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Normative Data for Voice Range Profile (VRP) of Young Adults - A Pilot Study

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ABSTRACT

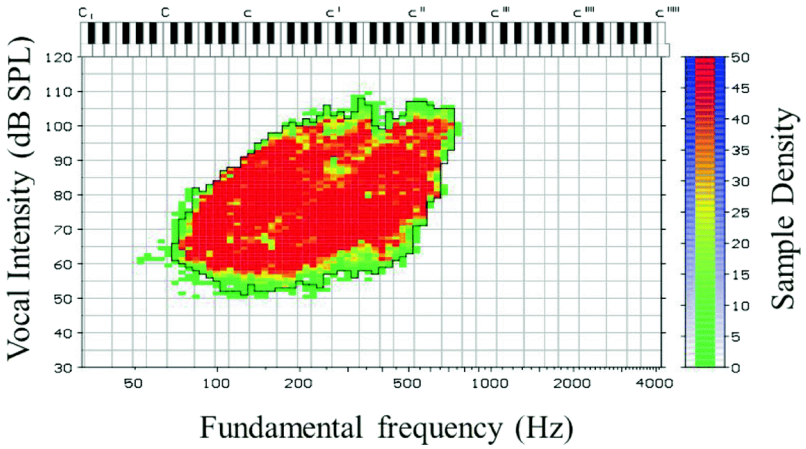
Background: A comprehensive assessment battery for individuals with dysphonia should encompass various aspects of voice use. This study aimed to create a normative reference dataset for voice range profiles of young adults.
Method: voice range profile recording from 80 healthy individuals (males and females) aged 18 to 25 years. Seven voice range profile variables were examined including habitual frequency, minimum and maximum Fundamental frequency and intensity, along with their respective ranges.
Result: An age-specific voice range profile normative dataset was established. Mean and standard deviation values were as follows: Habitual fundamental frequency - 207.79±45.34 Hz, Maximum fundamental frequency - 425.46±93.37Hz, minimum fundamental frequency - 178.08±47.30Hz, Fo range - 253.67±89.26Hz, maximum intensity - 82.43±7.60dB, minimum intensity - 67.18±5.81dB and intensity range - 15.25±7.16dB.
Conclusion: The normative dataset designed for young adults, serves as a valuable resource for optimizing voice assessments. It particularly benefits young adults experiencing dysphonia.

Keywords: voice range profile, fundamental frequency, frequency range, intensity range

INTRODUCTION

The Voice Range Profile (VRP) serves as a graphical representation illustrating an individual's voice, depicting both frequency and intensity on a graph or VRP contour/plot. The vertical axis represents intensity in dB (sound pressure level), while the horizontal axis represents the fundamental frequency (Fo). The Union of European Phoniatricians presented a standardized protocol to be used for VRP [1]. From the VRP, various characteristics are derived, including habitual frequency, maximum and minimum fundamental frequencies fundamental frequency range, habitual intensity, maximum and minimum intensity, intensity range, octaves and semitones. VRP contour/plot, also adds an intriguing dimension to the analysis of voice characteristics [2].

