VOICE RANGE PROFILE IN VOCALLY TRAINED AND UNTRAINED CHILDREN

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CERTIFICATE

This is to certify that this dissertation entitled **"Voice Range Profile In Vocally Trained And Untrained Children"** is a bonafide work in part fulfillment for the degree of Master of Science (Speech Language Pathology) of the student with Registarion No. 15SLP026. This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other University for the award of any other diploma or degree.

Mysore
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CERTIFICATE

This is to certify that this dissertation entitled **"Voice Range Profile In Vocally Trained And Untrained Children"** has been prepared under my guidance. It is also certified that this dissertation has not been submitted earlier to any other university for the award of any other diploma or degree.

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DECLARATION

This dissertation entitled **"Voice Range Profile In Vocally Trained And Untrained Children"** is the result of my own study under the guidance of Dr. R. Rajasudhakar, Lecturer in Speech Sciences, Department of Speech – Language Sciences, All India Institute of Speech anh Hearing, Mysore, and has not been submitted earlier to any other University for the award of any other diploma or degree.

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Dedicated to.....

My Sweet Parents

&

Cool Guide

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Give thanks for a little and you will find a lot- Hausa Proverb

"Thank you" is the best prayer that anyone could say. I say that one a lot. Thank you expresses extreme gratitude, humility, and understanding –Alice walker.

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TABLE OF CONTENT

LIST OF TABLES

CHAPTER I

INTRODUCTION

"Our Voice is the mirror of our soul"

Voice, articulation and language are the essential elements for human speech production. When a disorder related to any of these elements is present, the ability to commmunicate may be impaired. One of the most prime component of speech is voice, provides the speaker to produce speech with the vibratory signal. Production of voice is considered as both a powerful communication tool and artistic medium.

The voice is unique to human in all of the animal kingdom and is the rudimentary method of human communication (verbally). The frequency range and flexibility of sound production allows the voice to express emotions of human soul.

Voice production is dependent on the interrelationship of many different vocal elements. Those elements include respiration, phonation, and resonance, as well as the psychophysical components of pitch, loudness, and rate.

The production of speech is primarily initiated by the airflow from the lungs (respiratory system) followed by modulation of the upcoming airstream by the phonatory system which is again modified by the resonatory and the articulatory system to bring out the utterances. For the production of smooth speech all the subsystems should be working intact and efficiently.

Person’s voice gets influenced by human interaction and culture. In earlier days voice was only one method used for communication. We do not use our voice only for purpose of communication with others rather we use while we speak to ourselves and also for singing purpose.

Communication through voice begins from birth itself as birth cry and through that one communication channel made between the baby and mother. As the child develops, their voice plays a major role for fulfiling varoius purposes or needs like hunger, pain, and play etc. Some of children may develop sounds which will be very pleasurable to others while at the same time others develop their voice little harshness. Also, some others find that humming or singing brings pleasure and they get reward from the sorroundings like from family and friends. Generally that is the time when and how children engage in acting and singing and become more prominent in those skills in their school, high school, and so on. For some adults, singing becomes as an enjoyable and cheerful hobby while others made it as their passion and finally their profession.

One question would be coming in our mind that who are the professional vocalists? Tentatively we can say professional vocalists are those individuals who rely on their voices to be the major part of their occupation.

Occupational voice health is becoming more important day by day as more people rely on their voices for their work. Professional voice users are more prone to laryngeal pathologies than the general population due to their nature of work and life style (Stemple, Glaze & Gerdeman, 1995). These includes different professional who are expert and proficient in their respective field such as

teachers, salespeople, coaches, politicians, broadcasters, singers , clergy (religious leaders), telephone operators and many more. Usually the voice demands, the techniques and usage style and the overall quantity of use might vary considerably among all these above groups. In similar way, the quality demands and the ability to maintain their professional value differs. Without their voices, these individuals can not able to perform their required duties.

Professional voice users are one unique group among them, known as professional singers. From all the professional vocalists or vocal performer singers are prone to be affected by voice problems, even subtle ones. Generally there is a consistent expectation from the singers that they will accomplish their job at their best, with a strong, pure and clear voice with a wider range and unique character. Minute or slight changes in their voice quality can be easily reflected or make an impact to their voice quality and might be they can not be allowed to perform. Because of such expectations, singers always try to spend more time or most of the times in rehearsal or in pracitce. In that way they usually use their voice more time whether it will be in training or rehearse. Their voice should be very fine tuning with crystalize in the quality regardless to any style of singing. This perfectionistic drive and concentrating on hard work, tremendous effort and repetition is not only leads to excellence but also it may increase the risk of injury. A dramatic deterioration can be observed on the singer's voice if any kind of harm or damage happens to their voice, it not only leads to their voices but also on their psyche ,self-respect , pride, dignity and sense of self-worth.

The present approach to caring the singer's voice is to use an interdisciplinary team of the clinicians or a group of dedicated professionals including otolaryngologists, speech language pathologists, psychologists, singing voice specialists (Phoniatrists), and singing teachers. Among them, speech language pathologists (SLPs) are an integral part of that.

The salient principles of anatomic, physiology of voice production for the singer will be helpful in both assessment as well as in treatment and care of singer's voice. Learning or knowing vocal anatomy is the fundamental / primary step in preserving our gift of vioce. The voice is part of our identity and to protect that we should know how the voice works and how to maintain it throughout in our life.

The production of voice requires the interaction of many physiologic processes whether for singer's or nonsinger's while singing or in conversation. We should know in depth how the physiologic processes interact with each other and create voice and how singers can control and master their voices.

The vocal folds are often thought of as the source of voice. Although they are essential in the conversion of aerodynamic energy to acoustic energy, the vocal fold do not act alone. Voice production requires contribution from subglottal pressure, the vocal folds, and the supraglottal resonators.

Supraglottal factors can also affect the vocal intensity. The size, shape and placement of resonators are important. Trained speakers learn how to effectively control frequency and intensity independently. Trained singers can also increase

vocal intensity with less respiratory and vocal effort by changing the shape and stiffness of the vocal tract to tune formants (Titze,1994).

Voice professionals work in a wide range of disciplines and genres. The voice professionals who is singer/ music teacher or educator, a singer or a professional singer each demands peak vocal performance for longevity of career (Garrett, 2003).

