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Original Research Article

Voice profile of patients with laryngeal pathologies in Punjabi speaking Indian

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Abstract

Background: There are a number of pathologies leading to hoarseness. Factors like age, gender and race contribute in perception of voice in addition to disorders. The present study aims to compare the findings of various acoustic parameters between subjects with and without laryngeal pathologies and to compare the acoustic parameters in males and females in Punjabi speaking population.
Materials and Methods: A total of 500 subjects in the age group of 20-50 years was included under this study. Out of them 400 were in the study group having hoarse voice quality secondary to voice pathologies [glottic chink, chronic laryngitis, mass pathology on vocal folds (vocal nodules and vocal polyps) and vocal fold palsy] and 100 were in the age and gender matched control group. Voice analysis was done with /i/ vowel via computer with Dr Speech Software.
Results: The Jitter (%), Shimmer (%), SD Fo and Amplitude tremor were significantly higher in the study group (pathological voices), whereas the NNE, SNR and Ratio were significantly lower in the study group as compared to the control group. The Mean Fo of males is 132.23 Hz (125.48Hz-144.22 Hz) and females is 232.35 Hz (216.40 Hz-252.47 Hz) in Punjabi speaking Indian population (18-50 years). The females have significantly higher values in Normalized Noise Energy, HNR, Fo Tremor, and SNR in the control group.
Conclusion: Acoustic analysis of voice is an important tool to differentiate normal and pathological voices. This study helped in establishing the normal voice parameter ranges in Punjabi speaking adult population.

Keywords: Pathological voice, Acoustic voice analysis, Dr Speech, Punjabi speaking population, Normal voice parameters

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1. Introduction

Voice has been defined as "The laryngeal modulation of the pulmonary air stream, which is further modified by the configuration of the vocal tract".[1] Voice is important for daily communication production, which depends upon synchronous work by resonatory, phonatory and respiratory system. Deviation in any of these systems can lead to voice problems. In general population the prevalence of voice disorder in lifetime was reported to be 29.6%.[2] The prevalence of dysphonia in treatment seeking population was reported to be higher among females as compared to males (1.2% vs. 0.7%) and in those >70 years of age (2.5%). The most frequent causes were acute laryngitis, nonspecific dysphonia, benign vocal fold lesions, and chronic laryngitis.[3]

Hoarseness is a leading symptom of dysphonia and a sign of dysfunction of phonatory apparatus. Hoarseness is defined as a disorder characterized by altered vocal quality, pitch, loudness, or vocal effort that impairs communication or reduces voice related quality of life. There are a number of pathologies which can lead to this symptom and the most common are vocal cord nodules, laryngitis, paralysis, polyps, cysts and Reinke's Edema.[4-5] Glottic chink is caused due to an incomplete closure of the posterior vocal folds, with fairly good anterior glottal closure, associated with breathy dysphonia. Chronic laryngitis is a diffuse inflammatory condition symmetrically involving the whole larynx leading to hyperaemia of laryngeal structures in which the vocal cords appear dull, red and rounded. In mass pathologies, there are VC nodules and polyps. The nodules are bilaterally symmetrical benign extensions of the epithelium at the

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junction of the anterior one third and posterior two third of the true vocal folds. Vocal fold nodules interfere with the vibratory characteristics of the vocal folds by increasing the mass of the vocal folds and changing the configuration of the vocal fold closure pattern. The vocal polyps are benign extensions of the epithelium that appears on the free margins of the vocal folds secondary to vocal fold trauma. It appears as a fluid filled or blood engorged sessile or pedunculated mass and are found at the junction of anterior and middle one third of the vocal fold margin. The muscles which move the vocal cords are innervated by recurrent laryngeal nerve and superior laryngeal nerve (branches of CN X, Vagus nerve). In Vocal Cord Paralysis, there are lesions of these branches of vagus nerve leading to muscular weakness or paralysis of the vocal cords.

