Vocal Parameters in Children between 4 To 12 Years of Age: An Attempt to Establish a Prototype Database

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Abstract- **INTRODUCTION:** Childhood dysphonia requires precise assessments, necessitating establishment of normality standards among genders and age ranges. Computer based software have been used to establish acoustic parameters for infant and adult voice but not for children.

AIMS: This study aims to check fundamental frequency (Hz), jitter%, shimmer %, noise to harmonic ratio (NHR) of children aged between 4 and 12 years.

METHODS: 180 normal school going children were divided into 6 groups (n=30 in each); Group 1a and 1b-4 to 6 years males and females; 2a and 2b–7 to 9 years males and females; 3a and 3b-10 to 12 years males and females. Sustained phonations of /a/ were recorded using Sony digital recorder and aforementioned parameters were analyzed using VisiPitch IV.

RESULTS AND DISCUSSION: Mean fundamental frequency was highest for age group 4 to 6 yrs. The mean jitter dropped down according to increase in age group. The mean shimmer% and mean NHR increased according to increase in age group. The mean jitter%, shimmer % and mean NHR for males was higher than that for females.

CONCLUSIONS: Distinct vocal profile of males and females is evident with significant differences among various parameters between and within ages and genders.

Index Terms- vocal parameters, children, prototype database,dysphonia.

I. INTRODUCTION

A voice disorder is present when a person's quality, pitch, and loudness differ from those of a person's of similar age, gender, cultural background, and geographic location, or when an individual indicates that his or her voice is not sufficient to meet daily needs, even if it is not perceived as deviant by others (Colton & Casper, 1996; Stemple, Glaze, & Klaben, 2000). The prevalence of voice disorders in school age children is between 5% and 9% (Boone, McFarlane, & Von Berg, 2005; Carding, Roolstore, & Northstone, 2007). However, some studies have suggested a prevalence rate as high as 23% (Powell, Filter, & Williams, 1998). This variation in the prevalence of voice disorders in children may result from different methodologies and criteria for identifying voice disorders (Duff, Proctor & Yairi, 2004).

The incidence of voice disorders in children is often estimated at between 6% and 9% (Boyle, 2000; Hirschberg, J., Dejonckere, P., Hirano, M., Mori, K., Schultz Coulon, H 1995). However, other sources identify ranges of 2% to 23% (Deal, McClain, & Sudderth, 1976; Silverman & Zimmer, 1975). In one study, 38% of elementary school-aged children were identified as having chronic hoarseness (Leeper, 1992).

Many authors have studied childhood voice abnormality, but there have been fewer studies of the normal childhood voice. Children vocal disorders are relatively frequent, affecting 6 to 23% of the children population (Nicollas, Giovani, Triglia, 2008). The range of etiological factors associated with child dysphonia requires early and precise assessments and diagnosis. In order for these assessments to be reliable it is necessary to establish well-defined normality standards among the genders and different age ranges.

Many studies have been conducted to establish acoustic parameters for the infant voice, adult voice, but not of children. Voice analysis computer-based software have normative values for various voice parameters for the adult population considering both genders; however, not for the pediatric population.

Interpretation of instrumental measures of voice requires a standard against which one can compare obtained values. Without normative values, it would be impossible to competently assess an individual's vocal performance based on measures obtained during a diagnostic evaluation. However, normative values reported through research studies vary according to the demographic being analyzed, elicitation techniques, equipment, and analysis method. Using these measurements, individual measures can be compared to normal and pathological groups (Stemple, Glaze and Klaben 2000). Normative measures for F0 in female adults range from 151.2-256.6 Hz and from 118.4-152.7 Hz in adult males (Altenberg & Ferrand, 2006; Gamboa, Jimenez-Jimenez, Nieto, Montojo, Orti-Pareja, Molina 1996; Oguz, Demirci, Safak, Arslan, Islam & Kargin, 2007). Normative measures for MPFR in female adults range from 19.9-35 semitones and from 20.9-36 semitones in adult males (Gamboa et al., 1996; Robinson J. L., Mandel, S., & Sataloff, R. T., 2005; Robert, Pouget, Giovanni, Azulay, & Triglia, 1999). Normative measures for MPT in female adults range from 10.5-26.0 seconds and 12.1-35.6 seconds in adult males (Awan, 2006; Fishman & Shipp, 1970).