For a healthy singing voice, it is important to know how to: (a) sing with healthy technique (i.e; balancing airflow, phonation, resonance, articulation agility), (b) sing in the correct voice category/range, (c) sing in the correct pitch are where voice comfortably sits, (d) choose music that has tessitura (pitch area) and range that matches one's own tessitura and range, (e) sing the genre of music with the healthiest possible stylistic tools (grit, growling) (Garrett, 2003).

The functional demands that singers place on the laryngeal mechanism in terms of range of frequency, amplitude control, acoustic variation, and overall vocal stamina are significant and unique (Aronson, 2011).

A comprehensive voice evaluation for a singer should include a carefully collected case history, acoustic, and aerodynamic data. The acoustic and aerodynamic data are important tools to document the patient's vocal quality and perceived vocal effort, respectively.

Assessment of voice need for the management of voice disorders. Some purposes are; 1) To make a diagnosis with severity levels for different voice problems, 2)

To find out the causes of the voice problems, 3) To facilitate the planning of voice treatment, and 4) To evaluate the outcomes of the voice treatment.

Many components comprise the diagnostic voice evaluation, which includes (1) Medical examination, (2) Patient interview, (3) Perceptual evaluation, (4) Patient self-evaluation, (5) Instrumental analysis of voice (both acoustic and aerodynamics) and (6) The functional evalutaion of vocal fold movement.

Earlier, clinical voice evaluation was restricted to auditory-perceptual voice quality evaluation. Instrumental analyses become more popular with advancing technologies.

Computer assisted voice analysis programs can complete the analysis and present the results in the form of numbers in few seconds, but clinicians should not rely on numerical values alone. Clinicians should know what the parameters are assessing and interpret the results accordingly in relation to laryngeal anatomy and phonatory physiology (with reference to different clinical population). Clinician should know/understand the usefulness and limitations of the instruments.

Instrumental measures used in the assessment of voice are behavioral tests of vocal performance that should refer to both habitual voice use and maximum performance tasks. Evaluation of habitual voice provides information about how the patient typically uses the voice production system.

In the past, to quantify the vocal parameters acoustic measures have been developed. These parameters shows the vibratory pattern of vocal fold. These

acoustic measures advantage is that those can be used to quantify and to monitor changes in voice between pre and post treatment & they are non-invasive. One such measure, often used by the Speech Language Pathologists is the voice range profile (VRP), also known as Phonetogram. It is a graphical representation that reflects the speaker's ability to produce maximum and minimum intensities at fixed percentages of his/her maximum frequency range of phonation under controlled conditions of vowel production and mouth opening (Schutte & Seider, 1983). VRP gives us information about the interaction of frequency and intensity variables occurring during the sustained phonation. This measure appears to be valuable in assessing both the normal and abnormal voices. The VRP in its original pattern describes the physiological capabilities of an individual voice. The information from VRP is useful to the voice clinician for both diagnostic and therapeutic purpose. In literature, the practical uses of phonetography (instrument) can be summarized as:

(a) Assessment of the normal voice and also useful for testing voice potentialities of singers, (b) documenting/monitoring the influence of therapy or surgical intervention and (c) comparing the values or datas in between selected groups (Schutte & Seider, 1983).

The voice range profile (VRP) which is also called phonetogram, is a non invasive tools for diagnosing of voice disorders in children (McAllister et al., 1994). The phonetogram or VRP measures provides an indications of a "damage risk criterion" through which a professional vocalist can able to evaluate the demands of a particular song in comparisons to the indicated capabilities of the

voice. Performer's can expand their musical capacity/capability of voice to achieve the physiological limits through the musical training and vocal maturation without getting any injury to their vocal mechanism (Coleman, 1987).

VRP recordings provide visual feedback and it can be helpful for singers and also for voice patients for identifying and communicating difficult vocal areas by considering the variation in frequency and intensity domains.

Singing requires skilled voluntary control in phonation task and also demands certain capacities of the voice source. Such capacities are the comfortable range of both intensity and frequency, those we can measure by using VRP and the areas will be represented in a phonetogram (Sulter, Schutte & Miller, 1995). Above mentioned authors has qouted that the voice capabilities are different for different individual, depending on person's laryngeal anatomy, as well as physical and physiological conditions. This variation happens according to their vocal function. Singing experience associated with improved neuromyogenic control over the voice source due to greater natural capacities in singer or singer learnt how to control their voice mechanism (Sulter et al., 1995).

The development of assessment for acoustic measures to obtain a difference between trained singers and untrained singers /nonsingers by using VRP which is a very easily accessible and more practicable method to explore and obtain the quantitative value of vocal output. Both the loudest and softest phonations in the entire frequency range values can be plotted as frequency against intensity /sound pressure level (SPL). There are two meaures can be quantify and determine as the

voice output, and those are SPL and Fundamental frequency (F0). Both the parameters can be determined through the use of voice range profile, one of the tool mostly use musical analysis by plotting the maximum and minimum SPL or intensity within the range of frequency of an individual.

In childhood, there are lot many factors like experience, opportunity, biological prospective, growth and maturation, interest, opportunity, family support, education and at the end socio cultural backgrounds/conditions are crucial in the development of musical behavior (Nettl, 1983).

Studies have been performed extensively in Western Context on voice ranges in vocally trained as well as vocally untrained adults. Some studies are also done on voice ranges in children between trained and untrained. Normative voice range profile had established in children and as well as in adults with trained and untrained individuals. In vocal training, the gender differences were also obtained. In India, an analytical study by Chaterjee et al. (2011) examined the effect of age and gender on VRP in Bengali adult speaker using phonetogram.

Shipp and Izdebski (1975) has derived one conclusion from studies that the different ways singers can alter the position of the larynx in comparison with untrained subjects and singers can modify in their respiratory movements while singing. Subjects who has undergone for singing training can use their dynamic and pitch ranges very extensively and can be able to produce phonetograms with larger capacities (Watson & Hixon, 1985).

Singers require voluntary control of phonation, while utilizing the comfortable range of intensity and frequency. They need to fulfil some demands for singing. (LeBorgne & Weinrich, 2002).

So we can assume that children are using their voice for singing practice (vocal habits) and some risk factors will be already established in childhood which may lead to voice disorders in their later life. So there should be a special emphasis given in the taking care of children's normal voices and in disorder childeren (Schneider et al., 2010).