Traditionally, the visual inspection of larynx and subjective perceptual evaluation of voice quality was used to diagnose the laryngeal pathology. Perceptual assessment served as a standardized means of communication among clinicians. With advent of time, more objective procedures have come up, like Dr. Speech software, Multi-Dimensional Voice Program (MDVP), which display a variety of voice parameters from a single vocalization and also provide us with the quality estimates.

The parameters considered in computer based Dr. Speech software developed by Tiger DRS, USA are: Habitual fundamental frequency (Fo), Jitter percent, Shimmer percent, Fo tremor, Mean Fo, Standard deviation Fo, Minimum Fo, Maximum Fo, Normalised noise energy, Harmonic to noise energy, Signal noise ratio, Amplitude tremor, Ratio %. There are studies which present with the parameters that are most sensitive to differentiate between normal and dysphonic groups, e.g. in the study by Kumari,[6] normalized noise energy, maximum phonation time, mean fundamental frequency, maximum fundamental frequency and minimum fundamental frequency were the five sensitive variables and Dogan et al. reported fundamental frequency, soft phonation index, and jitter values as most sensitive parameters.[7]

2. Need for the Study

Hoarseness of voice due to various laryngeal pathologies can lead to deviation of acoustic parameters. Voice features also varies with the culture and race. Punjabi is the primary language of Punjab, India and is a native language of about 130 million people, and is ranked the 10th most widely spoken language in the world (2010 edition of the National encyclopedic). There is a dearth of research done specifically in the Punjabi speaking population. Hence, this necessitates to have a normative range of acoustic voice features and also differences with the pathological voices.

3. Aims

To compare the findings of various acoustic parameters between subjects with laryngeal pathology with age matched normal subjects and to compare the gender differences within the control group.

4. Materials and Methods

Study centre: The study was conducted at the Audiology and SLP unit of department of ENT.
Participants: A total of 500 subjects in the age group of 20-50 years were included under this study. Out of them 400 (Male- 203, Female-197) were in the study group and 100 (Male-45, Female-55) were in the age and gender matched control group. In the study group subjects having hoarse voice quality secondary to voice pathologies; glottis chink, chronic laryngitis, mass pathology on vocal folds [including unilateral (vocal polyps) & bilateral pathologies (vocal nodules)] and unilateral adductor vocal fold palsy, were taken.

4.1. Inclusion criteria

In Study group: Native Punjabi speakers (20-50 years) who were diagnosed to have any one of the four laryngeal pathologies during their first visit to the department of ENT were included. The Medishield Rigid 90 degree laryngoscope with distal light source was used for vocal cord visualization.
In Control group: Native Punjabi speakers (20-50 years) having no voice problem as reported by self were included in the study.

4.2. Exclusion criteria

Following subjects were excluded

1. Subjects having Upper respiratory tract infection at the time of the testing
2. Subjects with any speech and language problem (except voice problem)
3. Subjects with any systemic disorders and psychological problem
4. Subjects already undertaking voice therapy
5. Subjects with congenital laryngeal pathologies.
6. Subject with mass pathologies other than vocal nodules and polyps
7. Subjects with abductor vocal fold paralysis and bilateral adductor paralysis

Procedure: Acoustic analysis was done using Dr. Speech Version-5 developed by Tiger DRS, Inc. using Proton Boom 815 super Uni-directional microphone (positioned 15-20 cm away from the subject's mouth) in a sound free environment. The following parameters were assessed for /i/ vowel:

1.Habitual fundamental frequency (Fo)	8. Maximum Fo
2. Jitter percent	9. Normalised noise energy
3. Shimmer percent	10. Harmonic to noise energy
4. Fo tremor	11. Signal noise ratio
5. Mean Fo	12. Amplitude tremor
6. Standard deviation Fo	13. Maximum phonation time
7. Minimum Fo	14. s/z ratio
	15. Ratio %

4.3. Statistical analysis

Student's t-test was done in order to make comparisons between various parameters of the study as indicated objectives of the study. Probability (P) values <0.05 were considered significant.

