Normative Data for Multi-Dimensional Voice Program (MDVP) for Adults - A Computerized Voice Analysis System

[1]Hema N., [2]Sangeetha Mahesh & [3]Pushpavathi M.

Abstract

Multi-Dimensional Voice Program (MDVP) is one of the instruments which provide the detailed acoustic analysis on all parameters. Among Western population many studies have been conducted to develop normative data across gender, dialect and language. The present study is aimed to develop norms for voice variable of MDVP in Indian population and compare same across western norms. Subjects considered were thirty male and thirty female normal subjects without any voice/communication disorders with age range of 18 to 25 years. MDVP- Computerized voice analysis (model 3950) system was used, voice parameters were displayed using Visi-Pitch IV hardware system. Voice sample was collected by asking subjects to phonate /a/ in their comfortable pitch and constant amplitude. The mean, standard deviation and the range (Indian norms) of MDVP is obtained using Independent t-test and is compared with the Western norms to see the significant difference in the voice variables using one sample t-test. Difference is seen only in perturbation measurements. Comparison between genders has shown significant difference for few voice variables. The reason for increase in all the perturbation measurements of Indian norms would be due to difference in the vocal tract length, mass and tension. Factors like F0 level, phonatory initiation and termination also affects jitter magnitude in sustained phonation. More variation in amplitude perturbation may be due to room acoustics and microphone placement. Increment for soft phonation index may be due to the difference in manner of vowel phonation among the Indian and the Western population. Difference across the genders may be attributed to specific method of muscle excitation, laryngeal mucosal mechanism, sample size and higher Fo. These results can be attributed as norms which can be clinically used for the Indian population. It is apparent that measurement of acoustic variable has important application in diagnosis and treatment of voice disorders.

Keywords: Perturbation, Soft phonation index, MDVP

Voice plays a major role in speech and communication. Therefore voice needs to be constantly monitored and in the event of abnormal functioning of voice, an immediate assessment should be undertaken which would lead to the diagnosis which not only identifies the voice disorder but also acts as an indicator for the treatment and management to be followed.

Computer-assisted voice analysis represents an important diagnostic advancement because it provides objective acoustic measurements. There are many computer based techniques which are designed to extract different parameters of voice. Voice is a multi dimensional series of measurable events. It is necessary that various dimensions of voice are measured to obtain accurate knowledge about vocal function. The Multi-Dimensional Voice Program (MDVP) is one of the software tools for quantitative acoustic assessment of voice quality, calculating more than 30 parameters on a single vocalization. The Multi- Dimensional Voice Program (MDVP) in conjunction with the Computerized Speech Lab (Kay Elemetrics Corp, Lincoln Park, NJ) is a highly versatile voice processing and spectrographic analysis software package ideally suited for use in the pediatric and adult population. It provides an objective, reproducible and noninvasive measure of vocal fold function**.** The MDVP compares the acoustic variables graphically or numerically with a built-in normative database. MDVP is unique in its ability to work accurately over a wide range of pathological voices. Its normative references are based on an extensive database of Western norms and disordered voices and results are graphically

[1]Speech Language Pathologist, Department of Clinical Services, All India Institute of Speech and Hearing, Manasagangothri, Mysore- 570006, email:hema_chari2@yahoo.com,. [2]Clinical Lecturer, Department of Clinical Services, All India Institute of Speech and Hearing, Manasagangothri, Mysore- 570006, email:sangmahesh9@yahoo.co.in,. [3]Reader and Head, Department of Clinical Services, All India Institute of Speech and Hearing, Manasagangothri, Mysore- 570 006, email:pushpa19@yahoo.co.in,

and numerically compared to these normative threshold values. MDVP quickly and easily provides a revealing snapshot of voice quality.