Anatomical and perceptual differences between children and adults justify the need for normative data specific to pediatric populations. The most obvious difference between an adult and a pediatric larynx is the size of the vocal mechanism. The structure of the pediatric larynx is much smaller than the typical adult larynx. In newborns, typical vocal fold length ranges from 2.5 to 3.0 mm (Hirano, Kurita, & Nakashima, 1983). The pediatric

larynx grows continually as a function of age, with vocal cord length ranging from 11 to 15 mm in typical ranges from 2.5 to 3.0 mm (Hirano et al., 1983). The pediatric larynx grows continually as a function of age, with vocal cord length ranging from 11 to 15 mm in typical adult females and 17 to 21 mm in typical adult males (Hirano et al., 1983). Position, composition, and configuration of the pediatric larynx also differ from those of adults. A child's larynx is positioned higher in the pharynx than an adult's larynx (Fried, 1983). In children, the cartilages of the larynx are softer than those in adults, making it less susceptible to trauma but more susceptible to collapse. Also, the vocal folds in children have a much higher proportion of membranous tissue and lower proportion of ligamentous tissue than the vocal folds in adults (Hirano et al., 1983). Another major difference is the configuration of cartilages. In children the epiglottis is typically omega-shaped and pliable, and the configuration places the epiglottis in more direct contact with the tongue and sometimes the soft palate (Fried, 1983).

Differences between the voices of adults and children can be attributed to the smaller structure of the pediatric larynx and vocal folds, as well as the more membranous, less ligamentous composition of vocal structures. For example, average speaking F0 is higher for children than adults. Because of these differences in anatomy and voice production between adults and children, normative data for the adult population should not be used as evaluative measurement standards for the pediatric population (Sapienza, Ruddy, & Baker, 2004).

II. AIM AND OBJECTIVES

This study aims to offer a contribution in the description of voice parameters in children; more specifically, the purpose is to check the acoustic voice features of male and female children aged between 4 and 12 years, all of whom were pre-school or school children from public or private schools. The vocal parameters selected were fundamental frequency (Fo), jitter%, shimmer % and noise to harmonic ratio (NHR)

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III. NEED FOR THE STUDY

Vocal nodules are the main laryngeal lesions found in children (Wetmore, 2005). Other predisposing factors include: bacterial laryngitis, laryngeal papillomatosis, congenital tumors and others (Faust, 2003). Many authors have studied childhood voice abnormality, but there have been fewer studies of the normal childhood voice. Acoustic measurements have been extensively used to make deductions about the underlying speech physiology. Acoustic measurements have also been used to examine the changes to the physiology of voice production across development and typical aging but not used for assessment of vocal parameters in children in order to establish a database to compare with. Hence, the need for the present study.

IV. MATERIALS AND METHODS

Subjects comprised of 180 (90-males, 90-females) normal school going children, divided into six groups according to age and gender. Group 1a - 4 to 6 yrs males (n=30), Group 1b - 4 to 6 yrs (females, n=30); Group 2a - 7 to 9 yrs (males, n=30); Group 2b – 7 to 9 yrs (females, n=30); Group 3a-10 to 12 yrs (males , n= 30), Group 3b - 10 to 12 yrs (females, n=30). Subjects were without vocal symptoms. Voice samples of sustained vowel /a/ were collected using digital Sony voice recorder. The following voice parameters were analyzed using MDVP analysis of VisiPitch IV (3950B of Kay Pentax) - Fundamental frequency (Fo Hz), Jitter %, Shimmer% and Noise to Harmonic Ratio (NHR). The mean and standard deviation for the aforementioned parameters for each group was calculated. The data was subjected to two way ANOVA to find out whether significant differences existed across and within the age and gender groups.

