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A COMPARATIVE STUDY ON VOICE RANGE PROFILE (VRP) AND SPEECH RANGE PROFILE (SRP) IN ADULTS WITH AND WITHOUT VOCAL NODULES

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Abstract:
Vocal sound is based on the complex yet co-ordinated interaction of phonatory system, resonatory system and respiratory system. The present study had the objective to determine the voice range profile and speech range profile in normophonic and dysphonic adult speakers with vocal nodule.
15 Male and 15 Female subjects' age range between 20-40 years were considered in both normophonic and dysphonic groups. These subjects were screened for voice separately through VHI, GRBAS, Dr Speech analysis(Version 4) and vocal folds visual inspection done by strobovediolaryngoscopy (KayPentax, 9400).
Both groups were asked to phonate /a/ to register VRP and SRP from low to high pitch. Speaking Voice (SV) was determined by reading 20 sentences in Bengali language at a habitual pitch. The ShV (Shouting voice) was obtained by asking patients to say /ehi/ twice as loud as they could. The various parameters such as fundamental frequency, maximum and minimum frequency, SPL range, maximum and minimum intensity and area for VRP and SRP were recorded by using phonetogram software Dr speech (Version 4).
The statistical analysis was done and central tendency(mean) was used for measuring the mean of age range. t-test was conducted to evaluate significant difference of VRP and SRP between normophonic and dysphonic subjects for all eight parameters.
As a result, a significant difference was found in VRP and SRP between normophonic and dysphonic groups. From the result, In VRP, the p-value of frequency parameters (Male and Female) was <0.0001, p-value of intensity parameters (Male and Female) were 0.137 (SPL Range), 0.0001 (I max), 0.0002 (I min),p-value of area parameters (Male and Female) was 0.1206, and p-value of semitones parameters (Male and Female) was 0.0015. From the result, in SRP, the frequency parameters of SRP, p-value was <.0001.
In conclusion SRP procedure was easier and faster to administer than VRP. Normophonic group shown reliable changes in frequency and intensity while doing VRP, they were able to maintain the lowest and highest frequency with respect to loudness. VRP and SRP values were predominantly higher in normophonic than dysphonic group in both male and female, except fundamental frequency.

Keywords:- Phonetogram, Voice Range Profile, Speech Range Profile, Vocal Nodule.

INTRODUCTION

The voice is unique and complex in the entire human being and it is the root of human verbal communication. It plays a key role in humans to express their emotions.
Basically, the process behind the generating voice can be classified into three parts; the lungs, the vocal folds and the articulators (Zemlin,2011)[1].

The voice is an integral part of that uniquely human attribute known as speech. The larynx and its capabilities are important in two broad areas: biological function and speech. (Bateman, 1984)[2].
Hence, the voice is a powerful tool that not only delivers the message but also adds to its meaning. By the age 18yrs or so, the voice reaches its mature or adult stage.

The fundamental frequency is where it will remain for several decades. The individual has full control over the dynamic range(loudness) of the voice and can produce many variations of pitch and voice quality. These vocal abilities reflect the maturation of the anatomical and physiological systems for the support of speech (Kahane,1982)[3].

Phonetography is accessible and readily available tool in research field which helps in measuring the potentiality of voice output (Klingholz and Martin, 1983)[4].

The speech range profile, or what is sometimes referred to as an habitual or speech Voice Range Profile (VRP),distinguishes itself from the physiological Voice Range Profile (VRP) recording in that it specifically aims at recording continuous speech.

This type of phonetographic recording was introduced quite early, with the appearance of the computerised phonetograph. Ma et al. (2006)[5] concluded that speech range profile (SRP) would be an acceptable alternative to traditional Voice Range Profile (VRP) for screening the presence of dysphonic in a busy clinic where quick screening results are desirable.

It is clear from the above studies that Speech Range Profile(SRP) has a potential for clinical application. Chatterjee, Halder, Bari, Kumar,and Roychoudhary (2011)[6] administered a study which was aimed to analyze the change in acoustic parameters based upon age and gender effects and to obtain normal voice range profile (VRP) of adult male and female of three different age range.

METHODOLOGY

Descriptive survey with Expost-facto research design was used. For this study, samples were taken from normal population and voice problem cases.

A total number of 60 participants, aged between 20 to 40 years were taken for the study. The subjects were divided into two groups. Among them, 30 were normal and other 30 were dysphonic.

