Normative Score for Nasometer in Kannada

Jayakumar T & M Pushpavathi*

Abstract

As there are very few established normalized nasalance score there is a strong need for establishment of regional norms. Several studies have shown that nasalance is sensitive to the phonetic composition of the speech stimuli, native language, regional dialect, age, and gender. Hence the present study is aimed at developing the normative nasalance scores across age and gender in children and adults in Kannada using Nasometer II 6400. The present study used 100 normal subjects who are native speakers of Mysore dialect Kannada. Subjects were divided into two groups (50 children and 50 adults). Both groups consisted of equal number of males and females. Eight sentences were constructed in each category (oral & nasal), among which five sentences were selected for norms. Oral and nasal syllables were selected for children who were not able to repeat the sentences. Subjects were also asked to read or repeat all the sentences two times for the purpose of test-retest reliability. The data was analyzed using SPSS software. Results revealed good test-retest reliability and > 66% of correlation obtained between perceptual and objective method. For children the nasalance value for nasal sentences was 51.03 (7.02) and for oral 9.08 (3.49). For syllable repetition task nasalance value for nasal syllables was 66.44 (6.63) and for oral syllables 10.66 (4.07). No significant difference was evident across gender for sentences and syllable repetition. In adults, significant difference was evident across gender. This may be attributed to the basic structural and functional differences between genders. Adults had higher nasalance value compared to children. In males, for nasal sentences the value was 48.27 (8.74) and for oral 8.77 (4.76). In females, for nasal the value was 58.22 (8.40) and for oral 14.69 (5.86). Overall present study shows that adults had higher scores compared to children, especially females had higher score than male in adult age group. As the age increases the sympathetic transfer of acoustic energy from oral cavity to the nasal cavity also increases in females.

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 and perception of speech. Nasality is one of the important parameters 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, velopharyngeal dysfunction is the main cause, which leads to nasality in speech. Normal velopharyngeal function varies according to the characteristics of the speech produced. Hyper nasality is the common problem in subjects with repaired/un repaired cleft palate, which affects the speech intelligibility.

Nasality can be assessed by subjective as well as objective methods. Perceptual judgment of nasality is done using various rating scales. Since this is a subjective task, standard data/normative data cannot be established due to many disadvantages associated

* Reader in Speech Pathology, All India Institute of Speech and Hearing, email: pushpa19@yahoo.com

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. Some of the indirect methods such as acoustic and aerodynamic techniques have been developed to measure the nasalance (Flectcher et al., 1989; Warren et al., 1993). TONAR (The Oral to Nasal Air Pressure Ratio) is one among them but this technique is not a real time analyzer and the use of this instrument for analyzing running speech was not well accepted due to the above limitations.

Assessment of nasality disorders in speech is 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 suitable treatment. Use of instrumentation has become an important part of the assessment and treatment of individuals with velopharyngeal dysfunction. So, need for a reliable, objective measure of speech nasality with high levels of content validity was largely met with the commercial introduction 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 and 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 output of the instrument provides the percentage score that reflects the relative amount of nasal energy in a subject's speech.

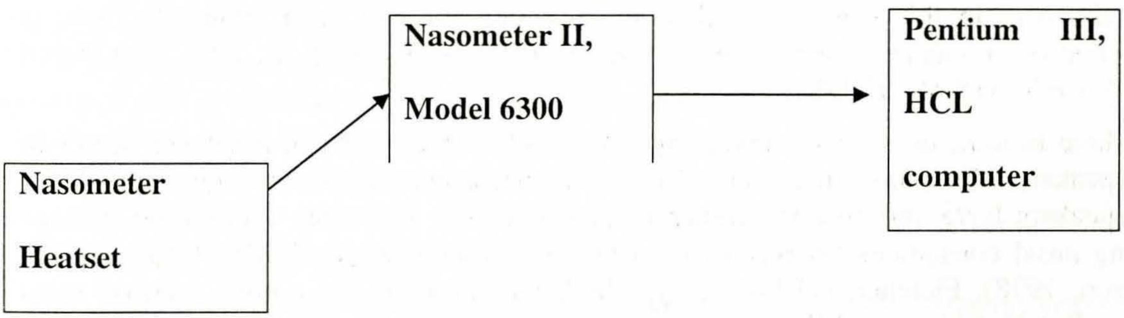

Figure 1: Schematic representation of the instrumentation of Nasometer measurement

Since the Nasometer was first introduced several studies have reported its usefulness in the assessment of resonance problems associated with velopharyngeal and nasal obstruction. Most studies reported to have suggested that the Nasometer is a clinically useful tool (Dalston, 1990; Parker et al., 1989; Seaver & Dalston, 1990; Dalston et al., 1991 a,b,c; Harpaman, 1991). 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).