As revealed in the professional literature on voice analysis, one or two voicing parameters alone (e.g., only jitter and shimmer) are not sufficient to accurately describe an aberration in a patient's voice. Jitter values may be within normal limits in a patient who demonstrates a breathy voice quality, and periodic modulation over many glottal periods (tremor) should be differentiated from cycle-to-cycle modulation. Similarly, turbulence caused by incomplete glottal closure can contribute a different type of "noise" compared to noise from aperiodic vibration and long-term periodic modulation of amplitude (amplitude tremor) may have physiological causes that differ from those of long-term periodic modulation of frequency. With the multi-dimensional analysis approach of the MDVP, the clinician can assess more comprehensively the patient's pathology and can track changes over time. Additionally, because the MDVP presents cycle-to-cycle frequency modulation (i.e., jitter or pitch perturbation) in many different variations, for example absolute jitter, relative average perturbation (RAP), pitch period perturbation quotient (PPQ), the results can be readily compared with results described in the professional literature highlighting periodic measurement of these parameters during the course of therapy may well provide an useful index so as to the success of the treatment.

Xue and Deliyski (2001) conducted a study to obtain normative acoustic data of voice for elderly male and female speakers and explored the educational implications of the effects of aging on selected acoustic parameters. Voice samples from 21 male and 23 female elderly speakers aged 70 to 80 years were obtained on measures of 15 selected Multi-Dimensional Voice Program acoustic parameters. The data was compared with the published norms which are reported by Putzer (2001) considering six MDVP parameters for young and middle-aged adult male and female subjects. The results showed that, compared with young and middle-aged adults, elderly speakers had significantly different (usually poorer) vocal output on all of the selected acoustic parameters of voice. These findings illustrate the importance of establishing acoustic norms and thresholds for elderly men and women and also on adult subjects. The study stress the necessity of using discretion in making diagnostic measurements of elderly speakers' acoustic parameters of voice.

Campisi, Tewfik, Manoukian, Schloss, Pelland-Blais and Sadeghi (2002) established the first pediatric normative database for the Multi-Dimensional Voice Program. One hundred control subjects (50 boys and 50 girls) aged 4 to 18 years contributed to the normative database. The voices of 26 patients (19 boys and 7 girls) with bilateral vocal fold nodules were also analyzed and compared with the normative data. Mean values of each of the acoustic variables were compared. The voices of patients with vocal fold nodules had significantly elevated frequency perturbation measurements compared with control subjects (P<.001). They also concluded that the vocal profile of children is uniform across all girls and prepubescent boys. Subjects with vocal fold nodules demonstrated a consistent acoustic profile characterized by an elevation in frequency perturbation measurements. Normal acoustic reference ranges may be used to detect various vocal fold pathologic abnormalities and to monitor the effects of voice.

Need for the study

The voice analysis using MDVP on normal population shows the interpretation with reference to western norms. Almost all normal Indian individuals' voice variables are shown as affected on the graphical display of MDVP. Hence, it becomes difficult to compare the data in pathological cases. The reason for this could be due to the difference in the vocal and the resonatory structures between the Indian and the Western population. Previous studies indicate changes in acoustic values using MDVP across different groups. Hence there is a need to develop separate norms for the Indian population in adult subjects.

Objectives of the study

1. To establish the normative database for the Multi-Dimensional Voice Program in adults and to compare across gender.
2. To compare the normative data with the western norms.

Method

Apparatus

Wipro-personal computer was used to operate MDVP module which acquires, analyzes and displays voice parameters using Visi-Pitch IV hardware system (Model 3950). The MDVP uses the signal conditioning and analog/digital hardware to sample speech at 50 KHz for sustained voicing. The MDVP extracted up to 33 acoustic voice variables from each voice analysis. These variables were displayed numerically and graphically and were classified into 6 groups: (1) fundamental frequency information; (2) frequency perturbation; (3) amplitude perturbation; (4) noise and tremor evaluation; (5) voice break, subharmonic and voice irregularity; or (6) miscellaneous. The parameters are depicted in Table1.