Group I: This group included 30 normophonic subjects (mean age= 25.6, SD ± 5.6) in which 15 subjects (mean age=26.8, SD ± 3.2) were male and 15 subjects (mean age =24.9, SD± 5.8) were female. The Normophonic subjects were having a Voice Handicapped Index (VHI) score of ≤ 20 with no vocal pathology found in Strobovideolaryngoscopy(Kay PENTAX, Laryngeal strobe, model 9400) and normal voice parameters were found in Dr. Speech analysis.

The inclusion criterias followed for Group I were, the normophonic subjects were untrained singer and non-professional voice users, no regular medication which will affect voice, did not have any chronic medical problem for the last 6 months, having no any respiratory tract infection, no hormonal, psychogenic and neurological voice disorder, no any recent history of common cold and throat infection, no having history of smoking or regular consumption of alcohol, proficient in speaking and reading Bengali language, did not have under gone any laryngeal and neck surgery.

The exclusion criterias for Group I, were the normophonic subjects were having normal hearing sensitivity as defined by pure tone threshold at frequency from 0.25 to 8 KHz (≤ 20 dB HL) and were excluded from the influence of menstrual cycle.

Group II: This group included 30(mean age= 27.9, SD±8.7) dysphonic subjects in which 15 subjects (mean age= 27, SD±2.8) were male and 15 subjects (mean age 26.5±4.1) were female.

The inclusion criterias for Group II were the Dysphonic subjects were having bilateral vocal nodule which diagnosed by using Strobovediolaryngoscopy(Kay PENTAX, Laryngeal strobe, model 9400) with Voice Handicapped Index score of > 20 and predominantly hoarseness were found in Dr. Speech analysis and GRABAS (Hirano et al 1981)who have not taken speech therapy, not taking speech/voice therapy, should be untrained singer and non-professional voice users, not on regular medication which will affect voice, did not have any chronic medical problem for the last 6 months, no any respiratory tract infection, having normal hearing sensitivity as defined by pure tone threshold at frequency from 0.25 to 8 KHz (≤ 20 dB HL), did not have under gone any laryngeal and neck surgery, no any recent history of common cold and throat infection, no history of smoking or regular consumption of alcohol, proficient in speaking and reading Bengali language, were able to follow the proper changes in the voice from lowest pitch to highest pitch for Voice Range Profile (VRP).

The Exclusion criterias for Group II were the Dysphonic subjects were not having hormonal, psychogenic and neurological voice disorders and were excluded from the influence of menstrual cycle. Instruments were used Dr. Speech Phonetogram version 4 (Tiger DRS, Inc., 1998), MAX CM- 903 Electret Condenser microphone , RadioShack USA Model No: - 33-2055) sound level meter. Phonetographic recommendations by the Union of European Phoniatricians (UEP) (Schutte and Seidner, 1983)14 were followed.

The microphone with omidirectional characteristics was placed at the angle of 45 degree at the distance of the 30 cm from the speaker's mouth. The commonly present surrounding noise should not exceed 40 dB (A).

Measurements were done in a room with moderately damped vibrations. Phonetograms were registered at speech science laboratory of Ali Yavar Jung National Institute for the Hearing Handicapped, Eastern Regional Centre, Kolkata.

The microphone collects the voice sample and sends it via the sound card in a digitized form whereupon the software, using a default algorithm, extracts the metrics from the sample and creates the phonetogram which is displayed on the screen.

An automated procedure was used to measure the Voice Range Profile(VRP) of the subjects. Subjects were instructed to phonate a sustained vowel/a/ as soft and as loud as possible from the lowest to the highest frequencies.

Before recording, subjects were asked to practice pitch gliding for at least three times for vocal warming-up to facilitate the production of maximum vocal performance. The low Voice Range profile(VRP) intensity contour was measured first followed by measurement of their upper intensity contour. Low loudness was obtained without whispering, while the maximum loudness was reached without causing any kind of discomfort in the throat.

In order to motivate patients to perform to their maximum capacity, the investigator provided verbal support and auditory examples if needed so.

The Voice Range profile (VRP) was measured twice for each intensity contour. The required time to obtain the Voice Range profile (VRP) was approximately 20 min.

The following parameters were analyzed: Lowest Frequency (Fmin, Hz), Highest Frequency (Fmax, Hz), number of Semitones (ST) and Minimum Intensity (Imin, dB SPL), Fundamental Frequency (F0), Maximum Intensity (Imax,dB SPL).