Figure 1 **depicts the VRP plot**



The VRP contour offers a comprehensive visual depiction of fundamental frequency (Fo) and intensity (SPL dB). It provides essential insights into an individual's vocal range, detecting voice breaks [2] and offers valuable visual feedback during voice therapy [1]. This tool is particularly beneficial for professional voice users such as teachers and singers, who require an expansive vocal range to meet their performance goals. It is crucial for Speech-Language Pathologists (SLPs) to recognize that VRP is a sensitive voice assessment tool influenced by internal factors like age and gender, as well as external factors, including the recording protocol. Maintaining careful control over variables such as the acoustic environment, microphone placement, individual comfort, and, in the current context of the pandemic, the use of masks is essential. Given that wearing masks can impact intelligibility, it is important to consider its potential effect on VRP recordings. Despite these considerations, VRP stands as a valuable tool for both clinical and research assessments of vocal physiology and function. The significance of utilizing Minimum and maximum values of fundamental frequency (Fo) and vocal intensity as descriptors of vocal functions are also emphasized [3]. These parameters not only provide objective measurements, but also hold relevance for assessing normal individuals, those with dysphonia, and professional voice users. A study done on individuals with dysphonia examining the impact of vocal range in both baseline and post-therapy phases indicated the reliability of the Voice Range Profile (VRP) as a tool not only for assessment but also for therapeutic purposes. This suggests its potential utility for professional voice users aiming to enhance their vocal range in alignment with occupational requirements [4]. The Voice Range Profile (VRP) serves as a valuable tool for investigating an individual's vocal range ability, offering insights applicable to both professional voice users and individuals with pathological conditions. Each person, whether trained or untrained, possesses a unique vocal range influenced by the characteristics of their vocal folds. Norms have been established for vocal range, considering specific age groups. While many studies focus on fundamental frequency range and intensity range, those targeting professional voice users also incorporate measures such as octaves and semitones. Having normative data across all age groups is crucial for both diagnostic and therapeutic purposes. Previous research studies in Western and Indian populations, particularly focusing on pediatric populations and professional voice users. However, a literature survey reveals a limited number of studies focusing on young adults. Consequently, there is a pressing need to establish a normative database for young adults in India.

Hence, the aim of the study is to establish a normative database in voice range profile (VRP) for young adults (18 to 25 years).

MATERIALS & METHODS

Participants

A total of 80 individuals participated in the study divided into 8 groups. Each group comprising of 10 young adults in the age range of 18 to 25 years with good physical and mental status. Individuals with a history of voice disorders or vocal complaints, fever, asthma, gastroesophageal reflux, thyroid dysfunction, allergies and/or infections of the upper and lower respiratory tract, smoking or alcohol consumption were excluded from the study.

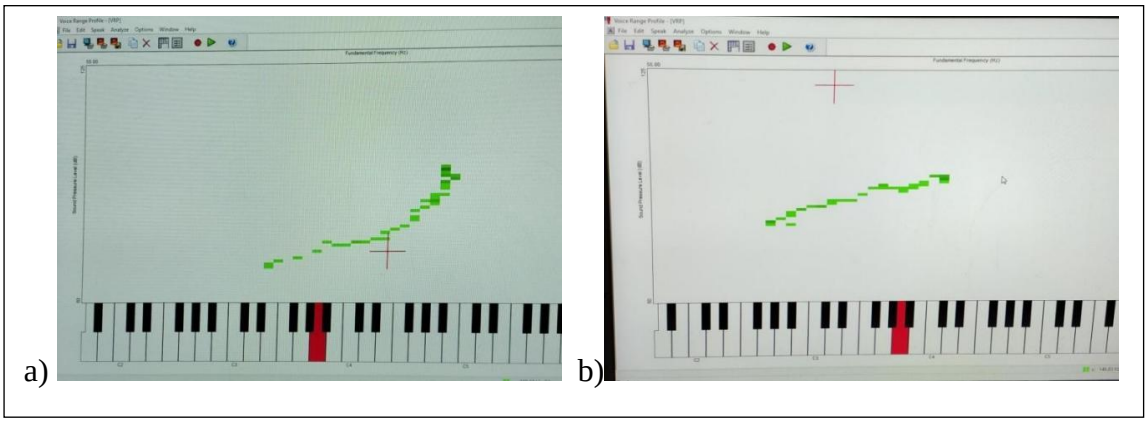
Instrumentation

In this study, the voice sample recording was done using Computerized Speech Lab (CSL), a professional grade acoustic instrumentation that is considered as an essential tool for collecting quantitative objective data for documentation and research purposes. It can also be used to measure the acoustic characteristic of voice. The participant's voice signal is directly recorded in the module of CSL software Model 4326 such as VRP and MDVP, using the standard CSL hardware with a condensor microphone (Shure).

