nasal and oral sentences using Nasometer (6400.II). The summary of the normative data for Kannada speaking children and adult is shown in Table 16**.** The reported normative nasalance data provide important reference information for the assessment of nasality disorders. Speech pathologist can measure the nasality for the diagnosis and effect of a specific therapy approach and the plastic surgeon can evaluate the effect of different surgical techniques.

Very few Indian studies have done on developing a normative data in Indian context. Nandurkar (2002) conducted a study on 10 normal children and 10 children with repaired cleft palate using the Nasometer (Model 6200-II). Results showed that normal children scored 7-12% of nasalance in monosyllable stimulus. . Correlation coefficient computed between the objective measurement and the perceptual judgments of nasality and the results revealed moderate correlation between the two measures. Due to small number of sample, results were not generalized and this study lacks in reliability measurement.

Sunitha et al. (2005) conducted a study to establish the normative data in Tamil speaking individual. The nasalance cut-off scores ranged between 13% and 17% across the gender and age for Tamil language. The results showed the normative nasalance value for oral stimuli (9-15%), nasal stimuli (58-62%), and predominately oral stimuli

(20-40%). With the availability of the ten standard sentences, age and gender norms were established. In this study the reliability measures were not considered.

The following table 17 & 18 shows the normative data for oral sentences and nasal sentences for children across language.

Author (Year)	Language	N	Speech sample	Mean	S.D
Fletcher et al. (1989)	American	117	Zoo passage	16	05
Watterson et al. (1996)	American	20	Turtle	16	03
Trinadade et al. (1997)	Brazilian Portuguese	20	Brazilian Portuguese, zoo	09	03
Van Doorn & Purcell (1998)	Australian	245	Zoo passage	13	06
Sweeney et al. (2000)	Irish	70	5 oral sentences	14	05
Nadurkar (2003)	Marathi	10	oral sentences		
Sunitha et al. (2004)	Tamil	120	oral sentences	12	03
Present study (2005)	Kannada	50	5 oral sentences	09	3.5

Table 17: Normative nasalance for oral stimuli in different languages for children.

Author (Year)	Language	N	Speech sample	Mean	SD
Fletcher et al.(1989)	American	117	Nasal passage	61	07
Trinadade et al. (1997)	Brazilian Portuguese	20	Brazilian Portuguese, nasal	51	06
Van Doorn and Purcell (1998)	Australian	245	Nasal passage	60	08
Sweeney et al. (2004)	Irish	70	One nasal sentence	51	07
Sunitha et al. (2004)	Tamil	120	Nasal sentences	60	10
Present study (2005)	Kannada	100	5 nasal sentences	51	07

Table 18 : Normative nasalance for nasal stimuli in different languages for children.

The above results indicate that there is a difference evident in nasalance value for oral and nasal sentences across various languages. Even though the present study is not aimed at comparing scores across languages, an effort was made to analyze the data. This result support the findings of Sever et al., 1991; Van Doorn & Purcell 1998; Nichols, 1999 and Van Lierde et al. (2001) who reported variation in the nasalance value across various language.

Clinical interpretation of normative data:

Establishing the cut off scores for clinically significant abnormalities is important in many areas of medical epidemiology. It can be approached from a clinical or statistical perspective (Barker and Rose, 1984). For the Nasometer, the issue of determining cut off nasalance score for clinical populations has been approached from both statistical and clinical perspective. Initially clinical perspective had been widely used Dalston et al. (1991a, 1993), who used clinical rather than statistical approach. Perceptual ratings on a numerical scale were predetermined to be clinically significant at a particular value. Then, nasalance scores for the same subjects were measured independently of the perceptual judgments. Cut off scores for nasalance were set as those that give the best over all correct prediction of the presence or absence of abnormal nasality.

Regardless of the methodology differences that have led to the development of cut off scores, it is quite clear that cut off score determines that there are some speakers whose resonance is judged to be normal and who have abnormal resonance. Table 19 shows cutoff value for children and adult.

<table>
<tr><td colspan="2">Age group and gender</td><td>Cut off value for nasal sentences (Mean +/_ 2SD)</td><td>Cut off value for oral sentences (Mean +/_ 2SD)</td></tr>
<tr><td colspan="2">Children</td><td>44.01 - 58.05</td><td>5.59 - 12.57</td></tr>
<tr><td colspan="2">Syllable repetition for children</td><td>59.81 - 73.07</td><td>6.59 - 14.73</td></tr>
<tr><td rowspan="2">Adults</td><td>Male</td><td>39.53 - 56.54</td><td>4.01 - 13.53</td></tr>
<tr><td>Female</td><td>49.82 - 66.62</td><td>8.83 - 20.55</td></tr>
</table>

Table 19: Cut off score for across age and gender.