In order to obtain the SRP, the Speaking Voice (SV) and Shouting Voice (ShV) were recorded. The SV was carried out by asking subjects to read aloud twice 20 sentences at their most comfortable pitch and loudness as in daily conversation. Subjects were allowed to practice reading the sentences aloud before actual recording.

The sentences chosen were characterized by different prosodic features (i.e.: interrogative, affirmative, exclamatory) and they expressed different feelings (i.e.: happiness, angry, sadness, disbelief, disappointment). The ShV (Shouting voice) was obtained by asking patients to say /ehi/ twice as loud as they could. The examiner provided suggestions such as "Imagine being in a street where there is a lot of traffic noise, you have to call someone who is away from you, on the other side of the street" in case the subject could not understand exactly how to say /ehi/.

Three initial trials were done before the recording for facilitation of the subjects. Overall, the recording time to obtain the SRP was approximately 10 minutes for individual subject. To test the repeatability of the SRP, it was recorded three times in 30 randomly selected subjects (30 subjects of control group and 30 subjects of dysphonic group).

Each test was performed after one hour from the other.

The parameters analyzed in the SRP were: Lowest Frequency (Fmin, Hz), Highest Frequency (Fmax, Hz), number of Semitones (ST) and Minimum Intensity (Imin, dB SPL), Fundamental Frequency (F0), Maximum Intensity (Imax, dB SPL).

The collected was saved into the Microsoft excel (2007) for statistical analysis & for preparing tables and graphs. In Statistical analysis, Central tendency (mean) was used for measuring the mean of age range. Standard deviation was calculated for measuring the standard deviation (S.D). t-test (p-values) was conducted to evaluate significant difference of VRP and SRP between normophonic and dysphonic subjects for all eight parameters. (SAS software 9.2 version). This analysis was done for getting results on values of VRP and SRP for normophonic and dysphonic males and females individually.

RESULTS AND DISCUSSION

The aim of present study were to compare result across two group of subjects i.e. normophonic and dysphonic adult speakers with respects by using Voice Range Profile (VRP) and Speech Range Profile (SRP) and compare the results between male and female groups in between normophonic male and female, dysphonic male and female by using voice range profile (VRP) and Speech Range Profile (SRP).

For many years, VRP was a used in a classification of singing voice and diagnosis of dysodia (Siupsinskiene, 2003)[7]. Nevertheless, due to the ease of handling and it provides visual results, over time VRP has become widely used to check the frequency range of phonation even in non- professional voice users. . As widely accepted in the literature, the critical points of a phonetogram are the highest and lowest frequencies and the softest intensity (Wuyts et al., 1998, Heyning 2000, Molenberghs 2000)[8]. However, even if these three points may reflect the individual's a physiological vocal limit or capacity, several authors(-Ma et al., 2006, Coleman 1993, Gramming and Akerland 1991)[9] have dis¬cussed their reliability and validity.

Indeed, the VRP is subject to different procedural factors that can lead to high intra- and inter-subject variability (Gramming and Akerland 1988)[10]. Basing on our long-standing clinical experience, we noted that non-professional voice users often show trouble in perform¬ing VRP, with both the traditional and the fully auto¬mated procedures.

Traditional VRP is recorded using sustained phonation. Other factors such as the patient's embarrassment and lack of ability to match the pitch also made it difficult to

perform VRP recordings in both dysphonic and healthy speakers. The literature reports that to obtain a satisfactory VRP around 20-30 min are necessary.
In our experience, the time spent for the VRP is consistent with these data.