V. RESULTS AND DISCUSSION

The results are discussed as follows:-

1. **Fundamental frequency Fo(Hz):** The mean overall Fo (Hz) dropped down according to the increase in age. The overall mean fundamental frequency was highest (264.24) for age group 4 to 6 yrs and lowest (245.32) for age group 10 to 12 yrs. The Fo drop in different age ranges indicates the growth in laryngeal structures with age (Wertzner, 2005). The mean overall Fo (Hz) for males (252.69) was lower than that for females (260.89). All the three pairs of age groups differ significantly ($p < .025$) from each other with respect to their overall Fo. For both the genders 10 to 12 yrs old children have the lowest mean Fo. These results are similar to those obtained by Abo-Ras, El-Maghraby and Abdou (2013) when analyzing voice parameters of Egyptian school going children of similar ages. The results are presented in Table 1 and displayed in Graph 1.

Table 1: Mean Fundamental frequency Fo in Hz and Standard Deviation for the age groups and across genders:

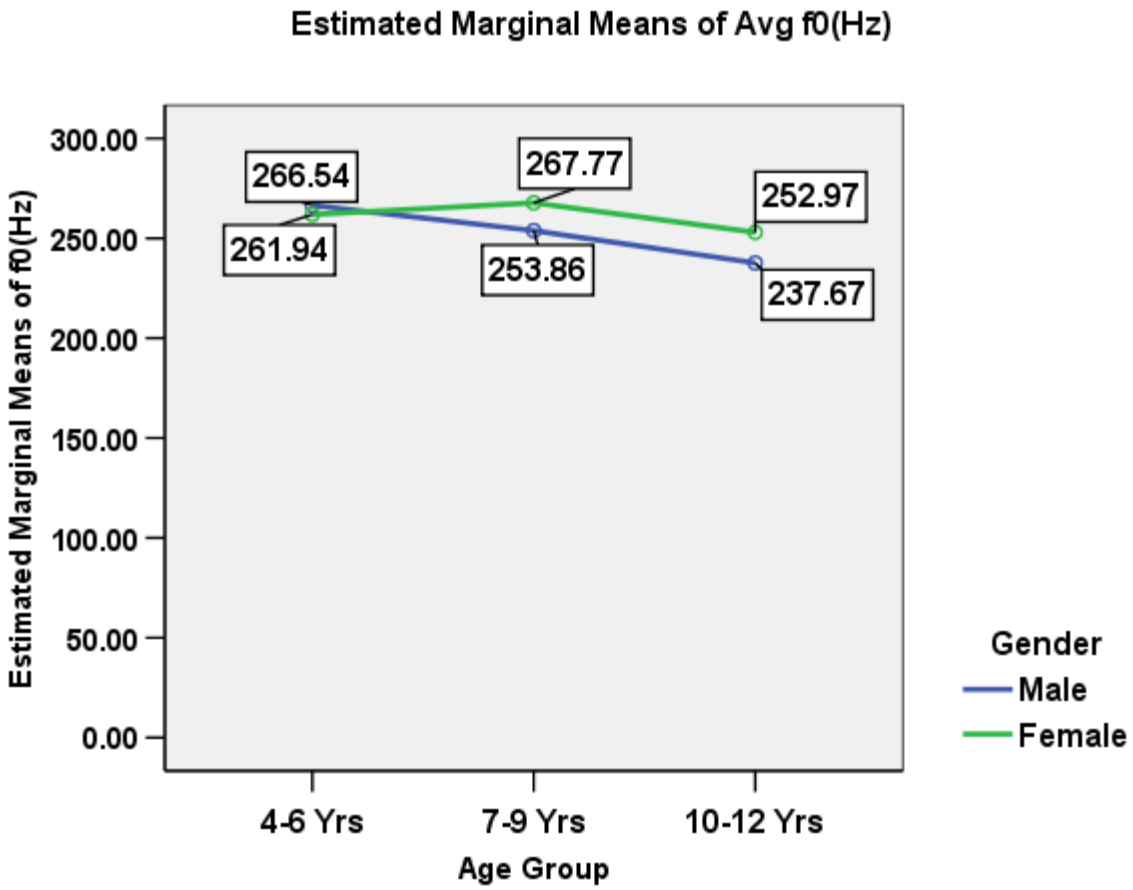
FUNDAMENTAL FREQUENCY (F0 in Hz)				
Gender	Age Group	Mean	Std. Deviation	N
Male	4-6 Yrs	266.54	2.87	30
	7-9 Yrs	253.86	3.82	30
	10-12 Yrs	237.67	10.91	30
Female	4-6 Yrs	261.94	3.18	30