For many years, this debate has been ongoing among the authors that how children are getting voice problems and reoprting as having hoarser voice and dysphonic.It has also noticed that now a days children having voice problems are reporting more in number in the voice clinics. Some scholars attributed and assumed that one of the risk factor is might be using of either inappropriate voice range or in the influence of social factors (Schneider et al., 2010).

Many studies have been performed in western countries on voice ranges in vocally trained children, especially in choir singers (Pederson et al., 1985). Normative of voice range profiles has been established for trained as well as in untrained children in western countries (Wuyts et al., 2002).

Need For the Study

- Although there are many teachers, voice trainers, choirmasters, speech language pathologists, and ENT's are involved in the care and the training of children. To take better care of children's voice, it might be helpful to know the voice ranges & its limit of vocally trained and untrained children.
- As one knows VRP can be used to measure the singer's voice range, the effect of singing training makes an impact/changes in physiological/laryngeal capabilities of singers. To quantify those changes there is a need to explore VRP measures in vocally trained singers.
- Very limited data is available on VRP for school going children in India. So, the present study made an attempt towards exploring the VRP measurement for children in Indian context.

Hypothesis

- There will be no significant difference on Voice Range Profile parameters between the vocally trained and untrained children.

Objectives of the study

- To evaluate the effect of singing training on Voice Range Profile in vocally trained children (between 8 - 10 years).
- To document the Voice Range Profile data of typically developing school going children (between 8 - 10 years of vocally untrained children).

- To compare & document the Voice Range Profile measures between vocally trained and untrained children.
- To compare between intensity and frequency parameters of Voice Range Profile, both vocally trained and untrained children.

CHAPTER II

REVIEW OF LITERATURE

Awan (1991) conducted a study with the purpose to inspect untrained verses trained vocalists using the phonetogram. The presnt study was aimed to (a) determine differences in the phonetographic measures between the two groups of adults (young) with vocal training and without vocal training, (b) to compare the measures between the groups such measures are of frequency range and maximum, minimum, and comfortable intensities. All the parameters were obtained from 20 subjects who are trained (mean age = 22.3 years) who had received formal vocal training for a period of 2 years and 20 untrained subjects (mean age = 21.3 years). In this present study, “musical” or “controlled” ranges of sustained phonation of vowel /a/ were given importance rather than “physiological” ranges (quality, duration and pitch) due to possibility of reducing laryngeal abuse and also it gives information about vocal performance and as well as in vocal capability. Results reported that (1) Phonetographic measures were obtained for trained versus untrained vocalists; (2) There was a significant higher value seen in range of F0 and maximum, minimum, and comfortable level of SPL in trained vocalists in comparision to untrained subjects. From the results of this study, one can say that for revealing the vocal characterstics of vocally trained and untrained subjects VRP or phonetogram would be the most ideal option.

Awan (1993) compared the speaking fundamental frequency (F0) and as well as intensity measures in young adults with and without the vocal training in both the gender, and also superimposition of F0 and the intensity values upon VRP or phonetograms in speaking task. This study is an extension of the previous study by Awan (1991). This present study had addressed three main questions (a) Do there is any differences in F0 and SPL / intensity in speaking task between untrained vs. trained vocalists? (b) Do the group differences are seen in regarding to speech area within the vocal area? And at the last (c) Is there any significant corelations between the F0 and Intensity measures of by using VRP and in speech? In this present study, “musical” or “controlled” ranges of sustained phonation of vowel /a/ were taken rather than “physiological” ranges (quality, duration and pitch) due to possibility of reducing laryngeal abuse and also it gives information about vocal performance and as well as in vocal capability. Before of the testing in phonetograph, each individual’s recording was made by reading the first paragraph of “the Rainbow Passage” in normal speaking voice. Parameters were extracted for the analysis from the second sentence of the reading passage. Results reported that (a) there was no significant differences seen in mean speaking F0’s both the groups, but in trained vocalists it had seen that speaking F0 ranges are greater than untrained vocalists, which suggested that training (vocal) may have some influence on respiratory capacity, laryngeal and supralaryngeal dynamics. (b) The mean intensity levels and speaking intensity ranges in speech was significantly greater in trained vocalists than untrained vocalists, which indicated that training has some sort of impact on vocal

capabilities as in speech. (c) mean speaking F0 for trained and untrained participants was found in the vicinity of the 5 – 7% frequency level of the entire phonational F0 range (in Hz), which is equivalent to 12 – 16% of the phonational F0 range in semitones. Same findings were found in both the groups. (d) the overall speech area (mean speaking F0 and minimum and maximum speaking F0 peaks) was found in the lower 23- 31% of the entire phonational F0 range (in semitones), where the untrained subjects can utilize phonational range (in semitones) at lower of 25% with the comparision to the trained vocalists, where e this particular area was extended to 28- 31% , So it qouted that trained participants had more flexibilty than untrained subjects in terms of vocal frequency for the speech and (e) In trained female subjects there was a significant correlations were reported between the total intensity range and intensity range which is used in speech task and in trained group a siginificant correlations were found in between total F0 range and speaking F0 range. For the application of phonetogram these results have important implications and as well as to monitor the outcomes of vocal training exercises in speech and in voice therapy cases too.

Sulter, Schutte and Miller (1995) established normative data of phonetograms for trained subjects and as well as for untrained subjects and analyse the effect of some specific factors on voice capabilities. Eg - gender related differences has been analyzed in this study. To determine the impact of factors like the voice training and gender, authors have included 224 Dutch participants, who weredivided into four different groups. The untrained group consisted of 92

female subjects in the age range of 17 to 44 years and 47 male subjects having age range of 17 to 35 years. In the trained group 42 female participants within the age range of 18 to 59 years and 43 male participants within the age range of 21 to 75 years were included in the presnt study. The subjects who were under trained category, had a training experience minimum of 2 years. The vocal training was either singing in choir or receiving individual singing lessons. Phonetograms were analyzed by the use of two methods, among them one is based on the rescaling method and another is conjoint method. In phonetograms, the frequency and intensity analysis mostly concentrating on the VRP features of shape, area and weighted dynamic range (WDR) and central position were measured. Author reported that in gender, male subjects could produce softer phonations in comparison to female but they have produced louder phonations in specific areas of their comparable frequency ranges. Trained vocalists had larger enclosed area basically larger frequency range was found in female subjects based on the extended soft voice capacities. The shape analysis also shown differences for both the factors of vocal training and as well as in gender too. Authors attributted that in the trained participants, the differences amy be seen in natural capacities which may be due to a superior learned control over their voice mechanism.