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 & Puecell, 1998; Van Lierde, 2001; Whitehill, 2001; Nandurkar, 2002; Van Lierde et al., 2003; Sweeney et al., 2004; Sunitha et al., 2005).

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 within 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, referred to as sentence categories. Data was collected and analyzed using the Kay Nasometer (Model 6200.3). Nasalance scores were obtained for the total speech sample and each sentence category. Normative nasalance score were obtained for total speech sample (26% with SD of 5), high-pressure consonant sentence (14% with SD of 5), low-pressure consonant sentences (16% with SD of 6) and nasal consonant sentences (51% with SD of 7). Authors 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. Analysis of the high pressure and low pressure category nasalance score may help in the differential diagnosis regarding hyper nasality and nasal air flow error. But this differentiation was not well established in this study.

Sunitha et al. (2005) conducted a study to establish the normative data in Tamil speaking individuals. In the first phase, ten meaningful sentences using 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 values than boys. The results showed the normative for oral stimuli (9-15%), nasal stimuli (58-62%) and predominantly 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 ten standard sentences age-gender norms were established. In this study the reliability measures was not been included. There is evidence that the nasalance scores varies even across dialects (Seaver et al., 1991; Van Doorn & Purcell, 1998; Nichols, 1999).

There is some controversy regarding gender differences in mean nasalance scores in normal speakers. Mean nasalance score also vary across gender. 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.

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).

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 group mean nasalance score for boys was 26% (SD 4.18) and for girls was 27% (SD of 4.12). There was no significant difference in nasalance scores between males and female speakers.

Very limited studies have been done on the effect of age on nasalance scores. Trindade, (1997) and Whitehill (2001) reported no significant difference across age. Nichols (1999) reported the minimal difference between adults (4%) and younger children (5%) for nonnasal passage.

Van Lierde et al. (2003) reported that adults had significantly higher nasal resonance scores for the vowels /a/, /i/, and /u/ 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 scores 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 greater influence on nasalance scores than the age of speakers (Sweeney et al., 2004).

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 reading materials (Rainbow passage, zoo passage) are included in the nasometry package for use in assessment of resonance disorders. Researchers initially used the passages (Carney & Sherman., 1971; Dalston et al., 1990 b; Dalston & Seaver, 1992), some of them used sentences (Sweeney et al., 2004; Van Lierde et al., 2003; Nichols, 1999; Van Lierde, 2001) and some used passage as well as sentences (Anderson, 1996; Van Doom et al., 1998; Whitehill, 2001).

Recently many authors have proposed shorter stimuli (MacKay & Kummer, 1994; Watterson et al, 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). Watterson et al. (1999) studied five English speaking normal children and 20 children at risk of velopharyngeal dysfunction whose mother tongue was 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. 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. Overall, selection of the speech sample to be used for Nasometer testing has been shown to affect results.

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

Need for the Study

Assessment of resonance disorders 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 setup. 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). The 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

1. 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.
2. To study the effect of age and gender differences on nasalance scores in Kannada speaking children and adult population.

Method

Subjects:

One hundred normal subjects participated in the present study. Each subject was evaluated by an experienced speech pathologist to check oral structure and function. Normal speech and language abilities were 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 speakers of Mysore Kannada dialect. Subjects were divided into two groups.

Table 1: Details of subject

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

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 sentences, 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 within 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 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.

Table 2: List for syllable repetition

		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

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 headset 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 {Nasalance = (Nasal / Nasal + Oral) × 100}

Procedure:

Initially to find the content validity the 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 point perceptual rating scale was used. Rating of '0' indicates fully oral or no nasality, '4' indicate 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 headset 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.

Once the Nasometer headset was correctly positioned the subjects were instructed to read the speech stimulus if he/she is a literate. In case of 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 all the sentences after 30 minuets 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 additional 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 throughout 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 for each sentence was 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.

Results

I. Test -retest reliability:

Test retest reliability was assessed by making the subjects utter all the sentences after 30 minutes. Results indicated good reliability for each sentence (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.

Table 3: Test-retest reliability of sentences

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

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 2a, 2b, 3a, and 3b. The sentences which are shown in yellow color bar were eliminated for the further analysis.