Acoustic Variables	Symbol
Fundamental Frequency Information Measurements	
Average fundamental frequency, Hz	Fo
Average pitch period, ms	To
Highest fundamental frequency, Hz	Fhi
Lowest fundamental frequency, Hz	Flo
Standard deviation of the fundamental frequency, Hz	STD
Phonatory fundamental frequency range, semitones	PFR
Fo tremor frequency, Hz	Fftr
Amplitude tremor frequency, Hz	Fatr
Frequency Perturbation Measurements	
Absolute jitter, μs	Jita
Jitter, %	Jitt
Relative average perturbation, %	RAP
Pitch period perturbation quotient, %	PPQ
Smoothed pitch period perturbation quotient, %	sPPQ
Fundamental frequency variation, %	vF0
Amplitude Perturbation Measurements	
Shimmer, dB	ShdB
Shimmer, %	Shim
Amplitude perturbation quotient, %	APQ
Smoothened amplitude perturbation quotient, %	sAPQ
Coefficient of Amplitude Variation, %	vAM
Noise and Tremor Evaluation Measurement	
Noise-harmonic ratio	NHR
Voice turbulence index score	VTI
Soft phonation index score	SPI
Fo tremor intensity index score, %	FTRI
Amplitude tremor intensity index score, %	ATRI
Voice Break, Subharmonic and Voice Irregularity Measurements	
Degree of subharmonics, %	DSH
No. of voice breaks	NVB
No. of subharmonic segments	NSH

Table1: Parameters of MDVP

Subjects

Sixty control subjects (30 males and 30 females) aged 18 to 25 years participated as subjects. All subjects were healthy and had no history of laryngeal or voice pathologic abnormalities. All subjects had normal hearing and orofacial structure.

Procedure

The subjects were seated comfortably in a quiet room. The subjects were instructed to phonate to a microphone which is fixed and placed at distance (2 inches). The subject was then instructed to sustain the vowel /a/ at their comfortable level three times in a comfortable pitch and constant amplitude. To standardize the input amplitude, the input signal was adjusted to a predetermined level. This adjustment prevented signal loss and system overloading.

Four seconds voice sample was selected by trimming few milliseconds in the initial and the final position of the recorded samples. The MDVP analysis was then performed, and the acoustic voice variables were displayed.

Statistical Analysis

The normative data were analyzed using a statistical software program (SPSS). Mean, standard deviation and the range for each acoustic voice variable was calculated. Independent t-test was used to find the significant difference in acoustic voice variables between Indian adult male and female subjects. One sample t-test was used to analyze the significant difference between the western norms and the norms obtained in the present study (Indian norms).

Results and Discussion

1) To establish and compare the normative data in adults across gender.

The mean, standard deviation and the minimum to maximum range of each acoustic voice variable were obtained for male and female subjects. The details regarding the variables are provided in Table 2.

The parameters related to fundamental frequency for female ranged from 187.87 Hz to 268.42 Hz and for male fundamental frequency ranged from 106.71 Hz to 166.56 Hz. The other parameters like average pitch period (T0), lowest fundamental frequency (FL0) and other ranged from 2.21 ms to 4.39 ms for females and for males it ranged from 1.29 to 7.65 ms.

The parameters related to frequency perturbation measurement ranged from 0.56 to 0.99 and absolute jitter (JITA) was 42.77 ms for females and for males the range was from 0.43 to 0.98 and 53.98 ms respectively.

The parameters related to amplitude perturbation measurements ranged from 2.19 to 8.82 in terms of percentage and shimmer (SHDB) was 0.28 in terms of dB for females and for males it was from 2.46 to 10.13 and 0.29 respectively.

