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Original Research Article

A comparative study of the vocal parameters between hypofunctional and hyperfunctional dysphonia using perceptual and cepstral spectral index of dysphonia measures

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ABSTRACT

Background: The main goal of the present study was to obtain the cepstral spectral index of dysphonia (CSID) scores for normophonic, hypo-functional dysphonic and hyper-functional dysphonic Indian population along with correlation of CSID and GRBAS scores for normophonic, hypo-functional dysphonic and hyper-functional dysphonic population using sustained production of vowel and oral passage of Bengali language.
Methods: A total of 60 participants between 20-50 years were selected for the study. The participants were divided into three groups viz., 30 normal subjects, 15 subjects with hypofunctional dysphonia and 15 subjects with hyperfunctional dysphonia. The subjects were screened for speech and hearing defects. Recordings of sustained vowels and passage were done and then fed to measure CSID through PRAAT and software developed by C-DAC. Statistical analyses were done for the analyzed data using SPSS.
Results: Significant differences ($p<0.05$) were found in CSID scores across hypofunctional dysphonia group and hyperfunctional dysphonia group when compared to normophonia group. There were no significant differences ($p>0.05$) between hypofunctional and hyperfunctional dysphonia group in CSID score. A significantly strong correlation of CSID scores with the 'G' rating of GRBAS scores ($p<0.01$) were found for both hypofunctional dysphonia and hyperfunctional dysphonia groups. ROC analysis showed high sensitivity and specificity of CSID scores in two dysphonia groups with respect to normophonia group.
Conclusions: The current study revealed significant differences obtained in CSID scores across normophonia, hypofunctional dysphonia and hyperfunctional dysphonia groups suggesting it as assessment tool to determine the presence of dysphonia.

Keywords: Normophonia, Hypofunctional dysphonia, Hyperfunctional dysphonia, CSID

INTRODUCTION

Every individual has a distinct voice.[1] As per definition of American speech and hearing association (ASHA) dysphonia is defined as any deviation in pitch, quality/ loudness of voice when contrast to that ofother people of same age, gender, geographical region.[2] Hypofunctional dysphonia is an outcomeof an incomplete glottal closure and hyperfunctional dysphonia arises as consequence of voice abuse or misuse.[3,4] Perceptual assessment is core foundation for voice evaluation and for treatment outcomes.[5] To assess severity and type of dysphonia both perceptual and objective methods have been used. GRBAS used for perceptual evaluation of voice.[5,6] CSID is used for acoustic analysis of voice. It is multivariate acoustic measure of voice incorporating both spectral and cepstral parameters for dysphonia.[7] CSID extracted using PRAAT software and in house developedsoftware by C-DAC.[8] Acoustic variables for CSID cepstral peak prominence (CPP), low/ high (L/H) or spectral ratio (ratio of spectral energy <4 kHz) denoted as SR and standard deviation of L/H spectral ratio (σ SR). This is calculated as: CSID=154.59-(10.39×CPP)-(1.8×SR)-(3.79×σSR)

The aim of the study is to compare the vocal parameters between the three groups- normophonia, hypofunctional dysphonia and hyperfunctional dysphonia using GRBAS. The GRBAS was rated by three experienced speech language pathologists. CSID measures were obtained using PRAAT and the software developed by C-DAC.

METHOD

Comparative ex post facto research design was used for this study. The study was carried out across March 2019 to September 2019. A total of 60 participants within age range 20-50 years (mean=39.12 years; SD=8.56), were selected. Sample size was calculated using the formula-

$$S=Z^2 \times P \times \frac{(1-P)}{M^2}$$

Table 1: Demographic data of participants.