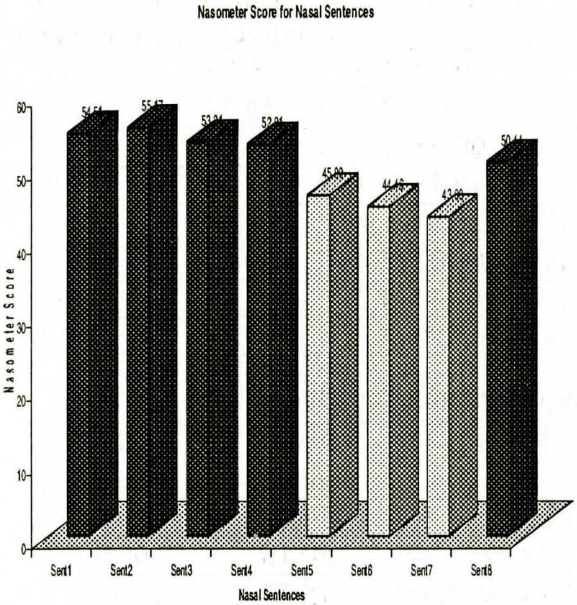

Figure 2a: Descriptive analysis of nasal sentences in children.

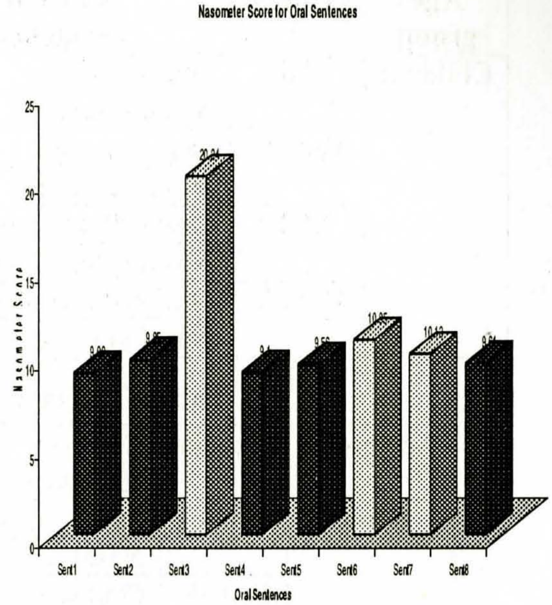

Figure 2b: Descriptive analysis of oral sentences in children

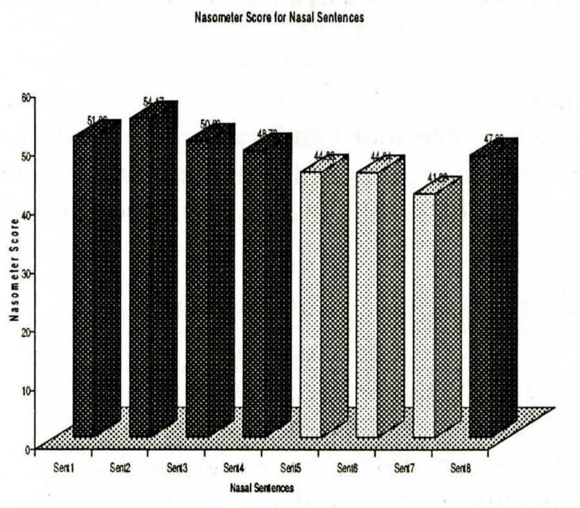

Figure 3a: Descriptive analysis of nasal sentences in adults

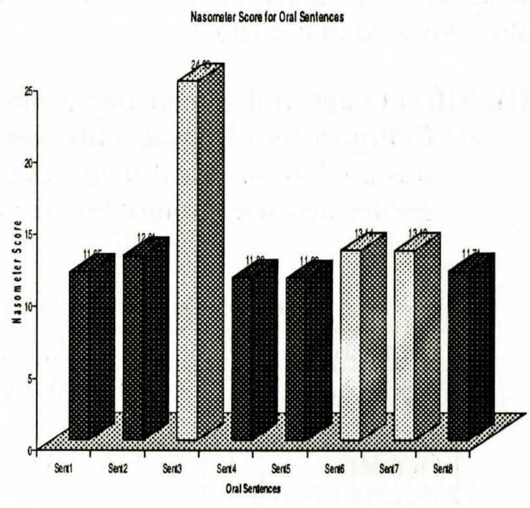

Figure 3b: Descriptive analysis of oral sentences in adults.

Table 4 indicates the normative nasalance score for children across the gender. The scores for the syllable repetition is also depicted along with the SD 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.

