Voice Range Profile (VRP) in Young Phono-Normal Southern Indian Females: A Normative Study

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September 2023

CERTIFICATE

This is to certify that this dissertation entitled is **Voice Range Profile (VRP) in Young Phono-Normal Southern Indian Females: A Normative Study,** a bonafide work submitted in part fulfillment for the degree of Masters in Science (Speech-Language Pathology) of the student Registration Number P01II21S0031. This has been carried out under the guidanceof the faculty of this institute and has not been submitted earlier to any other University for an award of any other Diploma or Degree.

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DECLARATION

This is to certify that this dissertation entitled **Voice Range Profile (VRP) in Young Phono-Normal Southern Indian Females** is the result of my own study under the guidance of Dr. Rajsudhakar, Associate Professor in Language Pathology, Department of Speech-Language Pathology, All India Institute of Speechand Hearing, Mysuru and has not been submitted earlier to any other University for anaward of any other Diploma or Degree.

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Dedicated to Achan & Amma

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"Dream, dream, dream. Dreams transform into thoughts and thoughts result in action'.'

-Dr A.P.J. Abdul Kalam

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TABLE OF CONTENTS

Chapter No.	Title	Page No.
	List of Tables	ii
I	Introduction	1-5
II	Review of Literature	6-15
III	Method	17-19
IV	Results	20-23
V	Discussion	24-27
VI	Summary and Conclusion	28-29
	References	30-31

LIST OF TABLES

Table No.	Title of tables	Pg. No.
4.1	Mean, Standard deviation, and Median of voice range profile parameters	20
4.2	Mean, Standard deviation, and Median of voice range profile parameters between Group I and Group II	22
4.3	Results of one-way Manova for subgroup comparison (based on age)	23

CHAPTER I

INTRODUCTION

Voice is the component of speech that provides the speaker with the vibratory signal upon which speech is carried. Voice is recognized as the acoustic medium and an effective communication means. It supplies expressions, feelings, intent, and mood to our daily spoken thoughts and acts as the melody of our speech. Voice is the term used to describe the laryngeal modulation of the pulmonary air stream, which is further influenced by the length of the tract. There are four parameters of voice, including Pitch, Quality, Loudness, and Flexibility, that interfere with communication. Voice quality can be objectively assessed in various ways and serves as the main means by which speakers convey their physical, psychological, and social traits to the outside world.

The fluctuating and muscular process that underlies the highly challenging phenomenon of sound development in the voice box can be investigated and recognized at the glottal level. However, other parts of the body and other essential elements are known to have a significant effect on vocal performance. These include respiratory issues that prevent sufficient subglottal pressure and airflow to cause vocal fold vibration, perception, and neurological mechanisms of vocal control, including auditory and kinesthetic feedback, the presence of psychologically influencing factors, and stressful situations. As a result of all of that, multiple measurements are advised for the most recent evaluation of vocal function because voice quality is not precisely defined and is a multidimensionally perceived construct. Subjective and objective approaches, such as frequency-dependent sound pressure level measures (voice range profile [VRP] measurement), acoustic-aerodynamic analysis, and videolaryngostroboscopy, are used in these assessments. Subjective methods include auditory-perceptual assessment and patients' self-assessment of voice.

There are many techniques for evaluating voice. If based on a systematic rating technique, clinically well-trained listeners' perceptual voice evaluation can be believed in, and training for voice therapists can be more effective if perceptual acoustic correlations are found. This allows the speech-language pathologists to categorize the problem and explain the voice in a holistic profile. This assessment makes an effort to reduce the uncertainty that a large number of synonyms and undetermined descriptors may cause. Since no particulars are produced by perceptual judgments and no single technique is universal, certain problems are intrinsic to the process.

Self-assessment and clinician evaluation are the two parts of subjective voice analysis. The GRBAS scale, which rates subjective voice qualities like roughness, breathiness, asthenicity, and strain on a four-point scale from 0 to 3 was employed for the clinician's evaluation. The patients were given standard reading material for the perceptual evaluation, and their voices were recorded and then analyzed.

A two-dimensional depiction of a voice's range in frequency and amplitude is provided by this therapeutic technique known as Voice range profile (VRP) or phonetogram (Sulter et al., 1995). Phonetogram defines voice range limits are determined by graphing fundamental frequency (F0) versus intensity (Awan et al., 1991). The phonetogram typically shows the frequency (Hz) range showing the physiological limits of a person's voice along the horizontal axis and the strength, or sound diagnostic and therapeutic purposes. The most common criterion for determining voice type is VRP, however it should not be the only factor to consider. It is also essential to emphasize that voice training makes it possible to expand low and high vocal range, perform naturally, increase voice quality, and explore more difficult repertoire, all of which guarantee vocal health. Since this noninvasive technology produces objective and acoustic results, speech pathologists are increasingly utilizing

software for acoustic analysis. The collection of information through software helps in measuring and diagnosing voice issues, establishing the effectiveness of therapeutic interventions, and comparing pre and subsequent-intervention outcomes (Cardoso et al., 2020).