Ethical Concerns: The protocol was approved by the institutes ethical committee. None of the subjects underwent any invasive or experimental procedures. Consent was obtained from the subjects. None of the procedures had known side-effects. Confidentiality was maintained. Results were communicated to the subjects. Subjects identified to have any abnormal results during the tests conducted were given appropriate guidance/services as required.

5. Results

In order to compare the voice parameters on Dr. Speech software, voices were analyzed between the study group (N=400) and the Control group (N=100). As shown in Table 1, the comparison is excluding the frequency related parameters, considering male and female voice differences. A statistically significant difference was obtained in all parameters except HNR.

The parameters including fundamental frequency of voice, were compared separately for females and males for study and control group as shown in **Table 2** and **Table 3** respectively. A statistically significant difference was observed in Max Fo in females, Mean Fo and Min Fo in males.

Table 1: shows Independent t-test result of the comparison of voice parameters between Control group (N=100) and Study group (N=400).

	Study group		**Control Group**			
Parameter	**Mean**	**SD**	**Mean**	**SD**	**t-value**	**p-value**
Jitter (%)	0.69	0.48	0.47	0.27	5.61	0.000**
Shimmer (%)	2.84	1.95	2.23	0.68	3.07	0.002**
SD Fo (Hz)	2.77	1.99	2.19	0.99	2.9525	0.003**
NNE (dB)	-9.23	8.25	-14.68	2.74	6.5126	0.000**
HNR (dB)	21.72	5.77	21.98	3.97	0.425	0.67
SNR (dB)	18.98	4.94	20.94	3.62	3.72	0.000**
Amplitude tremor (Hz)	3.54	2.89	1.89	0.8	5.65	0.000**
Ratio (%)	29.25	6.68	31.77	9.73	3.05	0.002**

Table 2: shows Independent t-test result of the comparison of voice parameters in females between Control group (N=55) and Study group (N=197).

	Study Group		**Control Group**			
	Mean	**SD**	**Mean**	**SD**	**t-value**	**p-value**
Habitual Fo (Hz)	234.08	28.27	232.61	35	0.3229	0.747
Fo Tremor (Hz)	3.66	4.1	4.75	4.77	1.66	0.094
Mean Fo (Hz)	231.79	32.74	232.35	34.27	0.111	0.912
Min Fo (Hz)	222	33.22	216.4	39	1.063	0.289
Max Fo (Hz)	238.48	37.18	252.47	27.39	2.599	**0.009****

Table 3: shows Independent t-test result of the comparison of voice parameters in males between Control group (N=45) and Study group (N=203)

	Study Group		**Control Group**			
	Mean	**SD**	**Mean**	**SD**	**t-value**	**p-value**
Habitual Fo (Hz)	143.46	27.2	132.23	30.13	2.4301	4.572
Fo Tremor (Hz)	2.69	2.78	2.52	3.1	0.79	0.468
Mean Fo (Hz)	149.07	33.63	132.23	30.15	3.0673	**0.002****
Min Fo (Hz)	144.39	34.03	125.48	28.75	3.4623	**0.001****
Max Fo (Hz)	153.56	35.56	144.22	39.81	1.556	0.1204

Comparison was done between males and females within the control group for the parameters not relating to fundamental frequency as shown in **Table 4**. Significantly statistical difference was seen in Normalized Noise Energy, HNR, Fo Tremor, and SNR between males and females.

Table 4: shows independent t-test result of the comparison of voice parameters between males (N=45) and females (N=55) in Control group.