Table 4: Normative nasalance value for children

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 5: Normative nasalance value for adults

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 indicates the normative nasalance score for adults across the gender. The scores for the syllable repetition is also depicted along with the SD 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.

III. Effect of age and gender on nasalance score:

a) **Comparison of nasal sentences score across age and gender:** 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 6.

Table 6: Comparison of nasal sentences across age and gender

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)

The table 6 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 table 7 and indicated no significant difference across gender in children but significant difference was evident in adults for nasal sentences.

Table 7: Comparison of nasal sentences within age group.

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

b) **Comparison of oral sentences score across age and gender:** 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 table 8.

Table 8: Comparison of oral sentences across age and gender

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 and gender for oral sentences

(** Significance at 0.001)

Table 8 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 9. The results indicated no significant difference across gender in children but the significant difference was evident in adults for oral sentences.

Table 9: Comparison of oral sentences within age group.

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

Scatter plot was plotted for the performance of children and adults with respect to the oral and nasal sentences. The following Figures 4a, 4b and 5a, 5b depict the same.

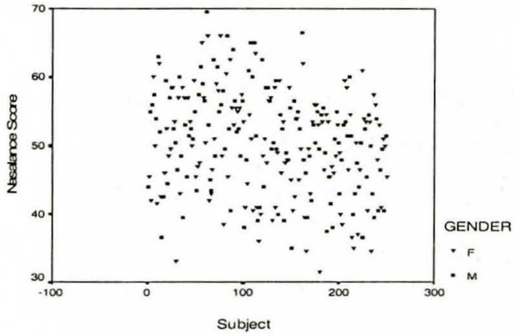

Figure 4a: Scatter plot for gender differences in children for nasal sentences

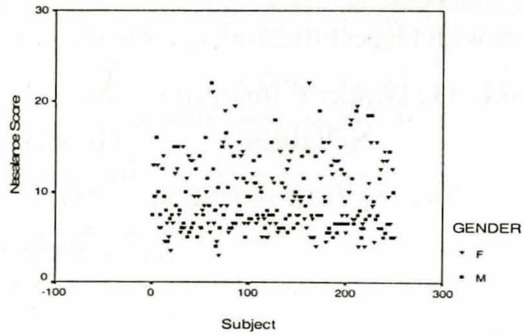

Figure 4b: Scatter plot for gender differences in children for oral sentences

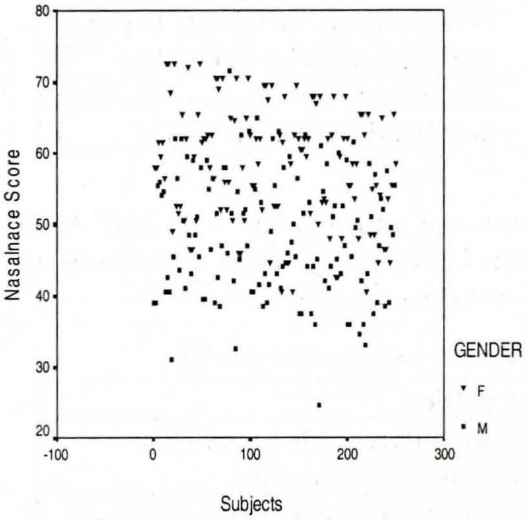

Figure 5a: Scatter plot for gender differences in adult for nasal sentences

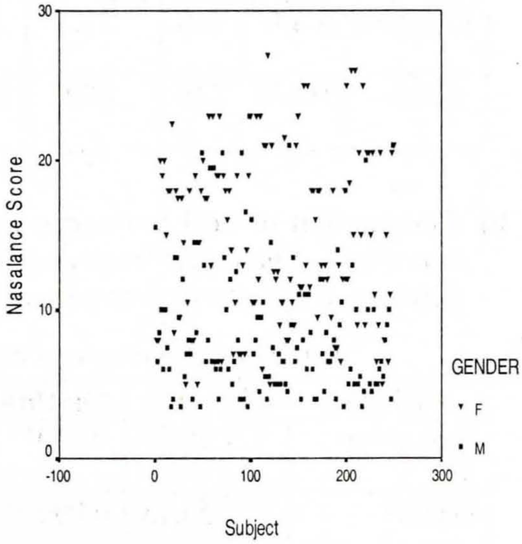

Figure 5b: Scatter plot for gender differences in adult for oral sentences

IV. 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 ways to measure the nasalance. Table 12 shows mean and S.D. of nasal syllable repetition. One of the interesting findings obtained by this result was the higher nasalance value for high vowel context (/ni/ and /mi /) compared to the other syllables.