Participants	N	Mean age (Years)	SD
Normophonia	30	33.56	±11.8
Hypofunctional dysphonia	15	44.2	±6.86
Hyperfunctional dysphonia	15	39.6	±7.04

Written consent was obtained from all the participants. Ethical clearance was obtained from the research committee of the institute. Participants with normal cognition, speech and language ability as well as hearing and vision with the basic education of 10th class were included. Participants having cognitive problem, abnormal oro peripheral mechanism or any co morbidities were excluded. The participants were divided into three groups, one group were consisting of 30 (mean=33.56 years, SD=11.80) subjects with normophonia, another group consisting of 15 (mean=44.2 years, SD=6.86) subjects with hypo- functional dysphonia and 15 (mean=39.6 years, SD=7.04) subjects with hyper-functionaldysphonia, irrespective of gender.

PRAAT software, version 6.1.03 was used to measure CPP in CSID.[9] Software developed by C-DAC measures L/H spectral ratio, standard deviation of L/H ratio using C programming. Voice samples of subjects were recorded with high-quality unidirectional microphone in an acoustically treated room. Distance between microphone and the participant's mouth was 4-6 cm.[10] Voice recordings digitized at sampling frequency of 44.1 Hz and 16 bits/sample quantization. GRBAS scale used for subjective assessment of voice parameters. Materials used for study were sustained vowels /a/ /i/ /u/ for 5 sec where stable middle 3 second portion extracted and oral passage in Bengali which contains oral consonants with mean nasalance score 12.780 and SD 3.8127 respectively, trans-adapted from English for reading.[11]

Statistical analyses

Data was subjected to Shapiro-Wilks test for normality. The results revealed the given data was significantly deviating from normal distribution (p>0.05). Measures of central tendency (arithmetic mean) and dispersion (standard deviation) and median were undertaken for CSID in each groups and across the groups. A non-parametric Kruskal-Wallis test was carried out to see the significant difference across the groups. Mann-Whitney U test was carried out to see the pair-wise significant difference between the groups. The reliability test Cronbach's Alpha was carried out to see the reliability across 3 raters. The non-parametric Spearman rank correlation was carried out to see the correlation between the parameters and the GRBAS.

RESULTS

Statistical analysis has been performed using SPSS (version 20.0). Data was subjected to Shapiro-Wilks test for normality. The results revealed the given data was significantly deviating from normal distribution (p>0.05).

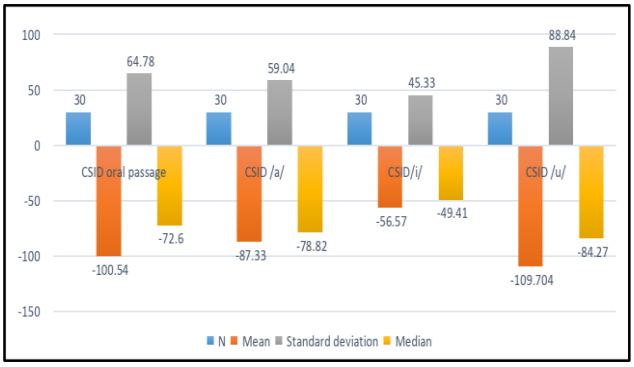

Figure 1: Distribution of CSID score in individuals with normophonia.

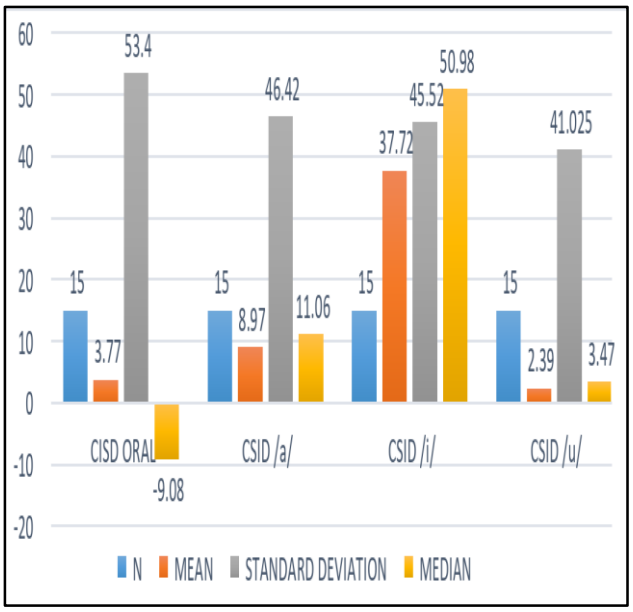

Figure 2: Distribution of the CSID score in subjects with hypofunctional dysphonia.