	7-9 Yrs	267.77	8.22	30
	10-12 Yrs	252.97	4.83	30

FUNDAMENTAL FREQUENCY RANGE- GENDER			
Gender	Mean	Lower Bound	Upper Bound
Male	252.69	251.36	254.01
Female	260.89	259.57	262.22

FUNDAMENTAL FREQUENCY RANGE-AGE GROUPS			
Age Group	Mean	Lower Bound	Upper Bound
4-6 Yrs	264.24	262.62	265.86
7-9 Yrs	260.81	259.19	262.43
10-12 Yrs	245.32	243.70	246.94

Graph 1: Fundamental frequency Fo(Hz) across age groups and gender:



2. **Jitter %:** The mean overall jitter drops down according to the increase in the age group. The overall mean jitter is highest (1.14) for age group 4 to 6 yrs and lowest (0.605) for age group 10 to 12 yrs. Jitter and jitter % showed the same declining behavior as age increased. The mean overall jitter % for males (0.976) is higher than that for females (0.484). The results of jitter% of this study are similar to those of a study by Abo-Ras et al. (2013). Between-subjects statistics indicates that the main effect of gender is statistically significant, thus, the overall mean jitter for females (0.484) is lower than that for males (0.976). Males 4 to 6 yrs had higher mean jitter % compared to that for the other groups. Females 4 to 6 yrs had higher jitter % than others. The jitter % across age groups and gender is presented in Table 2 and displayed in Graph 2.

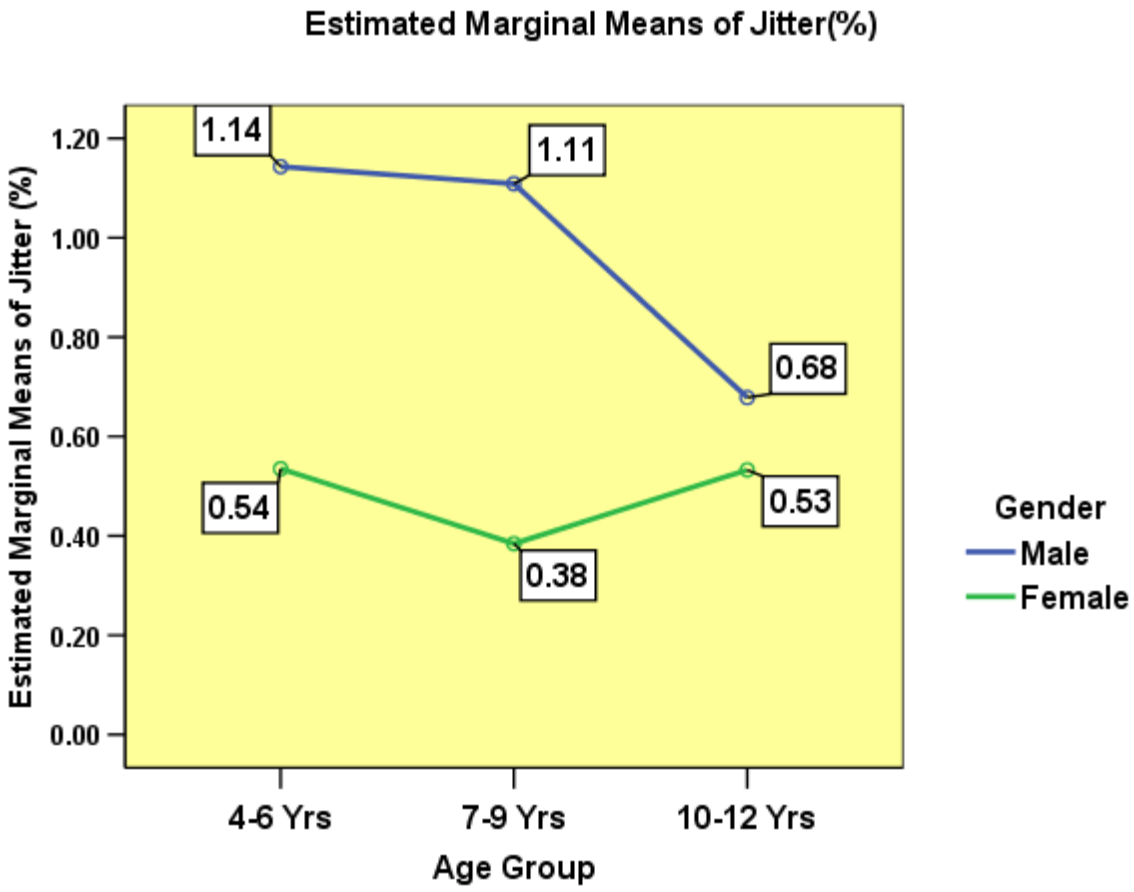
Table 2: Jitter % and Standard Deviation for the age groups and across genders:

JITTER %				
Gender	Age Group	Mean	Std. Deviation	N
Male	4-6 Yrs	1.14	0.10	30
	7-9 Yrs	1.11	0.06	30
	10-12 Yrs	0.68	0.05	30
Female	4-6 Yrs	0.54	0.07	30
	7-9 Yrs	0.38	0.09	30
	10-12 Yrs	0.53	0.07	30

JITTER %- GENDER			
Gender	Mean	Lower Bound	Upper Bound
Male	0.97	0.96	0.99
Female	0.48	0.46	0.49

JITTER %- AGE GROUPS			
Gender	Mean	Lower Bound	Upper Bound
4-6 Yrs	0.83	0.82	0.85
7-9 Yrs	0.74	0.72	0.76
10-12 Yrs	0.60	0.58	0.62

Graph 2: Jitter % across age groups and gender:



3. **Shimmer %:** The mean overall shimmer% increases according to the increase in the age group. The overall mean shimmer % is lowest (0.34) for age group 4 to 6 yrs and highest (1.12) for age group 10 to 12 yrs. The mean overall shimmer % for males (1.02) is higher than that for the females (0.15). Between-subjects statistics indicates that the main effect of gender is statistically significant, thus, the overall mean shimmer% for females (0.15) is lower than that for males (1.02). The middle age group has lower mean overall shimmer% and the highest age group has the highest value. Males (10 to 12 yrs) have higher mean shimmer % compared to others. For females mean shimmer % is overall similar for all the age groups. The results are presented in Table 3 and displayed in Graph 3.