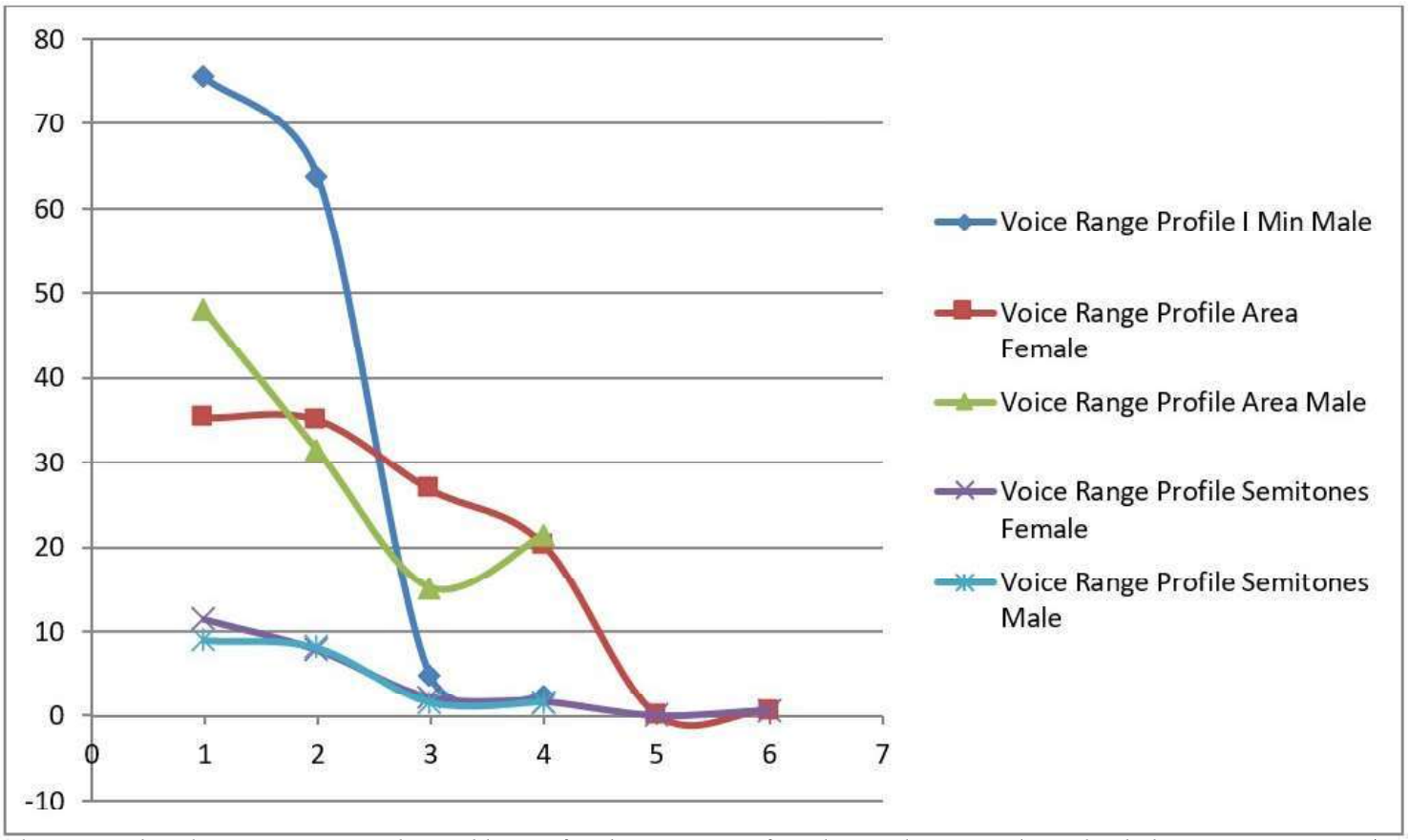
In contrast, overall the procedure that we utilized for SRP required an average time of 10 min for each subject. Our SRP included the reading aloud and shouting voice tasks that are easy to perform because they reflect habitual speech behaviours.

Table: Normophonic vs Dysphonic Data on VRP and SRP among males and females

Range of Profile	Parameters	Group	Mean (Hz)		SD		P value	
			Female	Male	Female	Male	Female	Male
Voice Range Profile	Fo Range	Normophonic	160.8	108.77	12.876	11.321	0.2161	.8667
		Dysphonic	170.73	107.93	23.899	15.304		
	Fo Max	Normophonic	379.6	283.67	36.565	27.93	<.0001	<.0001
			266.57	180.76	43.721	15.697		
		Dysphonic	35.111	31.547	20.338	21.551		
Speech Range Profile	Fo Range	Normophonic	167.1	110.92	34.628	10.178	0.2043	.9151
		Dysphonic	152.97	110.35	23.734	17.753		
	Fo Max	Normophonic	361.46	236.42	36.989	12.598	<.0001	<.0001
		Dysphonic	298.15	197.69	31.989	7.914		
	Fo Min	Normophonic	233.17	160.94	20.715	11.068	<.0001	<.0001
		Dysphonic	183.68	98.193	24.904	6.6652		
	SPL Range	Normophonic	17.6	19.1	3.3846	3.3138	<.0001	<.0001
		Dysphonic	10.393	11	1.42	2.3679		
	I Max	Normophonic	81.167	89.433	6.8359	4.3456	<.0001	<.0001
		Dysphonic	67.873	73.18	1.9714	1.7346		
	I Min	Normophonic	66.593	78.073	6.6034	4.0271	0.0167	.0008