Bohme and Stuchlick (1995) investigated and developed a standard childhood voice profile by explaining the voice capacity of healthy untrained children. 277 healthy children within the age range of 5-14 years with no history of any vocal music training participated in this study. Following to the standards of the Union

of European Phoniatricians, analysis of the voice profile was done. The measured Phonetograms parameters were tabulated according to age and gender in a group . The mean and standard deviations of the maximal and minimal volume were calculated on each individual note of the vocal range. In each group for establishing highest and lowest limits of voice ranges the median value was used. The authors found that there is no age- dependent changes in the voice profiles in the groups of 7 – 10 year old children. Results reported that boys phonated louder than the girls. From the findings, authors have consrtructed a "standard childhood voice profile" of the untrained children by considering the 7 to 10 years age group . After the age of 10 years, an incriment of the dynamic range at the lowest frequencies was reported. Authors also reproted that the voice of 13 and 14 years old boys could not be determined because of pubertal voice changes.

Heylen, Wuyts, Mertens, Bodt, Pattyn, Croux and Van de Heyning (1998) evaluated the vocal performance of Children by the help of Voice Range Profile Index (VRPIc). The aim of current study was to make a report on the vocal frequency, intensity, and VRP morphologic characteristics of 230 normal and dysphonic children between the ages of 6 and 11 years. They have attempted to quantify the functional performance of a child's voice based on a specific combination of several VRP characteristics. The Voice Range Profile Index for children (VRPIc) is meant to allow for the quantitative evaluation of treatment effectiveness. In other words, it had given idea that how the VRPIc can be used for screening the voice disorder in children or to quantitatively monitor the voice

treatment effectiveness. The participants were 94 normal children (53 boys and 41 girls) and 136 (87 boys and 49 girls) dysphonic children were included in the study. Using t he Phonomat automatic voice field measuring system-equipment with following to the procedure recommended by the Union of European Phoniatricians, VRP measures recording was done. With some “warm up” exercises like singing, the participants were instructed to inhale in comfortably and to sustain the vowel /a/ for at least 2 seconds using a “habitual/optimal” pitch and loudness, as they use in daily speech. Then a “rough” contour was made by asking the child to phonate at their lower and upper Fundamental frequencies (F0s) using the maximum and minimum intensities at each frequency range extreme. For each semitone (ST), the upper and lower contours were taken within the child’s frequency range, so that for each of the 12 ST per octave intensities are recorded. Each child’s VRP was summarized by six frequency characteristics: (a) Lowest F0 (F0-Low); (b) Highest F0 (F0-High); (c) F0 range (F0 range = F0-High – F0-Low); (d) Number of semitones in modal register (ST-modal); (e) Number of ST in falsetto register (ST-falsetto); and (f) Semitone range (ST-range). The VRP was also summarized by the following three intensity characteristics: (a) Lowest intensity (I-Low); (b) Highest intensity (I-High); and (c) intensity range (I-range = I-High – I-Low). The authors reported that statistically there was no significant differences ($p > .05$) in the VRP characteristics between the boys and girls tested in the study. Finally, from this study, it has been pointed out that the VRPIc is not a new voice measure, but rather it is an index constructed of those VRP characteristics most sensitive to

vocal pathology. VRPIc for healthy and dysphonic children are scaled to +10 to –10, respectively, by using VRPIc the clinician can able to rate a child's vocal performance whether in healthy or in dysphonic children. For this method 90% and 83% was found for the sensitivity and specificity repectively.

Heylen, Wuyts, Mertens, Bodt and Heyning (2002) calculated normative voice range profiles (VRP) of teachers (both males and females), who are professional voice users. The authors had commented that calcualtion of mean values are not much reliable due to the oval shape of the VRP and the calculation median values are also unreliable for measuring VRP. So they presented a normative VRP which includes prediction intervals (PI) of 95% for both frequency and intensity, by based on a series of mathematical transformations of original VRP and typical shape of the VRP was obtained, based on recordings of 43 male with the age of 22- 54 years and 46 female with the age of 22- 51 years. All healthy voiced individuals were included in this study. These normative VRPs has obtained by considering 95% prediction intervals (PI) for both frequency and intensity. If VRP points of child lies outside of the error bars, that means that the individual's VRP value is deviant from normality. Like that the normative VRPs will directly help the clinician (otolaryngologists and speech-language pathologists) to assess whether child's voice is normal or pathological from obtaining their voice ranges. It offers a basis for reference in the evaluation of individual voices.

Leborgne and Weinrich (2002) examined the expansion of the VRP over a period of time by providing some intensive vocal training. The study aimed to assess

over a period of nine months is there any effects training (vocal) on the singers. Singers require voluntary control of phonation by using their comfortable range of F0 and SPL. Phonetogram measures and the changes were examined, with the primary focus on expansionof frequency range and/or intensity control was the primary focus of the study after aperiod of training. 21 first-year master's level vocal music students were participated in the study, who had taken the intensive vocal training. Four types of voices were included those are (17 sopranos, 1 mezzo-soprano, 2 tenors and 1 baritone) with the age ranged of 20 to 26 years. Result of this study revealed that after nine months of vocal training made a significant differences in mean frequency range and minimum intensity across frequency levels of singers and with the continuation of training can improve singer's ability. Authors did not found any significant difference for the mean maximum intensity across frequency levels after vocal training.

Wuyts, Heylen, Mertens, Bodt and Van de Heyning (2002) calculated normative voice range profiles (VRPs) for a group of untrained boys and girls. The authors had suggested that for the clinicians, the VRP of untrained children are the most relevant for the comparision between healthy and pathological voices. Author criticised the study done by Bohme and Stuchlick in 1995, by using VRP data of 45 boys and 67 girls, and the calculation of " Standard childhood voice profile" based on the calculation of mean and standard deviations for each note. The authors had commented that calcualtion of mean values are quite unreliable dur to the oval shape of the VRP. So they presented a normative VRP that contains

95% prediction intervals (PI) for both frequency and intensity, which is based on a series of mathematical transformations of original VRP. and by using this method typical shape of the VRP was obtained for a group of untrained boys and girls between 6 and 11 years based on 35 and 39 recordings, respectively. All individuals had healthy normal voice. VRP recording was performed using the Phonomat automatic voice field measuring system-equipment according to the procedure recommended by the Union of European Phoniatricians. Following some “warm-up” exercises such as singing the children were instructed to inhale in a comfortable way and to sustain the vowel /a/ for at least 2 seconds using a “habitual” pitch and loudness, as used during daily speech. A “rough” contour was then generated by having the child vocalize at his or her lowest and highest F0s using the softest and greatest intensities at each frequency extreme. The upper and lower contours were completed for each semitone within the child’s frequency range, so that intensities are recorded for each of the 12 semitones per octave. These are based on a series of mathematical transformations of the original individual VRPs inorder to maintain the normative VRPs, the typical oval VRP shape. The developed normative VRPs are directly applicable in the clinical practice by otolaryngologists and speech-languagepathologists. Authors described that in few instances when VRP points lie outside these error bars, it means that the VRP of the individual is deviant from normality. The more points that lie outside the normal ranges, the more the VRP can be regarded as pathological.