A nonparametric Kruskal Wallis H test was performed to see the inter group difference i.e., between normophonia, hypo functional dyphonia and hyper function dysphonia in GRBAS and CSID scores. Further, Mann Whitney U test was performed to see the pair wise difference between the groups.

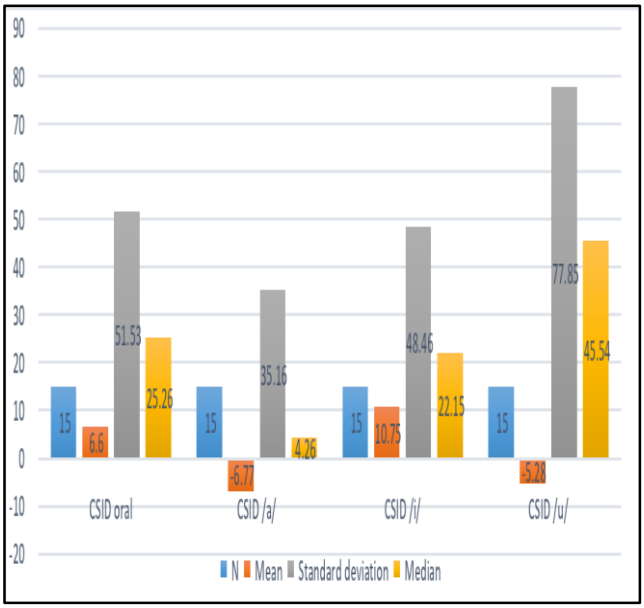

Figure 3: Distribution of the CSID score in subjects with hyperfunctional dysphonia.

Table 2: Results of Kruskal Wallis H test w.r.t change in GRBAS and CSID scores across oral passage and vowels (/a/, /i/, /u/) across groups.

Groups		N	Mean rank	χ^2	P value
GRBAS oral passage	Normophonia	30	18.28	33.34	0.000*
	Hypofunctional dysphonia	15	40.80		
	Hyperfunctional dysphonia	15	44.63		
CSID oral passage	Normophonia	30	17.87	31.439	0.000*
	Hypofunctional dysphonia	15	42.60		
	Hyperfunctional dysphonia	15	43.67		
GRBAS /a/	Normophonia	30	20.17	27.716	0.000*
	Hypofunctional dysphonia	15	42.67		
	Hyperfunctional dysphonia	15	39.00		
CSID /a/	Normophonia	30	17.87	31.736	0.000*
	Hypofunctional dysphonia	15	44.93		
	Hyperfunctional dysphonia	15	41.33		
GRBAS /i/	Normophonia	30	20.45	37.093	0.000*
	Hypofunctional dysphonia	15	40.60		
	Hyperfunctional dysphonia	15	44.80		
CSID /i/	Normophonia	30	20.45	20.037	0.000*
	Hypofunctional dysphonia	15	41.83		
	Hyperfunctional dysphonia	15	39.27		
GRBAS /u/	Normophonia	30	18.78	34.148	0.000*
	Hypofunctional dysphonia	15	41.90		
	Hyperfunctional dysphonia	15	42.53		
CSID /u/	Normophonia	30	17.35	34.167	0.000*
	Hypofunctional dysphonia	15	44.83		
	Hyperfunctional dysphonia	15	42.47		

*Significant at 0.05 level, n=60. There was significant difference in GRBAS and CSID score in normophonia, hypofunctional dysphonia and hyperfunctional dysphonia subjects.

Table 3: Mann Whitney U test results for pair-wise comparison between normophonia and hypofunctional dysphonia groups.