In the last two decades, lingWAVES has risen to become one of the most popular systems used for professional voice and speech analysis, biofeedback, and documentation. The primary characteristics of this distinctive system are a combination of analysis and processing using both established and emerging technologies, as well as simple handling. The modular structure of lingWAVES enables the availability of various module combinations (suites), permitting the system to be used by various professional users, from speech and language pathologists.

A study was conducted by Chatterjee et al. (2014) on the Indian population, particularly among Bengali speakers. This study examined how gender and age influence the acoustic voice characteristics and established the normal voice range profile (VRP) among adult males and females in three different age groups. The results of this study revealed that the fundamental frequency of males and females differed significantly at three age groups. Andersen et al. (2021) studied young females normative voice range profiles. The results of Andersen et al. (2021) is limited to Dutch young females in the age of 18 to 28 years of age.

Need for the study

The voice range profile (VRP) represents the patient's voice range in terms of pitch and range of intensity and the interaction between these two factors. Measurements inferred from the VRP appear useful for evaluating healthy and disturbed voices. The voice clinician uses this data for both therapeutic and diagnostic

purposes.

In the past, multiple studies have been done by using voice range profiles to develop norms among untrained children (Wuyts et al., 2002); professional voice users, especially in teachers (Heylen et al., 2002); choir (trained) children (Pedersen, 1993); voice disorders, like functional dysphonia (Airainer, 1993); superior laryngeal nerve paralysis (Eckley et al., 1998); voice therapy efficacy (Speyer et al., 2003).

The voice range profiles (VRP) that was published in the literature were more of from the Western population. Studies on the voice have shown that ethnicity has a substantial impact on vocal traits (Jayakumar et al., 2012). Studies on the normative voice range profile among young Indian adults are scanty. Studies by Chatterjee et al. (2014) have employed Bengali adults to investigate how gender and age influence VRP measures. Chatterjee et al. (2014) established normative VRP for both young males and females where the number of participants in that study were very less (fifteen females). Hence, there is a need to establish the nominative VRP in young Indian adults, especially in South Indian females.

Aim of the study

The present study aimed to establish normative reference database on voice range profile in young south Indian females.

Objectives of the study

The objectives of the study are:

1. To measure the maximum and minimum frequency (pitch) values in young Southern Indian females and

2. To measure the maximum and minimum values of intensity (loudness) in a young Sothern Indian female using voice range profile.

Chapter II

Review of Literature

Wuytz et al. (2002) investigated normative data for voice range profiles (VRP) among untrained girls and boys. Participants between the age range of 6 and 11 years, consisting of 35 boys and 39 girls were participated in the study. Phonomat automatic voice field measuring system was used to record VRP (Homoth medizin elektrokin GmbH COKG stimmfeldmessung version 3.0). All the participants had a healthy voice. The results provide prediction intervals (PI) of 95% for both frequency and intensity that are part of the normative VRP. The fundamental frequency (F0 Hz) and sound pressure level (dB(A)) of prolonged vowel production are recorded by the photo mat. and provided visual feedback. Instruction given to the participants was as follows, the vowel 'a' should be pronounced comfortably and loudly for at least two seconds as it is pronounced in normal speech", after some warm-up activities like singing. A standard error on the mean value is 0.4 For 35 boys and 39 girls. The mean translation, T and average compression, C for 35 boys are 6.1 and 0.680 $\pm$ 0.024, respectively. For girls, mean translation and average compression values are 5.7 and 0.669 $\pm$0.021, respectively. The above study has used this method to calculate VRP based on several statistical transformations of the original VRP.

Heylen et al. (2002) investigated the typical vocal range characteristics of male and female professional voice users. The study was conducted on 89 subjects (43 normal male and 46 normal female teachers) with the mean age and age range of 40 years, 22-54 years for males, and 31 years, 22-51 years for females, respectively. Based on 43 and 46 recordings, they were estimated among a group of men and women teachers. The frequency and intensity of 95% prediction intervals are included in these normative VRPs. Automatic voice field measuring system Phonomat was used to

record VRP. The patient receives visual feedback in addition to the mean fundamental frequency and sound pressure level of a sustained vowel production, that are captured by the phonomat. The participants were told to take a relaxed breath in and to phonate the vowel /a/ for a minimum of two seconds with a pitch and volume that were "habitual" for their daily speech. As a warm-up exercise subject were then urged to experiment with the range of their voices by varying/gliding pitch and volume from low to high. There were 46 female teachers in total, the VRPs were shifted over a typical $T = (10.5 \pm 0.4)$ semitones to produce the norm VRPs. The average translation and compression for the 43 male teachers were $T = (5.8 \pm 0.5)$ semitones and $C = 0.662 \pm 0.017$, respectively. Following the mathematical translation and compression of each unique VRP, they provide based on the estimation of standard deviations and 95% prediction intervals. The authors had given two separate contours for males and females wherein, VRP of any individuals that lie outside the vertical error bars or innermost and outermost contours indicates voice deviancy.