		Dysphonic	35.111	31.547	20.338	21.551		
Speech Range Profile	Fo Range	Normophonic	167.1	110.92	34.628	10.178	0.2043	.9151
		Dysphonic	152.97	110.35	23.734	17.753		
	Fo Max	Normophonic	361.46	236.42	36.989	12.598	<.0001	<.0001
		Dysphonic	298.15	197.69	31.989	7.914		
	Fo Min	Normophonic	233.17	160.94	20.715	11.068	<.0001	<.0001
		Dysphonic	183.68	98.193	24.904	6.6652		
	SPL Range	Normophonic	17.6	19.1	3.3846	3.3138	<.0001	<.0001
		Dysphonic	10.393	11	1.42	2.3679		
	I Max	Normophonic	81.167	89.433	6.8359	4.3456	<.0001	<.0001
		Dysphonic	67.873	73.18	1.9714	1.7346		
	I Min	Normophonic	66.593	78.073	6.6034	4.0271	0.0167	.0008
		Dysphonic	61.467	69.633	4.1505	7.6739		
	Semitones	Normophonic	10.036	8.4267	3.0504	1.343	0.3523	.0383
		Dysphonic	9.1333	9.6267	2.087	1.6624		
	Area	Normophonic	46.131	49.593	12.609	15.031	0.1995	0.0965
		Dysphonic	38.38	39.193	19.052	17.924		

Chart I: Voice Range Profile in normophonic and dysphonic data in female versus male.



Above graphical representation showed lower fundamental frequency in male than female in normophonic data. And females had higher maximum and minimum fundamental frequency than males.

Mean value of fundamental frequency in female and male was 161.8 Hz and 108.77 Hz and the mean value of the maximum fundamental frequency for female and male was 379.6 Hz and 283.67 Hz. As well as the mean value of minimum fundamental frequency for female and male was 235.2 Hz and 185.73 Hz. Males had higher mean value than female in all three parameters i.e. SPL range, maximum intensity level and minimum intensity level. The mean value of the SPL range in females and males was 11.92dBSPLand 14.92dBSPL,The maximum intensity level in female and male was 74.993 and 85.753 and minimum intensity level in females and males was 63.167 dBSPLand 75.533dBSPL.

Mean value of minimum fundamental frequency in females was 221.2667 (standard deviation ± 13.28) and 122.00 (standard deviation ±13.398) in males. Mean value of semitones in females was 11.469and in males it was 9. Males were having higher area enclosed by phonetogram than females. Mean value of area in females and males were 35.355 and 48.093. These findings were supported by Chatterjee, Halder, Bari, Kumar, and Roychoudhry (2011) where they found the mean value of fundamental frequency range in female was 164.9333 Hz (standard deviation ± 16.04) and male was 50.80 Hz (standard deviation ± 16.15), mean value of maximum fundamental frequency was 385.533 (standard deviation ± 12.78) in females and 170.80 (standard deviation ± 23.87) in males, they found mean value of maximum intensity in female and male was 105.7487 dB (standarddeviation 14.496) and 107.2133dB (± 13.134) and minimum intensity level was 96.8933dB (±15.11) and 100.6867dB (±14.32), but in this study intensity range was higher in females than males.

Semitones were higher in normophonic females than males, mean value of semitones in female was 9.6667dB* semitones (standard deviation 1.04654) and in males 7.4667dB* semitones (standard deviation 2.06559), mean value of male and female subjects were 12.9000 (standard deviation 7.3) and 11.9667 (standard deviation 6.3531).

In case of dysphonic data, as shown in above graphical representations, mean values of frequency parameters (fundamental frequency, maximum frequency, minimum frequency) were higher in female subjects than male subjects but in intensity parameters (intensity range, maximum intensity, minimum intensity) mean values were higher in male subjects than female subjects. As showed in above graphical representation. Mean values of semitones were higher in male subjects (8.1333) than female subjects (7.8667) but mean value of area was higher in female subjects (35.113dB* semitones) than male subjects (31.547dB* semitones).