	Male		**Female**			
Parameter	**Mean**	**SD**	**Mean**	**SD**	**t-value**	**p-value**
Habitual Fo (Hz)	132.23	30.13	232.61	35	15.1776	0.000**
Mean Fo (Hz)	132.23	30.15	232.35	34.27	15.3890	0.000**
Min Fo (Hz)	125.48	28.75	216.40	39	13.0076	0.000**
Max Fo (Hz)	144.22	39.81	252.47	27.39	16.0565	0.000**
Jitter (%)	0.58	0.97	0.48	0.32	0.7189	0.1
Shimmer (%)	2.20	.42	2.14	0.68	.5165	0.61
NNE (dB)	-5.95	4.81	-14.85	3.15	11.1197	0.000**
HNR (dB)	19.28	4.73	21.96	4.39	2.933	0.004**
Fo Tremor (Hz)	2.52	3.1	4.75	4.77	2.7025	0.008**
SNR (dB)	17.58	4.83	21.41	3.86	4.4081	0.000**
Amplitude Tremor (Hz)	1.83	1.81	1.84	0.79	0.0369	0.971
Ratio (%)	32.77	11.88	31.06	7.9	0.8604	0.392
SD Fo (Hz)	2.35	2.04	2.51	1.01	0.5106	0.611

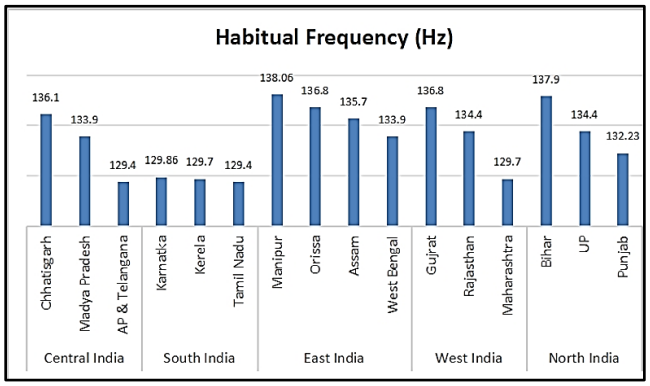

Figure 1: shows the habitual frequency (Hz) of male voice in different states of India

In order to compare the habitual frequency of Punjabi speaking population with other languages of India, the comparison has been displayed in **Figure 1** on the basis of already established data using the same Dr. Speech software. There is no established data for females of other languages.

6. Discussion

Among patients in general, the reported prevalence of dysphonia, with the cardinal symptom of hoarseness, is around 1% and the lifetime prevalence is approximately 30% as reported.[2-3] Hoarseness can result because of many laryngeal pathologies and affects the overall quality of life. In the present study, subjects of glottic chink, chronic laryngitis, mass pathology on vocal folds [including unilateral (vocal polyps) & bilateral pathologies (vocal nodules)] and unilateral adductor vocal fold palsy were taken in the study group.

While doing the comparison of Normal and Pathological voices, a statistical significant difference was seen in Jitter, Shimmer, SD Fo, NNE, SNR, Amplitude tremor and Ratio as shown in (**Table 1**). The Jitter (%), Shimmer (%), SD Fo and Amplitude tremor were significantly higher in the study group (pathological voices), whereas the NNE, SNR and Ratio were significantly lower in the study group as compared to the control group.

Jitter is the variation of fundamental frequency (period) of successive glottal pulses, and shimmer is the variation of amplitude of successive glottal pulses.[8] The F0 SD value reflects the overall unstable voice characteristics of the fundamental frequency.[9] In a study to compare the acoustic voice analysis of normal voices with patients with COVID-19, the results showed a notable difference in fundamental frequency variation (F0SD) between the healthy and infected participants, and an increased jitter and shimmer in both males and females.[10] The difference in SD Fo may arise from tremor and insufficient control over laryngeal muscles in the experimental group. In a study, it is reported that *Jitter* (%), *Shimmer* (%), *HNR*, *SNR*, *NNE*, *STD F0*, and *STD amplitude* are the seven parameters which suitably differentiate normal and disordered voices.[11] In another study to compare the acoustic parameters of Normal and pathological voices in Indian Population using Pratt Software, the values of jitter and shimmer local were significantly higher in the pathological voices and HNR had statistically significant lower values in pathological voices in comparison to normal voices.[12] Similarly Chacko et al also found significant difference in Jitter, Shimmer and HNR between the two groups.[13] Teixeira et al reported that the values of jitter and shimmer were significantly higher in the pathological group as compared to the control group and there was no significant difference seen in HNR in the two groups.[14] It has also been concluded by researchers that NNE is more sensitive than HNR in detecting the presence of glottal noise and is more