In the present study, it was judged to have normal resonance for all but for few people the nasalance cut off score were more than two SD beyond the mean. Thus any clinician using nasalance scores to assist in the judgment of abnormal nasality needs to be aware that voted cut off scores act as a guide only to the limits of nasalance that correspond to the perception of normal resonance. Additionally small variation around the cut off values should be treated with caution. The reliability scores in the present study indicate that there is a little variation of repeated sentences by two or three point.

The test retest reliability of each sentence was in the range of 85-95%. Which shows good reliability. These results are similar to the results obtained by Seaver et al.

(1991) and Sweeney et al. (2004). But some studies have reported weak reliability for the nasal passage (Van Doorn and Purcell, 1998 and Whitehill, 2001). However, these studies have also showed that adults had little lower reliability compare to children in both oral and nasal sentences. It can be attributed to reflexive repetition of children. In children the repetition appears to be more automatic and reflexive which is controlled in lower cortical structures. In adults higher centers are the one, which is controlled. Hence, variability is more in adult speech (Abbs and Kennedy, 1982).

A correlation between the perceptual and objective method showed only 66%. It showed moderate correlation between the perceptual and objective method. Paynter et al., 1991; Watterson et al., 1996; Nandurkar, 2002 also found similar result with respect to compression of perceptual and objective method

Nasalance score across age:

The other aims of the present study are to find the variation of nasalance score across children and adults. Fifty children (25 males and 25 females) and fifty adult (25 males and 25 females) had participated in the present study. The results of the present study showed that there is a significant (P< 0.001) difference in the nasalance score across children and adult. Adults exhibited higher nasalance score for nasal as well as oral sentences. But, significant difference was not evident in children for nasal and oral sentences. Similar results were obtained by Hutchison et al. (1978), Trindade (1997), and Van Lierde et al. (2003), Fletcher (1989), Nichols (1999) & Terron (1991). Van Lierde et al. (2003) suggested that age related differences in nasal resonance scores were not based on obvious alteration in velopharyngeal function, but more related to development change in speech mechanisms and differences in speech programming.

Hoit et al. (1994) opined that the elevated nasalance scores among aged speaker may not be due to impaired velopharyngeal closure but may be due to age related structural changes in the palate that “increases the sympathetic transfer and acoustic energy from the oral cavity to the nasal pathways”. In support of this contention, Hoit et al. (1994) cite research suggesting that the velar musculature and lymphatic structures atrophies with increasing age (Tomoda et al., 1984, Van Lierde et al., 2003). Taylor et al. (1996) reported that the hyoid bone descends and moves slightly outeriorly up to the age of eighteen. The nasal cavity also changes as the body grows and the increasingly larger nasal cavity may lead to more nasalance and higher scores. But this study does not support the findings of Whitehill (2000), who reported no significant correlation between age and mean nasalance score. But their result was attributed to small sample considered for the study.

Nasalance score across gender:

In the present study 50 children with equal number of males and females and 50 adults with equal number of males and females were participated. The normality scores obtained for nasal and oral sentences for children and adult were compared. Significant difference was not found across gender in children for oral and nasal sentences. But significant difference was found among adults across gender. The results can be possibly attributed to the basic structural and functional differences across gender.

Adults exhibited significant difference compared to children. This may be due to anatomical differences between male and female during middle age compared to children. The resonance of voice is influenced by the size, shape and surface of the intfraglottal and supraglottal resonating structures and cavities. (Shprintzen and Bardach, 1995). The mechanism for velopharyngeal valuing has been found to be different for men and women. McKerns and Bzoch (1970) suggested that velar length is greater in men, the height of elevation is greater and the inferior point or contact is most usually above palatal plane. In the female, the similar results are not found. The other finding that supports the present result is the acoustic transmission of palate. As the age increases the sympathetic transfer of acoustic energy from oral cavity to the nasal cavity also increases in females (Hoit et al., 1994).

Previous studies found that female speakers have significantly higher nasalance scores than male speaker on passage containing nasal consonants (Seaver et al., 1991; Van Lierde et al., 2001; Fletcher, 1978; Hutchinson, 1978) In the present study it also been found that females had higher nasalance value in both category of sentences . The results were attributed to increased respiratory effort and increased nasal cross-sectional area in female and also due to filter characteristics of the Nasometer.