PROCEDURE

An informed consent was obtained before the voice recording. The participants were subjected to 2 tasks. Task 1: Phonation in habitual pitch - Participants were seated comfortably in an upright position, maintaining a distance of 10cm from the mouth. They were instructed to take a deep breath and phonate the vowel /a/, sustaining it for at least 13 to 15 seconds at a comfortable level. Task 2: Gliding (low to high) task - Participants were demonstrated the gliding task and given two trials for practice. The study focused on analyzing the following parameters: Fundamental frequency range, Maximum fundamental frequency (max. Fo), Minimum fundamental frequency (min. Fo), Energy level (dB), Maximum energy, Minimum energy.

Fig 2 a). VRP contour of 24 yr old female participant and 2 b). VRP contour of 24 year old male participant



RESULT

Exploratory analysis was used to establish the normative dataset for voice range profile of young adults in the age group of 18 to 25 (N=80). Mean values were calculated for all the seven parameters (Habitual frequency, Maximum Fo, Minimum Fo, Frequency range, Maximum Intensity, Minimum Intensity, Intensity range) across each age group and analyzed.

In the analysis of voice parameters, including fundamental frequency and energy levels during pitch gliding tasks was observed and tabulated for 80 participants across 8 groups. Habitual frequency confirmation ranged from 176 Hz to 230 Hz, with maximum Fo between 373 to 475

Hz, and minimum Fo between 175 to 195 Hz. The fundamental frequency range for all participants was 196 to 298 Hz. Analyzing individual age groups revealed maximum Fo values (Hz) ranging from 386.39 to 475.6630, minimum ranging from 148.9880 to 195.1650 and Fo range from 196.2800 to 298.7550, each with respective standard deviations as indicated in Table 1. For energy levels, the, maximum (Emax) was consistently between 79dB to 86 dB across all age groups, while minimum (Emin) ranged from 65 to 69 dB. The energy range was 11 to 20 dB. Individual age group analysis showed mean values of Emax (dB0 ranging from 79.600 to 87.4000 and Emin (dB) ranging from 65.9000 to 69.6000. The range of Emax and Emin had mean values between 11.9000 to 20.2000, each with respective standard deviations (Table 1).