useful in comparing pathological voices from normal voices.[15] The findings of the present study in regard to Jitter, Shimmer, NNE, SNR, SD Fo are in compliance with the studies done previously, whereas not much literature is available for the study of Amplitude tremor, which is higher in the group of vocal cord pathologies.

When the frequencies of voice in study and control group were compared, in females the statistically significant difference was observed in Maximum Fo (higher in Control group); and in males significant difference was observed in Mean F0 and minimum Fo (higher in the study group). It is hence observed that the range of voice is reduced in both males and females of pathological group. Human voice is categorized by the F0 as it yields cues about age, sex and individual height and is related with vocal fold mechanisms such as length, mass and strain.[16] Voice is also a personal feature where no two voices are perfectly equal to each other. There are differences voices of various languages and ethnological background in both males and females.[12] The present study is done on Punjabi speaking Indian population, which has never been studied in the -past. In our study statistically significant differences in males and females acoustic voice parametrs of fundamental frequencies were observed as expected. The Mean Fo of males is 132.23 Hz (125.48Hz-144.22 Hz) and females is 232.35 Hz (216.40 Hz-252.47 Hz) in Punjabi speaking Indian population (18-50 years). Similar results were observed in the previous studies.[17-18] In a study done by Sachdeva et al in one of the state in India, the mean Fo in Adults males is 128 Hz and females is 225 Hz.19

No statistically significant difference was seen in Jitter, Shimmer, Amplitude Tremor, Ratio and SD Fo in males and females of the Control group. Significantly statistical difference was seen in Normalized Noise Energy, HNR, Fo Tremor, and SNR between males and females. The females have higher values in all the parameters significantly.

It was studied by the researcher that the HNR characterizes the relationship between the the acoustic wave of a sustained vowel (which includes the periodic component, vocal fold regular sign) and the additional noise coming from the vocal folds. This ratio was found to be significantly higher for females.[20] In a study done by Soni, HNR showed a statistically significant difference in the age group 18–25 in males and females.[18] In a study on Pakistani Adults, gender differences were significant in fundamental frequency, jitter, shimmer, and harmonics-to-noise ratio.[21] The study is in accordance with the earlier published works with gender differences in HNR, and not much literature was available with regard to NNE, Fo tremor and SNR. The values were withing normal range as per DR. Speech Software but statistically higher values were observed in females.

Habitual frequency is the frequency level of voice that is more frequently used during speech,[22] it is also the measurement of most frequent F0 (Mode F0). There is a role of cultural difference on habitual voice other than age and gender. In a study to establish normative data for adult Male Indian population across India, data was collected from 15 states of India as shown in (**Figure 1**), excluding Punjab.[23] It was reported that there was no statistically significant difference found in Habitual frequency of different languages but the South Indian states have the lowest Habitual frequencies as compared to other states of India. As per literature, the mean speaking frequency is at 100–120 Hz in males and is approximately one octave above in males which is mean speaking frequency at 200–220 Hz.[24] However, if compared to the Indian Population, the frequency is slightly higher in males in all the states of India as compared to the established data.

7. Conclusion

Acoustic analysis of voice is an important tool to differentiate normal and pathological voices. There is an importance of establishing normal standards of acoustic parameters as there is a wide range within normal voices. This study helped in establishing the normal voice parameter ranges along with comparison to the pathological voices in Punjabi speaking adult Indian population.

8. Conflict of Interest

None.

9. Source of Funding

None.

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