Schneider, Zumtobel, Prettnhofer, Aichstill and Jocher (2010) conducted a study in vocally healthy children by using VRP (voice range profile) measurements and evaluated the singing voice capabilities with different social and vocal/musical backgrounds. This particular study was done for gathering the data on voice range as well as in vocal capabilities. This is a cross-sectional study, where authors had included 186 children (within the age range of 7 to 10 years) from five diffrent schools. VRP measurements were obtained. For gathering information about vocal strain and vocal training through interviews and questionnaires and the answers were used for classification (KLA) of singing (S) activity (AK) [KLASAK] and vocal training. All children reached a mean singing voice range of at least two octaves. Children were classified as two groups as vocal strain or vocal training with the proper use of interviews and questionnaires. The authors did not find statistically significance differences in VRP measures between the groups. In the following step percentiles were calculated. P25 (first quartile), P50 (second quartile ¼ median), P75 (third quartile), and P90 (ninth decile) were calculated for both minimum SPL values while soft singing and maximum SPL values while loud singing. Twenty-five percent of all children (P25) reached a minimum voice range of almost two octaves namely 22 semitones (ST) from 220 to 784 Hz with soft and loud singing. The evaluation of P50 points out that half of the children had a voice range of 24 ST (two octaves) while soft singing and an enlarged voice range up to 26 ST while singing loud. Children of P25 and P50 still had a restricted dynamic range due to increased minimum SPL values and lower maximum SPL

values; and they were not able to sing louder than 90 dB. However, 50% of the children can sang softer or louder than the SPL values measured for P50. The measurements of third quartile (P75) let conclude that 25% of children have even a larger voice range than 29 dB (from 196 Hz/g to 1047 Hz/c3) and can sing at most frequencies louder than 90 dB. P90 demonstrated that 10% of the children sang even lower or higher than the frequency range between 196 Hz/g and 1319 Hz/e3. These 10% of the children sang softer and also louder than the SPL values. For the percentile analysis, the absolute lowest and highest frequencies reached by the children were calculated. The voice range seems not to be constrained by social but by voice/musical background: children of vocally/musically encouraged schools had wider voice ranges. The authors concluded that to investigate/ estimate the vocal constitution and vocal capabilities by the help of percentile VRP in children.

Chatterjee, Halder, Bari, Kumar and Roychoudary (2011) investigated the effect of age and gender on changes in acoustical parameters of voice and also attempted to obtain the normal voice range profiles across the gender and age. The study consisted of 90 normal individuals who were further divided into three age groups of 20 – 30 years, 40 – 50 years and 60 – 70 years. Each of these three groups had 30 participants (males and females were 15 in each group). The task of the participants involved phonation of vowel /a/ in seven consistent registering (after several training with seven singing registers in their natural scale) in normal loudness. Using Dr. Speech software phonetogram, VRP measures such as maximum and minimum fundamental frequency, frequency range and sound

pressure level and areas were measured from the phonation samples. The results of the study indicated that there was a significant difference reported only for the parameter of fundamental frequencies between males and females whereas the other parameters showed no statistically significant differences. The authors attributed these varied findings to the endocrinal changes in females which subsequently results in more massive vocal folds. Results for female groups indicated that there was increase in F0 with advancing age from young, through middle age to old. The increase in the mass of vocal folds resulted in reduced F0 in the older group. Elderly males had a significantly higher F0 than young and middle aged due to vocal cord atrophy and tissue stiffening. The authors concluded that there is a need to consider age as a potential factor before evaluating the vocal functions.

Chatterjee, Kumar and Chattopadyay (2012) compared the vocal performance of trained and untrained singers in Rabindrasangeet. The authors had the following aims; 1) To compare variations of acoustic parameters in trained and untrained singers of Rabindrasangeet 2) To obtain an ideal/optimal range of the parameters to the professional Rabindrasangeet singers and 3) To establish a baseline measure in which singers can be categorized in terms of vocal pathology as an effective estimate of clinical pedagogy. For the purpose, the study consisted of two group of participants 30 untrained Rabindrasangeet singers and 30 trained singers of Rabindrasangeet. The participants in each group consisted of 15 males and females. Their ages ranged from 18 to 30 years with an mean age of 20.9 years. The trained singers had a training experience of 4 – 10 yeras with an

average age of 7 years. The participants of the study required to produce 1 minute live singing of Rabindrasangeet and these were analyzed using the phonetogram. The results of the study indicated that there was a difference between phonetograms of untrained and trained singers. The authors attributed these differences between the groups can be trained subjects has greater natural capacities by the practice or a superior learned control over their voice production mechanism. These findings suggests that vocal trained subjects has a better breath control during voicing and the ability to oscillate vocal folds at lower sub glottal pressures. The findings of the study further emphasized on considering the vocal nature of task in singers.