As noted in the instrument manual, this device has a 300 Hz band pass input filter with a center frequency of 500 Hz. The 3 dB down point on the lower skirt of this filter is 350Hz. Also the slope of the skirts were designed to be very gradual (80 dB per decade) It is conceivable that this filter may have more effectively possesses the speech of the women. Since the present result shows there is no gender difference in children, thought children have equal (or) more fundamental frequency as women. But the present study clearly depicts that the filter mechanism may not be the possible reason.

The possible reason could be the underlying anatomical and physiological differences related to velopharyngeal closure across genders. Additionally recent research has demonstrated that beside the size of the vocal folds, vocal fold morphological structure and vibration and closure patterns differ between male and female. In particular several studies have demonstrated that incomplete vocal fold closure with a posterior chink between the fold is normal for women (Oates and Dacakis, 1997). The extents to which these laryngeal physiological differences are reflected in velopharyngeal differences are yet to be studied. But the present study does not support the findings of Trindade et al., 1997; Van Doorn & Purcell, 1998; Sweeney et al., 2004, who reported no significant differences across gender.

Over all the present study adds to the body of evidence that there are age and gender differences in nasalance scores. The interesting finding is that the age and gender difference studied at the same time when compare to other published studies. Clinically the normative data reported in the present study may help identifying children with resonance disorders. It may also be used to monitor the success of the rehabilitation techniques such as speech therapy and surgery.

CHAPTER - V

SUMMARY AND CONCLUSION

Assessment of nasality disorders in speech is a proved to be difficult perceptual task for speech language pathologist. To assess and study nasalization and disorders of nasalization, speech language pathologist prefers the indirect methods, since it is a noninvasive and does not require medical professional support. Several methods have been reported to assess nasality by using instrument. One of the methods, for measuring the nasality is by calculating the "nasalance". In 1983, Kay Elemetrics introduced instrument to measure the nasalance know as Nasometer. It is microcomputer-based instrument, which gives reliable, objective measure of speech nasality. Several studies have shown that nasalance of normal speech is sensitivity to the phonetic composition of the speech stimuli, native language, regional dialect, age, and gender. As there are very few established normalized nasalance score, there is a strong need for establishment of regional norms. Hence the present study is aimed at developing the normative nasalance scores across age and gender in children and adults.

The present study consisted of one hundred normal subjects with normal oral structure and functions. All the participants were native speaker of Mysore dialect Kannada. Subjects were dived in to two groups. First group consisted of 50 children;

second group consisted of 50 children. Both the groups had equal number of males and females. For the purpose of stimuli, experienced speech language pathologists whose mother tongue was Kannada prepared two sets of Kannada sentences. Eight sentences were constricted in each category and ten speech pathologists were asked to rate the sentences through perceptual rating five sentences in each category. Oral and nasal syllable were selected for the children who were not able to repeat the sentences. The Nasometer II 6400 was used to for the data collection and analysis and the software was connected to HCL Pentium III personal computer. The instrument was calibrated prior to the data collection. Nasometer headset was placed on the subject's head. Once the headset is positioned properly the subject were instructed to read or repeat the sentences. Subjects were also asked to read or repeat the all sentences again, after 30 minuets for all the subjects for the purpose of test retest reliability. After the completion of each speech sample, the nasalance trace was stored on computer file for later analysis. The data was analyzed for children and adult separately using descriptive statistic, independent t test, and two-way ANOVA using SPSS software (version, 10.0) package. Results revealed good test retest reliability, and only 66% of correlation obtained between perceptual and objective method. One of the main aims of the present study is to establishing the normative. Following table shows the normative nasalance score for children and adults.

Age group and gender		Nasal sentences score (SD)	Oral sentences score (SD)
Children		51.03 (7.02)	09.08 (3.49)
Syllable Repetition for children		66.44 (6.63)	10.66 (4.07)
Adults	Male	48.27 (8.74)	08.77 (4.76)
	Female	58.22 (8.40)	14.69 (5.86)

Table 20: Normative nasalance score

The present study established normative nasalance score for children and adults .In children the nasalance value for nasal sentences the nasalance value was 51.03 (7.02) and for oral sentences 9.08 (3.49). For syllable repetition task, nasalance value for nasal syllables 66.44 (6.63) and for oral syllables 10.66 (4.07). No significant difference was evident across gender. For syllable repetition task, nasalance value for nasal syllables 66.44 (6.63) and for oral syllables 10.66 (4.07). In adults, significant difference was evident across gender. In males, for nasal sentences the nasalance value was 48.27 (8.74) and for oral sentences 8.77 (4.76). In females, for nasal sentences the nasalance value was 58.22 (8.40) and for oral sentences 14.69 (5.86).