Kelly et al. (2019) explored the long-term follow-up study on the impact of the surgery on transgender females for pitch-raising using acoustics and patient-reported information as outcome measures. The study's objective was to assess glottoplasty (GP) and cricothyroid approximation (CTA) effects and to look into long-term repercussions. There were 24 participants, with the average age between 35 and 67 years. Of these, 13 patients had GPs, and there were 11 patients with CTA. Patients completed pre and post-questionnaires during voice therapy that followed the surgery, and at one-year follow-up while sound recordings were made in a booth with soundproof. From the voice and speech range profiles, fundamental frequency measures were taken and compared to transgender data. There was a dramatic increase in the minimum frequency in VRP after CTA (95 to 123 Hz). A decline in the maximum frequency was observed

after GP and further declined after CTA. The study concludes that the improvements in voice with different interventions can be tracked using VRP in routine clinical practices.

Chatterjee et al. (2014) conducted a study on the Indian population particularly among Bengali speakers. The study's objectives were to determine the normal voice range profiles (VRP) among adult males and females in three different age groups and to look at how gender and age influence changes in acoustic characteristics. A total of 90 individuals included 15 men and 15 women in the three age categories (20–30 years, 40–50 years, and 60–70 years). None of the subjects had any reported respiratory, vocal, auditory, or any other motor or sensory impairments; they were all native Bengali speakers. Tools included the SPSS program (11.0) and Phonetogram of Dr. Speech Software (version 4). Sound pressure level (SPL), semitone, size of the VRP, fundamental frequency range, maximum and minimum fundamental frequencies, and fundamental frequency range were all measured. The vowel /a/ was phonated by the participants in seven reliable registers at average loudness. The tools measured the above-mentioned parameters. SPSS software was used to statistically evaluate the responses. Females mean maximum frequency values were 385.5 Hz, 351.8 Hz, and 317.1 Hz for the first, second, and third groups, respectively. Their mean minimum frequency values were 212.2 Hz, 212.6 Hz, and 203.3 Hz, and their mean frequency range was 164.9 Hz, 139.2 Hz, and 139.4 Hz, respectively, for the first, second, and third groups. The fundamental frequency of males and females differed significantly. For other parameters, the authors found that there is no such significant difference. Although the researchers examined the VRP parameters among young adult male and females, though the number is very less to consider as norms (only 15 in each gender and 30 in each age group).

Andersen et al. (2021) studied the voice range profile normative in young

females. The authors included 39 females with healthy voices aged 18-28 years in the study. REDCap electronic data capture tools, which are also hosted at Odense University Hospital, Odense, Denmark, were used to collect all data. DuMiCHAS (Dual Microphone Calibrated Headset Amplifier Soundcard), model NO. V2.0 ALPHATRON medical systems and Voice Profiler version 5.0 USB IVACX software were used for the recordings on a Lenovo laptop. The partcipants were made to phonate /a/ from high to low and low to high to find the minimum and maximum frequency and its range and also minimum and maximum intensity and its range. The results of this study indicated an age-specific VRP normative dataset was established. An age-specific VRP normative data set was established. The mean ST (semitones) range was 34.7 with the average minimum frequencies of 143.6 Hz, and the average maximum frequencies of 1063.5. The mean SPL range was 65.6 + 5.0 dB, ranging from mean minimum SPL of 43.2 dB and a mean maximum SPL of 108.9 dB. The authors concluded that a normative data set usable for optimization for future voice assessment and management planning for younge females who suffer from vocal nodules.

Sanchez et al. (2014) studied the speech and voice range profile of adults with untrained normal voices. 63 vocally healthy participants who did not receive training for voice from Australia were recruited (aged between 21 and 65 years; 30 males and 30 females). Participants were asked to changing/gliding their pitch and loudness on the vowel /a/ for the VRP task. For the speech range profile, the Rainbow passage was used to read aloud at a comfortable pitch and loudness. The study's findings demonstrated that only the semitone range and area parameters had significantly test-retest variations. No significant test-retest difference was found in SRPs only for the parameter’s semitone range and area, and there were no significant test-retest parameter differences were found for the VRPs. The paired t-test significance was carried out in

this study. The SRPs values maximum F0, minimum F0, and semitone range are 318.40 Hz, 131.11 Hz, and 14.61 Hz, respectively and the mean maximum SPL, minimum SPL, and SPL range values is 79.24 dB, 59.36 dB, and 19.88 dB, respectively. The VRPs values of maximum SPL (dB), minimum SPL (dB), and SPL range were 109.3 dB, 47.00 dB, and 62.3 dB, respectively and the maximum F0, minimum F0, semitone range was 1275.34 Hz, 117.69 Hz, and 41.15 Hz, respectively. These findings highlight the necessity of developing standardized phonetogram recording techniques as well as standardized software and hardware for recording phonetogram. Their research provided phonetogram data for individuals with healthy voices in addition to details about gender influences on phonetogram characteristics. Particularly for SPL measurements in VRPs, some of these findings are significantly different from those obtained in earlier studies. Even though their study gives information about the gender effect on phonetogram recording, there is still a lack of number of participants. Further studies can be done on similar lines but with large samples.