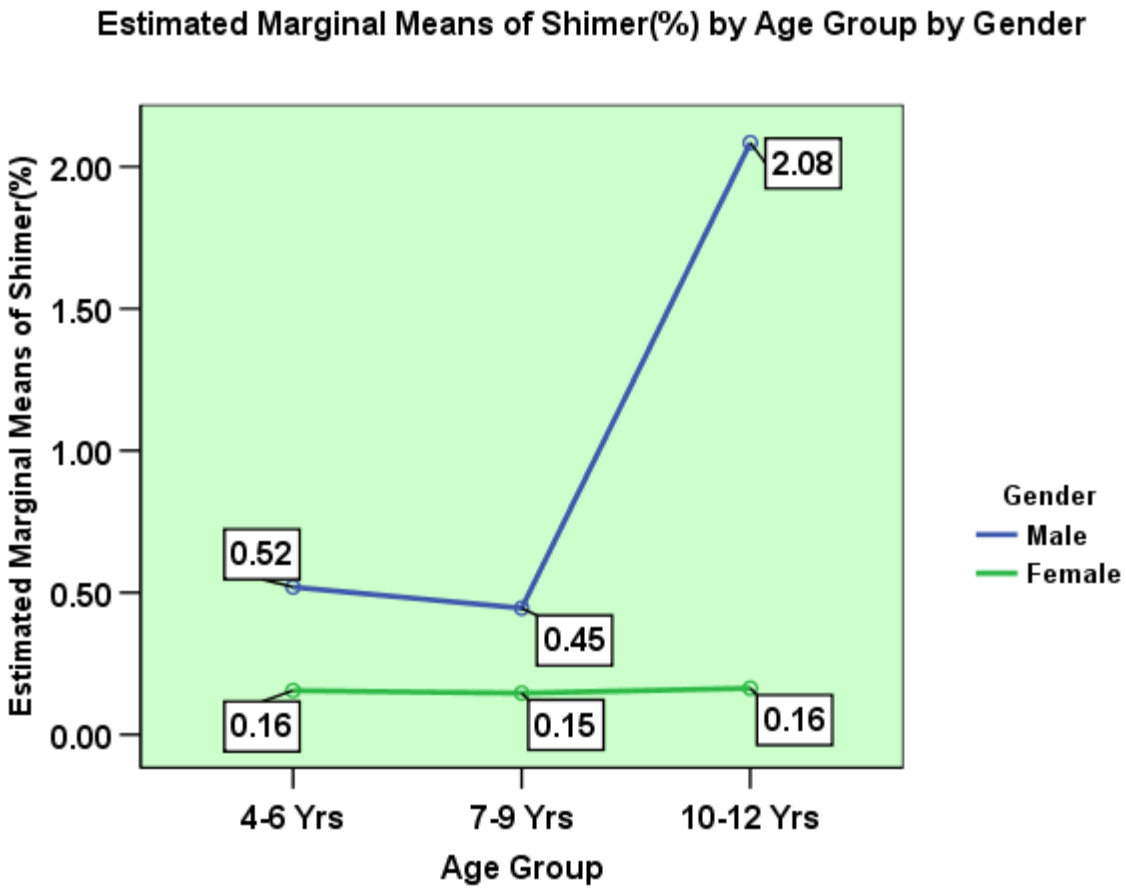
Table 3: Shimmer % and Standard Deviation for the age groups and across genders:

SHIMMER %				
Gender	Age Group	Mean	Std. Deviation	N
Male	4-6 Yrs	0.52	0.05	30
	7-9 Yrs	0.45	0.09	30
	10-12 Yrs	2.08	0.20	30
Female	4-6 Yrs	0.16	0.02	30
	7-9 Yrs	0.15	0.01	30
	10-12 Yrs	0.16	0.02	30

SHIMMER %- GENDER			
Gender	Mean	Lower Bound	Upper Bound
Male	1.02	1.00	1.04
Female	0.15	0.14	0.17

SHIMMER %- AGE GROUPS			
Gender	Mean	Lower Bound	Upper Bound
4-6 Yrs	0.34	0.31	0.36
7-9 Yrs	0.30	0.27	0.32
10-12 Yrs	1.12	1.10	1.15

Graph 3: Shimmer % across age groups and gender:



4. **Noise to Harmonic Ratio (NHR):** The mean overall NHR increases according to the age group. The overall mean NHR is lowest (0.116) for age group 7 to 9 yrs and overall similar for 4 to 6 yrs and 10 to 12 yrs. The mean overall NHR for males (0.13) is higher than that for females (0.11). The difference in this likely to be significant. Between-subjects statistics indicates that the main effect of gender is statistically significant, thus, the overall mean NHR for females (0.11) is lower than that for the males (0.13). Female age groups have lower NHR values than male age groups. These results are similar to those obtained by Nicholas et al., (2008). The results are presented in Table 4 and displayed in Graph 4.