The significant difference was evident across gender in adults. This difference may be attributed to the basic structural and functional differences between gender, children and adult. The resonance of voice is influenced by the size, shape and surface of the intfraglottal and supraglottal resonating structures and cavities (Shprintzen and Bardach, 1995). As McKerns and Bzoch (1970) suggested that velar length, elevation is greater for men compare to women. The other possible reason could be the, effect of acoustic transmission of palate. As the age increases the sympathetic transfer of acoustic energy from oral cavity to the nasal cavity also increases (Hoit et al., 1994). Over all present study shows that adult had higher score compare to children, especially females had higher score that male in adult age group. One of the possible reasons mentioned by Seaver et al. (1991) was related to filter characteristics of the Nasometer. Since the present result showed that there is no gender difference in children, the filter mechanism may not be possible reason. The possible reason could be the underlying anatomical and physiological differences related to velopharyngeal closure across gender. Additionally recent research has demonstrated gender differences in vocal fold vibration pattern (Oates and Dacakis, 1997). The extents to which these laryngeal physiological differences are reflected in velopharyngeal differences are yet to be studied.

Over all the present study adds to the body of evidence that there are age and gender differences in nasalance scores. Clinically the normative data reported in the present study may help identify and treating individuals with resonance disorders.

Limitation of the present study

- Only limited age range and limited number of subjects in each age range was considered for the present study.

Future directions:

- Normative data need to develop for other age range and geriatric population.
- Normative nasalance value across dialect variation in Kannada and other Indian languages needs to be investigated.
- Vowel differences and effect of length of stimuli on nasalance score may also be considered.

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Appendix – I

(i) Nasal Sentences

The postgraduate speech language pathologist who is native speaker of Kannada constricted the following eight nasal sentences. The sentences mean lengths of utterances were limited to three to four words. These are the sentences which were given to ten speech language pathologist for the perceptual rating.

ªÀÄ£ÀÄ D£ÉÆÃªÀÄ£ÀÄ £É£ÃrzÀ
£À£Ã£ÀªÀÄ£ÉÄAzÀ§AzÀ£ÀÄs
£Á£ÀÄ D£ÉÆÃªÀÄ£ÀÄ £É£ÃrzÉ
ªÀÄUÀªÀÄ£ÉÆÃÀ ªÉÄÃ°zÉ
ªÀÄÄªÀÄ ªÀÄq¦ÀAzÀ§AzgÀÄÀ
«ÄÃ£ÀÄUÉ£ÉÆÀ §A¢zÉ
£Àj £É®¢AzÀ£ÉÆÉÄAvÀÄ
ªÀÄÄªÀÄ£ÀªÀÄ£ÉªÀÄUÀÄ¼ÀÄÉj£À¼zÉ

The following five nasal sentences were selected for developing normative nasalance score, which will be used for Nasometric assessment for Kannada speaking children and adults.

ªÀÄ£ÀÄ D£ÉÆÃªÀÄ£ÀÄ £É£ÃrzÀ
£À£Ã£ÀªÀÄ£ÉÄAzÀ§AzÀ£ÀÄ
£Á£ÀÄ D£ÉÆÃªÀÄ£ÀÄ £É£ÃrzÉ
ªÀÄUÀªÀÄ£ÉÆÃÀ ªÉÄÃ°zÉ
ªÀÄÄªÀÄ£ÀªÀÄ£É ªÀÄUÀÄ¼ÀÄÉj£À¼zÉ

(ii) Oral Sentences

The postgraduate speech language pathologist who is native speaker of Kannada constricted the following eight oral sentences. The sentences mean lengths of utterances were limited to three to four words. These are the sentences which were given to ten speech language pathologist for the perceptual rating.

PÁUÉPÁ®Ä PÀÆ¼ÀÄ
VÃvÀ¨ÉÆUÀºÉÆÃUÀÄ
zÀ§ÀzÁj vÀ¦ÀvÀÄ
C¥¦À¥À vÁ
¨Á®Ä vÀ§® ¨Áj¸ÀÄ
¨ÉÆqÀPÁr UÉN r zÀ
¸ÀjvÀPÀ¦jÀ vÁ
EzÀÄ ºÉ¸À§m¦É

. The following five oral sentences were selected for developing normative nasalance score, which will be used for Nasometric assessment for Kannada speaking children and adults.

PÁUÉPÁ®Ä PÀÆ¼ÀÄ
VÃvÀ¨ÉÆUÀºÉÆÃUÀÄ

C¥À¥À vÁ

¨Á®Ä vÀ§® ¨Áj¸ÀÄ

EzÀÄ ºÉ¸À§mÉ