Dienerowitz et al. (2021) established normative data using the voice range profile for singing voice features in children and adolescents with normal singing activity. This study developed and characterized age- and gender-specific normative data for singing voice using the VRP for clinical diagnosis—analysis of 1,578 primarily untrained children's singing voice profiles between the ages of 7 and 16.11 years. Participants were required to mimic a singing tone at certain pitches, resulting in the maximum fundamental frequency and SPL. Maximum phonation time was also measured. The mean highest frequency of boys was 751 Hz and the lowest mean frequency was 397 Hz. It was found to be increasing with age. The minimum frequency was 194 Hz and lowered to 92 Hz with increases in age. The mean maximum frequency decreased from 755 Hz to 725 Hz in females. The mean minimum frequency was

lowered from 202 Hz to 175 Hz. The study's findings showed that the mean of the highest and lowest frequency in VRP among males increased with age. The authors reported that the mean maximum frequency and minimum frequency among girls in VRP were decreased as a factor of age. The authors concluded that the current study provides accurate information about children's singing voices with variables. Limitations of this study included that this study considered data only from one region in Germany. It is necessary to undertake multicentric studies in order to describe the singing voice on a worldwide scale. Further, the normative data may be inaccurate due to the authors' failure to account for various ethnicities or native languages. Due to a lack of representativeness, only the reported results were appropriate for Caucasian subjects. More research must be done to determine whether the VRP is the ideal technique for evaluating vocal problems.

Schneider et al. (2010) studied normative VRP in children who are trained and untrained vocally between the ages of 7 and 10 years. The authors assessed the singing voices of vocally healthy youngsters from various social and vocal/musical backgrounds. There were 186 children, overall. Exams were conducted on 108 females and 78 boys. Under field circumstances, VRP measurements were made. Vocal strain and training questionnaires were used, and the results were used to classify singing activity and vocal training. All participants had an average vocal range of singing at least 2 octaves. The outcome of the questionnaires and interviews were used to categorize the children based on voice training and strain. Percentiles were determined in the following step. 25% of the participants were able to sing softly and loudly with a voice range of at least 22, or nearly two octaves. Around half of the participants had a voice range of 24 semitones (2 octaves) with gentle singing, their vocal range increased to 26 ST with loud singing. 25% of children had a voice range even larger

than 29 dB (from 196 Hz/g to 1047 Hz/c3) and could sing at most frequencies louder than 90 dB, according to the third quartile data (P75). P90 revealed that 10% of the children can sing at frequencies lower or higher than the 196 Hz/g to 1319 Hz/e3 range, which was the study's focus. There were no significant differences between the groups (Social and vocal/musical background) and the VRP measurements. The instrument used for this study was Phonomat software (Homoth). The authors concluded that the percentage of VRP that was introduced might be used to assess a child's voice skills and development. The authors of this study stated that the voice range profiles of P25, P50, P75, and P90 needed to be evaluated and correlated in clinical practice, including laryngostroboscopic examinations

Speyer et al. (2003) studied the effect of voice therapy on VRP in chronic dysphonic patients of various structural etiologies. A total of 62 participants (28 men and 34 women) were included in this study aged between 18 and 76 years. The main components of logopedic voice treatment included advice for maintaining good vocal hygiene, exercise training, and integrating the newly acquired vocal behavior in natural speaking and voicing. Speech samples were collected before therapy within six weeks on three different days. In terms of jitter, shimmer, and noise-to-harmonic ratio, the authors found no significant systematic differences. The therapy lasted for three months and therapy was attended twice a week where 30 minutes was the duration of therapy. An automated procedure for obtaining VRP was used. Patients were instructed to phonate a sustained vowel /a/ as loud as possible and soft as possible. The findings of this study show that dysphonic patients found VRPs in a variety of shapes, including a typical shape. Another 40% of patients' VRPs showed long, narrow extensions in the higher frequency range, while 40% of patients had typical shapes. A voice range profile was obtained using an automated process (Pabon phonetograph35; Laryngograph Ltd,

London, UK). The pretreatment baseline reported by the authors were maximum frequency value is 54.5 semitone (median) and median minimum frequency value is 28.5 semitone. It was also found that the respective minimum and maximum intensity were 52 dB and 99.5 dB. Post-therapy values on the minimum frequency and minimum intensity were reported to shown significant reduction compared to pre-therapy values. No significant changes were reported by authors on maximum frequency and maximum intensity after voice therapy. The diversity and irregular shape of the VRP contours were one of the major disadvantages of employing them with dysphonic patients. Due to this diversity, parameters that require more or less smooth VRP contours are unsuitable for studying patients with dysphonia. As a result, reliable and straightforward VRP measures need to be utilized in studies on dysphonic patients to describe the outcomes of voice therapy.