D'Alatri and Marchese (2014) attempted to compare the measures of vocal limit using speech range profile (SRP) and voice range profile (VRP) to validate the utility of VRP in differentiating normal from that of pathological voices in non-professional female speakers. The study involved two groups consisting of 46 normal individuals and 148 individuals with dysphonia. The mean age was 36.61 years (age range of 19-60 years) in the control group and mean age of 40.08 years (age range of 18-68 years) in dysphonic group.The VRP task required subjects to sustain the vowel /a/ as soft and as loud as possible from the lowest to the highest frequencies using an automated procedure, whereas the SRP task involved the recording of the speaking voice (SV) and the shouting voice (ShV) and subjects were asked to read a list of having 20 number of sentences aloud twice at their most comfortable pitch and loudness as they use in daily conversation and to shout twice /ehi/ as loud as they could. The results of the

study revealed that both group of participants were able to perform SRP. Forty of 46 individuals (85%) in control and 102 of 148 (68.91%) cases in dysphonic groups were able to perform VRP. In the dysphonic group the VRP was not recorded because of the inability to perform or, inadequacy of the vocal signal. In the healthy group, the vocal limits derived from the two vocal profiles were similar, while in dysphonic subjects the SRP area was larger compared with that of VRP and mean values of VRP parameters were statistically different comared to those of SRP. This suggests that in healthy subjects the SRP can be an alternative procedure to VRP. These findings suggest that SRP may be a better tool to evaluate the functioning of vocal limits compared to that of VRP. Even though the study revealed very promising findings, the generality of the study is still questionable. Due to the matter of fact that, the study considered only female participants in the normal group and this factor of not including the other gender hinders the generality of the study.

Although there are many teachers, voice trainers, choirmasters, speech language pathologists, and ENT's are involved in the care and training of children. To take better care of children's voice, it might be helpful to know the voice ranges & its limit of vocally trained and untrained children. As one knows VRP can be used to measure the singer's voice range, the effect of singing training makes an impact/changes in physiological/laryngeal capabilities of singers. To quantify those changes there is a need to explore VRP measures in vocally trained singers. Very limited data is available on VRP for school going children in India. So, the

present study made an attempt towards exploring the VRP measurement for children in Indian context.

Objectives of the study

- To evaluate the effect of singing training on Voice Range Profile in vocally trained children (between 8 - 10 years).
- To document the Voice Range Profile data of typically developing school going children (between 8 - 10 years of vocally untrained children).
- To compare & document the Voice Range Profile measures between vocally trained and untrained children.
- To compare between intensity and frequency parameters of Voice Range Profile of both vocally trained and untrained children.

CHAPTER III

METHOD

Two groups of children participated in the study. Group –I consisted of 20 children who underwent formal singing training (minimum of 2 years) and Group-II consisted of 20 children who did not receive any formal training for singing. Hence, a total 40 children were participated in this study. Among them 10 were male participants and 10 were female participants in each group. The age of the participants were within the age range of 8 to 10 years.

Inclusion criteria for Group I

1. Participants didnot have any history of speech, language, hearing or communication difficulty.
2. Participants didnot report of any upper respiratory tract infection at the time of the study.
3. Participants had at least minimum of two years of formal training in singing, especially Carnatic style.

Inclusion criteria for Group II

1. Participants didnot have any history of speech, language, hearing or communication difficulty.
2. Participants didnot have any kind of upper respiratory tract infection at the time of the study.

3. Participants didnot receive have any formal training in singing (for shorter or longer duration) and this was ensured by administering a Singing Experience Checklist (Appendix 1).

Instrumentation and recording procedure

LingWAVES software (WEVOSYS, Germany) was employed in the present study. LingWaves is a high quality software-hardware unit by which SLP can able to analyse the human voices. It comes with a sound level meter (SLM) with a microphone attached to it. The SLM was placed on a tripod stand, and through this stand the SLM was adjusted to the patient's mouth level. The LingWaves software is a combined analysis tool for the measurement of the quantitative (singing/voice range profile) and qualitative voice parameters.

Each participant was tested individually. Objectives of the study were explained to the participants. Both oral and written consent were obtained from them (Appendix 2). The participants were made to stand and the microphone was adjusted according to the height of the participant. The participants were explained about the task and the demonstration of each task was highlighted to the participants. The participants had performed three trials for each task and reliability was established between the three trials (Sihvo, Laippala, & Sala, 2000).

For eliciting maximum phonational intensity range, throughout the recording, the examiner had provided the participants with hand signals to encourage and prompt for individual's maximum intensity (Coleman,1993).

For eliciting maximum phonational frequency range: The maximum and minimum phonational frequencies were elicited by discrete- step task from the mid (habitual) level (Zraick, Nelson, Montague & Monosoon, 2000).

Prior to the actual recording, participants were asked to Practice pitch gliding five times by "warm up" excercise to facilitate the vocal performance (Coleman, 1993). All participants were provided positive reinforcement and feedback before proceeding to next steps. The following tasks had recorded from each participant;

Tasks

1. Frequency :

   The participants were asked to phonate vowel /a/ from comfortable pitch to the highest pitch and asked to phonate vowel /a/ from comfortable pitch to the lowest pitch possible without any pitch breaks.

2. Intensity level :

   The participants were asked to sustain the vowel /a/ at a comfortable pitch from the softest loudness to the maximum loudness possible. In another way, the participant can start phonating at comfortable loudness and slowly increase the loudness level to the highest and then slowly decrease the loudness level to the softest level that they can.

3. Participants were asked to phonate /a/ sounds with changing their loudness to maximum(loud) and minimum (soft) by keeping frequency at constant level that is high pitch level and low pitch level individually.

Parameters

The present study has measured the following six parameters;

Minimum fundamental frequency (F0 Min), maximum fundamental frequency (F0 Max), fundamental frequency range (F0 Range), Minimum Intensity (I0 Min), Maximum intensity / sound pressure level(SPL) (I0 Max) and Intensity range (I0 Range).

Analysis

The LingWAVES software automatically calculated and displayed the parameters such as F0 Minimum, F0 Maximum, F0 Range, I0 Minimum, I0 Maximum & I0 range. All these variables were measured & tabulated separately for both the groups. Also, comparison were made between the two groups.

Statistical Analysis

Analyses were done using Statistical Package for Social Sciences (SPSS version 21) software. Descriptive statistics was carried out to calculate mean and standard deviation for the measured six parameters (F0 Minimum, F0 Maximum, F0 Range, I0 Minimum, I0 Maximum & I0 range) of each group. The data was administered SHAPIRO – WILK's test for normality. Since , the data has followed normal distribution Parametric test (Independent two sample t- test) was carried out to see the significant differences between the groups.

CHAPTER IV

RESULTS

The present study was aimed to document and compare the Voice Range Profile measures between vocally trained and untrained children. A total of forty participants in the age range of 8 – 10 years partcipated in the study and participants were grouped into two. Group-I consisted of twenty of Vocally trained children and Group- II consisted of twenty untrained children . Among twenty of them, 10 were male participants and 10 were female participants in each group. The Voice Range Profile paramters were measured using LingWAVE software such as F0 Maximum, F0 Minimum, F0 range, I0 Maximum, I0 Minimum & I0 range. All the obtained values were tabulated and compared between the two groups by using SPSS Software (Version 21).