Table 1: Mean values of the VRP parameters

Parameters	**Age**	**N**	**Mean**	**Std. Deviation**	**Std.Error**	**95% Confidence Interval for Mean**		**Minimum**	**Maximum**
						LowerBound	**UpperBound**		
Hab	18	10	215.93	37.18	11.76	189.32	242.53	126.00	264.18
	19	10	214.63	34.22	10.82	190.15	239.11	146.16	245.33
	20	10	188.18	50.63	16.01	151.96	224.40	109.66	242.95
	21	10	216.83	54.78	17.32	177.64	256.02	111.68	267.54
	22	10	209.34	35.63	11.27	183.84	234.83	120.73	264.00
	23	10	230.76	15.88	5.02	219.39	242.12	211.07	250.65
	24	10	176.72	58.89	18.62	134.59	218.85	102.06	266.35
	25	10	209.92	51.29	16.22	173.23	246.61	114.76	265.00
	Total	80	207.79	45.34	5.07	197.70	217.88	102.06	267.54
MaxF0	18	10	386.39	32.02	10.12	363.48	409.30	349.23	440.00
	19	10	373.51	64.32	20.33	327.49	419.52	233.08	466.16
	20	10	393.70	86.58	27.38	331.76	455.64	164.81	493.88
	21	10	464.91	109.94	34.76	386.25	543.56	369.99	739.90
	22	10	425.61	55.46	17.53	385.93	465.28	349.23	554.37
	23	10	441.70	86.34	27.30	379.93	503.47	369.99	622.25
	24	10	442.23	99.97	31.61	370.70	513.75	233.08	554.37
	25	10	475.66	142.48	45.05	373.73	577.59	246.94	739.99
	Total	80	425.46	93.37	10.43	404.68	446.24	164.81	739.99
MinF0	18	10	175.96	39.12	12.37	147.97	203.95	110.00	233.08
	19	10	177.25	31.97	10.11	154.38	200.12	130	220.00
	20	10	188.22	88.82	28.08	124.67	251.76	87.31	415.30
	21	10	176.68	47.64	15.06	142.60	210.76	92.50	220.00
	22	10	185.48	35.16	11.11	160.33	210.63	103.83	220.00
	23	10	195.16	11.49	3.634	186.94	203.38	185.00	220.00
	24	10	148.98	46.64	14.75	115.62	182.35	87.00	233.08
	25	10	176.90	44.01	13.91	145.42	208.39	98.00	233.08
	Total	80	178.08	47.30	5.288	167.55	188.61	87.00	415.30
Range	18	10	210.41	24.57	7.77	192.84	227.99	184.42	259.90
	19	10	196.28	50.59	16.00	160.08	232.47	102.27	261.19
	20	10	255.59	37.81	11.95	228.54	282.64	205.18	327.99
	21	10	288.43	120.53	38.11	202.20	374.66	172.00	532.34
	22	10	240.12	72.67	22.98	188.13	292.10	149.90	389.56
	23	10	246.53	87.67	27.72	183.81	309.25	172.00	426.25
	24	10	293.22	106.58	33.70	216.97	369.46	136.91	437.83
	25	10	298.75	123.10	38.92	210.69	386.81	136.94	584.43
	Total	80	253.67	89.26	9.980	233.80	273.53	102.27	584.43
Emax	18	10	81.80	5.63	1.78	77.77	85.82	75.00	89.00
	19	10	81.40	6.34	2.00	76.86	85.93	71.00	90.00
	20	10	82.30	7.25	2.29	77.10	87.49	73.00	95.00
	21	10	86.00	6.96	2.20	81.02	90.97	77.00	98.00
	22	10	81.40	8.24	2.60	75.49	87.30	69.00	93.00
	23	10	79.60	6.50	2.05	74.94	84.25	70.00	91.00
	24	10	87.40	11.20	3.54	79.38	95.41	73.00	113.00
	25	10	79.60	6.04	1.91	75.27	83.92	71.00	89.00
	Total	80	82.43	7.60	0.850	80.74	84.13	69.00	113.00
Emin	18	10	69.60	8.88	2.80	63.24	75.95	50.00	81.00
	19	10	69.50	3.62	1.14	66.90	72.09	63.00	76.00
	20	10	66.40	6.22	1.96	61.94	70.85	53.00	76.00
	21	10	67.00	3.43	1.08	64.54	69.45	63.00	73.00
	22	10	65.80	6.90	2.18	60.85	70.74	56.00	82.00

	23	10	66.10	4.90	1.55	62.58	69.61	58.00	73.00
	24	10	67.20	7.19	2.27	62.05	72.34	60.00	83.00
	25	10	65.90	3.51	1.11	63.38	68.41	61.00	74.00
	Total	80	67.18	5.81	0.650	65.89	68.48	50.00	83.00
Range	18	10	12.20	6.89	2.17	7.26	17.13	5.00	28.00
	19	10	11.90	4.65	1.47	8.57	15.22	5.00	20.00
	20	10	15.90	6.83	2.16	11.00	20.79	7.00	30.00
	21	10	19.00	7.18	2.27	13.86	24.13	9.00	33.00
	22	10	15.60	5.91	1.86	11.37	19.82	9.00	29.00
	23	10	13.50	6.24	1.97	9.035	17.96	6.00	28.00
	24	10	20.20	10.99	3.47	12.33	28.06	11.00	46.00
	25	10	13.70	4.02	1.27	10.81	16.58	9.00	20.00
	Total	80	15.25	7.16	0.80	13.65	16.84	5.00	46.00