Eckley et al. (1998) studied voice range in patients with paralysis and paresis of the superior laryngeal nerve. They evaluated the musical frequency range (MFR) and physiological frequency range (PFR) of phonation that was evaluated on 56 adults, including 39 females and 17 males (30 singers and 26 nonsingers) within the age range of 20-44 years. Prior to an in-depth history and otolaryngological physical examination, all patients were evaluated using the authors' voice user questionnaire. Further, they divided the singer group into 3, they are classical singers, nonclassical singers, non singers (nonprofessional and professional). For clinical evaluation, strobovideo laryngoscopy was used. For the PFR task, the patient was asked to glide from lowest note to the highest falsetto using /a/ vowel, and for the MFR task, the patient was asked to produce the vowel /a/ from their lowest to their highest musically acceptable note, measured in Hz and converted into semitone (ST). A control group of 22 males and 33 females (41 singers and 14 nonsingers) with no history/complaint of voice problem

were included in this study.

The mean PFR value for the singers in the control group was 37.8 ST for males and 37.3 ST for females, while the same for the non-singers in the control group was 37.4 ST for males and 35.1 ST for females. Males and females with control singers had mean MFR values of 37.4 ST and 35.1 ST, respectively, while males and females without control singers had mean MFR values of 34.3 ST and 26 ST, respectively. For classical singers with SLN paresis, the mean PFR values were 33.9 ST for females and 30.3 ST for males, while the mean PFR values for non-singers were 25.7 ST for females and 30 ST for males. The mean MFR values of classical singers were 33.1 for females and 28.3 ST for males; the mean non- signer's values were 22.2 ST for females and 30.4 for males. The authors found that the participants with SLN palsy/paralysis had lower PFR and MFR compared to the control participants. This study found that singers with SLN pathology had considerably higher PFR and MFR than singers without SLN pathology. The authors found that sopranos and tenors had much larger mean MFR ranges than other vocal ranges, notably in non-singers. The authors concluded that MFR offers useful data about practical voice performance skills. This study considered only SLN pathology. A small number of prior research on this topic directed to further studies even by considering RLN pathology.

Heylen et al. (1998) studied the evaluation of vocal performance in children using the voice range profile index. The study examined a total of 230 typically developing children; in that, 94 were typically developing (53 boys and 41 girls) and 136 were dysphonic children (87 boys and 49 girls) between the ages of 6 and 11 years, concentrating on their voice frequency, intensity, and VRP structural characteristics. The phonomat automatic voice field measurement system (Homoth Medizin-elektronik GmbH and COKG, stimmfeldmessung version 3.0) was used to record VRP. The

children were told to take a comfortable breath in, hold, and phonate the vowel /a/ for at least 2 seconds at their habitual pitch and volume, then vocalize at their lowest and highest F0 utilizing the softest and loudest intensities. Between boys and girls, there was no statistically significant difference in VRP measures. The lowest F0 value of healthy individuals and dysphonic individuals was 192.8 ± 2.5 Hz and 196.3 ±2.5 Hz, respectively. The highest F0 values for both healthy and dysphonic individual was 857 ±21 Hz and 550 ± 11 Hz, respectively. The frequency range of both healthy and dysphonic individuals was 663 ± 22 Hz and 354 ± 13 Hz, respectively. The lowest intensity of both healthy and dysphonic individuals was 48.2 ± 0.3 dB and 52.4 ± 0.3 dB, respectively. The highest intensity of both healthy and dysphonic individuals was 98.0 ± 0.6 dB and 95.2 ±0.5 dB, respectively. The intensity range of both healthy and dysphonic individuals was 49.7 ± 0.6 dB and 42.7 ± 0.6 dB, respectively.

The results of the study conclude that the mean lowest F0 and the lowest intensity values of dysphonic children are higher compared to the healthy individual but the other parameters such as mean highest frequency, mean frequency range, mean highest intensity, and mean intensity range of healthy individuals are higher compared to healthy children. For every VRP data, the difference between the normal and dysphonia groups was statistically significant. The authors concluded that VRP measurements seem to be highly helpful for evaluating voice. The typical and dysphonic individual participants' numbers were unequally distributed in this study. This study considered only children within the age range of 6-11 years. Further studies can compare adults versus children in a similar direction.

CHAPTER III

METHOD

3.1 Participants

A total of 100 participants were selected for the study in the age group of 20-30 years who were young females. The participants were students of All India Institute of Speech and Hearing who enrolled in both Bachelor's and Master's degree programs.

3.2 Inclusion criteria

i. Participants whose voice quality was rated as "Zero" on the GRBAS I scale were included in the study. The GRBASI rating scale was administered by the investigator of the study.

ii. All the participants were reported to have normal hearing sensitivity.

3.3 Exclusion criteria

Young females without any history of voice disorders, diabetic mellitus / hypertension, thyroid and hormonal problems, any neurological abnormalities, any major surgeries of the head and neck, and throat infections, fever, or any other medical conditions were excluded.

3.4 Instrumentation

The data collection was done using LingWAVES instrument (WEVOSYS). Phonetogram VDC module and the standard voice protocol of lingWAVES software (WEVOSYS - Medical Technology, Germany) were used. Sound level meter (SLM) – (TECPEL 331 Sound level meter) was used to acquire the phonation sample. The Lingwaves is an incredible source of equipment and software that analyzes human voices. A microphone and sound level meter (SLM) are both features of the Lingwaves.

The participant's mouth level can be adjusted by moving this SLM on a tripod stand. The Lingwaves application serves as both a quantitative (singing/voice range profile) and qualitative (voice parameters) analysis tool.