Parameters	GENDER							
	Female				Male			
	Mean	SD	Min	Max	Mean	S. D	Min	Max
Fundamental Frequency Information Measurements								
F0	228.26	15.52	192.21	261.87	131.62	12.72	111.96	176.73
MF0	228.52	15.65	192.20	261.86	130.17	14.15	101.92	176.71
T0	4.39	0.30	3.81	5.20	7.65	0.69	5.66	8.97
FHI	237.62	17.28	198.10	268.42	136.51	12.43	114.32	166.56
FL0	219.77	14.45	187.87	255.64	125.49	10.83	106.71	155.96
STD	2.21	0.87	1.24	5.16	1.29	0.35	0.70	1.86
PFR	2.34	.57	1.67	3.67	2.42	.80	1.33	4.67
FFTR	4.10	1.64	1.81	8.17	3.56	1.48	2.19	7.68
FATR	2.64	1.82	.00	4.10	4.19	1.53	2.43	7.05
Frequency Perturbation Measurements								
JITA	42.77	24.15	19.10	139.21	53.98	22.90	19.89	111.37
JITT	.99	.55	.41	2.95	.73	.35	.27	1.64
RAP	.58	.32	.25	1.78	.44	.21	.15	.99
PPQ	.56	.30	.25	1.68	.43	.20	.16	.95
SPPQ	.60	.28	.34	1.67	.63	.20	.27	1.35
VF0	.95	.38	.53	2.42	.98	.26	.47	1.50
Amplitude Perturbation Measurements								
SHDB	.28	.04	.20	.44	.29	.06	.18	.54
SHIM	3.14	.65	.60	3.99	3.33	.72	2.09	5.00
APQ	2.19	.28	1.66	2.70	2.46	.49	1.45	3.66
SAPQ	2.91	.43	2.09	3.81	3.98	.90	1.69	6.19
VAM	8.82	2.10	5.28	13.73	10.13	2.95	5.40	15.77
Noise and Tremor Evaluation Measurement								
NHR	.12	.06	.09	.46	.14	.07	.10	.55
VTI	.04	.03	.02	.21	.03	.00	.02	.05
SPI	14.47	4.60	6.38	23.09	17.59	10.82	6.47	61.99
FTRI	.14	.07	.03	.34	.22	.10	.10	.47
ATRI	1.88	1.89	.00	4.19	2.86	1.55	.53	6.10
Voice Break, Subharmonic and Voice Irregularity Measurements								
DSH	.10	.16	.00	.65	.00	.04	.00	.27
NVB	.00	.00	.00	.00	.00	.00	.00	.00
NSH	.21	.53	.00	2.67	.02	.12	.00	.67

Table 2: Acoustic variables across gender

The parameters related to noise and tremor evaluation measurement scores ranged from 0.04 to 14.47 and for noise to harmonic ratio (NHR) the ratio was 0.12 for females and for males scores were from 0.03 to 17.59 and ratio 0.14 respectively.

The other parameters related to voice break, subharmonic and voice irregularity measurements ranged from 0.00 to 0.21 in terms of number and degree of subharmonics (DSH) was 0.10 in terms of percentage for females and for males it ranged from 0.00 to 0.02 and DSH was 0 respectively.

Independent samples test was used to find the difference across the gender. The results showed significant difference between the male and female subjects which were evident only for few acoustic variables as shown in Table 3. Under fundamental frequency measurements, the acoustic variables included fundamental frequency, mean fundamental frequency, average pitch period, highest fundamental frequency, lowest fundamental frequency, standard deviation of the fundamental frequency. These differences are normal across the gender which may be attributed to the size, length, tension and mass of the vocal folds which determine these factors. Under frequency perturbation measurements, jitter percentage and relative average perturbation showed difference and under amplitude perturbation measurements, amplitude perturbation quotient, smoothed amplitude perturbation quotient had significant difference between the genders, female subjects showing little increase in value compared to male subjects. The significant difference across the gender was evident on few parameters like F0, tremor, intensity index and degree of subharmonics.