Groups		Mean rank	Mann-Whitney U	Z value	P value
GRBAS oral passage	Normophonia	17.27	53.00	4.692	0.000*
	Hypofunctional dysphonia	34.47			
CSID oral passage	Normophonia	16.73	37.00	4.528	0.000*
	Hypofunctional dysphonia	35.53			
GRBAS /a/	Normophonia	17.33	51.5	4.179	0.000*
	Hypofunctional dysphonia	34.33			
CSID /a/	Normophonia	16.65	34.50	4.589	0.000*
	Hypofunctional dysphonia	35.70			
GRBAS /i/	Normophonia	17.20	51.50	5.132	0.000*
	Hypofunctional dysphonia	34.60			
CSID /i/	Normophonia	17.90	72.00	3.685	0.000*
	Hypofunctional dysphonia	33.20			
GRBAS /u/	Normophonia	17.20	49.50	5.297	0.000*
	Hypofunctional dysphonia	34.60			
CSID /u/	Normophonia	16.13	72.00	3.685	0.000*
	Hypofunctional dysphonia	36.73			

*Significant at 0.05 level, n=60. There was significant difference in CSID scores and GRBAS scores between normophonia and hypofunctional dysphonia subjects.

Table 4: Mann Whitney U test results for pair-wise comparison between normophonia and hyperfunctional dysphonia groups.

Groups		Mean rank	Mann-Whitney U	Z value	P value
GRBAS oral passage	Normophonia	16.52	30.50	5.224	0.000*
	Hyperfunctional dysphonia	35.97			
CSID oral passage	Normophonia	16.63	34.00	4.601	0.000*
	Hyperfunctional dysphonia	35.73			
GRBAS /a/	Normophonia	18.33	85.00	4.346	0.000*
	Hyperfunctional dysphonia	32.33			
CSID /a/	Normophonia	16.65	36.50	4.540	0.000*
	Hyperfunctional dysphonia	35.70			
GRBAS /i/	Normophonia	16.60	33.00	5.569	0.000*
	Hyperfunctional dysphonia	35.80			
CSID /i/	Normophonia	17.97	74.00	3.636	0.000*
	Hyperfunctional dysphonia	33.07			
GRBAS /u/	Normophonia	16.72	49.00	5.308	0.000*
	Hyperfunctional dysphonia	35.57			
CSID /u/	Normophonia	20.17	36.50	4.539	0.000*
	Hyperfunctional dysphonia	28.67			

*Significant at 0.05 level, n=60. There was significant difference in CSID scores between subjects with normophonia and subjectswith hyperfunctional dysphonia.

Table 5: Mann Whitney U test results for pair-wise comparison between hypofunctionaldysphonia and hyperfunctional dysphonia groups.

Groups		Mean rank	Mann-Whitney U	Z value	P value
GRBAS oral passage	Hypofunctional dysphonia	14.33	95.00	0.741	0.459
	Hyperfunctional dysphonia	16.67			
CSID oral passage	Hypofunctional dysphonia	15.07	106.00	0.270	0.787
	Hyperfunctional dysphonia	15.93			
GRBAS /a/	Hypofunctional dysphonia	16.23	101.50	0.476	0.634
	Hyperfunctional dysphonia	14.77			
CSID /a/	Hypofunctional dysphonia	17.13	88.00	1.017	0.309
	Hyperfunctional dysphonia	13.87			

Continued.

Groups		Mean rank	Mann-Whitney U	Z value	P value
GRBAS /i/	Hypofunctional dysphonia	14.07	91.00	1.035	0.300
	Hyperfunctional dysphonia	16.93			
CSID /i/	Hypofunctional dysphonia	14.07	91.00	0.892	0.372
	Hyperfunctional dysphonia	16.93			
GRBAS /u/	Hypofunctional dysphonia	15.90	106.50	0.255	0.799
	Hyperfunctional dysphonia	15.10			
CSID /u/	Hypofunctional dysphonia	16.20	102.00	0.436	0.663
	Hyperfunctional dysphonia	14.80			

*Significant at 0.05 level, n=60.

Cronbach's alpha for the reliability across three raters for perceptual rating of hypo-functional-dysphonia was 0.945 and for hyper-functional dysphonia was 0.728 which is greater than 0.70.