3.5 Procedure

The recording was done in a soundproofed space. Inside the room, the noise level was under 30 dB SPL. The objectives of this research and aim were explained to the participants. The participants provided their consent verbally and in writing. The study was carried out as per guidelines prescribed by AIISH's Bio-behavioral ethics. The participants were made to stand and perform the tasks as recommended by WEVOSYS. The participant's height has been taken into consideration when adjusting the microphone. A 30 cm space was kept between the microphone and the participant's mouth to prevent any distortions during recording. The participants were explained about the tasks and a recorded sample of the tasks was played back to the participants. For each task, the participants performed three trials, and the average of the three trials was used to calculate the vocal range profile. The following instructions were taken into account and recorded for each participant:

3.6 Tasks

A) Maximum frequency (MaxF0 Hz)

Participants were instructed to phonate the vowel /a/ at a range of pitches, from low to high. They were designed to easily move from a comfortable pitch level to the maximum pitch level possible without losing voice control or changing pitches mid-task. Three trials were given for the task and the average of these trials was taken as the mean value of the highest phonation frequency.

B) Minimum frequency (MinF0 Hz)

The Participants were instructed to phonate the vowel /a/ at a range of pitches, from low to high. They were designed to smoothly transition from a comfortable pitch to the lowest pitch level without losing voice control or pausing between tasks. Three trials were given for the task and the average of these trials was taken as the mean value of the lowest phonation frequency.

C) Frequency Range (F0 range Hz)

It is the frequency difference between maximum F0 and minimum F0.

D) Maximum Intensity (Max I0 dB)

The participants were asked to phonate the vowel /a/. They were made to glide from comfortable loudness to the highest intensity level or loudest possible phonation without losing control of voice, or pitch/loudness breaks between the task. Three trials were given for the task, and the average of these trials was taken as the mean value of the highest intensity value in phonation.

D) Minimum Intensity (Min I0 dB)

Participants were instructed to phonate the vowel /a/. They were made to phonate from the comfortable loudness to the lowest intensity level possible without losing control of voice, or pitch/loudness breaks between tasks. Three trials were given for the task, and the average of these trials was taken as the mean value of the lowest intensity value in phonation.

E) Intensity range (I0 range in dB)

It is the intensity difference between maximum I0 and minimum I0.

3.7 Statistical Analysis

In this present study, a total of six parameters were analyzed using SPSS software (SPSS version 2.0). Descriptive statistics were used to calculate the mean, median, standard deviation, 95% Confidence Interval for the mean, and interquartile range.

Shapiro-Wilk's test was done to check the normality distribution of the data. A parametric test (One Way Manova) was done to find out whether any statistical difference was present between age groups (20-25 years and 25-30 years).

CHAPTER IV

RESULTS

The study aims to determine the normative voice range profile in the young phono-normal south Indian population. 100 participants in the age range of 20-30 years were considered for the study. Six parameters were included in this study that are Frequency minimum, Frequency maximum, Frequency range, Intensity maximum, Intensity minimum, and Intensity range. Normative values of each parameter were recorded and statistical analysis was done using the software (SPSS, Version 20.0), which is a statistical software package for social science. Parametric test and descriptive statistics were performed. Results of the present study are presented separately for six parameters as mentioned above. Table 4.1 shows the mean, standard deviation, and median of voice range profile parameters.

Table 4.1

Mean, Standard Deviation, and Median of Voice Range Profile parameters.

SL NO	VRP Parameters	Mean (Hz/dB)	Standard deviation	Median	95% confidence interval for mean		Interquartile range
					Lower bound	Upper bound	
1	Maximum Frequency	477	111.85	459	455	499	148
2	Minimum Frequency	185	36.08	181	178	192	41
3	Frequency Range	293	118.78	266	269	317	175
4	Maximum Intensity	98	7.64	98	97	100	9
5	Minimum Intensity	68	6.60	68	66	69	9
6	Intensity Range	31	8.52	31	29	33	11

Maximum Frequency (MaxF0 Hz*)*: It is the highest F0 value in VRP task. The mean value of maximum frequency in young females (20-30 age range) is 477 Hz, Median is 459 Hz, and the Standard deviation is 112 Hz.

Minimum Frequency (MinF0 Hz*)***:** It is the lowest F0 value in VRP task**.** The mean value of minimum frequency in young females (20-30 age range) is 185 Hz. The standard deviation of minimum frequency and median of minimum frequency are 36 Hz and 181 Hz, respectively.

Frequency Range *(*F0 range Hz*)***:** It is the difference between maximum F0 and minimum F0. The mean value of the frequency range in young females (20-30 age range) is 293 Hz, the Median is 317 Hz, and the Standard deviation is 119 Hz.

Maximum Intensity (Max I0 in dB): It is the highest intensity in the phonation. The mean value of maximum Intensity in young females (20-30 age range) is 98 dB, the median is 98 dB, and the standard deviation is 7.64 dB.