Parameters	t-test for Equality of Means		
	t	df	Sig. (2-tailed)
Fundamental Frequency Information Measurements			
F0	26.36	58	.000
MF0	25.53	58	.000
T0	23.50	58	.000
FHI	26.00	58	.000
FL0	28.59	58	.000
STD	5.33	57	.000
PFR	.43	58	.668 *
FFTR	.84	22	.406 *
FATR	1.70	15	.110 *
Frequency Perturbation Measurements			
JITA	1.84	58	.070 *
JITT	2.19	58	.032
RAP	2.02	58	.047
PPQ	1.93	58	.058 *
SPPQ	.48	58	.627 *
VF0	.42	57	.675 *
Amplitude Perturbation Measurements			
SHDB	.77	57	.440 *
SHIM	1.02	57	.309 *
APQ	2.67	58	.010
SAPQ	5.86	58	.000
VAM	1.97	58	.054 *
Noise and Tremor Evaluation Measurement			
NHR	.91	58	.362 *
VTI	.82	57	.415 *
SPI	1.42	56	.159 *
FTRI	2.68	37	.011
ATRI	1.12	16	.276 *
Voice Break, Subharmonic and Voice Irregularity Measurements			
DSH	1.11	54	.272 *
NSH	1.93	56	.059 *

Table 3: t value of the acoustic variables across gender. (Note: '*' indicates no significant difference)

The gender difference is apparent in adolescents where there is a substantial drop for male voice compared to female voice. This result is in support with the finding of Sorenson and Horii (1983), who reported higher jitter value in normal female speakers compared to normal male speakers. Vocal jitter has specific method of muscle excitation based on neuro muscular model of Fo and has a specific physiology, where the laryngeal mucosal mechanism contributes for Fo perturbation. Contrary to the present study, Robert and Baken (1984) found higher jitter values in males compared to females. They attribute this difference to Fo. As the Fo increases, the percentage of jitter value decreases. In the present study significant difference was not seen for shimmer parameters. They have found difference with Shridhara (1986) who studied laryngeal waveform of young normal males and females and found that the shimmer value is more for females compared to males. Sussman and Sapienza (1994) examined the developmental and sex trends in fundamental frequency in 17 boys and 14 girls aged 6.1 to 9.2 years. They found that the fundamental frequency for vowel production of boys and girls (aged <12 years) was not significantly different but were markedly different from men. This is due to the subject selection as they had selected only children.

2) Comparison of acoustic variables between the Indian and Western norms

Parameters	Female groups			
	Indian norms		Western norms	
	Mean	SD	Mean	SD
Fundamental Frequency Information Measurements				
F0	228.26	15.52	243.97	27.45
MF0	228.52	15.65	241.08	25.10
T0	4.39	0.30	4.41	0.43
FHI	237.62	17.28	252.72	26.57
FL0	219.77	14.45	234.86	28.96
STD	2.21	0.87	2.72	2.11
PFR	2.34	0.57	2.25	1.06
FFTR	4.10	1.64	3.07	1.96
FATR	2.64	1.82	2.37	1.74
Frequency Perturbation Measurements				
JITA	42.77	24.15	26.92	16.65
JITT	0.99	0.55	0.63	0.35
RAP	0.58	0.32	0.37	0.21
PPQ	0.56	0.30	0.36	0.20
SPPQ	0.60	0.28	0.53	0.22
VF0	0.95	0.38	1.14	1.00
Amplitude Perturbation Measurements				
SHDB	0.28	0.04	0.17	0.07
SHIM	3.14	0.65	1.99	0.79
APQ	2.19	0.28	1.39	0.52
SAPQ	2.91	0.43	2.37	0.91
VAM	8.82	2.10	10.74	5.69
Noise and Tremor Evaluation Measurement				
NHR	0.12	0.06	0.11	0.00
VTI	0.04	0.03	0.04	0.01
SPI	14.47	4.60	7.53	4.13
FTRI	0.14	0.07	0.30	0.15
ATRI	1.88	1.89	2.65	1.93
Voice Break, Subharmonic and Voice Irregularity Measurements				
DSH	0.10	0.16	0.20	0.10
NVB	0.00	0.00	0.20	0.10
NSH	0.21	0.53	0.20	0.10

Table 4: Indian and Western norms in terms of mean and standard deviation in female group.

Table 4 provides data of acoustic variables between the Indian and Western norms of female and male group of subjects. The statistical analysis, one sample t-test was used to find the differences between the groups of Indian and Western male and female adult subjects. Significant difference was noted between the Western norms and the Indian norms for all the parameters. There was slight variation/increment in frequency and amplitude perturbation measurements in Indian population.