Table 6: Spearman rank correlation between CSID scores and GRBAS scores across hypofunctional, normal and hyperfunctional groups for oral passage and vowels (/a/,/i/,/u/).

'G' GRBAS and CSID scores	Hypo functional	Normal	Hyper functional
For oral passage	0.713	0.518	0.866
For vowel /a/	0.922	0.591	0.910
For vowel /i/	0.799	0.476	0.778
For vowel /u/	0.840	0.521	0.910

There was significant correlation between CSID scores and GRBAS scale in subjects with hypofunctional dysphonia.

In hypofunctional dysphonia group ROC analysis of CSID score in oral passage showed sensitivity index of 86.7% and specificity index 86.7% with approx. cut off-47.82.

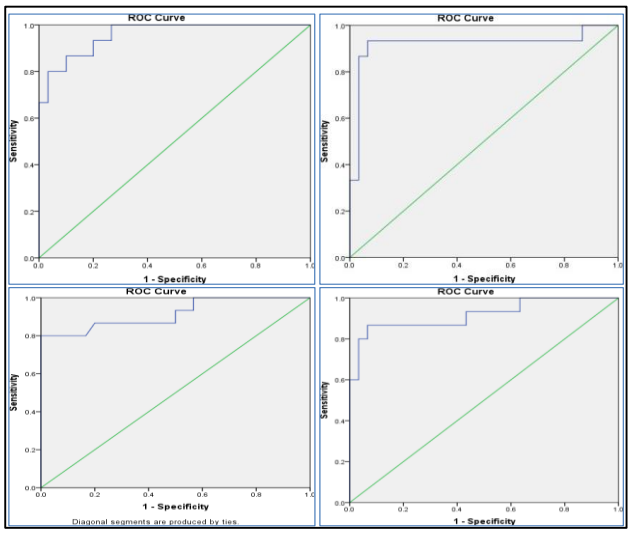

Figure 4: Sensitivity, specificity of CSID in hypofunctionaldysphonia for/u/, /i/, oral passage and /a/ (clockwise starting from top left).

The area under the ROC curve using mean G as the state variable (mean G=0 showed normal voice quality, mean G>0 indicating disrupted voice quality) and CSID score in oral passage as the test variable was 0.918 (95% CI: 0.819-1.000, p<0.001).

ROC analysis of CSID in sustained vowel /a/ sensitivity was found to be 86.7% and specificity was 80%, with approximated cut off -45.30 in hypofunctional dysphonia group and CSID score in sustained vowel /a/ as the test variable was 0.921 (95% CI: 0.828-1.000, p<0.001).ROC analysis of CSID in sustained vowel /i/ sensitivity was found to be 93.3 % and specificity was 86.7% with approximated cut off -28.14 in hypofunctional dysphonia group and CSID score in sustained vowel /i/ as the test variable was 0.920 (95% CI: 0.805-1.000, p<0.001).

ROC analysis of CSID in sustained vowel /u/ highlighted sensitivity of 93.3 % and specificity of 80%, with approximated cut off -55.97 in hypofunctional dysphonia group and CSID score in sustained vowel /u/ as the test variable was 0.958 (95% CI: 0.905-1.000, p<0.001).

In hyperfunctional dysphonia group ROC analysis of CSID score in oral passage showed sensitivity of 93.3%, specificity of 83.3%, with approximated cut off -51.72.

The area under the ROC (AUC) using mean G as the state variable (meanG=0 suggested normal voice quality, mean G>0 indicating disrupted voice quality) and CSID score in oral passage as the test variable was 0.924 (95% CI: 0.840-1.000, p<0.001).