Minimum Intensity (Min I0 in dB): It is the lowest intensity value in the VRP task. The mean minimum Intensity value in young females (20-30 age range) is 68 dB, the Standard deviation is 6.6 dB, and the median is 68 dB.

Intensity Range (I0 range in dB): It is the difference between maximum I0 and minimum I0. The mean value of the Intensity range in young females (20-30 age range) is 31 dB, the Median is 31 dB, and the Standard deviation is 8.52 dB.

Subgroup Analysis

The hundred participants in this study were divided into two groups based on age. Group I included 76 participants in the age range of 20-25 years, whereas group II included 24 participants in the age range of 26-30 years. VRP parameters were analyzed between groups I and II and Table 4.2 shows mean, standard deviation, and median

VRP parameters between groups I and II.

Table 4.2

Mean, Standard deviation, and Median of voice range profile parameters between groups I and II.

Sl no	VRP Parameters	Groups	Mean	SD	median	95% confidence interval for mean		Inter-quartile range
						Lower Bound	Upper Bound	
1	Maximum Frequency (Hz)	G I	466	104	455	442	490	137
		G II	511	131	497	456	566	188
2	Minimum Frequency (Hz)	G I	189	38	187	180	198	49
		G II	172	26	172	161	182	27
3	Frequency Range (Hz)	G I	278	110	261	253	304	130
		G II	339	134	333	282	396	237
4	Maximum Intensity (dB)	G I	97	7	98	96	100	10
		G II	100	8	99	97	103	13
5	Minimum Intensity (dB)	G I	68	6	68	66	69	8
		G II	68	9	65	64	71	12
6	Intensity Range	G I	30	8	30	29	32	11
		G II	32	10	31	28	37	8

Shapiro- Wilk's test revealed that the VRP parameters in group I (20-25 years) and group II (26-30 years) were not normally distributed. Hence, one - way Manova test was done, as inferential statistics, to analyze any difference between the two age groups on VRP parameters. Table 4.3 shows the results of one way Manova for age wise comparison on VRP parameters.

Table 4.3

Results of one-way Manova for subgroup comparison (based on age)

Sl no	Parameters	df	F	p
1	Maximum Frequency	1	2.960	0.088
2	Minimum Frequency	1	4.474	0.037*
3	Frequency Range	1	4.493	0.029*
4	Maximum intensity	1	1.554	0.216
5	Minimum Intensity	1	0.002	0.967
6	Intensity Range	1	1.155	0.285

(*0.037 and 0.029 indicate significant at 0.05 level)

The results of the One-way Manova test showed a significant difference between age groups on minimum frequency ($F= 4.474$; $p<0.05$) and frequency range ($F= 4.493$; $p<0.05$). That is, the mean minimum frequency of group II (26-30 years) is significantly lower (172 Hz) when compared to group I (189 Hz). Similarly, group II had a significantly higher mean frequency range (339 Hz) when compared to group II (278 Hz). The mean maximum frequency of VRP is higher in group II (511 Hz) than in group I (466 Hz). Though the mean maximum frequency is higher in group II, but there is no statistically significant differences between group I and group II on frequency maximum values. One Way Manova's result of intensity parameters revealed that there is no statistically significant difference between group I and group II on maximum intensity, minimum intensity, and intensity range. That is, the three VRP parameters of intensity between groups I and II are similar, suggesting that age is not a factor for intensity parameters in VRP.

CHAPTER V

DISCUSSION

The aim of the study was to determine the normative voice range profile in young females in the South Indian population. A total of 100 participants were selected for the study in the age group of 20-30 years who were young females. The participants were students of All India Institute of Speech and Hearing who got enrolled in both Bachelor's and Master's degree programs. The inclusion criteria for this study include young females whose voice quality was rated on GRBASI rating scale with a score of '0' (zero) for the overall grade 'G'. The exclusion criteria include young females with any history of voice disorders, diabetic mellitus / hypertension, thyroid and hormonal problems, neurological abnormalities, major head and neck surgeries, throat infections, fever, or other medical conditions were excluded from the study. Information consent was taken from the participants for their participation. The participants' voice range profile samples were recorded using LingWAVES instrument (WEVOSYS). Participants' voice samples were recorded by asking them to glide the vowel /a/ from lowest to highest and highest to lowest pitch, as well as intensity.

The first objective of this study is to determine the minimum frequency, maximum frequency, and frequency range values in South Indian female voices. The present study found that the mean maximum frequency, mean minimum frequency and mean frequency range as 477 Hz, 185 Hz, and 293 Hz, respectively. Chatterjee et al. (2014) reported the normative for VRP measures for young Bengali speakers (for both males and females). Chatterjee et al. (2014) found that the maximum frequency, minimum frequency and frequency range for females as 385 Hz, 221 Hz, and 164 Hz, respectively. The results of the present study demonstrated higher values of mean maximum frequency, mean minimum frequency, and mean frequency range when compared to Chatterjee et al.'s (2014) study. The relatively better frequency related

measures of VRP would potentially be attributed to increased number of participants in the present study. Although the previous study included less number of females (15 in number) between the age range of 20 and 30 years. Similarly, the study done by Andersen et al. (2021) on young females found that the mean maximum frequency, minimum frequency, and frequency range to be 1063.5 Hz, 143.6 Hz and 34.7 Hz (ST), respectively. The results of the present study are not in agreement with the findings of Andersen et al. (2021) where the maximum frequency and frequency range were higher than the present study findings and also minimum frequency was lower than the present study findings. The differences noticed on VRP measures between Andersen et al. (2021) and present study would be due to methodological differences. Andersen et al. (2021) measured VRP parameters in thirty-nine Dutch young females who were between 18 and 28 years and recorded VRP with the help of Voice Profiler version 5.0 USB IVACX software. Whereas, the present study employed one-hundred young south Indian females between 20 and 30 years and used LingWAVES software for VRP recording.