The results of the present study are discussed under the following headings;

(i) Frequency related measures.

(ii) Intensity related Measures.

(iii) Effect of training on VRP measures.

(i) Frequency related Measures

The mean and standard deviation of three parameters in frequency related measures were calculated for both the groups which are shown in table 4.1.

Table 4.1

Mean and Standard deviation (SD) of three parameters of frequency related measures in Group- I and II

Parameters	Group I		Group II	
	Mean	**SD**	**Mean**	**SD**
F0 Min (Hz)	139	47.44	190	42.91
F0 Max (Hz)	418	37.90	413	45.67
F0 Range (Hz)	279	53.58	223	49.98

(Note: F0 Min – Minimum Fundamental Frequency; **F0 Max** – Maximum Fundamental Frequency; **F0 Range** –Range of Fundamental Frequency).

Statistical test was used to check the significant difference between groups on three parameters. Independent two- sample t-test was done for comparison of parameters between group - I and group – II. From Table 4.1, the mean values of two parameters of frequency related measures were higher in group-I comparison to group-II except of the F0 min which was lower in trained children than the untrained children . Among three parameters there was a statistically significant difference was found for F0 Min ($p < 0.05$), F0 range ($p < 0.05$) between the two groups. That means, the parameters like F0 Min was significantly lower in group I than the group II and F0 range was significantly higher in group-I in comparision to group II.

(ii) Intensity related measures

The mean and standard deviation of three parameters in intensity related measures were calculated for both the groups which are shown in table 4.2.

Table 4.2

Mean and Standard deviation (SD) of three parameters of intensity related measures in Group- I and II

Parameters	Group I		Group II	
	Mean	**SD**	**Mean**	**SD**
I0 Min (dB)	55	10.15	66	10.38
I0 Max (dB)	100	7.85	102	5.88
I0 Range (dB)	45	11.29	36	11.40

(Note: I0 Min – Minimum Intensity; **I0 Max** – Maximum Intensity; **F0 Range** – Range of Intensity).

Statistical test was used to check the significant difference between groups on three parameters. Independent two- sample t-test was done for comparison of parameters between group - I and group - II. From Table 4.2, the mean values of parameters of intensity related measures are higher in group-I comparison to group-II, except of the I0 min which was lower in trained children than the untrained children. Among three parameters there was a statistically significant difference was found for I0 Min ($p < 0.05$) and I0 range ($p < 0.05$) between the two groups. That means, the parameter I0 Min was significantly minimum in

group I compared to group II. Also, the I0 range was significantly higher in group-I than group-II.

(iii) Effect of training on VRP measures

Table 4.3 shows the results of the Independent two- sample t-test for group comparision of all parameters.

Table 4.3

Results of the Independent two- sample t-test for group comparision.

Parameters	F	T	df	Sig (p-value)
F0 Min (Hz)	0.46	3.579	38	0.001*
F0 Max (Hz)	0.786	-0.354	38	0.725
F0 Range (Hz)	0.020	-3.417	38	0.002*
I0 Min (dB)	0.090	3.448	38	0.001*
I0 Max (dB)	1.691	0.957	38	0.345
I0 Range (dB)	0.022	-2.396	38	0.002*

(* indicate significant at 0.01 level)

To summarize the results, there were six parameters measured in the study namely F0 Min, F0 Max, F0 range, I0 Min, I0 Max and I0 range in both the groups. Results of the statistical tests revealed that almost all parameters were significantly higher in group-I (Vocally trained children) compared to group-II (Untrained children).

CHAPTER V

DISCUSSION

The primary objective of the present study was to measure and document the voice range profile data in vocally trained children and as well as in untrained children. Further, the secondary objective was to compare voice range profile (VRP) measures between vocally trained and untrained children.

The present study is an exploratory study done to document and compare the Voice Range Profile measures (Frequency related measures and Intensity related measures) between vocally trained and untrained children. As per examiner's knowledge, this is the first attempt to document and compare the Voice Range Profile measures between vocally trained and untrained children in the age range of 8 – 10 years in Carnatic singing style.

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

First, ***the minimum fundamental frequency (F0 Min) was significantly lower in group I (trained children) compared to group II***. Lower F0 min in trained children reflects that the vibration of the vocal folds is less per second compared to untrained children. The lower F0 min in trained children is attributed to training effect where those children can able to sing/phonate at very low-pitched voice/raga when compared to untrained children. The results of the present study is in consonance with the previous findings of Sulter et al. (1995) where the authors reported that the trained subjects had greater natural capacities and had learned to control over the voice mechanism.

Second, ***the range of the fundamental frequency (F0 range) is significantly higher /wider in group I (trained children) compared to group II***. That means, the trained children has wider range in their fundamental frequency which reflects they have a better control over their frequency range. The higher F0 range in trained children indicate the greatest flexibility of the vocal folds where it can able to vibrate both at low as well at high frequency. This ability in group I (trained children) is attributed to singing training effect. The results of the present study is in agreement with the findings of Hixon (1978), Gould (1974), Watson, 1985) and (Sundberg, 1987). F0 range is wider in trained vocalists (singers) may be due to the usage of different posture (Hixon, 1978), increase in respiratory control (Gould, 1974 & 1977; Large, 1971), increase in lung volume and increase in rib cage volume (Watson, 1985). Differences seen in respiratory mechanism between the trained group and the untrained group likewise differences can be seen in laryngeal mechanism where trained singers can use appropriately the various modes of phonation like damped of folds (Gould, 1977), control over the airflow (Sundberg, 1987) and isometric contraction (Titze, 1978).

Results of the present study support the findings of Sulter et al. (1995) and Awan (1991) who reported that trained singers performed significantly larger/higher frequency range than untrained singers. Also, Leborgne (2002) reported that singing students has shown improvement significantly in their mean frequency range between pre and post training over a period of nine months.