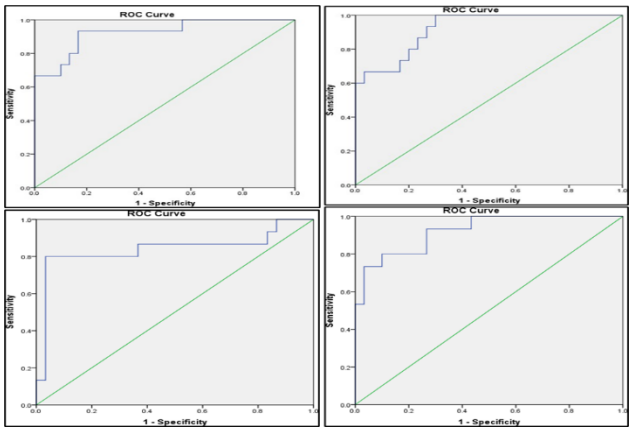

Figure 5: Sensitivity, specificity of the CSID in hyperfunctional dysphonia for oral passage, /a/,/u/ and /i/(clockwise starting from top left).

In hyperfunctional dysphonia group ROC analysis of CSID score in sustained vowel /a/showed sensitivity of 86.7%, specificity of 76.3%, with approximate cut off -50.77 andCSID score in oral passage as the test variable was 0.924 (95% CI: 0.840-1.000, p<0.001).

In hyperfunctional dysphonia group ROC analysis of CSID score in sustained vowel /i/ showed sensitivity was 80%, specificity was 76.3%, with approximate cut off -36.75 and CSID score in sustained vowel /i/ as the test variable was 0.840 (95% CI: 0.686-0.994, p<0.001)

In hyperfunctional dysphonia group ROC analysis of CSID score in sustained vowel /u/ showed sensitivity was 93.3%, specificity was found to be 73.3%, with approximate cut off -64.74 and CSID score in sustained vowel /i/ as the test variable was 0.918 (95% CI: 0.835-1.000, p<0.001)

DISCUSSION

This particular study aimed to compare CSID between hypofunctional dysphonic with hyperfunctional dysphonic subjects. Watts and Awan showedthe mean CSID score in dysphonic group was much higher than that of control groups which is corroborated in the present study.[12] The Kruskal Wallis H test results showed significant differences among all the three groups in CSID and GRBAS scores. Mann Whitney U test showed significant differences in CSID and in GRBAS with p=0.000 (p<0.05) in oral passage and sustained vowels /a/, /i/ and /u/ between normophonic and hypofunctional dysphonic groups. Similar findings were highlighted between the normophonic and hyperfunctional dysphonic group (p=0.000). The hypofunctional dysphonic and hyperfunctional dysphonic group revealed no significant differences in CSID and GRBAS scores.

Correlating the CSID score with perceptual rating scale (GRBAS) was done using Spearman's rank correlation Coefficient. From that analysis it was found that in hypofunctional dysphonic and hyperfunctional dysphonic group CSID scores has a significant correlation with 'G' in GRBAS.[13] CSID in hypofunctional dysphonia group and hyperfunctional dysphonia group showed high sensitivity andspecificity in continuous speech context as well as in sustained vowels /a/, /i/, /u/ A study reported CSID showed higher scores for connected speech than sustained vowels which are not in accordance to the present study.[14]

Limitation

The results obtained in the study lend support to the proposition that any voice assessment should encompass objective, subjective, and quality-of-life measures (Carding, 2000). This study lacked the use of quality-of-life measures or any self-rating questionnaire for group and assessment of hypofunctional dysphonia hyperfunctional dysphonia group. In the present study, the vocal parameters did not account for gender difference. Several studies of CSID incorporate different algorithms to measure CSID scores and latest algorithm given by Awan was taken to measure CSID scores in this study.

CONCLUSION

The present study was successful to highlight the changes in components of voice based on CSID and GRBAS. Significant differences were obtained across the normal and dysphonic groups based on the stimuli used. Both CSID and GRBAS provide a complete understanding of the assessment of voice with respect to perceptual and acoustic analysis. This thereby helps us conclude that CSID along with GRBAS can be effective to mark the outcome of voice therapy with comparison of preand post therapy voice profiles.

The CSID can be used as a tool for comparison between the pre and post therapeutic outcome measurement for dysphonic subjects.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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