Parameters	Male groups			
	Indian norms		Western norms	
	Mean	SD	Mean	SD
Fundamental Frequency Information Measurements				
F0	131.62	12.72	145.22	27.45
MF0	130.17	14.15	141.74	25.10
T0	7.65	.69	7.05	0.43
FHI	136.51	12.43	150.08	26.57
FL0	125.49	10.83	140.41	28.96
STD	1.29	.35	1.34	2.11
PFR	2.42	.80	2.09	1.06
FFTR	3.56	1.48	3.65	3.73
FATR	4.19	1.53	2.72	1.75
Frequency Perturbation Measurements				
JITA	53.98	22.90	41.66	16.65
JITT	.73	.35	0.58	0.35
RAP	.44	.21	0.34	0.21
PPQ	.43	.20	0.33	0.20
SPPQ	.63	.20	0.56	0.22
VF0	.98	.26	0.93	1.00
Amplitude Perturbation Measurements				
SHDB	.29	.06	0.21	0.07
SHIM	3.33	.72	2.52	0.79
APQ	2.46	.49	1.98	0.52
SAPQ	3.98	.90	3.05	0.91
VAM	10.13	2.95	7.71	5.69
Noise and Tremor Evaluation Measurement				
NHR	.14	.07	0.12	0.00
VTI	.03	.00	0.05	0.01
SPI	17.59	10.82	6.77	4.13
FTRI	.22	.10	0.31	0.15
ATRI	2.86	1.55	2.13	1.93
Voice Break, Subharmonic and Voice Irregularity Measurements				
DSH	.00	.04	0.20	0.10
NVB	.00	.00	0.20	0.10
NSH	.02	.12	0.20	0.10

Table 5: Indian and Western norms in terms of mean and standard deviation in male group.

Significant difference was present between the Indian and the Western norms. During speech using a normal phonatory mechanism a certain degree of variability in frequency is expected and indeed necessary. As Moore (1958) reports presence of small amount of perturbation is required in normal voice. Secondly, more variation in amplitude perturbation is also seen across the genders. This difference could be due to the room acoustics, the microphone placement and the difference in the vocal tract length, mass and tension. Other factors such as intensity, Fo level, and type of phonatory initiation and termination affect the jitter magnitude in sustained phonation (Moore & Von Leden, 1958; Jacob, 1968; Koike, 1973; Hollien, Michel & Doherty, 1973). The other acoustic voice variable, the soft phonation index shows increment when compared with Western norms. The reason for this is the manner of vowel phonation used by subjects. The Western population phonates using more of open mouth with increased loudness whereas the Indian population uses approximately closed mouth with reduced loudness. First the smaller sample size considered for Indian norms could have contributed for the discrepancy between the Western and the Indian norms. Increment in sample size among Indian subjects may be required to validate the results.

The overall difference between the Western and the Indian population is more in female group compared to male group suggesting increased variability in females.

Conclusions

The functional assessment of pathologic voices is commonly achieved using perceptual and equipment-based clinical tools. The lack of consistency and standardization in the basic methods of perceptual assessment continues to be a major clinical problem. Instrumental diagnostic modalities such as video stroboscopy, electroglottography, and phonetography are indispensable components of a modern voice laboratory. This equipment based tools, however, require costly and specialized instrumentation, an experienced clinician, cooperative patients, and interpretation of complicated graphs and mathematical formulae. The main objective of this study was to establish normative Indian database for the MDVP.

This is a first attempt to develop Multi-Dimensional Voice Program (MDVP) norms among Indian population. The results can be attributed as norms which can be clinically used for the Indian population. However, as sample size is comparatively small, there is a need to validate the same results. It is apparent that the measurements of acoustic variable has important application in both diagnosis and treatment of voice disorders. As a final conclusion our skilled ear should be the primary evaluation tool for any voice evaluation. The acoustic analysis should play a supporting role.

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