Table 10: Mean values for nasal 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

b) **Nasal syllable repetition across gender :** To find the gender differences in the nasalance score independent t-test was used. Results did not reveal significant differences across gender with respect to nasal syllable repetition.

Table 11: Gender difference in the nasalance score for nasal syllables in children

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

The table 11 shows that there is minimal difference present between male and female subjects. But it 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.

Table 12: Mean value of oral 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

d) **Oral syllable repetition across gender:** Table 13 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 higher nasalance values, results did not reveal any significant difference across gender with respect to oral syllable repetition.

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

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

Summary of the normative nasalance result:

Table 14 indicates the normative nasalance value for children and adults across sentences 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) whereas in females, for nasal sentences the nasalance value was 58.22 (8.40) and for oral sentences 14.69 (5.86).

Table 14: Normative nasalance value

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)

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 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 been done on developing normative data in Indian context (Nandurkar, 2002; Sunitha et al., 2005). Sunitha et al. (2005) found that 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 ten standard sentences, age and gender norms were established. In this study the reliability measures were not considered.

Tables 15 & 16 show the normative data for oral sentences and nasal sentences for children across language.

Table 15: Normative nasalance for oral stimuli in different languages for children.

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 16: Normative nasalance for nasal 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

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 Seaver et al. (1991); Van Doorn and Purcell (1998); Nichols (1999) and Van Lierde et al. (2001) who reported variation in the nasalance values across various languages.

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 & Rose, 1984).

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 17 shows cutoff values for children and adult using statistical method.

Table 17: Cut off score for across age and gender.

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

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 compared 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 comparison 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. The results 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 developmental 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).

Nasalance score across gender:

Statistically 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 infraglottal and supraglottal resonating structures and cavities (Shprintzen & 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 of contact is most usually above palatal plane. In female similar results are not found. The other finding that supports the present result is the acoustic transmission of palate. As 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 also it has 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 350 Hz. Also, the slope of the skirts were designed to be very gradual (80 dB per decade). It is conceivable that this filter may more effectively possess the speech of the women. Since the present result shows there is no gender difference in children though 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. 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 differences were studied at the same time when compared 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.

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Appendix – I

(i) Nasal Sentences

Eight nasal sentences

ಮನು ಆನೆಯನ್ನು ನೋಡಿದ
ನವೀನ ಮನೆಯಿಂದ ಬಂದನು
ನಾನು ಆನೆಯನ್ನು ನೋಡಿದೆ
ಮಂಗ ಮನೆಯ ಮೇಲಿದೆ
ಮಾವು ಮಂಡ್ಯದಿಂದ ಬಂದರು
ಮೀನಳಿಗೆ ನೆಗಡಿ ಬಂದಿದೆ
ನರಿ ನೆಲದಿಂದ ನೆಗೆಯಿತು
ಮಾವನ ಮನೆ ಮಂಗಳೂರಿನಲ್ಲಿದೆ

Selected five nasal sentences

ಮನು ಆನೆಯನ್ನು ನೋಡಿದ
ನವೀನ ಮನೆಯಿಂದ ಬಂದನು
ನಾನು ಆನೆಯನ್ನು ನೋಡಿದೆ
ಮಂಗ ಮನೆಯ ಮೇಲಿದೆ
ಮಾವನ ಮನೆ ಮಂಗಳೂರಿನಲ್ಲಿದೆ

(ii) Oral Sentences

Eight oral sentences

ಕಾಗೆ ಕಾಲು ಕಪ್ಪು
ಗೀತ ಬೇಗ ಹೋಗು
ದನ ದಾರಿ ತಪ್ಪಿತು
ಅಪ್ಪ ಪಟ ತಾ
ಬಾಲು ತಬಲ ಬಾರಿಸು
ಬೇಡ ಕಾಡಿಗೆ ಓಡಿದ
ಸರಿತ ಕತ್ತರಿ ತಾ
ಇದು ಹೊಸ ಬಟ್ಟೆ

Selected five oral sentences

ಕಾಗೆ ಕಾಲು ಕಪ್ಪು
ಗೀತ ಬೇಗ ಹೋಗು
ಅಪ್ಪ ಪಟ ತಾ
ಬಾಲು ತಬಲ ಬಾರಿಸು
ಇದು ಹೊಸ ಬಟ್ಟೆ