DISCUSSION

Establishing a normative data is mandatory as it could help speech language pathologists to determine the depth of dysphonic component. Each component in the assessment protocol of voice disorders has its own advantages. The frequency range across a wider age group of 20 to 70 years and found that females have a greater frequency range (157.3 to 1223.7 Hz) than males (86.1 to 785.4 Hz) [5]. The current study was not able to represent a gender distribution. The fundamental frequency was considered to make sure each of the participants had a normal Fo value appropriate to age and gender, which also helps us in identifying that there is no significant change in the anatomical and the physiological changes in this age group of 18 to 25. It was also observed that the VRP plot for male falls towards the very low musical note of the piano whereas female range falls in the high musical tone which is displayed as a continuous bar in the VRP module during the recording. Normative VRP differs for each participant according to the physiological makeup, although everybody maintained a steady glide from lowest to the highest frequency in terms of morphological pattern. The voice range for the pediatric population from 6 to 11 years of age. It was observed that the minimum frequency for 16 year old teens was 81.9 Hz for males and 175 Hz for females. The maximum frequency was 397 Hz for males and 725 Hz for females. But in the current study, the minimum frequency was found to be 87 Hz and the maximum was 554 Hz [6]. There seems to be a considerable difference between the 16 yr old teens and the 18 year old adults, which can again be attributed to the continuation of the anatomical and physiological variations, which probably extends beyond the pubertal age as studied by various authors. Teachers/trainers were able to select songs in suitable ranges for children depending on the age matched VRP plot and values depending on the morphological pattern [7]. When the intensity level is analyzed, we see that there was an increase in the intensity along with the increase in the fundamental frequency. The relationship between the pitch and intensity is long studied [8]. It is also interesting to know that the area of voice within which the vocal intensity and pitch varies is considered to be the actual range of phonation defined as the effective vocal volume.

In the current study, from the 80 participants, the maximum intensity level was 113 dB and minimum were 50 dB which is in coherence with the study conducted on Bengali adult speakers [9]. They found that sound pressure level maximum values for young adults (age range 21-34 yrs for males and 20-39 yrs for females) were 126 dB for males and 122 dB for females, and sound pressure level for minimum of 51 dB and 44 dB for males and females respectively. This variation in the intensity level (both maximum and minimum) is expected when the individual phonates at the lowest and highest pitch suggesting a strong correlation between the pitch and the loudness levels [8, 6, 10, 11]. The normative database for VRPs is highly useful and applicable in clinical practice. It can be definitely considered as a reference for evaluation and management of

individual voices, which was concluded through a study conducted on male (43) and female (46) teachers, where their voice range was recorded using the task of sustained phonation, vowel /a/ at different pitch and loudness levels. The final goal of the calculation of a normative VRP is to compare an individual's VRP with that of an individual with dysphonia to identify the degree of pathology along with the other tools in the assessment protocol. VRP can also be very much used during the management phase as well as a biofeedback device or post-therapy to make the individual understand better with regard to their voice output [7]. In a study done on wide range group (21-65 years), older female participants had low minimum F0 ie, as the age increases the minimum F0 tends to drop down increasing the frequency range to a certain limit due to the physiological changes due to hormonal impact during the menopause phase. This kind of pattern is not seen in young females giving a picture of lower frequency range compared to the older adults [12,13]. These kinds of differences have to be definitely taken care during the assessment procedure using VRP. A normative dataset established from females in the age range 18 to 28 years also comment the high utility of VRP along with other assessment protocols [14].

CONCLUSION

The results of this study provide an age-specific dataset for young adults, offering valuable information for SLPs involved in the assessment and treatment planning of individuals suffering from dysphonia. We recommend the integration of the full Voice Range Profile (VRP) as a standardized component of the diagnosis-specific voice assessment for young adults. This approach can enhance the precision and comprehensiveness of voice evaluations, aiding in more targeted and effective treatment planning for individuals with dysphonia in this age group.

Declaration by Authors

Ethical Approval: Not Required.
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Conflict of Interest: The authors declare no conflict of interest.

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