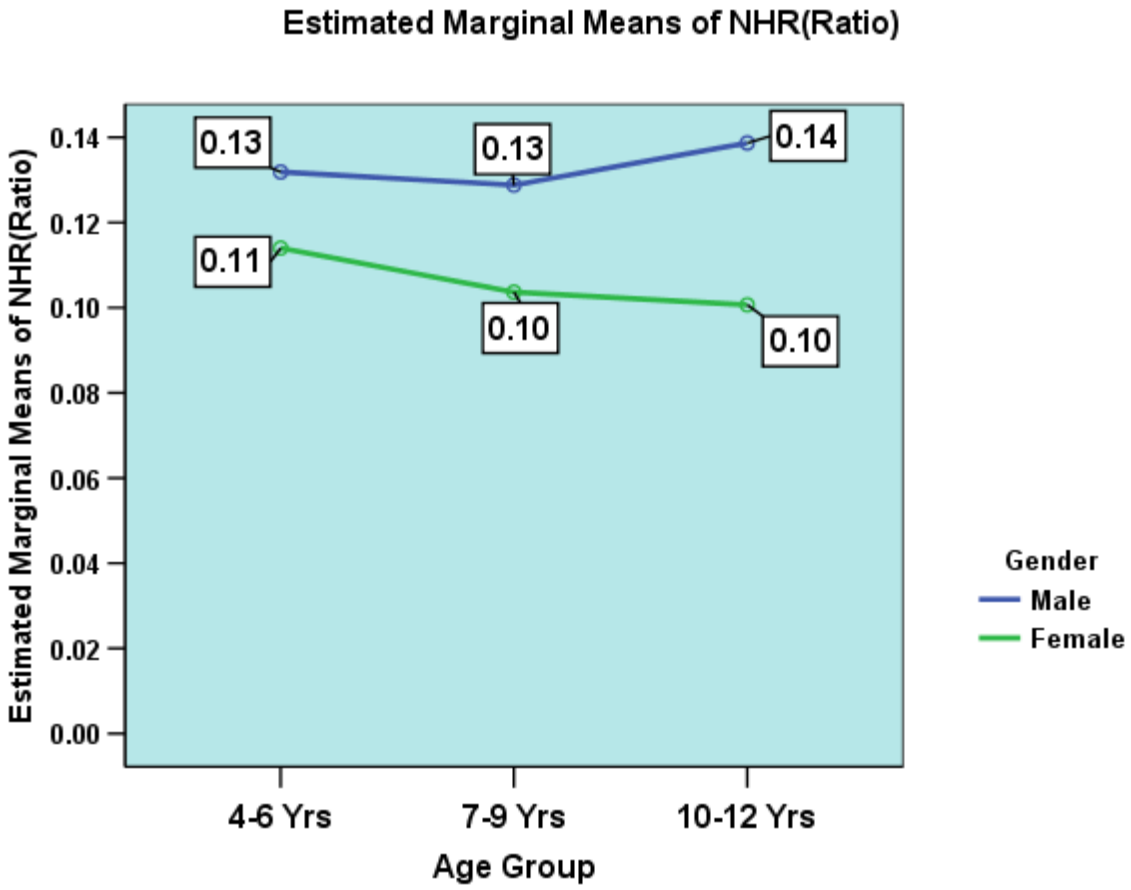
Table 4: Noise to Harmonic ratio (NHR) and Standard Deviation for the age groups and across genders:

NOISE TO HARMONIC RATIO (NHR)				
Gender	Age Group	Mean	Std. Deviation	N
Male	4-6 Yrs	0.13	0.004	30
	7-9 Yrs	0.13	0.005	30
	10-12 Yrs	0.14	0.013	30
Female	4-6 Yrs	0.11	0.010	30
	7-9 Yrs	0.10	0.009	30
	10-12 Yrs	0.10	0.009	30

NOISE TO HARMONIC RATIO (NHR)– GENDER			
Gender	Mean	Lower Bound	Upper Bound
Male	0.13	0.13	0.13
Female	0.11	0.10	0.11

NOISE TO HARMONIC RATIO (NHR)- AGE GROUPS			
Gender	Mean	Lower Bound	Upper Bound
4-6 Yrs	0.123	0.12	0.13
7-9 Yrs	0.116	0.11	0.12
10-12 Yrs	0.120	0.12	0.12

Graph 4: Noise to Harmonic ratio (NHR) across age groups and gender:



VI. SUMMARY AND CONCLUSIONS

By this study a small contribution is made in the description of voice patterns in children. This is a small prototype database which shows results similar to other Western and Middle Eastern studies. A distinct vocal profile of girls and boys is evident, with changes noted at different ages and with significant differences among various parameters between and within genders. To construct a representative database of normal children, we recommend the recruitment of large number of subjects, and many other acoustic parameters.

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