There is no evidence of study done on comparison of frequency and intensity parameters, semitones and area parameters of Voice Range Profile (SRP) between dysphonic male and female subjects in the literature and journals.

Frequency parameters, mean values of all three parameters (fundamental frequency, maximum frequency and minimum frequency) were higher in female subjects than male subjects.

Intensity parameters showed higher values in male subjects than female subjects. Mean values of fundamental frequency in normophonic male and female subjects were 167.1 Hz and 110.92 Hz, mean values of maximum frequency in normophonic female and male subjects were 361.46 Hz and 243.39 Hz and mean values of minimum frequency in normophonic female and male subjects were 223.17 Hz and 160.94 Hz.

The mean values of SPL range in normophonic female and male subjects were 15.725dBSPL and 19.1dBSPL, the mean value of maximum intensity in normophonic female and male subjects were 81.167dBSPL and 89.433dBSPL and the mean values of minimum intensity in normophonic female and male subjects were 66.593dBSPL and 78.073 dBSPL.

The finding was supported with the study of Balasubramanium, Bhat, and K.T. (2014)[11] had done a study on Indian population.

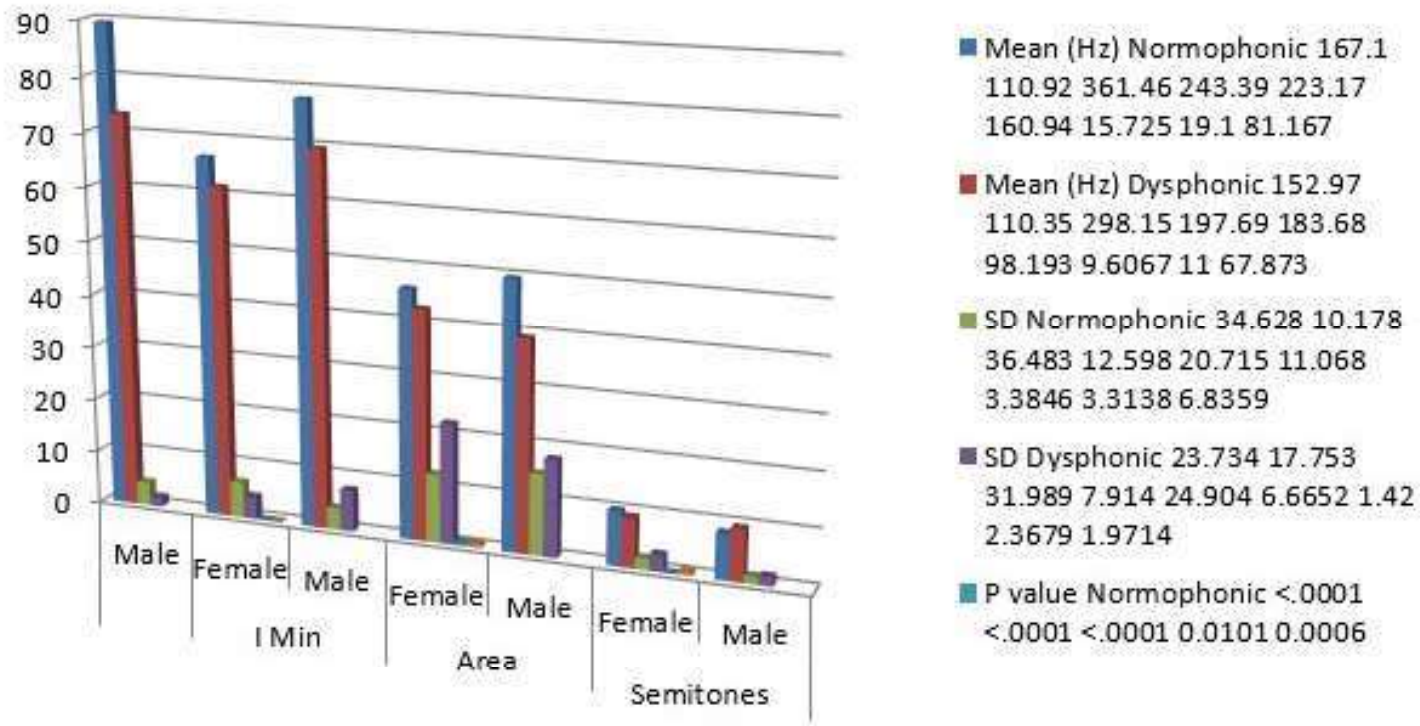
The results were showed difference in all parameters of fIn study, SRP measure was obtained from the normal male and female adults in the age range of 18 to 40 years.