The second objective of this study is to determine the minimum, maximum, and intensity range in south Indian female voices. The present study found that the mean maximum intensity, mean minimum intensity and mean intensity range as 98 dB, 68 dB, and 31 dB, respectively. Andersen et al. (2021) found that the mean value of maximum intensity, minimum intensity and intensity range as 108.9 dB, 43.2 dB, and 66.5 dB, respectively. The present study findings on VRP intensity parameters are not in consonance with the findings of Andersen et al. (2021) where the maximum intensity and intensity range were relatively higher than the present study findings and also, minimum intensity was much lower than the present study findings. The reason for differences in the findings could be attributed to the cultural and regional influences,

where the present study was conducted in south Indian population whereas the study done by Andersen et al. (2021) was on Dutch female population. Similarly, Chatterjee et al. (2014) reported that mean maximum intensity, mean minimum intensity, and mean intensity range for females was 105.7 dB, 97dB and 7 dB, respectively. When comparing the results of maximum intensity reported by Chatterjee et al. (2014) study, maximum intensity obtained in the present study was relatively lower. On the other hand, minimum intensity and intensity range parameters of VRP were relatively better in the current study when compared to Chatterjee et al. (2014) study. Thus, the results of the present study partially support the findings of Chatterjee et al. (2014) study and the differences observed between Chatterjee et al. (2014) and present study findings could be software used, number of participants and the population studied. Chatterjee et al. (2014) employed Dr Speech software to measure VRP on 15 young Bengali female participants.

Subgroup analysis revealed that group II participants had higher mean maximum frequency, mean minimum frequency, and mean frequency range when compared to group I participants. Similarly, the mean maximum intensity and intensity range are higher in group II when compared to group I. There is no difference found for mean minimum intensity in both groups. Results of one-way Manova revealed that mean minimum frequency and mean frequency range parameters are significantly higher in group II compared to group I. For other parameters such as mean maximum frequency and VRP intensity parameters shown no statistically significant difference between group I and group II. The results of the present study hinted that higher age group (26-30 years, group II) would have better control on frequency measures. The higher value of standard deviation on VRP parameters in group II indicates variability or less homogenous, owing to smaller sample size. However, the effect of age as a

factor on VRP parameters needs to be explored further with equal and greater number of subjects in each age group.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The objective of the present study was to determine the **Normative voice range profile in the young phono-normal south Indian population.** In the present study, a total of 100 young females in the age range of 20- 30 years were considered. Participant's voice samples were recorded by asking them to glide vowel /a/ from lowest to highest and highest to lowest in terms of pitch and intensity/loudness. Participants who got G0 on GRBASI rating scale indicating normal voice quality were considered for the study. The data recording was done in a sound-treated room with a noise level of less than 30 dB. The voice recording was done using LingWAVES software (WEVOSYS).

Pitch gliding from low to high and loudness gliding from soft to very loud voice were measured thrice. Measurements were done from three trials; the average was taken for further analysis and compared.

The results of the present study revealed several points of interest;

First, the measured normative VRP parameters for frequency such as minimum frequency, maximum frequency, and frequency range were 185 $\pm$ 36.08 Hz, 477 $\pm$ 111.85 Hz, and 293 $\pm$ 118.78 Hz, respectively.

Second, the measured normative VRP parameters for intensity such as minimum intensity, maximum intensity, and intensity ranges were 68 $\pm$ 6.6 dB, 98 $\pm$ 7.64 dB, and 31 $\pm$ 8.52 dB, respectively.

Third, VRP parameters in terms of frequency were found to be better for the higher age group (26-30 years) compared to the younger age group (20-25 years). Whereas, intensity parameters of VRP did not reveal any difference between the closer age groups. However, this needs to be investigated further.

Clinical implication

1. The results of the present study provided a normative voice range profile for young females in the age range of 20-30 years, which can augment in the clinical decision-making process, where this can serve as a clinical reference database.
2. The degree of deviance in pathological voice can be understood from the normative values of voice range profile obtained from the present study.
3. The results of the present study help the voice clinician to document the effectiveness of voice therapy by comparing the pre-post VRP parameters.

Limitations of the study

1. The study did not consider male participants.

2. The study did not correlate VRP parameters with other voice measures like perceptual, physiological, and aerodynamic correlates of voice.

Future directions

1. This study can be carried out in other age groups.

2. Further studies can also be done on different voice disorders to understand the age-related pathological changes.

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