Third, ***the minimum intensity level (I0 Min) is significantly lower in group I (trained children) compared to group II (untrained children)***. The trained children in the present study might know how to use their voice efficiently and have greater control in using the subglottal air pressure. The trained children are not abusing their voices aslike untrained children and they might also know the importance of the voice more than the untrained one. Further, the trained children can able to use their voice as minimum as they want or need. The results of the present study is in consonance with the previous findings of Chatterjee et al. (2012) and Akerlund et al. (1992). Chatterjee et al. (2012) reported that there are some possibilties for singers by controlling their breathing mode during voicing they can able to oscillate the vocal folds even using lower subglottal pressure. Akerlund et al. (1992) reported that singers had the ability to phonate at slightly lower intensities almost all over the frequency range.

The singer to becoming mastery they need a good coordination between resonance, phonation and respiration which in a result of to improve the ability to maintain in a minimal intensity. Also, Leborgne et al. (2002) reported that after training, singers had performed significantly lower in their vocal intensity which suggest that singers were continuing to master the ability to coordinate the entire vocal mechanism.

Forth*, the range of the intensity (I0 range) is significantly higher/wider in trained children (group I) than the untrained children (group II).* This can be

attributed to the effective use of subglottal air pressure and as well as the respiratory energy by trained children than untrained children. Also, the trained children have an enhanced control over the intensity output (Sulter et al, 1995). The present study results were in agreement with previous findings of Gramming and Sundberg (1988) who found that trained subjects had wider/larger range in I0 that may reflect the enhanced use of both sublaryngeal and supralaryngeal mechanisms.

Fifth, ***no significant difference found in maximum fundamental frequency (F0 Max) and maximum intensity (I0 Max) between group I and group II.*** The performance on F0 Max and I0 Max was relatively greater in trained children compared to untrained children. But, there was no statistically significant difference found between the groups. The possible reason could be the trained subjects are more concerned about their voice mechanism and they did not phonate beyond their optimum level to the extreme where it might make an adverse effect to their vocal mechanism.

Sixth, ***VRP measures were greater in group I (trained children) than group II.*** Singing training improves the physiological voice measures such as maximum phonation duration, s/z ratio and vocal range parameters such as frequency and intensity. This inturn enhances the respiratory control and thereby improves vocal efficiency. The results of the present study supports the previous findings of Lebourge (2002) and Sulter et al. (1995).

Lebourge (2002) found that singing training has considerable effect on expanding the singer's ability which could ultimately resulting in increasing the frequency

range and as well as dynamic range. Also, Sulter et al. (1995) concluded that singing experience/training improves vocal behaviours owing to the enhanced neuro-myogenic control over the voice source.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The aim of the present study was to document the Voice Range Profile data of both trained and untrained children within the age range of 8 to 10 years. Also, evaluate the effect of singing training on VRP in vocally trained children between 8 to 10 years. Two groups of subjects participated in the study where group I consisted of 20 vocally trained children and group II consisted of 20 untrained children. Each of the group had 10 girls and 10 boys.

The voice range profile parameters measured in the study were F0 Min, F0 Max, F0 Range, I0 Min, I0 Max, and I0 Range using LingWAVES software. Participants were asked to phonate vowel /a/ from their comfortable pitch level to the highest pitch and from the comfortable pitch level to the lowest pitch as possible by them. Similar task was carried out for measuring the intensity parameters. All six parameters were measured and tabulated separately for each group and group comparison was made after descriptive statistics by using SPSS software.

The result of the present study revealed that the Voice range profile (VRP) parameters such as F0 Min, F0 Range, I0 Min, and I0 Range had shown statistically significant difference ($p < 0.05$) betweeen the two groups and not for F0 max and I0 max. Hence, the null hypothesis considered in the study was rejected.

From the above findings, it can be concluded that there is an effect of vocal training (singing) on voice range profile parameters and thus the findings suggest a good physiological control over the vocal mechanism in vocally trained children compared to untrained children.

The study found some interesting aspect on the significant parameter that differed untrained children from trained children. Operationally the ‘effect size’ is calculated based on the mean difference of parameters between the groups (Higher Mean value – Lower mean value). The effect size for F0 Min: 51 Hz; F0 range: 56 Hz; I0 Min: 11 dB and I0 range: 9 dB.

Implication of the study

- The VRP data fromthis study might help music teachers, voice trainers and choirmasters to become aware of what children’s physiologic range of singing.
- The result of the present study will help the voice teacher/trainer to monitor children’s singing range in the optimum capacity while practicing songs.
- In clinical practice, VRP measurement in children will help speech language pathologists to diagnose whether they are using their voice within physiological limits or not.

Limitation of the study

- Less number of participants included in the study
- Phonation task was employed instead of singing task.

Future directions

- Future study can be done by considering more number of participants.
- Future studies can be done in other types of singing style i.e; Hindustani style and Western style.
- It can be done to develop normative values for VRP measures in both trained and untrained children especially lesser than 8 years & greater than 10 years of age.
- Studies can be done to utilize VRP as a tool to monitor the vocal behaviors in voice therapy where the efficacy of voice therapy can be evaluated.
- Further studies can be focused by accounting various other tasks like singing, speaking, shouting and reading for VRP measurement.

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Appendix 1

Singing Experience Checklist

1. Do you like to listen to music ? (Yes / No)
2. Do you like to sing? (Yes / No)
   a) If yes, How often do you sing?
      i) 2-3 times in a day ii) 3- 5 times in a day iv) >5 times in a day.
   b) What is the duration of singing (approximately) in a day?
      i) <30 minutes ii) 1 – 2 hours iii) > 2 hours.
3. Have you ever been undergone for music training? (Yes / No)
   a) If yes, how many years ----------
   b) If yes, what kind of training?

Appendix 2

CONSENT FORM

All India Institute of Speech and Hearing, Manasagangothri,
Mysore, 570006

TOPIC: 'Voice Range Profile in Vocally Trained and Untrained Children'.

I, Shubhasmita Mahakud, Master student, doing dissertation regarding the above mentioned topic under the guidance of Dr. Rajasudhakar, Dept. of Speech Language Sciences at AIISH. I would be profiling the voice range of singers and nonsingers in childern by measuring frequency and intensity domains such as Maximum F0, Minimum F0,range of F0, Maximum I0 , Minimum I0 & range of I0 by using "Ling WAVE" software. All the samples will be kept confidential. It will be helpful for SLP's to understand the range of voice in children as well as it might help music teachers, voice trainers, and choirmasters to become aware of what children's physiologic range of singing.

Consent

I (.....) have been informed about the aim and implication of the study as mentioned above. I hereby agree to participate in the study.

Signature