requency and intensity in between male and female subjects. The mean value of maximum frequency in male and female subjects were124 Hz and 205 Hz, the mean value of minimum frequency in male and female subjects were 107 Hz and 178 Hz, the mean value of maximum intensity in male and female subjects were 93dB and 90dB, the mean value of minimum intensity in male and female subjects were 83dB and 82dB and the mean value of intensity range in male and female subjects were 10 dB and 8 dB.

The mean value of semitone was higher in female subjects than male but mean value of area was higher in male subjects than female subjects. The mean values of semitone in normophonic female and male subjects were 10.036and 8.4267, and mean values of area in normophonic female and male subjects were 46.131dB* semitones and 49.493dB* semitones.

There is no evidence of study done on comparison of semitones and area parameters of Speech Range Profile

Chart II: Speech Range Profile in normophonic and dysphonic datas in female versus male.



As showed in above graphical representation, mean value were higher in female dysphonic subjects than male dysphonic subjects for all three parameters of frequency that is fundamental frequency, minimum frequency and maximum frequency.

The mean value of fundamental frequency in female and male were 152.97 Hz and 110.35 Hz, the mean value of maximum frequency in female and male were 298.15 Hz and 197 Hz and the mean value of minimum frequency in female and male were 183.68 Hz and 98.193.

As showed in intensity parameters (i.e. intensity range, maximum intensity and maximum intensity) mean values were higher in male subjects than female subjects. The mean value of intensity range in female and male were 9.6067dBSPL and 11 dBSPL, the mean value of maximum intensity in female and male were 67.873dBSPL and 73.347dBSPL and the mean value of minimum intensity in female and male were 61.467dBSPL and 69.633dBSPL. Mean value of semitones were slightly higher in male (i.e. 9.1333) subjects than female subjects (i.e. 9.6267).

But mean value of area was higher for femalesubjects (i.e. 42.736dB* semitones) than male subjects (i.e. 39.193dB* semitones).There is no evidence of study done on comparison of frequency and intensity parameters , semitones and area parameters of Speech Range Profile (SRP) between dysphonic male and female subjects in the literature and journals.

CONCLUSION

In conclusion SRP procedure was easier and faster to administer than VRP. Normophonic group shown reliable changes in frequency and intensity while doing VRP, they were able to maintain the lowest and highest frequency with respect to loudness. And while reading the 20 Bengali sentences for SRP normophonic subjects were able to changes there pitch and loudness according to the type of sentences. As well as in dysphonic group subjects were shown no difference in fundamental frequency but they were unable to reach higher frequency and intensity level as normophonic group in both VRP and SRP.

The present study attempted to obtain a normative data for the VRP and SRP in the age range of 20 to 40 years for males and females with and without vocal folds pathology (i.e. bilateral vocal nodules). The normative data obtained offers a valuable tool for the speech and language pathologists in the assessment and management of patients with voice disorders. This could also be used to track the changes following the vocal treatment and also to assess the efficacy of the given treatment procedure.

The findings of the study can be strengthened by expanding the research on a larger population and in different communicative environments. Further research is needed to evaluate the role of VRP and SRP in other specific vocal pathology like (vocal folds paralysis, spasmodic dysphonia, vocal polyps, vocal cyst etc) in untrained or trained singers with age group like children, adolescence and older individuals.

Moreover, it will be necessary to assess the sensitivity of SRP and VRP in detecting changes following medical, surgical and behavioural vocal treatment.

This study will help to discuss the role of SRP and VRP as a diagnostic tool, emphasizing its advantages in routine voice assessment.

LIMITATIONS OF THE STUDY

A) The derivation of features from phonetograms without distorting its shape.

B) The particular attention paid to the dynamic possibilities of the F0-SPL range used in normal speech. To demonstrate this method of automated evaluation, a normal phonetogram as well as a pathologic (dysphonia) phonetogram was processed, and the resulting parameter values werecompared with normative data. In future this study will present the data of normophonic and dysphonic (with vocal nodules)subjects.

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